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"Panta Rhei"

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Athens, Greece



BOOK OF ABSTRACTS

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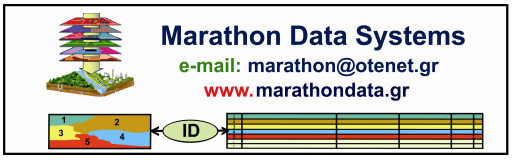
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Contents

Committees …….. iv
Preface …….. vii

Keynote Speeches …….. 1
I. Advances in Hydrological Processes …….. 15
II. Climate and Water Resources …… 69
III. Water Resources Management ……... 105
IV. Droughts and Water Scarcity …….. 135
V. Water Quality and Environmental Processes …… 163
VI. Urban Water Networks …… 237
VII. Agricultural Water Management …… 263
VIII. Groundwater Hydrology and Contamination ……..... 297
IX. Legislation and Policies ……. 331

Index …….. 355

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Preface

This volume contains the Abstracts of all the papers which are accepted for presentation in the 10th World Congress of EWRA on Water Resources and Environment "Panta Rhei", Athens, 5-9 July 2017. The Congress is organised jointly by the National Technical University of Athens (School of Rural and Surveying Engineering/Centre for the Assessment of Natural Hazards and Proactive Planning) and the Environmental and Water Resources Institute of the American Society of Civil Engineers.

All the abstracts/papers included in this Book of Abstracts have been accepted after review both at the abstract and the full paper stages.

The abstracts/papers included by this volume belong to the conferences of the Congress as follows:

I. Advances in Hydrological Processes
II. Climate and Water Resources
III. Water Resources Management
IV. Droughts and Water Scarcity
V. Water Quality and Environmental Processes
VI. Urban Water Networks
VII. Agricultural Water Management
VIII. Groundwater Hydrology and Contamination
IX. Legislation and Policies

The full text of the accepted papers can be found in the Proceedings of the Congress which are published as a Special Issue of the journal EUROPEAN WATER. The full text of invited speeches are included in the Special Issue of the journal WATER RESOURCES MANAGEMENT with the title "Facets of Modern Water Resources Management" devoted to the 30-year Anniversary of the journal.

This volume (as hard copy) and the Proceedings (in electronic form) are available to all the participants of the Congress.

Closing, I have to thank all the members of the Organising Team for their devoted work and all the authors/delegates for their cooperation. Also, I thank the Sponsors of the Congress for their kind offer and support.

G. Tsakiris
President of Organising and Scientific Committee

Keynote Presentations

Bringing Future Climatic Change into Water Resources Management Practice Today

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ABSTRACT

The global climate is changing and altering the hydrologic cycle that results in (i) reduction of water supply; (ii) increase in frequency and magnitude of flood and drought events; (iii) damage to the shoreline areas; (iv) increase in irrigation water use; (v) decrease in quality of all freshwater sources; and (vi) increase in functional and operational requirements for the existing water infrastructure. The paper provides the review of water resources management challenges posed by the climate change. In order to provide guidance for including climate change impacts into water management studies, a generic approach is detailed for potential implementation in practice. Methods for selecting global climate models and emission scenarios, followed by bias correction and downscaling are discussed. The paper ends with the description of one practical example, IDF_CC, a web based tool for updating intensity duration frequency curves under changing climate. The tool is designed in response to real needs of water engineering practice and has been in use in Canada since early 2015.

KEYWORDS

Climate change, water resources management, intensity-duration-frequency curves, uncertainty, complexity

Overview of Water Policy Developments: Pre- and Post-2015 Development Agenda

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ABSTRACT

The year 2015 marked the end of some important universal decisions regarding water developments. The International Decade for Action 'Water for Life' (2005-2015) was concluded so that a "Post-2015 Development Agenda" is now defined. 2015 was also the year when UN Millenium Goals (MDGs) came to an end to convert into the new Agenda, which is a process led by the United Nations (UN) to define the future global development framework. The proposed goal is now referred to as SDG's or Sustainable Development Goals, that extend existing commitments such as the MDGs and the priorities of Rio+20. SDG's will balance the economic, social and environmental dimensions of sustainable development with a strong linkage between environment and socioeconomic goals. They converge with the post-2015 development agenda, now called Agenda 30 as these goals will be valid until 2030. One of the major concepts of SDG's is water security, which is the basic element of the Global Goal on Water. Water security is the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality of water for sustaining livelihoods, human well-being, and socioeconomic development , for ensuring protection against pollution and waterrelated disasters, and for preserving ecosystems in a climate of peace and political stability. This paper discusses the developments in water management within the last 30 years, which eventually led to the above concepts. A summary is provided on key events and documents of these past years to point out how the international community has reacted towards present and emerging needs of the society.

KEYWORDS

Water management, post-2015 development agenda, sustainable development goals, water security, water allocation, Global Goal on Water

An evolutionary perspective on Water Governance: From understanding to transformation

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ABSTRACT

Many water related problems can be attributed to governance failure at multiple levels of governance rather than to the resource base itself. At the same time our knowledge on water governance systems and conditions for success of water governance reform is still quite limited. Water governance is a fast growing field of scholarly expertise which has largely developed over the past 10 to 15 years. This paper summarizes the development of the field over the past decade(s). On one hand it addresses the current state of understanding of factors that determine the success of water governance systems. On the other hand it has a strong emphasis and processes of transformation and change in water governance as governing the transformation of water governance is the key challenge in moving towards more sustainable water governance and management.

KEYWORDS

Water governance, Social learning, sustainability transformation

Water, agriculture and food: Challenges and issues

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ABSTRACT

Population growth, increasing demands for food, ever-growing competition for water, reduced supply reliability, climate change and climate uncertainty and droughts, decline in critical ecosystems services, competition for land use, changing regulatory environments, and less participatory water resources governance are contributing to increasing difficulties and challenges in water resource management for agriculture and food. The need for sustainable food security for our global population and the need for preserving the environment, namely natural and man-made ecosystems and landscapes, have created an increased need for integrated, participative and scalable solutions focusing the various levels of irrigation and nature water management, from the field crop to the catchment and basin scales. Meanwhile, challenges and issues relative to water management for agriculture and food have evolved enormously in the last 30 years and the role of active management of the components of the water cycle is assuming an increased importance since their dynamics are key to assure water use sustainability, mainly agriculture and natural ecosystems sustainability. However, different regions face context-specific challenges associated with water scarcity, climate, governance, and population requirements. The main and first challenge is producing enough food for a growing population, which is intimately related with challenges placed to agricultural water management, mainly irrigation management. This paper revises challenges and progress achieved in 26 the last 30 years focusing on irrigated agriculture, mainly water management, and its contribution to food security and the welfare of rural communities.

KEYWORDS

Water management, energy, climate change and uncertainty, water scarcity, participatory water governance, reference evapotranspiration, crop water requirements, irrigation management

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Kinematic Wave Theory of overland flow

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ABSTRACT

Kinematic wave (KW) theory is widely applied for modeling overland flow. The theory 6 is comprised of (1) continuous waves, (2) formation of shocks, and (3) propagation of shocks. This paper revisits the KW concept for overland flow from fluid mechanical and mathematical points of view. Then, it develops mathematical formulations of overland flow, based on the classification of overland flow problems and the influence of storm movement and areal coverage. Depending on the class of overland flow problems, the mathematical formulation involves free boundary problems that are not known beforehand and must be solved for along with the solution of the problem. Finally, the validity of the KW concept is revisited and the accuracy of the KW approximation can be expressed by Riccati equation that describes the error for the whole hydrograph.

KEYWORDS

Free boundary, shock, celerity, moving storm, Riccati equation, kinematic wave number

Smart water network modeling for sustainable and resilient infrastructure

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ABSTRACT

Urbanization can significantly increase the load on aging, inefficient and already strained sewer infrastructure, resulting in catastrophic pipe failure, unwanted spillage, property damage, and serious threat to public health. Urbanization can also dramatically alter the natural water cycle, resulting in diminished water quality, increased frequency and severity of flooding, channel erosion and destruction of aquatic habitat. Recent advances in smart water network (SWN) modeling technology have played a crucial and growing role in addressing these challenges. SWN technology has equipped practicing engineers with a comprehensive set of analytical decision making tools designed to help them preserve structural integrity, manage and reduce the risks of sewer overflow and urban runoff, improve resiliency and keep their urban drainage networks operating well into the future. These advances propel routine conveyance system analysis from basic planning and design to two-dimensional surface/subsurface flow modeling, real-time operation and control, analytical risk-based asset integrity and condition assessment, and optimal selection and placement of green infrastructure based on cost and effectiveness. SWN is providing critically needed support to federal, state, and local agencies and watershed practitioners - not only in optimizing their integrated water management and adaptation strategies, but in ensuring sustainable drainage, addressing environmental quality restoration and protection needs in urban and developing areas, and improving communities' resiliency. It is also within the grasp of utilities of all sizes, but they need to seize the opportunity.

KEYWORDS

Smart water, network modeling, real-time, asset management, green infrastructure, optimization

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Towards adaptation of water resource systems to climatic and socio-economic change

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ABSTRACT

Climate change is viewed as the major threat to the security of water supplies in most parts of the world in the coming decades, and the water resources literature continues to be dominated by impact and risk assessments based on the latest climate projections from General Circulation Models (GCMs). However, the evidence for anthropogenic changes in precipitation and streamflow records continues to be elusive which, together with the known high uncertainty in GCM ensemble projections, has led to the development of risk assessment methods which are not driven exclusively by GCMs. It is argued that a baseline risk assessment should retain the assumption of climatic stationarity, and be based on the modelling of observed interannual variability as a dominant process in determining water resource system reliability, augmented where justifiable by reliable information from GCMs. However, irrespective of what the climate does in the future, globalization and socioeconomic changes are the major drivers for increases in water demand and threats to water security, as exemplified by the burgeoning economies of the BRIC and MINT countries, and the large population increases and economic growth seen in many developing countries. It is suggested that more attention needs to be paid to adaptation to socio-economic change which is arguably more predictable than climatic change, based on what is already known about population and economic growth, lifestyle changes and human choices. More focus is needed on economic analyses that can inform the major investments in water use efficiency measures which can deliver the water savings needed to avert widespread water scarcity. The effectiveness of water use efficiency measures is largely determined by (a) the potential of modern information technology to achieve more efficient water resources management and water use and (b) human responses and choices in the uptake of measures. To assess the potential efficiency gains, it is argued that water resource systems modelling needs to evolve to incorporate the human dimension more explicitly, through Coupled Human and Natural Systems (CHANS) modelling. A CHANS modelling framework is outlined which incorporates agent-based modelling to represent individual choices within the human system, and prospects for assessing the effectiveness of efficiency measures involving individual human responses are discussed.

KEYWORDS

Climate change, climatic variability, socio-economic, adaptation, risk, impacts, vulnerability, demand-supply gap, real-time operational control, human system, agent-based modelling

The "WFD" implementation in the European Member States

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ABSTRACT

The Water Framework Directive (WFD), one of the most influential pieces of European water legislation, presents a general framework for integrated river basin management in Europe to meet the environmental objectives. More than 16 years after the WFD adoption and after the end of the first management cycle (in 2015), it is time for a screening assessment of the implementation of the WFD in the different Member States (MSs). This article provides a global overview about the evolution of WFD implementation in MSs, highlighting the progression of the European water bodies status, as well as, some of the main challenges of WFD implementation: ecological flows, pricing policies/economic analysis, climate change, exemptions, public participation and transboundary issues. The paper examines these different topic, drawing up their situation in different MSs. For that purpose, not only the foreseen second cycle of the River Basin Management Plans (RBMPs) is analysed as also, at a larger scale, the expectations and challenges for the future set by the WFD are examined.

KEYWORDS

Water Framework Directive, River Basin Management Plans

Mentoring new water resources professionals on engineering ethics

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ABSTRACT

Engineers maintaining high level of ethical standards is important to society and to the respective profession. We serve as the technical experts on behalf of society and with that role comes significant responsibilities. There are many causes for engineers to make unethical decisions, i.e., placing profit above protection of the public. Such reasons, for example, overbooked schedules, the unethical conduct of business associates, doing the "right thing" would cause a lot of trouble, and the pursuit of fame and fortune above all, etc. There are some common ethical dilemmas that new professionals may face: the acceptance of gifts from vendors or contractors, the billing of labor hours to unrelated project, and the inadequate reviewing of design work. New professions may lack the experience and abilities to successfully handle ethical dilemmas early in their careers. Mentoring new professionals, related to ethical standards may have a longlasting effect on individuals who are new in the engineering profession. Experienced engineers bring vast knowledge in discussions on how to resolve ethical dilemmas. A key aspect to being a successful mentor is to thoroughly understand the Code of Ethics. If an engineer's decision are highly supported by the Code of Ethics then it is much more likely that his (her) conduct will be more appropriate and acceptable.

KEYWORDS

Engineering ethics, Professionalism, Code of Ethics, Case Studies

The use of vertical flow constructed wetlands in wastewater treatment

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ABSTRACT

Alternative to conventional (i.e., the commonly used biological plants) wastewater treatment systems are presented which are appropriate for small communities and settlements. These systems are the natural treatment systems. The emphasis here is given on vertical downflow flow constructed wetlands (VF CWs). First, advantages and disadvantages of these systems are presented compared to conventional systems. Applications in treating different types of wastewaters and various pollutants are summarized. Components, treatment processes and performance are also presented. General description of facility compartments, layout and operation is given. Design guidelines on recommended unit areas, organic loading rates and hydraulic loading rates from various EU countries for CW systems used in municipal wastewater treatment, and data on the efficiency of such systems are also presented. Maintenance and operation issues are discussed. Finally, investment and operation and maintenance costs are addressed based on real data.

KEYWORDS

Constructed wetlands, Wastewater treatment, Horizontal subsurface flow, Vertical flow systems, Design issues

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Flood forecasting and decision making in the new millennium. Where are we?

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ABSTRACT

This paper reviews the development of real time flood forecasting systems from the early 1970 approaches to the recent probabilistic ones. A preliminary discussion on the motivations for developing real time flood forecasting systems is introduced to explain their evolution in the last four to five decades. It will be shown how recent probabilistic flood forecasts are more robust and effective than the traditional deterministic ones. In particular, when combined with Bayesian decision approaches, probabilistic forecasts are the most appropriate tools for rational decision making in flood warning and flood management. Moreover, they allow taking into account the information from several models to be taken into account by combining into a unique predictive density the deterministic predictions of several hydrological or hydraulic models of a different nature, while in the multi-temporal forecasting extensions, they provide to answers questions such as: Which is the probability of overtopping a dyke in the next 24 hours? When will this event be more likely to occur during the next 24 hours? The work concludes with a discussion on the still unresolved problems, namely how decisions makers can fully take advantage of the probabilistic forecasts and how these forecasts must be communicated to them in order to meet this objective.

KEYWORDS

Flood Forecasting, Deterministic, Probabilistic, Predictive Uncertainty and Knowledge, Multi-model forecasts, Multi-temporal forecasts

I. Advances in Hydrological Processes

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Water depth-damage functions for flood direct tangible damage evaluation in built-up areas in Sardinia (Italy)

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ABSTRACT

Flash floods occurring in the Mediterranean area lead to investigate on relevant damages caused by floods in Sardinian territory (Italy). The Flood Directive 2007/60/EC, requiring a cost-benefit analysis for the definition of mitigation measures, should be supported by appraisals of flood damages. Actual study background recognises the use of water depth-damage functions as key elements in decision-making evaluation of authorities. Flood damage functions are still not available for Italy and should be developed considering the regional territory. This paper revises the Joint Research Centre Model approach (Huizinga H.J., 2007) for Sardinian region and provides water depth-damage functions for direct tangible damage assessment. Historical data on flood damages were collected considering two recent events. The first event occurred the 22nd October 2008 in Capoterra town, in the South-East of the region, where it caused damages in structures of residential and touristic area for millions of Euros, and 4 victims; the second event occurred the 18th November 2013 in the North-East area determining damages in multi-storey buildings in Olbia town and 13 victims. The collected data were statistically studied considering the possibility of fitting relations between water depth and expected damage data using a Pearson III probability distribution. The water depth-damage functions show different trends due to building types in the two studied areas. The procedure was subsequently implemented considering synthetically generated flood events in order to estimate the expected mean annual damage values due to flooding in prone areas and to verify economic efficiency of planned mitigation measures.

KEYWORDS

Water depth-damage functions, flood damage estimation, Pearson III probability distribution, JRC Model validation

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A methodological approach for flood risk management in urban areas: The Volos city paradigm

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ABSTRACT

A methodological approach based on the implementation of the EU Floods Directive in Greece is developed and presented for flood risk management of urban areas. The flood risk assessment procedure is demonstrated for Volos city of Thessaly, Greece, where frequent flood episodes are observed due to intense storms. A unified deterministic extreme event-based methodology is applied for hydrologic and hydraulic modelling of floods. The hydrologic part is based on semi-distributed application of the HEC-HMS rainfall-runoff model with spatially-distributed design hyetographs. The SCS-CN method is used to estimate effective rainfall and the SCS synthetic unit hydrograph to produce extreme flood hydrographs at subwatershed scale. The hydraulic modelling is based on the propagation of flood hydrographs across the river network and the mapping of inundated areas using the HEC-RAS 2D model with flexible mesh size. Representation of the resistance caused by buildings have been simulated with the local elevation rise method using transformation of the Digital Terrain Model to a Digital Elevation Model. For the adopted design hyetographs upper and lower estimates on water depths, flow velocities and flood inundation areas are estimated taking into account structural and parameter uncertainty of the hydrologic and hydraulic models by varying antecedent soil moisture conditions and roughness coefficient values. The results indicate the uncertainty introduced on flood risk management in urban areas using typical engineering practices.

KEYWORDS

EU Floods Directive, flood risk management, hydrological modelling, 2D hydraulic modelling, HEC-RAS, building representation, urban floods

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On urban inundation and damage modelling

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ABSTRACT

Flood risk results from a complicated interplay of natural and anthropic factors. Therefore, risk modelling and assessment may require different modelling tools, related to individual facets of the problem. These may be organized in a chain where each model represents a ring. The interfaces among the single modelling rings represent a most critical part of the analysis that must be added to the inherent criticalities and uncertainties of each modelling step. In this work a prototypal case-study in northern Italy (the town of Sondrio, that is prone to flood risk by the Mallero river) is considered. A 100-year synthetic river flood was simulated and an outflow hydrograph was accordingly computed in an earlier study. The present work considered the further rings of the chain. A two-dimensional wave flooding the town was numerically modelled, simulating building blocks as impermeable obstructions. Different configurations of the blocks were considered within a sensitivity analysis of the modelling result to the geometric description. Hazard indicators were obtained and transferred to the following modelling ring. Flood-induced damages to buildings, considered proxies for the flood risk, were computed by a recently developed synthetic model, that provides absolute damage values based on a component-by-component analysis of physical damages to residential buildings. In the described sequential procedure, the hydraulic analysis served as a support for the following risk assessment. Therefore, the results of the sensitivity analysis for the hydraulic model were not useful per se but rather with reference to their implications for the quantification of damage and thus of risk.

KEYWORDS

Urban flood, risk assessment, two-dimensional wave, damage model

Flood risk and flood processes in a changing environment

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ABSTRACT

Driven by the EU- Flood Directive, flood risk management became one of the focusing points of water policy. Flood risk means the combination of the probability of a flood event with its adverse consequences. Unfortunately, the consequences of a changing environment on floods are hidden by high uncertainties about the stochastic behavior of flood inducing processes and their possible changes. Tools, which are able to combine statistical assessments with deterministic considerations, are rare. In this presentation, the problem of instationarity is discussed to demonstrate the need to close the gap between stochastic and deterministic flood hydrology. Some methodological tools will be presented which are useful for this purpose.

KEYWORDS

Floods, multivariate statistics, timescales, flood types, peak over thresholds

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Numerical modeling of Samsun Mert river floods

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ABSTRACT

Floods are considered one of the most important natural disasters after earthquakes in Turkey. As a result, there is currently great public interest in this issue and it is necessary to intensify research activities in order to understand natural disasters better and to reinforce risk management. The effect of climate change on meteorological events causes an increase in extreme events such as excessive precipitation in some regions. An extreme natural event becomes a disaster when it has a large impact on human settlements and activities. Study area Samsun city is placed in the north of Turkey in the middle of Blacksea region where Kizilirmak and Yesilirmak rivers poured deltas. Samsun with a height of 735 mm mean annual precipitation is above the national average. Samsun is exposed to flooding every two to three years. In this study flood risks of Samsun Mert river downstream area determinate with numerical modeling method. Numerical analysis has become the most basic tool recently used in modeling floods. Numerical model selection for studies provides advantages in developing and changing the solutions with time.Hydrological models were also created corresponding to 100 and 500 year return period floods. 1D and 2D hydrodynamic modeling was created with MIKE powered by DHI software; MIKE 11 and MIKE 21.

KEYWORDS

Flood modeling, MIKE 11, MIKE 21, Samsun, Turkey

Flood Directive implementation in Greece; Experiences and future improvements

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ABSTRACT

The implementation of the European Directive 2007/60 is a crucial step towards the development of a sophisticated flood management plan for the main River Basin Districts by including any necessary structural measures. For this reason, extensive hydrological and hydraulic analysis is needed under the ubiquitous uncertainty which cannot be eliminated by numerical models. In this study, we present our experience from the directive implementation and we discuss structural components of uncertainty in the flood modelling practice mostly related to the river network. We propose and review some of the most efficient engineering practices by examining issues like: (a) the consistency and accuracy of the required input data of the topography such as the Digital Elevation Model, cross-sectional measurements of the river and maps of land use; (b) the uncertainty components related to the hydrological SCS-CN framework and other hydrological methods for the determination of the input hydrograph; (c) the theoretical framework of each hydraulic model such as the scheme dimension (1d, 2d or coupled 1d/2d), the type of solution of the numerical scheme (explicit or implicit), the boundary conditions and the type of discretization (grid or section-based); (d) the uncertainty components related to the flood inundation modelling, such as the roughness coefficient at the river and floodplain; (e) the necessity of validation data such as the flow discharge, the flood inundation area, and the velocity measurements.

KEYWORDS

European Directive 2007/60, flood modelling, uncertainty, river geometry, roughness coefficient

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Spatial variability of flood source areas using "unit flood response" method

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ABSTRACT

In current study, two major aims were considered including investigation of the application of distributed ModClark model in flood hydrograph simulation and determination of FSA in distributed and sub-watershed condition in the Khanmirza watershed, Iran. Toward this attempt, at first, inputs of the model were extracted by ArcGIS 9.3 and then model was calibrated and validated. In next step, in order to determine FSA for cell units and sub-watersheds, by applying unit flood reaction method, at first, design rainfall with return periods of 25, 50, and 100 years at the Aloni station were extracted and then influence of each cell and sub-watershed on the output hydrograph in the outlet of the watershed were obtained. The results of model based on comparison between equal-width discharges show that at validation step, the model simulated the flood hydrograph with high precision with root mean square error, efficiency coefficient, and R2 of 1.53, 0.89, and 0.74, respectively. Also, according to the results of the current study, based on the flood volume relative error, peak discharge, base time, and time to peak, ModClark model had lower error in predicting the flood volume and peak discharge. The final results showed that FSA increases in sub-watersheds from downstream to upstream, while it doesn't follow any distribution in cell units. Also, the statistically significant positive linear correlation was found between FSA and CN values of each cell.

KEYWORDS

Flood, ModClark Model, Distributed Modeling, Cellular Automation

Evaluation of flood management plan on Cilemer river basin, Indonesia

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ABSTRACT

As one of the significant rice barn in Indonesia, Banten Province faces serious problems related to flood disaster which occurs in several paddy fields on the rainfall season, especially on January until March. One of the critical area which is oftenly flooded is Cilemer River Basin around Cilemer River. This river flows through 94.3 km with 56.957 Ha area of its river basin. The disaster causes an average loss of approximately USD 4.33 million every year, and an additional losses of morale due to the disruption of the community activities in the flood area. A flood management was proposed in a previous study by the local government, based on a 1D model. The total cost is approximately USD 16.196 Million, mainly to construct levees and to normalize the river. Unfortunately, this river basin is maintained by the province under a limited budget. Therefore, stake holders had studied and issued a flood management plan to divide the construction in three stages. the middlestream, downstream, and upstream of this river basin. In this study, the plan was evaluated in order to find a more effective solution, with a lower cost. The evaluation was conducted using a coupled 1D-2D model. The model is used to simulate the flood based on 2, 5, 10, and 25 years of return periods. The flood discharge was calculated based on five rainfall stations, Mandalawangi, Pasir Wangi, Pagelaran, Sanghiang Damar, dan Kadubera stations. The model was used to obtain the inundation maps for each return period, following each stage of the flood management plan. The results show that the completion of the second stage has successfully reduced the flooding, up to a 25 years return perio.

KEYWORDS

Cilemer, flood management, adaptive structural engineering, 2D Modelling

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Cluster analysis and classification of storm events at Rethymno

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ABSTRACT

Coastal urban areas, shorelines, ports and coastal structures are being increasingly threatened by violent hydro - meteorological phenomena such as storms, especially nowadays due to climate change and the climate variability. An extended analysis of storm events in Rethymno city of Crete Island, is attempted, under the frames of PEARL (Preparing for Extreme And Rare events in coastaL regions) an undergoing EU funded project. The aim of this paper is to present an integrated analysis of storm events and their thresholds by enhancing the storm definition for this location and finally to classify them by means of clustering methods. The storm is usually defined as the event exceeding a minimum significant wave height with a certain minimum duration, but the thresholds for the wave height, the duration and the calm period between two successive storms vary depending on the area of interest. Investigating extreme historical storm events and their future projections, the thresholds are defined as 90th percentile of the data set rather to describe the most rare events, checking simultaneously the independence between two successive events. Since the thresholds are selected, a storm's definition is created and the storm events are classified into five classes, depending on their severity. The classification is accomplished with cluster analysis based on the storm energy and the storm period. The different clustering algorithms and methods (hierarchical, k-means, partitioning around medoids and fuzzy clustering) are validated via appropriate indices and the results are presented, checking also their impacts on the coastal area.

KEYWORDS

Extreme events, storms, classification, clustering evaluation

Daily runoff estimation in Musi river basin, India, from gridded rainfall using SWAT model

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ABSTRACT

The main objective is to assess the spatial water availability in Musi river basin, India from gridded rainfall data and compare the results with the observed discharge data. Musi River passing through Hyderabad, India being one of the major sub basins of Krishna River and is catering various demands. In the recent past, it is suffering from severe spatial and temporal water availability problem. Thus, there is a need to quantify the spatial and temporal runoff availability in the Musi River for better water management. The spatial and temporal runoff has been estimated using Soil Water Assessment Tool (SWAT) model with the available data. The SWAT model has been developed and validated with India Meteorological Department (IMD) gridded rainfall data as one of the inputs and the daily runoff data observed at Dharmacherla (runoff data obtained from WRIS website of Central Water Commission (CWC)) as the model output. A rigorous calibration, sensitivity and uncertainty analyses are being carried out using SWAT-CUP. The obtained results are evaluated using performance measures such as Coefficient of determination ( ), Nash-Sutcliff Efficiency (NSE), Mean Absolute Error (MAE), and Percent bias (PBias). It is found that the results obtained from SWAT model are satisfactory. Based on the present study it may be concluded that SWAT model can be used to generate spatial and temporal runoff from IMD gridded rainfall data in Musi River Basin.

KEYWORDS

IMD gridded rainfall, Musi River India, Soil Water Assessment Tool, Spatial and temporal water availability, SWAT-CUP

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Distributed rainfall runoff modeling over Krishna river basin

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ABSTRACT

Floods can have catastrophic consequences and can have effects on the economy, environment and people. It initiates comprehensive assessment and forecasting of possible flooding events, which is typically carried out using hydrological models. Thus, the main objective of this study was to present a distributed hydrological model, namely Variable Infiltration Capacity (VIC) model for simulating the hydrological variables over Krishna River Basin, India and evaluating its performance by comparing with observed datasets. The main advantages of the VIC model compared to other physically based hydrological models, are the variable infiltration curve, which implement a nonlinear function of the fractional grid cell area to scale the maximum infiltration for enabling runoff calculations for sub grid-scale areas and the parameterization of baseflow using a nonlinear recession curve. Meteorological forcing at 0.5 degree by 0.5 degree spatial resolution from 1980 to 2005 over the basin were used to run the model at a daily time step. The model showed an acceptable performance during calibration and validation with Nash-Sutcliffe efficiency (NSE) = 0.34 and coefficient of determination (R^2) = 0.60 for calibration and NSE = 0.42 and R^2 = 0.68 for validation periods. The results from VIC model shows that it can handle large-scale variability, however it has a tendency to overestimate the streamflow in the downstream portion possibly due to not considering the effect of storage structures in the present model.

KEYWORDS

Hydrological model, VIC, Streamflow

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Application of HEC-HMS for the event and continuous simulation in high-altitude scarcely-gauged catchment under changing climate

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ABSTRACT

Aim of this study was to examine the most suitable combination of different methods (transfer and loss) provided by a standard rainfall-runoff model (HEC-HMS), used for the event based and continuous streamflow simulation, in a high-altitude (snow- and glacier-fed) scarcely-gauged Jhelum River catchment (western Himalayan), under potential changing climate scenarios. The observed and remotely sensed Tropical Rainfall Measuring Mission (TRMM) data were utilized to simulate daily streamflows. Further, the land use land cover layers were utilized as input data to design initial curve numbers (CN) of the study area. The model were calibrated during 2000-2007 and validated during 2007-2012, for different combinations of transfer (Snyder Unit Hydrograph and Clark Unit Hydrograph method) and loss methods for event based (Soil Conservation Service Curve Number (SCS-CN) and Green and Ampt) and for continuous simulation (Soil Moisture Accounting (SMA) and deficit and constant loss method) for the selection of most suitable combination to forecast the daily streamflow under potential climate change scenarios. Overall, all the combinations performed within the acceptable range with least NS coefficient of 0.76 for event based and 0.68 for continuous simulation. The combination of Green and Ampt and Clark UH for event based and SMA and Snyder UH for continuous simulation showed best efficient results than any other combination, in high-altitude scarcely-gauged catchment. Further, the hypothetical climate change scenarios showed a significant increase of annual streamflows (21.87%) of the Jhelum River catchment by the increase of 20% precipitation in comparison with 3 ^{o}C temperature increase (10.79%).

KEYWORDS

HEC-HMS, Event based, Continuous simulation, Hydrological Modelling

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Prediction and validation of turbulent flow around a cylindrical weir

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ABSTRACT

Weirs are commonly used for regulating, controlling and measuring the flow in a river or an open channel. When a weir is constructed across a river, sediment deposition occurs in the upstream of the structure and this can affect the function and efficiency of the weir. If these structures can be designed to pass sediment, the performance of the weir will not change over time because of sediment accumulation. In this study, the characteristics of turbulent flow around a cylindrical weir placed at a distance from the bed are investigated experimentally and numerically. The governing equations of the two-dimensional turbulent flow is solved numerically by using ANSYS Fluent. The volume of fluid (VOF) method is used to compute the free surface of the flow. Grid Convergence Index (GCI) is performed to examine the effect of the selected grid structure on the numerical results. In the numerical simulations, Renormalization Group k-ε, Shear Stress Transport k-ω and Reynolds Stress turbulence closure models are employed. The numerical results for the turbulent flow characteristics are compared with the experimental data obtained by Laser Doppler Anemometer measurements in a laboratory channel. Experimental validations of the velocity field and free surface profiles show that the computations by using the turbulence models are successful in predicting the turbulent flow characteristics around a cylindrical weir placed at a distance from the bed.

KEYWORDS

Cylindrical Weir, Laser Doppler Anemometer, Open Channel Flow, Turbulence Model, VOF

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Development of a flow estimation model at ungauged sites: A case study in Turkey

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ABSTRACT

The increasing effects of climate changes require estimation of low flows to design efficient Water Management Systems. And depending on the management practice, this can be needed for various return periods. Especially in Turkey, due to the scarcity of gauging stations and their lack of data makes system designs to be planned and implemented extremely difficult. Thus, the development of estimation techniques for low flows at ungauged sites is crucial. The purpose of this study was to develop a global model inclosing several return periods that could make clever predictions at ungauged sites. By taking into account the number of gauging stations, how they are spread around, and the number of data each station has (at least 20 years) the regions where low flows and drought are an issue in Turkey; Aegean Region, East Anatolia Region, and South East Anatolia Region were analyzed for the purposes of this study. A total of 31 gauging stations were selected from the following basins: Susurluk Basin (3), Gediz Basin (5), Büyük Menderes Basin (7) which belong to the Aegean Region; Fırat Basin (21), and Dicle Basin (26), which belong to the East Anatolia and South Anatolia Region. 7-day minimum flows (AM7_T) were then predicted for 2, 5,10, 20, and 50 year return periods with the best distribution model that fit each station. To determine the variables of the Global Model, out of 17 different metrological specifications that defined the stations, it was necessary to eliminate the ones that were correlated to each other and had no effect in explaining the variability of AM7_T. Principal component analysis was therefore applied on the meteorological specifications to see the correlation between the variables. A regression analysis was then performed on both the 17 meteorological specifications and the 7-day low flow predictions obtained from the frequency analysis. Ordinary least squares technique was applied on these two variables to determine the regression coefficients and in the end; one Global Model containing all of the return periods (2-50 years) was constructed. And to make this model more effective, global model was adjusted for each of the return periods. However, it is important to note that the methodology in this study was applied to specific regions. Thus, it is advised to carry out this study in all of Turkey with stations that have at least 50 years of data to obtain more efficient results.

KEYWORDS

Flow estimation, ungauged sites

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Time series analysis of water characteristics of streams in Eastern Macedonia – Thrace, Greece

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ABSTRACT

Water is one of the most important sources of water on earth supporting the existence of the majority of living organisms. Time series analysis, modeling and forecasting constitutes a tool of paramount importance with reference to a wide range of scientific purposes both in meteorology and hydrology (e.g. precipitation, water quality, humidity, temperature, solar radiation, floods and draughts). The present research applies the Box-Jenkins approach, employing SARIMA (Seasonal Autorregressive Integrated Moving Average) model to perform short term forecasts of maximum monthly water temperatures Nestos River at the junction with its trans-boundary tributary, Despatis River, at the specific location called Nestos River – Gefira Despati, situated within the range of Paranesti area, Drama Prefecture, Region of Eastern Macedonia-Thrace, North-Eastern Greece, North-Eastern Mediterranean Basin, modeling past maximum monthly water temperatures time series components structure and predicting future quantities in accordance to the past ones. The model which is mostly fit to both describe the past water quality data and thus generate the most reliable future forecasts is selected and rated by means of the (BIC-), (MAPE), (MAE) and (RMSE) model evaluation criteria. The conclusions of this research will provide local authorities (e.g. Water Directorate of Eastern Macedonia - Thrace, General Secretariat for Civil Protection, European Center for Forest Fires, Deputy Governor of Agricultural Economy, daily fire risk maps designers, hydraulic, irrigation and environmental engineers, city inhabitants, farmers etc., biologists, fish scientists etc.) valuable data in order to develop strategic plans, policies and appropriate use of available water resources within the Region of Eastern Macedonia-Thrace.

KEYWORDS

Water temperature time series forecasting, auto regressive moving average models, trend, seasonality, SARIMA models

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Application of bayesian algorithm in continues streamflow modeling of a mountain watershed

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ABSTRACT

Appropriate prediction of streamflow at mountain region poses substantial challenges to any hydrology modelling system. In this type of watershed, the rainfall-runoff process is typically rapid; thus, a key approach for a successful simulation is how to reduce the uncertainty and error in simulation. The focus of this study is on parameter and predictive uncertainty estimation of a semi-distributed hydrology model (i.e., ARNO). The ARNO model is coupled with the DiffeRential Evolution Adaptive Metropolis (DREAMzs) algorithm to calibrate fifteen hydrological parameters. Analysis suggests that DREAM efficiently reduced the uncertainty associated with modelling and performed best during moderate to moderately high flow. The 95 prediction uncertainty (95 PPU) bracketed most high and medium flows. Overall, application of DREAM algorithm to the ARNO model identified the uncertainty associated with the maximum soil moisture storage and the routing model components. ARNO parameter uncertainty largely depends on the complexity, and variability of streamflow records, and the simplicity of its lumped formulation. These results provide useful insights into the complexities of surface flow simulation and demonstrate the importance of reducing parameter and predictive uncertainty of a rapid response hydrologic system.

KEYWORDS

Parameter Uncertainty Assessment, ARNO, DREAMzs, Continuous Simulation, Mountainous Watershed

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Impact of extreme events on watershed dynamics

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ABSTRACT

This paper presents the methodology for a quantitative assessment of the impact of extreme events on watershed morphology and dynamics. By linking some key factors of erosion to land morphology and biota, a quantitative measure of the sustainability of aquatic life is also presented. The integrated watershed-morphology model is used to perform a formal sensitivity analysis of land dynamics to various hydrologic changes at the drainage basin level. Finally, by running simulation scenarios over long term periods, it is possible to establish quantitative measures of the trade-offs between the ecosystem services provided by water within a watershed.

KEYWORDS

Climate change, watershed dynamics, Numerical models, Erosion, Sedimentation

A Decision Support System for urban stormwater drainage management

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ABSTRACT

In the last decades, urban pluvial floods are occurring with increasing frequency all over the world, including developed countries (e.g. Italy) due to factors mainly referable to Climate and Land Use Changes (coupled with urbanization and increasing population). Urbanization is typically accompanied by increases in impervious surfaces, compaction of soils, and modifications to vegetation. This results in increased surface runoff, increased runoff velocity and stream erosion, decreased time of concentration of watersheds, and decreased water quality, due to water contamination from suspended sediments, heavy metals, hydrocarbons, nutrients, and pathogens. In the context of Urban Water Management, a useful role can be represented by innovative approaches, implementing optimization techniques and new technologies for Low Impact Development (LID) type of stormwater Best Management Practices (BMPs) for urban runoff control. The main goal of these strategies should be the improvement of the resilience of the cities against the increase of the storm water flows and the risk of flooding (urban flash floods). In this paper a Decision Support System for the identification of the best strategy for adapting to climate and land use changes is presented. This System allows to identify the most useful BMPs, among the usual ones in the technical literature (i.e. detention ponds, infiltration trenches, pervious pavement, green roofs, etc.). In particular the System interfaces a simulation model (SWMM5.1) with an optimization module (Harmony Search) able to identify the best combination of BMPs to adequately reduce flood peak discharges and volumes.

KEYWORDS

Best Management Practices, Low Impact Development, SWMM 5.1, Harmony Search, Urban Drainage Systems, Optimization Algorithms

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Modelling of a combined sewer system and evaluation of mitigation measures using SWMM

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ABSTRACT

Pluvial flooding is often unavoidable and unexpected and can only be mitigated with the design and implementation of appropriate measures. This study presents the analysis, the modelling, the identification of deficiencies in terms of capacity, the location of areas where flooding may occur, and the design of mitigation measures of a part of the combined sewer system of Athens (Zone D, Ano Patisia, Kypseli). The developed hydrologic and hydraulic model was based on the EPA Storm Water Management Model (SWMM5) software. The alternating block method was used to develop storm hyetographs. Floods of various return periods, i.e., 2, 5, 10, 25, 50 and 100 years, were tested. The mitigation measures examined, included, the enlargement of sewer sizes and the sizing of detention ponds parallel to the network. The results indicated that in case of sewer enlargement, the drainage capacity of the combined sewer system increases by 61%, while in the case of installation of detention ponds, the peak discharge at the exit of the system reduces by 29%. Overall, it was found that SWMM is a useful and easy to apply tool in testing the adequacy of existing drainage systems and the design of mitigation measures. SWMM can be used effectively for the simulation of urban drainage systems, and by comparing existing and proposed solutions, it can be a very useful tool for testing mitigation measures even for areas where there is no flow monitoring.

KEYWORDS

Combined sewer system, urban drainage, SWMM, flooding mitigation, detention ponds

WRF-PDM: Prognostic approach for discharge prediction in ungauged catchment

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ABSTRACT

In this study, the mesoscale model WRF (Weather Research & Forecasting model) is used for dynamical downscaling of European Centre for Medium Range Weather Forecasts (ECMWF) ERA interim reanalysis global datasets for obtaining hydro-meteorological variables. The WRF estimated precipitation and Evapo-transpiration are then used as input data for the Probability Distributed Model (PDM) for discharge prediction. For performance evaluation of the integrated framework, objective function like Nash Sutcliffe Efficiency (NSE) is used. Analysis of NSE indicates values of 0.85 and 0.82 during the calibration and validation respectively for the combination observed rainfall and station based reference Evapotranspiration (ETo). On the other hand, a marginally lower performance is reported by the combination Observed Rainfall and WRF based ETo (NSEcal= 0.82; NSEval= 0.80), while a very poor performance is reported by the combination Rainfall and ETo when both derived from WRF (NSEcal= 0.58; NSEval= 0.06). The overall analysis suggests that the WRF-PDM can be used for discharge prediction in the absence of ground based measurements. This study provides valuable information to the hydro-meteorologist on downscaled weather variables from global datasets and its applicability to rainfall-runoff modeling for river discharge prediction.

KEYWORDS

WRF-PDM, GLUE, Rainfall-runoff, Discharge, Sensitivity Analysis and Uncertainty Estimation

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Estimation of the Muskingum routing coefficients by using fuzzy regression

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ABSTRACT

The Muskingum model is a popular method to analyse the flood routing. Most of the methodologies for estimating the parameters of the routing are based on the distance between observed outflows and estimated outflows. In this work, for the first time, the parameters for a linear Muskingum model are determined by following a different principle. The coefficients are proposed to be determined based on the fuzzy linear regression principles. Therefore the scope of the fuzzy calibration is to assess the Muskingum routing parameters as symmetric fuzzy triangular numbers so that all the observed data must be included in the produced fuzzy band aiming at its minimum. This formulation leads to a constrained optimization problem with unknown variables the centres and the widths of the Muskingum routing coefficients. Instead of the identification of the parameters K, x, the problem is oriented to the determination of the coefficients C1 and C2. Based on the problem itself the constant term of the usual regression model has been eliminated. In order to reduce the fuzzy band a proposed mixed goal programming fuzzy regression analysis is also used. Thus, the produced fuzzy band can be reduced by enabling some observed data to be near the produced fuzzy curve. In any case the maximum observed outflow must be included within the produced fuzzy band.

KEYWORDS

Fuzzy Regression, Fuzzy sets and logic, Goal programming, Parameter estimation, Muskingum routing equation

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A simple model for low flow forecasting in Mediterranean streams

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ABSTRACT

Low flows commonly occur in rivers during dry seasons within each year. They often concur with increased water demand which creates numerous water resources management problems. This paper seeks for simple yet efficient tools for low-flow forecasting, which are easy to implement, based on the adoption of an exponential decay model for the flow recession curve. A statistical attribute of flows preceding the start of the dry period is used as the starting flow, as for example the minimum flow of early April. On the other hand, the decay rate (recession parameter) is assumed as a linear function of the starting flow. The two parameters of that function are time-invariant, and they are optimised over a reference time series representing the low flow component of the observed hydrographs. The methodology is tested in the basins of Achelous, Greece, Xeros and Peristerona, Cyprus, and Salso, Italy. Raw data are filtered by simple signal processing techniques which remove the effect of flood events occurring in dry periods, thus allowing the preservation of the decaying form of the flow recession curve. Results indicate that satisfactory low flow forecasts are possible for Mediterranean basins of different hydrological behaviour.

KEYWORDS

Dry period, recession rate, Savitzky-Golay filter, benchmark function, Monte Carlo calibration, uncertainty

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Influence of precipitation and land cover changes in a Mediterranean mountain watershed (Guadalaviar river, Spain)

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ABSTRACT

In this study the influence of recent (1984-2014) precipitation patterns and land cover changes in the water flow of the Guadalaviar River basin were analysed. The watershed is located in the southern Iberian Range (Spain) and is characterized by medium-high altitude (880-1849 m), extensive forest areas and low population density. This region is located in the confluence of the Tagus, Ebro and Turia great basins. The climate varies from cold continental sub-Mediterranean to mountain climate. Land cover maps were obtained from supervised classification of satellite imagery. Precipitation and water flow time series were obtained from official public institutions. Land covers dynamics in the study area seems to be more strongly influence by the process of rural abandonment than climatic variables. The expansion of shrubs and pine forest at expense of agricultural land is a quite slow process and the influence of short-term climate variability was not clearly revealed. The statistical analysis of precipitation and water flow time series anomalies revealed different water regimens and intense drought periods. A strong relationship between water flow and precipitation variability was evident for the portion of the river with a natural water flow. The significant relationship between precipitation and water flow after a reservoir was disrupted. Forestland expansion did not evidence a clear influence on precipitation or water flow patterns. However, other land cover changes (shrub vs. dryland agriculture) seemed to be greatly affected by precipitation variability along with other socio-economic factors.

KEYWORDS

Climate variability, land cover changes, Mediterranean mountain, remote sensing

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An implementation of a water balance model in the Evrotas basin

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ABSTRACT

This research paper focuses on the implementation of the "abcd" water mass balance model in Evrotas River Basin for the runoff simulation. The study area, which is located in Greece and more specifically at SE. Peloponnese, is the Evrotas river basin, covering a total area of 1739 km2 with its main watercourse of 90 km length. The model is performed in four subbasins of Evrotas; Oinountas (the outlet of which is in Kladas station), Rasina I (up to the Koumousta Station), Rasina II (up to the station located at the Rasina Airport) and Vivari (up to Sellasia station). The first three subbasins were studied on a daily step for an entire water year (2009-2010), while the later one on a monthly basis for a five-year period (2006-2009). The model's calibration was accomplished by the calculation of the Nash-Sutcliffe coefficient (N-S); for the estimated and the measured discharges. The performance of the "abcd" model was good for monthly flows simulation (N-S=0.82 for Vivari subbasin) and adequately in the daily interval application (N-S>0.62). Additionally, a sensitivity analysis in the parameters of the model is provided, establishing the different results per subbasin.

KEYWORDS

Water balance, "abcd" model, Evrotas, sensitivity analysis

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Multivariate modelling of meteorological droughts

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ABSTRACT

Drought is conventionally expressed as meteorological, hydrological and agricultural, dependent on the affected system and the variables used in the analysis. The main dimensions of the meteorological drought, apart from severity, are the duration of the event and the spatial extent of the affected area. The study presented in this paper attempts to perform frequency analysis for the pairs severity-duration and severity-areal extent, using 2D-Archimedean Copulas. The Gumbel-Hougaard, the Clayton and the Frank families of copulas have been tested. The proposed methodology is applied to the eastern part of the island of Crete, Greece. The area under study is divided in 1328 squares of 4km2 each. The sample of 30 years of precipitation and temperature data from 9 meteorological stations is reproduced 9 times. The Reconnaissance Drought Index is used for estimating the severity of each drought event. The duration is represented by the number of years under drought, whereas the areal extent is estimated by the number of squares under drought. The proposed methodology proves to be simple and practical and can contribute to more realistic decisions on measures against droughts by authorities and stakeholders.

KEYWORDS

Meteorological droughts, multivariate modelling, marginal probability distributions, drought severity, Reconnaissance drought index, Crete island

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Evaluation of different global optimization algorithms for calibration of a daily hydrological model

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ABSTRACT

Hydrological Modelling can be a highly complex problem, particularly due to difficulties caused by multiple dominant discharge states. Since manual adjustment of parameters is a time-consuming and labour-intensive task, automatic calibration techniques are generally required to obtain reasonable estimates of model parameters. Thus, in this research we aim to compare and assess calibration of a conceptual daily rainfall-runoff model (Hymod) with three global optimization methods (GOMs). Also, a case study (Karaj River Basin) was selected to assess and present the results. Calibration was carried out based on four performance criteria (KGE, NS, R2 and RMSE) with three year periods for all three optimization methods. KGE, as a new extension of the widely used Nash–Sutcliffe efficiency (NSE) was applied in this study to analyse different components which constitute NSE. Results indicated that particle swarm optimization (PSO) may be significantly more efficient and robust and will be able to simulate daily runoff with better performance criteria. Thus this method is able to obtain optimal values more accurately and in a faster manner for the five parameters of hydrological models within a multidimensional parameter space, which could provide the best fit between observed and simulated runoff.

KEYWORDS

Optimization Methods, Rainfall-Runoff Model, Karaj River Basin

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Ungauged drainage basins: Investigation on the basin of Peneios river, Thessaly, Greece

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ABSTRACT

The effect on flow prediction accuracy of the lack of streamflow data is investigated. For this a testing framework is set up which involves three stages. In the first stage a deterministic physics-based distributed rainfall-runoff model is calibrated. The selection of this model category is dictated by the will to minimise the number of parameters that need calibration. These parameters are the "sensitive parameters" which primarily affect simulated flows. All other parameters are set to their default values or values based on hydrologic experience. The Nash-Sutcliffe Efficiency (NSE) is selected as the metric of model performance. In the second stage the basin is considered as ungauged and sensitive parameters are synthetically generated using the uniform distribution. Thus a frequency distribution of NSE is obtained. The third stage involves the comparison of simulated flows obtained in the first two stages of analysis. The Precipitation-Runoff Modelling System, version IV (PRMS-IV) is selected as the simulator of hydrological processes. The system subdivides the basin into Homogeneous Recharge Units (HRUs). The test basin was the Peneios river basin at the gauging station of Sarakina. This is located in the Thessaly Water District, central Greece and has an area of 1076 km2. Results indicated that the sensitive parameters of the model are seven in number. Upper extreme values of the distribution of NSE in the case with the ungauged basin were found to be close to values of the calibrated model, whereas the mean NSE was lower by 34%.

KEYWORDS

Ungauged basins, Precipitation-Runoff Modelling System (PRMS), Homogeneous Recharge Units, Peneios river

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Effect of land cover/use change on soil erosion assessment in Dubračina catchment (Croatia)

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ABSTRACT

The assessment of erosion intensity and sediment production using Erosion Potential Method was made for the Dubračina catchment, Croatia. During the extensive research and data collection, several data sources for the land cover/use map were available: Spatial Plan, Corine database and Landsat images. Landsat data source was included in the study to provide a more up-to-date and higher resolution assessment and was available also for various time periods. Different information sources imposed the need to choose one data source as the most appropriate through the acknowledgement of their differences and the effect on the model outputs. The analysis presented in this paper also includes the change in erosion intensity and sediment production between the past and the present time. For this purpose, the land cover categories for Dubračina catchment were derived from the Landsat images. The most noticeable spatial change in erosion intensity between the two-time series is on sub-catchments Slani Potok and Mala Dubračina, where the area affected by excessive erosion was found to increase from the past to present time. The overall decrease in average values for the sediment production is noted from the past to present time but this change in values was not found to be significant, in contrast to the change in the spatial distribution visible on the maps.

KEYWORDS

Erosion Potential Method, soil erosion, erosion intensity, erosion sediment production, various data sources, changes in time, land cover/use

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Development of flood and mudflow events for the spatio-temporal risk assessment of networks

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ABSTRACT

Networks such as transport, water and power are critical lifelines to society. Network managers plan and execute interventions to guarantee their operational state under various circumstances, including after the occurrence of (natural) hazard events. Creating an intervention program demands knowing the probable network-related consequences (i.e., risk) of the various stochastic hazard events that could occur. The way such events are simulated has implications on (i) the overall computational cost of the entire risk assessment, which increases as the complexity of the network of interest increases, (ii) the accuracy of the individual risk estimations, as well as (iii) the quantified uncertainty of resulting risk estimations. To support network managers in their task to assess network-related risks, a method is presented here to develop rainfall-triggered hazard events, namely riverine flood events and mudflow events. The method enables the generation and simulation of hazard events that (i) are of a specific modeller-defined return period, enabling the characterization of the uncertainty of risk estimation for given return periods, and (ii) change over space and time, leading to the spatio-temporal estimation of network-related risk. The method is designed for network managers, and therefore, integrates computationally-efficient models that can be quickly coupled, and require data that is generally available or can be easily obtained or estimated, without impacting the integrity of the results. An example is presented to illustrate the application of the method to develop flood and mudflow events to be used in the assessment of risk for a road network in Switzerland.

KEYWORDS

Risk assessment, probabilistic modelling, natural hazards, flood, mudflow

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Site suitability analysis of soil and water conservation structures in watershed using GIS

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ABSTRACT

The planning of conservation measures to conserve water and soil resources taking hydrological planning unit as watershed is considered to be effective. Optimum utilization of natural resources like land, water, soil, vegetation, resources conservation measures and integrated development of the area along with the improvement in quality of lives of people are the main objective of watershed management program. In this study an attempt has been made for selection of the most suitable sites for water and soil conservation structures in GP IV watershed of Aurangabad district in Maharashtra, India using QGIS. Delineation of the catchment area is carried out after georeferencing them. The IRS LISS-III satellite imagery of Sillod study area is used and LULC classes have been derived from it. A soil map is obtained from National Bureau of Soil Survey and Land use planning, Nagpur, India. The slope map and drainage maps are obtained from SRTM Digital Elevation Model. The various thematic maps such as LULC map, soil map, drainage map, slope map are laid over each other and optimal allocation of check dams are proposed for construction according to guidelines for selecting suitable site for water harvesting structures according to Integrated Mission for Sustainable Development (IMSD) Govt. of India. For suggesting soil conservation structures site locations considering slope parameter, slope was divided into eight classes and accordingly structures are suggested for classes. The water balance study was also done for same watershed with monthly average temperature and precipitation data using Thornthwaite Mather model.

KEYWORDS

Geographic Information System, Watershed Management, Soil conservation, Water conservation

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Imputation of erosivity values under incomplete rainfall data by machine learning methods

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ABSTRACT

In this article, a comparison is presented of empirical equations to machine learning methods for the estimation and imputation of rainfall erosivity values, associated with significant amounts of rainfall measurements that are missing in the available recording rain gauge data of the Greek Hydroscope database. The empirical equations are mainly based on exponential relations between erosivity and rainfall, while the machine learning methods employed in this paper are feed-forward neural networks with Bayesian regularization and ridge regression with nonlinear transformation. The data came from 81 measuring stations of the Ministry of the Environment and Energy. In the employed algorithms, the output was the weekly cumulative erosivity value, which resulted from processing the data of all rain gauges and pluviographs, while the input data consisted of the weekly cumulative rainfall, the month, the co-ordinates and the elevation of the station, as well as the number of days for which the rainfall was recorded. For validation, a method of nested cross-validation was employed. The machine learning methods gave significantly better results compared to the empirical equations, thus reducing the effects of estimating R from only weekly rainfall records.

KEYWORDS

machine learning, missing values, imputation, rainfall erosivity

Impact of restoration measures in a densely urbanised area: The case of Buenos Aires

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ABSTRACT

In the Metropolitan Area of the Buenos Aires City (AMBA) does not exist regulation which prioritizes the need to preserve water reservoirs and still less to generate them to compensate for the growing anthropization of the territory and to mitigate the effects of climate change. The objective of this work is to evaluate the impact of altering the morphology of a sub basin of the Las Tunas stream, tributary of Lujan River, belonging to the "Pampa Ondulada Bonaerense" territory. The hydrological analysis was performed and the topographic characteristics of the basin were generated in HEC-HMS model, obtaining flow rates in different morphological situations. The input and output system flow rates are calculated using rainfall-runoff and flow-through procedures. The histogram method (for a given frequency of occurrence of the event) has been selected, which specifies the temporal distribution of precipitation intensity during the storm. The results indicated a lamination of the peak of the flooding in more than fifty percent with only preserving less than five percent of the study area to generate a temporary reservoir, which reveals the need to protect natural reservoir areas or generate them, in order to restore in the basins the hydrogeomorphological conditions precedent to anthropization. This reservoir becomes even more necessary when considering the effects of Climate Change on runoff due to the increase in precipitation intensity of extreme events.

KEYWORDS

Hydrogeomorphological Basin, Runoff, Climate Change

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Snowcover monitoring with MODIS product 10A2

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ABSTRACT

Snow is a valuable water resource that is sometimes neglected. Apart from being the primary water feeder for snow-fed rivers and streams allowing them a perennial flow regime and thus benefitting biodiversity and satisfying human water needs, snow also supports local economy in areas where winter tourism is an important source of income. One of these areas in Greece is the Kalavryta region where a large ski center is situated on the northern slopes of Chelmos (Aroania) mountain, one of the taller mountain ranges of Northern Peloponnese (2355 m), the name of which meant actually "snowy mountain". This research aimed at the monitoring of the snow cover of watersheds of Northwestern Peloponnese with the purpose to use time series of snow cover data (in the form of Snow Depletion Curves) as input to a Snow Melt Model. The entire time series (10 water years) of the MODIS 8-day composite snow product MOD10A2 was downloaded and processed. The overall purpose was to understand the hydrologic regime of Vouraikos river, a small perennial river outflowing in the Gulf of Corinth, and quantify the different mass balance terms, particularly the contribution of snowmelt. The well-known Snowmelt Runoff Model (SRM), a conceptual hydrological model based on the degree-day method was used for the simulations with good results. For the purpose of streamlining of the analysis, a toolbox was created in ArcGIS for skipping the time-consuming tasks of reprojecting, clipping and reclassifying.

KEYWORDS

Snow Cover Depletion Curves, SRM model, Modis Snow products, Northern Peloponnese, Hydrologic regimes, GIS

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Presenting the mathematical model to determine retention in the watersheds

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ABSTRACT

This paper presents a new mathematical model for computation of retention potential (S) based on the principle concepts of SCS-CN model. In the Mathematical model, not only rainfall-runoff concepts in SCS-CN model are precisely represented in a mathematical form, new concepts, called "maximum retention" and "total retention" are introduced, and concepts of potential retention capacity, maximum retention, and total retention have been separated from each other. In the proposed model, actual retention (F), maximum actual retention (Fmax), total retention (S), maximum retention (Smax), and potential retention (Sp), for the first time clearly defined. As a result, Sp is not a variable. It is a function of morphological characteristics of the watershed. Indeed, based on the mathematical relation of conceptual curve of SCS-CN model, the proposed model provides a new method for the computation of actual retention in watershed and it simply determined runoff based on. In the corresponding relations, in addition to Precipitation (P), Initial retention (Ia), cumulative values of actual retention capacity (F), total retention (S), runoff (Q), antecedent moisture (M), potential retention (Sp), total retention (S), we introduced Fmax and Fmin referring to maximum and minimum actual retention, respectively. The advantages of the modified version versus the original model includes better precision, higher performance, easier calibration and speed computing.

KEYWORDS

Model, mathematical, retention, watershed, SCS

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Considering data uncertainty in the water and sanitation sector: Application to large number of alternatives and criteria

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ABSTRACT

Priority-driven and target-focused management of water and sanitation services is essential to achieve long-term sustainability. However, in the context of water and sanitation, statistical uncertainty is an inevitable feature, as surveys are the primary sources of the information used in the decision making process. Therefore, it needs to be considered to have a greater confidence in the decisions made based on the collected data. Outranking approaches provide an opportunity to handle imprecision and uncertainty characteristic of water management problems. In particular, ELECTRE-III uses pseudo-criteria to consider uncertainty in the decision-maker's preferences, but does not take into account statistical uncertainty.
A new interpretation of ELECTRE-III, in which pseudo-criteria are linked to the data uncertainty, is presented in the paper. The modified outranking approach (E3M) is used to evaluate water and sanitation services in Kenya and rank its 338 subdistricts according to their performances on 9 different criteria. E3M proved to be an effective ranking tool, providing a detailed hierarchy between the subdistricts, even when dealing with hundreds of alternatives. However, a quadratic dependence between the number of subdistricts ranked and the computational cost of the method was found, indicating that for larger number of alternatives (order of thousands), the time required would rise to the order of hours. Future work should focus on optimising the method's algorithm and allowing its scalability to thousands of alternatives.

KEYWORDS

ELECTRE III, Data uncertainty, Water and Sanitation, Multiple criteria decision-making, Non compensatory

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Hydrological modelling of low flows for Operational Water Resources Management

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ABSTRACT

Hydrological modelling of low flows is performed in this study for operational water resources management. The HBV hydrological model is used to simulate, reconstruct and extent the observed discharges to a complete 30-year daily simulated discharge dataset at Yermasoyia river, Cyprus. Calibration and validation techniques are used to assess the validity of the hydrological model for low flow modelling. Low flows simulated and observed characteristics are estimated and compared using the monthly varying threshold approach. Then, the monthly threshold method and the inter-event time and volume criterion (IC) is applied to derive independent sequences of low-flow events. Severity-duration-frequency (SDF) curves of low flows are developed based on the annual maximum severities for fixed durations at 30, 60, 90, 180 and 360 days. The best theoretical probability distribution is then selected for each threshold method based on individual probabilistic analysis, and finally the SDF curves for the study threshold are derived to quantify the relationship among the severities, durations, and frequencies. Hence, based on typical simulated drought characteristics (deficit volume and duration), this study develops quantitative relationships for low flows among drought parameters using monthly varying threshold levels.

KEYWORDS

Hydrological droughts, low flows, hydrological modelling, low flow indices, severity–duration–frequency (SDF) curves, streamflow deficits, threshold level method

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A network model simulation proposal for River Basin Management Plans (RBMPs) in Turkey

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ABSTRACT

Turkey is a negotiating candidate country with the EU. Although Turkey has been developing its water resources policy taking into account of the present and future water needs of its growing population, developments at global level and the on-going EU accession process, it stands at a critical threshold value with regard to its per capita water demand and is expected to become a water-stressed country beyond 2030. Moreover, climate change impacts on water resources lead to irregularities in the flow regime, which constitutes an additional severe burden on water management Already heavy population in water scarce-regions has necessitated water transfer from adjacent basins. This management approach requires a comprehensive decision support system taking into account different situations. In this study, we aim to use a network simulation model within the Greater Istanbul Metropolitan Area that has been facing a heavy population increase caused by local immigration since the 1970's. We run the algorithm repeatedly for different random realizations of estimated inputs and we show that existing water resources are sufficient until 2040 with the projected demand, providing that existing resource conditions remain unchanged. Also the model results show that significant changes in resource replenishment which may be generated by natural and anthropogenic adverse impacts will draw back the horizon year of 2040.

KEYWORDS

Istanbul water supply system, water supply security, water transfer

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Assessment of bedload transport in gravel-bed rivers with a new fuzzy adaptive regression

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ABSTRACT

Bedload transport in gravel-bed rivers exhibits notable differences with increasing discharge. For low discharges, the bedload consists mainly of sand and fine gravel, originating from the upstream, while the surface armor layer remains intact. For high discharges, approximately for bankfull flows, the armor layer breaks up and the bedload, which increases considerably, comprises gravel from the surface layer as well as finer material from the subsurface layer. However, this transition occurs gradually, and for this range of discharges the contribution of each bedload transport mechanism is unclear. An adaptive fuzzy based regression is proposed in this article to include this no constant behaviour of the discharge-bedload relation. For low discharges, until a fuzzy threshold, a conventional (crisp) relation between bedload transport and discharge is established, while for high discharges, a curve with sharper slope must be derived to fit the bedload data. Between these curves and for a discharge range where the armor layer gets disrupted, the Sugeno theory of expert systems is used, that is, each fuzzy rule with a corresponding curve holds to some degree. Instead of the usual trial and error method, a two-phase training optimization based method to achieve this adaptive curve is proposed. The training method is a couple between the heuristic Particle Swarm Optimization method and the conventional regression method. In the present study, the proposed methodology is implemented on discharge-bedload data from several gravel-bed rivers from mountain basins of Idaho, U.S.A.

KEYWORDS

Armor layer, bedload transport, fuzzy rules, fuzzy sets and logic, Particle Swarm Optimization

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Capacity of channel impacted by vegetation - Chotarny channel (Slovakia) - case study

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ABSTRACT

Streams, especially in lowlands conditions, are impacted by submerged aquatic vegetation very often. This vegetation may increase resistance to flow, and by this way also change the discharge capacity or cause higher water levels. Also, it affects on the velocity profiles. Paper will describe the results of measurements in the Chotárny channel, which were focused on the problem how aquatic vegetation influence flow resistance, water depth and discharge capacity. The investigated area is the part of the Danube Lowland (south-west of Slovakia). The channel network at the Žitný Ostrov region was built up for drainage and also to provide irrigation water. The Chotárny channel is one of three main channels of this network. Measurements performed during six years at this channel were used for evaluation of vegetation impact on flow conditions. Results of measurement showed impact of submerged vegetation; it reduces flow velocities, discharge and increases water depth.

KEYWORDS

Aquatic vegetation, flow, roughness coefficient, discharge, water level

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Identification of potential locations for groundwater pumping and recharge to minimize the impact of floods and droughts in the Ganges basin

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ABSTRACT

Floods and droughts are very frequent in the Ganges basin that flows across four countries namely Nepal, India, Bangladesh and Bhutan. In the monsoon season, floods are causing damage to huge property, agriculture and loss for many lives. On the other hand in the non-monsoon season, downstream areas mostly in Bangladesh and Indian territories are facing acute water shortage for agriculture and navigation. During the last four decades, many studies were conducted by various researchers to understand the impact of groundwater pumping and recharge on floods and droughts. The results indicated that creating subsurface storage during the non-monsoon season by extracting groundwater and storing flood water during the rainy season can reduce the impact of both floods and droughts in the basin. Identification of such locations is very critical and detailed information is not available. In the present study, attempts were made to identify potential locations in Ramganga sub-basin of the Ganges for pumping, recharge and both pumping-recharge by integrating pertinent hydrological and hydrogeological information using Arc GIS. The analysis results revealed that in the Ramganga sub-basin, 14,515 km^2 area is suitable for groundwater pumping in the non-monsoon with simultaneous recharge in monsoon and 8,419 km^2 area is highly potential for immediate groundwater recharge. The implementation of the technique can increase the basin ecosystem service by increasing groundwater availability and river flows while reducing impacts of floods and droughts with huge potential to implement elsewhere in the similar kind of river basins.

KEYWORDS

Ganges basin, Ramganga, recharge, floods, groundwater pumping, Arc GIS

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Experimental and numerical simulation of the flow over a spillway

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ABSTRACT

This paper presents the results of modeling the flow over a side-mounted Ogee type spillway using experimental and CFD (Computational Fluid Dynamics) methods, specifically Ansys - CFX. This research aims to use CFD model to validate the simulation of the flow over an Ogee type spillway which is installed in the Hydraulics Laboratory of Democritus University of Thrace. To achieve this pressure-based, transient simulation of the flow which involves an interaction between liquid water and air, the Volume of Fluid (VoF) and the standard "κ-ε" turbulence numerical models, with standard wall functions, were used, which simulate the free surface of two-phase flow and the flow turbulence, respectively. Three individual meshes with different density in computational cells were created (coarse, medium and dense) using prismatic and tetrahedral elements. Numerical results of the volume fractions, velocity and water depths were plotted for various positions across the spillway and were discussed through a validation process by comparing the CFD model results with the results obtained from physical model. Even though some slight differences between numerical and experimental results were revealed, the graphical trends of the numerical results remain reasonably similar for all experimental tests, and had a close correlation to those achieved in the physical model.

KEYWORDS

Ogee type spillway, experimental simulation, numerical simulation, CFD, Ansys Fluent, VoF

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A review of the legislative framework on collective land reclamation projects in Greece

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ABSTRACT

Land reclamation is a major factor for efficient and sustainable agriculture and water resources management. In Greece, land reclamation projects gained ground especially since the middle of the past century. At that time, the development of infrastructure for the agricultural sector was a priority of the state, in order to reinforce agricultural production and rural development. Since then, many land reclamation projects have been constructed, having local and/or regional interest. These projects aim at providing modern and efficient means of irrigation and drainage, along with the improvement of the overall rural conditions (rural street networks, land reforms, etc.). An integrated basis of the legislative framework for the management of land reclamation projects was set by the end of 1950s, while several modifications and regulatory measures have been introduced thenceforth. Based on this framework, the main organisational structures, introduced for the management of the collective land reclamation projects, are the Organisations for Land Reclamation, to which the state assigns the administration, operation and maintenance of the relevant infrastructure. The members of these Organisations are the beneficiaries by the respective land reclamation projects. In this paper, a review of this legislative framework and its evolution over the past decades is presented and discussed.

KEYWORDS

Land reclamation works, irrigation projects management, land reclamation organisations, irrigation and drainage works

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Methodological framework to estimate the coastal sediment supply of the island beaches

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ABSTRACT

A new framework is developed to guide the assessment of the sediments deposition from the upland and upstream areas to the island beaches. The study of the coastal sediment supply of the insular river basins includes as the main processes the collection and analysis of meteorological and geomorphological data, the assessment of the climate trends, the use of erosion models to estimate the sediment 'output' of the various management scenarios including the effect of the climate change on the erosion processes. Important step in this procedure is the selection of the mathematical tool to estimate the erosion process considering the data availability. The widely used USLE equation is suggested for beaches that are not connected to any river. In case of beaches that are fed with sediment by an upstream river, a combination of a semi-distributed hydrologic and a hydraulic model is suggested. This framework was applied in Eressos beach, Lesvos, Greece with a drainage basin of the order of about 57 km2, 26 km2 of which are drained through Halandra stream to the Eressos reservoir (total capacity 2.76 Mm3). Only 17% of the produced sediment is reaching the marine environment, since 73% of the produced sediment is retained in the riverbed and into the Eressos reservoir. The findings of the current study show that the application of the developed framework and the combination of various modelling tools may close the uncertainty produced by the limited or absence of erosion monitoring.

KEYWORDS

Erosion, beaches, SWAT, HEC-RAS, sediment

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Influence of river routing methods on integrated catchment water quality modelling

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ABSTRACT

Compliance with the water framework directive (2000/60) in urbanised catchments requires effective water management strategies. Integrated catchment modelling (ICM) represents a key tool in the decision making process. ICM evaluate pollution dynamics by linking urban drainage infrastructure, wastewater treatment facilities and receiving water bodies. Within this set of linked sub-models the river model structure plays an important role. River hydraulic characteristics directly influence water quality processes (e.g. dilution of pollutant loads, pollutant residence time or reaeration dynamics). Several approaches exist in order to simulate flow routing phenomena. In general, these approaches can be categorised in hydraulic or hydrological routing methods. In this paper, we investigate the effect of river flow model structure on dissolved oxygen simulations. Specifically, three methods were compared: a simple hydrological storage method (SM), the fully mass-conservative Variable Parameter McCarthy-Muskingum Method (VPMM) and the solution of the full form of the one-dimensional Shallow Water Equations (1D-SWE). First, the comparison is performed in a simple benchmark case study in order to define the most sensitive parameters for the derived results. Second, the two hydrological methods are implemented in a real world case study for the Dommel catchment (the Netherlands), which is simulated using the software WEST for integrated urban water systems. Based on the results, it seems that the selection of river routing method can be a relevant factor, which should be carefully addressed.

KEYWORDS

Integrated Catchment Modelling, river routing, Muskingum method, water quality, WEST software

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Definition of Critical Support Area revisited

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ABSTRACT

Selecting the upslope contributing area threshold for channel initiation, herein termed as the Critical Support Area (CSA), is known to be crucial for extracting the hydrographic network from a Digital Elevation Model (DEM). Commonly, an arbitrary quantity is selected which is constant in both time and space. This study is aimed to investigate the spatio-temporal variation of CSA based on information from conventional maps. Specifically, maps at the scale 1:50000 for a Greek river basin are used to identify stream heads and the corresponding values of CSA for two seasons of the hydrological year: the wet and dry season. A DEM with a cell size of about 30 m is used for tests, which is based on the Shuttle Radar Topography Mission (SRTM). A Geographic Information System (GIS) is employed for data processing. For each stream head indicated on the map, raw data are extracted, which include CSA and statistics (mean and standard deviation) of the ground slope, square root of ground slope and height above the nearest drainage point (HAND) A variety of linear regression models were tested using untransformed data by regressing CSA on one or more of the remaining variables. No statistically significant relationship was found, which led us to propose the basin-wide median CSA for each season of the year as the best selection. The proposed CSAs are compared to the constant CSA of the common approach using multiple basin-wide geomorphometric characteristics.

KEYWORDS

Critical Support Area (CSA), upslope contributing area threshold for channel initiation, hydrographic network, Digital Elevation Model (DEM), geomorphometry

Integration of rain gauge errors in radar-rain gauge merging techniques

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ABSTRACT

Kriging interpolation methods are often applied without considering measurement uncertainty, but rarely rain gauge uncertainty is negligible. The most used technique to consider measurement uncertainty in Kriging is to include a nugget effect in the variogram model. The nugget is a measurement of the variance that one can expect between two measurements at short distance. Including a nugget in the variogram model is appropriate when the uncertainty is stationary in space; if a time variant variogram is not used, the uncertainty is considered stationary in time as well. This is not the case for rain gauge interpolation, because rain gauge uncertainty is proportional to the rainfall rate, which is highly variable in space and time. Kriging for Uncertain Data (KUD) is a technique proposed in literature to solve this problem, modifying the nugget effect for each time step and for each measurement point. Nevertheless, the application to rain gauge interpolation showed that the methodology is not stable in certain conditions. Several factors can affect the performance: the position and the number of rain gauges, their accuracy, spatial characteristics of the rainfall field, rainfall intensity, or the relative position of peaks compared to the rain gauge position. This work investigates the performance of KUD with three synthetic experiments, simulating the variation of rainfall spatial variability, rain gauge density, and rain gauge accuracy. The results suggest that rain gauge density in relation to the rainfall variability plays an important role in the performance of KUD.

KEYWORDS

Rain gauge interpolation, kriging, kriging for uncertain data

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Effect of varying calibration scenarios on the performance of a hydrodynamic sewer model

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ABSTRACT

Case studies concerning urban water management tend to be large, prestigious cities which have the financial and human resources to participate in research projects. This bears the risk that research outcomes are biased towards large municipalities. Consequently, the aim of this paper is to discuss calibration of a hydrodynamic model for the representative example of a small municipality. To exemplify the uncertainties immanent to the calibration process 17 scenarios - differing in assumptions for calibration - were estimated. The performance of the different scenarios was assessed using a hydrodynamic sewer model. The occurring flooding volume from the urban drainage system elicited by the rainfall data sets used as well as the combined sewer overflow was compared for the different scenarios and rain measurements. The different calibration scenarios proved to result in high deviations in the performance of the hydrodynamic model. It can be seen, that the selection of the applied calibration data is a very sensitive decision in the modelling process. The variations show that model calibration is of utmost importance. The differences in performance can lead to different outcomes design and decision-making processes possibly leading to higher volumes, which is not cost-effective, or to underestimation of the needs that will result in lacking robustness and malfunctioning of the network.

KEYWORDS

Calibration, urban drainage, uncertainties

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Surrogate modelling for simplification of a complex urban drainage model

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ABSTRACT

Urban drainage modelling typically requires development of highly detailed and complex models due to the nature of the underlying drainage processes. This makes activities such as model calibration, uncertainty quantification analysis and usage in real-time control (RTC) challenging and computationally expensive. The focus of this paper is to develop a surrogate model to simplify and accelerate a complex model and make it available for RTC in future studies. Hence, only the output of the model which is relevant for RTC is considered. Surrogate models may lead to larger uncertainties in the model predictions but can significantly decrease simulation runtime. Therefore, quantification of this uncertainty is addressed here as well. We use the detailed InfoWorks ICM software as the simulator for surrogate modelling. The case study area is within the Haute-Sûre catchment in Luxembourg. First, we ran the InfoWorks ICM model to produce a dataset of inputs and outputs of the simulator. Second, a surrogate model is developed based on this data. The surrogate model is able to give an estimation of the wastewater volume in the storage tank which can be used to control the combined sewer overflow (CSO) volume. The preliminary results show that the introduced surrogate model provides a reliable method to decrease model complexity and runtime significantly. It also allows for quantification of the uncertainty induced by model simplification for different simulations. However, further investigation is required to find the optimum model simplification in this regard.

KEYWORDS

Surrogate modelling, urban drainage, combined sewer overflow (CSO), uncertainty

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Multivariate autoregressive modelling and conditional simulation of precipitation time series for urban water models

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ABSTRACT

Precipitation is the most active flux and major input of hydrological systems. Precipitation controls hydrological states (soil moisture and groundwater level), and fluxes (runoff, evapotranspiration and groundwater recharge). Hence, precipitation plays a paramount role in urban water systems. It controls the fluxes towards combined sewer tanks and the dilution of chemical and organic compounds in the wastewater. Furthermore, small catchments (i.e., areas of about 20 ha) have a fast response to precipitation. Therefore, catchment average precipitation is a key component in urban water models. However, average catchment precipitation is not always accurately known when measured at rain gauges, because the location of the gauge might be outside the catchment boundaries or does not reflect the entire catchment. The objective of this paper is to develop a method to estimate the precipitation in a catchment given a known precipitation time series at a location outside of the catchment, while quantifying the uncertainty associated with the estimation. We developed a multivariate autoregressive time series model for conditional simulation of precipitation time series. The case study is a small sub-catchment (16.5 ha) in Luxembourg. The time series of precipitation outside of the sub-catchment are available for two stations and cover the year 2010. We calibrated the model using the R-package 'mAr' and applied the developed conditional simulation algorithm to generate multiple realisations of precipitation time series. The results show that the proposed method is suitable to estimate time series of precipitation at ungauged sites and can quantify the associated uncertainty.

KEYWORDS

Multivariate model, autoregressive model, precipitation uncertainty, input uncertainty, time series simulation

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A simplified methodology for flood simulation in urban catchments

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ABSTRACT

A simplified methodology for urban flooding simulation is proposed, combining the use of detailed, physically-based hydrodynamic models and the Unit Hydrograph theory. The methodology comprises the following steps: a) Unit Hydrograph derivation using a two-dimensional, physically-based detailed model; b) calculation of the losses in order to determine the effective rainfall depth; c) flood event simulation using the principle of the superposition. In this study, the above methodology is implemented in a, small urban catchment located in the city of Athens (Greece). The model used for the first step is FLOW-R2D. For the second step, the well-known SWMM software is used in order to determine losses, which comprise, runoff to the sewers of the system, initial abstraction, surface ponding, and, of less significance, infiltration. In order to derive a magnitude of the uncertainty of the results of the proposed method, an ensemble of 100 Unit Hydrographs is derived. The parameters which were modified in order to produce this ensemble were the Manning coefficients in the two friction zones (residential and urban open space areas). For the sampling, the Latin Hypercube technique was adopted. It is found that although the uncertainties to the derived results has to be taken into account, the proposed methodology can be a fast and efficient way to cope with the dynamic flood simulation in an urban catchment.

KEYWORDS

Urban flooding, FLOW-R2D model, SWMM software, unit hydrograph

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Comparison of different rainfall-runoff models performance: A case study of Liqvan catchment, Iran

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ABSTRACT

A vast part of Iran is located in arid and semiarid areas. In these localities, rainfall is typically meagre, irregular and highly variable. The precipitation variability in these areas causes uncertainties in runoff prediction. The mutual interaction between the climatic parameters including temperature, precipitation, evaporation, wind and etc. and hydrological factors like streamflow, concentration time, permeation and others has rendered the relationship between rainfall and runoff take a nonlinear and undetermined form. The objective of the present study is the simulation rainfall-runoff process via taking advantage of two conceptual models, namely HEC-HMS and IHACRES and three other empirical approaches models Including Artificial Neural Network (ANN), Multiple Linear Regression (MLR) and Simple Linear Regression (SLR); moreover, The models' performance has also been compared regarding the Liqvan River in Iran. Monthly time series data of Streamflow and Meteorological data were applied for the duration of 1972 to 2004. The R2, RMSE, Te and MAE indices are used to achieve desired model. IHACRES model showed a desirable performance in estimating the normal streamflow but the peak streamflows are overestimated. Similar to IHACRES, HEC-HMS model does not makes adequate performance in estimating the peak streamflows despite the fact that the HEC-HMS overall performance was better. MLR model could simulate the normal flow but peak streamflows are underestimated. Due to the simplicity of the SLR model, its simulation performance was unacceptable. ANN model provides more appropriate estimations in terms of peak streamflows in comparison to the other models. Also In total, the results of the evaluation showed that the ANN model was more accurate (R2= 0.80, RMSE= 0.29, Te= 0.004, MAE=0.003).

KEYWORDS

Rainfall-Runoff Simulation, Artificial Neural Network, HEC-HMS, IHACRES, Liqvan Catchment

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Model selection techniques in SWAT-based hydrological modelling

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ABSTRACT

Hydrological modeling is subject to issues of simplicity vs. complexity and accuracy vs. uncertainty. This recognition has led to a growing tendency among hydrologist to postulate several alternative hydrological models for a given problem. In this case, model selection techniques can be used as effective yet practical just-in-time approaches to rank these candidate models and select the 'best' one among them and/or attempt to construct a set of 'good' models. SWAT (soil and water assessment tool) is one of the most comprehensive large-scale watershed models with a large number of parameters capable of evaluating hydrologic processes, so its calibration is challenging. This study aims to investigate the efficiency of AIC model selection criterion for selecting a "good" calibration setting. To predict water discharge at Sirwan River Basin outlet, a SWAT model of the basin has been set-up. Depending on the number of calibration parameters and observation data, different calibration settings have been built using sequential uncertainty fitting (SUFI) approach. The calibration settings were compared then against Nash Sutcliff, P-Factor and R-factor statistics, as well as AIC model selection criterion. Results showed that a good calibration setting is the one with less number of observations according to the AIC.

KEYWORDS

Hydrological modeling, SWAT, calibration, model selection criteria

II. Climate and Water Resources

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The effect of storage under climate change in Southern European basins

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ABSTRACT

The dominant strategy to address water resources variability and uncertainty in water-scarce regions is the development of reservoir storage. This paper presents an analysis of the role of storage in water availability in Southern Europe as a strategy for climate change adaptation. Water availability is computed for 16 basins under current and future climate scenarios. Climate scenarios cover the full array of projections made under the SRES and RCP emission scenarios with a variety of regional climate and hydrologic models. Water availability is analysed as a function of emission scenario, changes in mean annual flow, changes in variability and reservoir storage. A total of 16 model runs were computed for the reference scenarios and 35 model runs for the climate change scenarios. Results were analysed under the hypothesis of equiprobability of all scenarios, comparing the probability distribution of water availability under reference conditions to that under climate change. The results show significantly different behaviours in the group of basins analysed. For basins with large storage values the reductions of water availability were similar to the reductions of mean annual flow. For basins with less storage, the probability distributions of reductions tend to differ, with increased uncertainty for availability. The role of storage was further analysed through a sensitivity analysis performed obtaining water availability under current and future conditions with variable values of reservoir storage, ranging from 25% to 200% of current values. The results show that uncertainty under climate change is reduced for basins with large storage values.

KEYWORDS

Water resources, climate change, water availability, reservoir storage

Assessment of climate-change impacts on precipitation based on selected RCM projections

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ABSTRACT

Regional climate models (RCMs) are essential to perform climate change impact studies. At the state of the art, many RCM products have limited accuracy, which reduces the reliability of climate change impact assessments. Bias correction techniques are commonly applied to obtain modified RCM data that are more consistent with observations. Nevertheless these techniques have been criticized by some researchers, for their limited physical basis. In this study we propose a different approach, suitable when a relatively high number of different RCM simulations are available for the region of interest. The proposed approach consists in first evaluating the available RCM datasets by measures of agreement with observed data, and then to perform climate change impact assessment only with those RCM data complying with certain accuracy requirements. The approach is applied to assess potential future changes of precipitation in Sicily. To this aim, daily data sets of the Euro-CORDEX initiative are used for both intermediate and extreme greenhouse gas concentration emission scenarios (RCP 4.5 and RCP 8.5). Changes in future precipitation are computed in terms of widely-used standard climate indices (ETCCDI), and statistical tests are applied to assess statistical significance of changes. Analysis of the accuracy of RCM data indicates that only 4 out of the 14 RCMs have limited biases. The ensemble of these four RCM models predicts an overall decrease of mean annual rainfall, as well as an increase of the maximum length of number of consecutive dry days, suggesting a potential future increase of water shortage problems and droughts in the studied region.

KEYWORDS

Climatic projections, EURO-CORDEX, Global warming, global circulation models, natural hazards

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Evaluating the water resources and operation of Boukan dam in Iran under climate change

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ABSTRACT

The operating policies of a reservoir dam in a river basin are dependent on the upstream river's inflow. As the latter may be affected by impacts of climate change which, in turn, may alter the water supply for the various stakeholders in the basin, studies to this regard are of utmost importance to ensure the sustainable development of the future water resources in the areas. Here we present the case study of the Boukan dam, located on the Zarrine river, highlighted as the main inflow source of Lake Urmia, which is the largest inland wetland of Iran and the largest lake in Middle East. Firstly the calibrated rainfall-runoff model SWAT is used to predict the various flow components of the Zarinne river for the historical and future periods until 2049, using downscaled input precipitation predictors of three RCPscenarios captured from one of the projections of the CMIP5-GCM ensemble, the CESM1-CAM5-model. These streamflow scenarios are then employed in the MODSIM water management model to simulate the present-day and future available water resources of the basin and to determine the optimal operation of the Boukan dam, based on some prioritization of the water allocation for the various water use sectors in the basin. Finally, the impacts of climate and demand changes on the dam operation are evaluated by comparing future and historical MODSIMsimulated average water budget and supply/demand ratio (SDR) for the three CESM-model scenarios. In summary, the results show that the region will face more intensive water shortages in the future, owing to climatic change and increasing demands.

KEYWORDS

Climate Change, SWAT, MODSIM Water Management Model, Reservoir Dam Operation, Lake Urmia, Iran

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Turkish Water Foundation (TWF) statistical climate downscaling model procedures and temperature projections

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ABSTRACT

The Turkish Water Foundation (TWF) statistical climate downscaling model is further developed and implemented to a set of monthly temperature observations. The TWF model is structured by two phases as spatial and temporal downscaling of Global Circulation Model (GCM) scenarios. The TWF model takes into consideration the regional dependence function (RDF) for spatial structure and Markov Whitening Process (MWP) for temporal features of the records. The impact of climate change on monthly temperatures is employed by downscaling Intergovernmental Panel on Climate Change – Special Report on Emission Scenarios (IPCC-SRES) A2 and B2 emission scenarios from Max Plank Institute (EH40PYC) and Hadley Centre (HadCM3). The main purposes are to explain the TWF statistical climate downscaling model procedures and to expose the validation tests, which are rewarded in same specifications as "very good" for all stations in the Akarcay catchment that is in the west central part of Turkey. It is, therefore, possible to say that the TWF model has reasonably acceptable skill for highly accurate estimation regarding standard deviation ratio (SDR), Nash–Sutcliffe efficiency (NSE) and percent bias (PBIAS) criteria. Regarding validated model, temperature predictions are generated from 2011 to 2100 by using 30-year reference observation period (1981-2010). Temperature arithmetic mean and standard deviation have less than 5% error for EH40PYC and HadCM3 SRES (A2 and B2) scenarios.

KEYWORDS

Climate change, downscaling, TWF model

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Influence of the geographic location of dams on spring daily flows magnitude during the 2007-2008 La Niña event (Québec, Canada)

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ABSTRACT

The 2007-2008 La Niña event was characterized by an abnormally snowy 2008 winter and an abnormally rainy 2008 spring in Quebec. These abnormally wet conditions led to abnormally high spring flows. The goal of the study was to test whether the geographic location of dams affects spring flows (April to June) released downstream from these structures. We compared flows measured downstream from two dams located in the upper portion (Gouin and Châteauvert) and two others located in the lower portion (Taureau and La Gabelle) of the watershed of the Saint-Maurice River (44,000 km²), one of the main tributaries of the St. Lawrence River in Quebec. This comparison using several statistical tests revealed that spring flows are abnormally high downstream from dams located in the lower watershed, but abnormally low downstream from dams in the upper watershed. This difference between the two portions of the watershed is due to the fact that, to control flooding in the lower watershed, much more water derived from snowmelt and rainfall was stored in reservoirs located in the upper part of the watershed, leading to extreme hydrological drought despite abnormally high winter snowfall and spring rainfall.

KEYWORDS

La Niña, spring flows, floods, extreme hydrological drought, reservoir, dam, Kruskal-Wallis test, Saint-Maurice

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An informational entropy application to test the goodness of fit of probability functions

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ABSTRACT

Increasing population, higher levels of human and industrial activities have affected the water resources in last decades. In addition, per capita demand for water in most countries is steadily increasing as more and more people achieve higher standards of living. Researchers should have more information about water resources as using and managing water resources efficiently. So, getting much and quick information had a great importance in water resources planning and management; and consequently, the determination of the characteristics of water resources had more importance. For this purpose, useful and easily applicable methods are searched to get optimum results and several test techniques are investigated to get much more information from the available water resources data. In the presented study, Informational Entropy method is introduced as an alternative test method to test the goodness of fit of probability functions. Presented study gives a brief detail on the applicability of Informational Entropy as a goodness of fit tool. For this purpose, mean precipitation data for 60 stations in Turkey are investigated. Results by testing the goodness of fit of probability functions by entropy-based method show that Informational Entropy can be applied for fitting the probability function according to the investigated datasets.

KEYWORDS

Informational Entropy, Probability Analysis, Trend Analysis

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A snow variability analysis in Iran in relation to global warming and climate change

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ABSTRACT

NOAA/NESDIS weekly Snow Cover Extent (SCE) and the reanalysis ERA-Interim monthly snow depth (SD) and density (SDR) time series are used to evaluate temporal snow variability in Iran. The possible linkage with climate warming is also investigated by analysing the time variation of SCE, air temperature (T) and frequency of snow occurrences at 14 selected observatories distributed over the country. Snow water equivalent (SWE) is estimated based on SD and SDR and then converted into SCE by classifying grid boxes with SWE greater than 1 mm as snow-covered grids, so that they are comparable with NOAA SCE data. The percentage of snow-covered grids to the whole ones over Iran is taken as an indicator for snow variability and climate change. For the time variability analysis, the winter season and each individual winter month are considered. Results for both datasets do not fully agree in showing the same time variability of the percentage of snow-covered grids. NOAA/NESDIS SCE data have no trend, while ERA-Interim SCE show a downward trend for winter (also evident in March) that is not statistically significant. Similarly, the time series of the frequency of snow days observed at stations are characterized by a not statistically significant downward trend. In winter, an inverse relationship is found between SCE variability/snow frequency occurrences and T in almost all stations, suggesting a possible link between the observed behaviour in the reanalysis SCE and the increasing T. However, the non-statistically significance of trends makes the relationship not robust and necessary of further investigations with longer time series.

KEYWORDS

Snow, climate change, SCE, SWE, NOAA/NESDIS, ERA-Interim, Iran

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Hydrological and water temperature modelling for dam decommissioning and climate change studies

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ABSTRACT

The Mactaquac Dam and Generating Station, a 672 MW run-of-the-river hydroelectric facility located on the Saint John River, Canada, will have to be decommissioned or reconstructed by 2030. In order to simulate the impact of reservoir emptying (drawdown) and climate change on the thermal regime of the lower reaches of the river, the CEQUEAU hydrological and water temperature model was used. The model was successfully calibrated and validated for both flow and water temperature, with Nash coefficients ranging from 0.63 to 0.86 for flow and RMSE ranging between 0.74°C and 1.3°C for temperature. Subsequently, different drawdown and climate change scenarios were simulated using the calibrated models. Median value of maximum water temperature in the river is expected to increase by 2-3°C by 2100, regardless of the dam reconstruction scenario.

KEYWORDS

CEQUEAU, hydrological model, water temperature, dams, climate change

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Assessment of impact of climate change on streamflows using VIC model

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ABSTRACT

Climate change, a change caused by human activities and natural variability, will have significant impact on frequency of extreme climatic events including intense storms, heavy rainfall, droughts, and an alarming rise in sea level. The purpose of this work is to study the effect of climate change on the streamflow pattern of Wainganga river basin by analysing the monsoon and non-monsoon flows for the near future (2020-2044). Variable Infiltration Capacity (VIC), a physically based macro-scale hydrological model is calibrated for optimum parameter sets obtained by trial and error method using observed meteorological data from India Meteorological Department (IMD) and observed streamflow from Central Water Commission (CWC). Statistically downscaled six Global Circulation Models (GCMs) have been used to predict the future global climatic Representative Concentration Pathways (RCPs) scenario 4.5 for the future time scale. The specific conclusions derived from the study reveals that the low flows as described by all the models have gone above the lower extreme of the observed streamflow during monsoon season. The high flow values in the monsoon as per the models are almost similar to that of the observed, except for two models. However, high flows during non-monsoon season show a significant increment as compared to the original series. Frequency analysis of ensemble mean of all the GCMs gives a similar return level for different return period as observed.

KEYWORDS

Climate change, Frequency analysis, GCM, Streamflow, VIC model, Wainganga river basin

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Weather generator utilization in climate impact studies: Implications for water resources modelling

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ABSTRACT

Weather generators are increasingly used in water resources studies, and more so with current concerns on climate change and its implications on the water resource. In general, generated weather data should go beyond matching values with observed data to mirroring statistical properties of observed data. With the use of generated data in future-cast studies, it is additionally important that generated data capture anticipated variabilities in climate. The generators, thus need to be evaluated prior to being applied in new areas and/or those with climate characteristics distinct from those in which they were developed. Furthermore, considering the stochasticity of weather, it is important that several realizations be generated to capture the range of variability in climate. We present some considerations based on experience with three commonly used climate generators: CLIGEN, LARS-WG, and WeaGETS. We then present a discussion on realizations and their impacts on the suitability of generated data. Finally, we discuss implications for water resources modelling.

KEYWORDS

Weather generators, statistical properties, realizations, modelling, water resources

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Causes of dimming/brightening in Greece and implications on reference evapotranspiration

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ABSTRACT

Many studies continue to investigate, in a changing climate, the decadal changes of surface solar radiation (SSR) known as Global Dimming/Brightening phenomenon (GDB) and its underlying causes. Contributing to the ongoing debate on whether GDB is global or just local phenomenon, this study analyses the temporal changes of Sunshine Duration (SD) measurements (as a proxy of SSR), for various areas in Greece, during the period 1968 to 2012. In addition to the temporal changes in aerosol concentrations and cloud cover (CL), changes in precipitable water (PW) and the effect of urbanization are also investigated as possible causes of GDB. Anomaly CL and PW series examined according to their time evolution are subsequently used to remove the CL effect and detect causes of GDB linked to atmospheric aerosols. Moreover, the population density index is used to quantify the impact of urbanization on GDB. The consistency of SSR trends with the trends of reference evapotranspiration (ET) and their impact on changes in the hydrological cycle has hardly been studied until now. In order to investigate the implication of GDB in ET changes, anomaly ET series, are estimated by the Reference Evapotranspiration Model for Complex Terrains (REMCT), which has already been tested and locally calibrated in Greece, for the same time period. The results show that the ET temporal changes rather follow the SD ones, indicating the GDB effect in the ET changes in Greece.

KEYWORDS

Global Dimming/Brightening phenomenon, Sunshine Duration, population density index, Reference Evapotranspiration Model for Complex Terrains

Using Weather Research and Forecasting (WRF) model for extreme precipitation forecasting in an Andean region with complex topography

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ABSTRACT

The Weather Research and Forecasting (WRF) model is broadly used for weather prediction and research due to its good performance, but atmospheric conditions simulation over complex topography is not always optimal. Consequently, WRF has an ineffectiveness resolving Chilean mountainous terrain and foothills, precisely the site where some of the main cities are located and the most extreme rainfall events take place. This work uses a mixed physic scheme to enhance initial forecasts made by Chilean Weather Agency (DMC): testing it over vertical levels, PBL (planet boundary layer), microphysics and lead time in the computational simulations. Even when the steep topography difficult the storm peak amount, and to a lesser degree, the exact storm beginning prediction, WRF do predict properly the N-hours with the biggest amount of rainfall (5 hours corresponding to Quebrada de Ramón's time of concentration) and the temperatures during the event. Finally, a Lin et al. or WSM 6-class microphysics was chosen as the best in this event, but further testing in more storms in this region is required.

KEYWORDS

Flash flood, numerical weather predictors, WRF, extreme rainfall events, Andean mountain

Impact of climate change on irrigation need and groundwater resources in Pinios Basin

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ABSTRACT

Initially an area-differentiated modelling of groundwater recharge in River Pinios Basin (Greece) was carried out for the reference period 1980–2000 based on the mGROWA model using daily precipitation data from 57 meteorological stations and average temperature data from 17 stations as climatic input data (Panagopoulos et al., 2014). After checking the plausibility of the related model results the model was applied to assess the impacts of climate change on groundwater recharge. For this purpose bias-corrected projected climate data from an ensemble of climate models driven by several general circulation models for the projected periods 2020–2050 and 2050–2080 have been used as input data. Results of all RCM–GCM combinations indicate a considerable decrease in groundwater recharge with variable rates between the applied projected periods (Panagopoulos et al., 2015).

KEYWORDS

Water balance, climate change impact assessment, water availability

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Investigations of trends in meteorological time series

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ABSTRACT

The present study performs the temporal trend analysis of the meteorological variables time-series in chosen climatic stations in Poland, Slovakia and Romania during period of 1962 (1967 in Poland)–2015. Climatic stations are situated in Carpathian Mountains area which has a humid continental climate with cold winters, no dry season, warm summers and strong seasonality. The Carpathians consist of a chain of mountain ranges that stretch in an arc from the Czech Republic (3%) in the northwest through Slovakia (17%), Poland (10%), Hungary (4%) and Ukraine (11%) to Romania (53%). The highest range within the Carpathians is the High Tatras, on the border of Slovakia and Poland, where the highest peaks exceed 2,600 m. The second-highest range is the Southern Carpathians in Romania, where the highest peaks exceed 2,500 m. Trend of long-term data of average temperature, precipitation, relative humidity and wind speed were investigated. The Mann–Kendall (MK) test and the Theil–Sen approach (TSA) were applied to quantify the significance of trend and magnitude of trend. Prior to the application of statistical tests, the pre-whitening technique was used to eliminate the effect of autocorrelation of precipitation data series. The application of the above-mentioned analysis has shown significant increasing trend mainly for temperature in the study area. The other investigated variables have shown increasing as well decreasing trends, but not significant at significance level of 95 %.

KEYWORDS

Precipitation, temperature, relative humidity, wind speed, Mann Kendall test

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Generation of daily synthetic flows for Switzerland

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ABSTRACT

The generation of synthetic flow series is a common tool to quantify the uncertainty and natural variability of the river flow regime, namely in stochastic problems related to water resources, whose solutions depend on the values of the streamflows and their temporal pattern. Uncertainties in hydrological data analysis reflect both the inability to quantify the phenomena and underlying processes, and the variable nature of hydrological events. While the former uncertainties are largely beyond the control of most end-users of hydrological data, the latter can be reduced if more information is made available. As the size of the samples becomes smaller, their capability to describe the natural variability of the hydrological systems decreases, thus increasing the uncertainty of the hydrological data-based modelling. In the previous framework, this paper presents an application of a two-level approach recently developed for the method of fragments to obtain synthetic daily flows by direct disaggregation of annual flows at 23 Swiss river gauge stations, covering a wide range of rainfall- and snowfall-driven discharge regimes. The results showed that the approach preserves the historical statistical characteristics not only of the annual and daily flows, to which is applied, but also of the monthly flows obtained indirectly, by accumulation of daily flows.

KEYWORDS

Daily flow, disaggregation modelling, method of fragments, Switzerland

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Impact of climate change on inflows using refined precipitation and temperature scenarios

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ABSTRACT

The modification of the natural inflows on watersheds due to future climate change is of great concern to environmental and water resource managers. Long-term sectorial impact studies on water supply planning require realistic assessment of future climate change on the basin scale. High spatial resolution scenarios have been developed from coupling Atmospheric-Ocean General Circulation Models (AOGCM) with Regional Climate Models (RCM). Furthermore, evidence of bias in the output of AOGCM RCM has prompted many researchers to refine already downscaled data to make model output more realistic at local scale. In this study, one calibrated hydrological (Temez) model is used to evaluate the modification of the natural inflows from different precipitation and temperature projections for the period 2071 2100 to Odeleite reservoir dam, located in the south of Portugal. Bias correction is made using the well-known delta change method which uses changes in average values from simulated data for the control period and the scenario period to correct observed values. The results indicate significant differences in the runoff for each RCP depending on the AOGCM RCM. The decrease of the natural inflows under RCP 4.5 is between -10% and -2%. Under RCP 8.5, the decrease of the natural inflows is much higher between -44% and -24%.

KEYWORDS

Climate change, AOGCM-RCM, bias correction, surface hydrology, hydrological modelling

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Spatial analysis of large atmospheric oscillations and annual precipitation in lake Urmia basin

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ABSTRACT

Precipitation is the main phenomenon that brings water from the surface of the oceans to the land surface all around the world. Oscillation of large atmospheric patterns, happening in oceans however is proved to have a great effect on the pattern of precipitation based on spatiotemporal and geographical properties of the region. Lake Urmia, as a wetland of international importance and the world's second largest hyper-saline lake is dealing with water shortage basin wide. Due to importance of studying behaviour of major role players in the basin, effect of several well-known large atmospheric oscillations namely, North Atlantic Oscillation (NAO), El Nino/Southern Oscillation (ENSO), Atlantic Multidecadal Oscillation (AMO), Arctic Oscillation (AO), Indian Ocean Dipole (IOD), Southern Annular Mode (SAM) and Pacific Decadal Oscillation (PDO) were investigated by means of zero-lagged cross-correlation projected on heat maps on the basin. Considering 95% confidence limit in the analysis, it is observed that the PDO, ENSO, IOD and SAM oscillations have significant correlations with annual precipitation. In addition, harmonic means of annual precipitation, Euclidian distance and mutual information coefficient were used in comparison with cross-correlation patterns in order to define the most effective oscillations. It is concluded that ENSO oscillation pattern has the most similar pattern with harmonic mean of annual precipitation while the PDO has the major effect across the basin.

KEYWORDS

Lake Urmia, large atmospheric oscillation, precipitation, spatial analysis

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Seasonal and annual trend analysis of meteorological data in Sanliurfa, Turkey

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ABSTRACT

Global rising temperature has become more of an issue among societies and governments worldwide due to the environmental changes and climate warming. In this regard, the trend analysis of hydro-meteorological variables (such as precipitation, temperature, wind speed, humidity etc.) provides reliable outcomes for a better planning and management of water resources. Historical data possess time dependent characteristics that are generally being affected by climate variability and changes. For this reason, it is vitally important to scrutinize the changes in hydro-meteorological parameters for water supply management. In this study, minimum temperature (MiT), maximum temperature (MaT), mean temperature (MeT), mean humidity (MH), mean wind speed (MWS) and total precipitation (TP) data are obtained for the period from 1975 to 2015 for Sanliurfa region which is an important agricultural area located at the southern east of Turkey. According to the meteorological data, the trend analysis is carried out using non-parametric Mann Kendall and Spearman's Rho tests. Sen's slope trend method is employed for detecting the slopes of trend. The beginning years for the trend of the stations which present statistically significant trend are estimated using Mann-Kendall Rank Correlation test. Accordingly, the variations in hydro meteorological data in Şanlıurfa province during 1975 to 2015 have been examined in detail.

KEYWORDS

Sanliurfa region, Trend Analysis, Mann-Kendall Test, Spearman's Rho Test, Sen's slope

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Quantile regression based method for investigating rainfall trends associated with flooding and drought conditions

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ABSTRACT

Conducting trend analysis of climatic variables is one of the key steps in many climate change impact studies in which the trend is often checked against aggregated variables. In addition, there is a strong need to explore the trend of data in different regimes. The quantile regression (QR) based method fits this need very well as it can reveal temporal dependencies of the variable in question, not only for the mean value, but also for its quantiles. As such, tendencies revealed by the QR will be immensely helpful in practice where different mitigation methods need to be considered for various level of severities.
In this study, the linear quantile regression method is employed to analyse the long-term trend of rainfall records in two climatically different regions: The Dee river catchment in the UK with daily rainfall data over 1970-2004 and the Beijing metropolitan area in China with monthly rainfall data from 1950 to 2012. Two quantiles are used to represent extreme wet condition (98% quantile) and severe dry condition (2% quantile). The results show that the quantile regression is able to reveal the patterns of both extremely wet and dry conditions of the areas. The clear difference between the trends at chosen quantiles manifests the utility of using QR in this context.

KEYWORDS

Climate change, trend analysis, rainfall, quantile regression

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Parametric study of trends in flood stages over time in the regulated Guadalquivir River (years 1910-2016)

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ABSTRACT

The present study aims to report on the trends in flood hazard over time in the Guadalquivir River (Southern Spain), one of the most affected rivers by climate change in Europe. A complex physical scenario is drawn in the near future due to the interaction of long-term rainfall predictions and the reduction in channel capacity in this intensively regulated river. During the studied period, that extends between the years 1910 and 2016, the three hydropower stations Marmolejo, Valtodano and Mengíbar have operated along the selected stretch of 70 km length. Less frequent wet periods but concentrated in heavy rainfall events have developed, provoking unexpected exceptional floods in urban areas as a consequence of the increase in sediment supply from unregulated tributaries and the altered fluvial regime at high stages. A parametric study has been conducted in order to quantify the relative influence of the factors controlling the flood stages, namely: in-channel sedimentation and encroachment of riparian vegetation. Instrumental and non-systematic hydrological data were combined to lengthen flood records and reconstruct the spatial patterns of rare and extreme events, a technique common in paleohydrology. The conclusions of this study reveal that the integrated water resource management in the Guadalquivir River Basin, which is strongly influenced by political economy factors, needs to be reconsidered in order to avoid the increase in impact of flood in the near future.

KEYWORDS

Guadalquivir River, backwater effect, silted-up reservoir, paleohydrology, vegetation encroachment

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Effects of climate and land use changes on runoff extremes

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ABSTRACT

This work proposes a modeling framework for the analysis of alterations in the watershed hydrological response and, more specifically, in runoff extremes, induced by climate change and urbanization. A weather generator and a cellular automata land-use change model are used to generate hypothetical scenarios accounting for relevant trends at the global scale. Such scenarios are successively considered to force a spatial-distributed hydrological model, which simulates, at high time-resolution, most of the key hydrological variables at the basin scale. The framework is applied to the Peatcheater Creek at Christie basin (OK, USA). The considered climate alterations are negative and positive variations in mean annual precipitation, obtained by different configurations of rainfall intensity and frequency, and simultaneous increase in temperature. Urbanization is conceptualized by an increase in the fraction of impervious areas within the basin. The analysis of the hydrological response simulated under the different scenarios, shows how the considered perturbations, acting separately or combined, may significantly alter the runoff generation mechanisms, resulting in relevant alterations of the extreme runoff events intensity and their associated return period.

KEYWORDS

Hydrological change, climate change, urbanization

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Forecasting of geophysical processes using stochastic and machine learning algorithms

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ABSTRACT

We perform an extensive comparison between four stochastic and two machine learning (ML) forecasting algorithms by conducting a multiple-case study. The latter is composed by 50 single-case studies, which use time series of total monthly precipitation and mean monthly temperature observed in Greece. We apply a fixed methodology to each individual case and, subsequently, we perform a cross-case synthesis to facilitate the detection of systematic patterns. The stochastic algorithms include the Autoregressive order one model, an algorithm from the family of Autoregressive Fractionally Integrated Moving Average models, an Exponential Smoothing State Space algorithm and the Theta algorithm, while the ML algorithms are Neural Networks and Support Vector Machines. We also use the last observation as a Naive benchmark in the comparisons. We apply the forecasting methods to the deseasonalized time series. We compare the one-step ahead as also the multi-step ahead forecasting properties of the algorithms. Regarding the one-step ahead forecasting properties, the assessment is based on the absolute error of the forecast of the last observation. For the comparison of the multi-step ahead forecasting properties we use five metrics applied to the test set (last twelve observations), i.e. the root mean square error, the Nash-Sutcliffe efficiency, the ratio of standard deviations, the index of agreement and the coefficient of correlation. Concerning the ML algorithms, we also perform a sensitivity analysis for time lag selection. Additionally, we compare more sophisticated ML methods as regards to the hyperparameter optimization to simple ones.

KEYWORDS

Stochastic algorithms, machine learning algorithms, multiple-case study, cross-case synthesis, multi-step ahead forecasting, one-step ahead forecasting, time lag selection, hyperparameter optimization

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Reliability estimation of rainwater catchment system using future GCM output data (Case study: Birjand City)

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ABSTRACT

Due to climate condition of arid area, a major part of rainfall will be out of reach in the form of flash floods and a few percent recharged to groundwater aquifers. Therefore in order to reach to a sustainable development, water resource management based on rainwater harvesting systems (RWHS) will be inevitable. The main aim of this study is reliability assessment of RWHS for future. In first step, monthly rainfall may be simulated using GCMs outputs in historical and future periods. Then data is downscaled spatially through BCSD for 20 grid points around of Birjand rain-gauge station. Monthly rainfall for this station is interpolated by ordinary kriging method during future period automatically and then top GCMs are selected. Finally using interpolated monthly rainfall time series, reliability assessment of RWHS may be examined in different roof area and storage tank capacity. Results indicate that a range of reliability of was estimated 0.05-0.45 RWHS in historical period and this range will be raised in future period based on simulated monthly rainfall corresponding to the top GCMs. That's why a significant volume of household water demand can be satisfied by relying on RWHS. Also variation of reliability of RWHS showed that reliability of RWHS under 2.6rcp will be more than 8.6rcp in future period generally.

KEYWORDS

Rainwater harvesting, climate change, reliability, kriging

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WSMN: An in-situ monitoring network for soil moisture monitoring in West Wales, UK

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ABSTRACT

Soil moisture (SM) is a significant component of climatological, hydrological and ecological systems. Thus, information on its variation over time and space domains is of key importance to both practitioners and researchers alike from a variety of disciplines. In view of the requirement for information on the spatial distribution of SM, ground-based observational networks have also been developed worldwide, providing soil moisture data operationally, and at no cost to the users' community globally. Such data are also pivotal in studies concerned with benchmarking related Earth Observation-based datasets, since ground measurements are often used as "reference" in validating satellite-derived products of SM. In this context, we present herein our recent progress towards the establishment of an autonomous in-situ network - named WSMN (Wales Soil Moisture Monitoring Network) - for obtaining, on a long term basis and in near real-time, measurements of SM and related parameters for west Wales, United Kingdom. The WSMN network currently consists of 9 stations based close to the Aberystwyth region and has been collecting data since 2011. The network is now fully deployed distributing all collected data via the International Soil Moisture Network (ISMN) platform. Herein, we present results on SM trends from a time series analysis conducted analysing the data collected until end of 2016. The availability of this new in-situ dataset is of very significant importance to the region as it is expected to help advance our understanding on the physical processes involved in water and energy exchanges at the local scale. At present, WSMN is also rapidly expanding thanks to funding obtained recently which allows more monitoring sites to be added to the network to the wider community interested in using its data.

KEYWORDS

Soil moisture, in-situ measurement networks, operational networks, ISMN, WSMN

EWRA

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Uncertainty in estimated water cycle determined with atmospheric budget, water budget and total water storage

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ABSTRACT

An intensification of the global hydrological cycle is highly determined by a climate change. But an essential part of human being is fresh water availability. The availability can be computed as a difference between precipitation and evapotranspiration, which can be taken exactly from GLDAS (from Global Land Data Assimilation System) models. For the purpose of water cycle analysis, a water storage is needed, here, observations from GRACE (Gravity Recovery and Climate Experiment) were used. GLDAS (Global Land Data Assimilation System) is based on both, simulation and prediction models and observed data in a long-term period, which are merged. The data is in a form of gridded meteorological dataset at the global scale. The aim GLDAS is integration and a land information system preparation. The result is a set of parameters, consisting of water storage, energy storage and fluxes. Post processing is carried out to Limiting bias caused by an atmosphere and constraints that are resultant of the land surface states is obtained during postprocessing.
The aim of the study is to estimate atmospheric budget on a basis of precipitation and evapotranspiration differentiate, considering Poland as a case study.

KEYWORDS

Atmospheric budget, precipitation, evapotranspiration, GLDAS, GRACE

Seasonal mean Baltic Sea level change in coastal zone

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ABSTRACT

The mean Baltic Sea level fluctuations are mainly due to long-term changes in the meteorological and hydrological phenomena, occurring within a few decades. In this paper, the analyses of mean Baltic Sea level changes on the three locations in Baltic Sea, in the period of January 2003 – December 2015. We estimate seasonal mean Baltic sea level changes in the coastal zone using different data resources, including sea level anomalies, from satellite altimetry, time-variable gravity observations from the Gravity Recovery and Climate Experiment (GRACE) mission, and terrestrial water storage from the NASA global land data assimilation system (GLDAS). Sea level anomalies (SLA) and terrestrial water storage (TWS) data have been determined with a temporal resolution of approximately one month. The results from all estimates are consistent in amplitude and phase at the annual period. Sea level anomalies and total water storage time series in three locations are similar, the periods of upward trends and downward trends happen in similar time. The results provide a good measure of average annual sea level change and variation of water stored within in sea and over land. These results indicate that is important to consider estimating longer-term time series of sea level anomalies and water storage as a way of tracking climate change.

KEYWORDS

Sea level anomalies, GRACE, GLDAS, Seasonal

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A simple scaling procedure to assess the impact of climate change on extreme precipitation

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ABSTRACT

In this study we used the products of the Regional Climate Models (RCMs) to evaluate the impact of climate alterations on extreme events across the Region of Sicily (Italy). Data have been retrieved from EURO-CORDEX simulations at 12 km of spatial resolution. Because of the low resolution, the RCMs products are likely unsuitable to reproduce consistently sub-daily heavy precipitations. For this reason, extreme events at daily scale were first checked out by comparing the quantiles estimated from raingauge observations and RCMs outputs. Secondly, we implemented a temporal downscaling approach to estimate rainfall for durations of 1, 3, 6, 12, 24 hours from the modeled daily precipitation. Lastly, future projections were analyzed at daily and sub-daily scale. Results indicated that estimated variations are not be homogeneous within the study area, with a general increase of extremes events proportional to the return period and inversely proportional to the duration.

KEYWORDS

Climate change, temporal downscaling, extreme precipitation, RCM

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Analysis of rainfall trend in southern Italy through the application of the ITA technique

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ABSTRACT

In the last decades, climate change has been the focus of considerable international attention due to the increase of phenomena such as flood, heat waves, forest fires and droughts. In this context, research on the patterns of precipitation trends, both at regional and local scale, has been paramount because these variations can negatively impact on ecosystems, agriculture, water supply and management, human welfare and regional political stability. In this paper, an investigation of the temporal rainfall variability has been carried out using a homogeneous monthly rainfall dataset of 559 rain gauges with more than 50 years of observation. The region under investigation is a large portion of the Italian peninsula, ranging from the Campania and the Apulia regions in the North, to Sicily in the South, and covering an area of about 85,000 km2. Possible trends in monthly and seasonal rainfall values have been investigated by means of a new graphical methodology (Innovative Trend Analysis), which allows the trend identification of the low, medium and high values of a series. As a result, different values and tendencies of the highest and the lowest rainfall values have emerged among the five regions considered in the analysis. Especially at seasonal scale, a negative trend has been detected in winter and in autumn in the whole study area, whereas not well defined trend signals have been identified in summer and spring.

KEYWORDS

Rainfall, trend, graphical techniques, southern Italy

Climate change mitigation and adaptation plan for West Athens

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ABSTRACT

Climate change is considered part of the natural variability of Earth's conditions, but anthropogenic amplification of the phenomenon has accelerated the natural processes rapidly. This paper incorporates climate change policies in spatial planning, by developing mitigation and adaptation plan for Athens. The municipalities of West Athens are chosen as the field of focused spatial interventions after the analysis of the wider study area and the mapping of vulnerabilities. The aim of the article is to demonstrate the necessity of a strategic plan, specifically for Athens, which is the largest urban area of Greece. The implementation of that kind of a plan in Athens is highly important due to the large history of natural disasters with fatal results and strong socio-economic vulnerabilities. As it is known, "the best cure is prevention" hence the immediate and active participation of society is required. The main spatial interventions should be focused on creating suitable green and blue infrastructure, because the most likely and most dangerous impacts are related to heat waves and flood events. In conclusion, is regarded necessary to take measures in socioeconomic level in order to protect vulnerable groups as exacerbated inequalities lead to reduced social adaptability to external pressures such as climate change.

KEYWORDS

Climate change, mitigation, adaptation, strategic plan, West Athens

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Are the multi-satellite precipitation datasets in line with land-based station datasets?

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ABSTRACT

Precipitation is a crucial variable for many hydrological studies from climate change scenarios to runoff estimation or prediction in gauged and ungauged catchments. The increasing availability of global satellite precipitation estimates in near real time is a potential asset for applications where ground-based measurements are sparse or missing. However, the evaluation of such datasets with reliable ground-based measurements is considered essential for the verification of their validity. In this study a dataset from the version 7 Tropical Rainfall Measuring Mission (TRMM) 3 hours Real-Time Multi-Satellite Precipitation Analysis package is used to estimate a spatiotemporal distribution of precipitation in mainland Greece. The data set currently contains three products, providing merged microwave, microwave-calibrated infrared (IR) and combined microwave-IR estimates of precipitation on quasi-global grids computed in near-real time at the spatial resolution of 0.25 degrees. With the aim to test the adaptation and fitting of the satellite-based precipitation on that recorded in synoptic stations, a dataset of Dionysos Satellite Observatory meteorological station is employed. The dataset includes 10 minute measurements for precipitation for the historical period from 2001 to 2013. This evaluation is performed at temporal scales ranging from annual to hourly. Spatial correlations and trends analysis (including seasonal variations) are performed. The results indicate that bias is still considerable for satellite products.

KEYWORDS

Tropical Rainfall Measuring Mission (TRMM), Land-based datasets, Multi-Satellite Precipitation, Trends analysis

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Spatiotemporal evaluation of reanalysis and in-situ surface air temperature over Ethiopia

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ABSTRACT

Water resources management and modelling studies are often constrained by the scarcity of observed data, especially of the two major variables i.e., precipitation and temperature. Modellers, hence, rely on reanalysis datasets as a substitute; though its performance heavily vary depending on the data availability and regional characteristics. The present study aims at examining the ability of frequently used reanalysis datasets in capturing the spatiotemporal characteristics of maximum and minimum surface temperatures over Ethiopia and to highlight the biases, if any, in these over Ethiopian region. We considered ERA-Interim, NCEP 2, MERRA and CFSR reanalysis datasets and compared these with temperature observations from 15 synoptic stations spread over Ethiopia. In addition to the long term averages and annual cycle, a critical comparison of various extreme indices such as diurnal temperature range, warm days, warm nights, cool days, cool nights, summer days and tropical nights are also undertaken. Our results indicate that, the performance of CFSR followed by NCEP 2 is better in capturing majority of the aspects. ERA-Interim suffers a huge additive bias in the simulation of various aspects of minimum temperature in all the stations considered; while its performance is better for maximum temperature. The inferior performance of ERA-Interim is noted to be only because of the difficulty in simulating minimum temperature.

KEYWORDS

ERA Interim, NCEP Reanalysis, MERRA, CFSR, Diurnal temperature range, reanalysis performance

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An investigation of the use of Sentinel-2 data for mapping wetlands: a case study from Greece

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ABSTRACT

This study aimed at evaluating the combined use of Sentinel-2 data with advanced machine learning image classification algorithms for mapping a typical wetland ecosystem in Greece. In addition, the potential added value of additional spectral information created from the initial bands and of elevation to the thematic information accuracy was also examined. As a case study the National Park of Koronia & Volvi lakes in Thessaloniki were selected due to its high environmental interest. A Sentinel-2 (S2) image acquired in August of 2016 and a Shuttle Radar Topography Mission digital elevation model (SRTM DEM) were the main datasets used in this study. The image was preprocessed using SNAP open source software. A Principal Component Analysis (PCA) and a Minimum Noise Fraction (MNF) transformation were applied to the original bands and the derivative bands were used to form two new multispectral images. The DEM was also stacked to the two images. The Support Vector Machines (SVMs) and Artificial Neural Network (ANN) classifiers were applied to the four images created. Accuracy assessment of the derived classification maps was conducted on the basis of the estimation of standard classification error statistics. Comparisons showed that for the particular dataset and study site the SVM algorithm outperformed ANN. Overall accuracy reached 91.32% (kappa: 0.9008) for SVMs and 82.07% (kappa: 0.7945) for ANN. Additionally, the inclusion of the DEM appeared to increase overall accuracies ~5% for SVMs and ~1% for ANN. In overall, results exemplified the appropriateness of the spatial and spectral resolution of the S2 imagery in obtaining a rapid and costeffective wetlands mapping. This is of considerable scientific and practical value, as it provides additional evidence on the suitability of S2 data for improving our ability to understand better the physical processes embedded in wetland ecosystems.

KEYWORDS

Wetlands, Koronia Lake, Sentinel, SRTM DEM, Greece, SVM, ANN, MNF, PCA

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On the use of climate-flood links and CMIP5 projections to predict flood hazard under climate change scenarios

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ABSTRACT

The Intergovernmental Panel on Climate Change (IPCC) assessed with medium confidence that there has been an anthropogenic influence in the intensification of heavy rainfall at the global scale. Nevertheless, when taking into account gauge-based evidence, no clear climate-driven global change in the magnitude or frequency of floods has been identified in recent decades. This work presents a study on the nonstationarity of floods in the Itajaí River, which is located in the Southeastern South America region, where the influence of El Niño-Southern Oscillation (ENSO) on hydrometeorological extremes has been reported. The analysis used a peaks-over-threshold (POT) approach and a Bayesian inferential framework, and revealed that occurrence rates and over-threshold peak magnitudes exhibit statistically significant and complex relationships with ENSO. The identified climate-flood link is further explored using sea surface temperature (SST) output from CMIP5 models under different representative concentration pathway (RCP) scenarios. Results are inconclusive as to whether it is possible to make a statement on scenario-forced climate change impacts on the flood regime of the Itajaí river basin. The overall outcome of the analysis is that, given that sample sizes are adequate, stationary models seem to be sufficiently robust for engineering design as they describe the variability of the hydrological processes over a large period, even if annual flood probabilities exhibit a strong year-to-year dependence on ENSO.

KEYWORDS

Nonstationarity, flood frequency analysis, climate change, design life level, CMIP5

III. Water Resources Management

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On the barriers to adapt to less water under climate change in Mediterranean countries

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ABSTRACT

This paper summarises barriers and constraints to adapting water resources management to climate change in the Mediterranean region. First, we synthesize and analyze the most promising strategies for adapting to less water in Mediterranean countries, expanding the application to other climatic regions. Theoretical measures include improved efficiency, optimisation of governance, enhancement of participation, development of risk-based choices, and economic instruments. Adjusting agricultural systems to water needs is a sound and feasible practice in both irrigated and rain-fed systems and presents a water saving potential up to 50% compared with a non-adjusted practice. Finally, the paper categorises the constraints to implement the measures, give specific examples about these issues and also quantify their impact. When considering constraints and opportunities to implement these water management practices, any environmental policy regulating their adoption should be based on recommending the use of extension and training to local actors on the application of the practices. While there is a continuing need to strengthen the climate change knowledge base (through research), improved understanding of climate change science will be insufficient on its own for adaptation policy development and to drive adaptation action. There is a complementary need to engage stakeholders, by developing suitable methodologies for assessment of impacts, vulnerabilities and planning as a pre-requisite for cost-effective adaptation. There may be many simple adaptation measures that could theoretically be introduced to address a particular risk or opportunity, these may only be practically possible under certain circumstances.

KEYWORDS

Water management, climate change adaptation, water availability, reservoir storage

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Sensitivity analysis of a probabilistic flood inundation mapping framework for ungauged catchments

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ABSTRACT

A common natural disaster worldwide is flash-floods. Usually, the catchments affected by flash floods are ungauged. The absence of flood records leads to remarkable uncertainty in floodplain modeling and mapping estimation. In this study, a probabilistic framework for floodplain mapping has been developed to assess the uncertainty related to the roughness coefficient parameter used in hydraulic-hydrodynamic modeling. The popular hydraulic-hydrodynamic model HEC-RAS was implemented using a Visual Basic Monte Carlo code, to assess roughness coefficient uncertainty at ungauged catchments. A high-resolution DEM, created by Terrestrial Laser Scanner data has been used. Pebble count field surveys and empirical formulas have been used for the estimation of the initial Manning's n roughness coefficient value. Several probability distribution functions were fitted to the estimated roughness coefficient values and evaluated using various "goodness-of-fit" criteria. The Manning roughness coefficient values were sampled using Latin Hypercube sampling technique. Finally, flood inundation probability maps have been produced. The validation process is based on historical flood extent data, a binary wet-dry interpretation and the use of Median Absolute Percentage Error as an evaluation statistical measure. The proposed framework have been implemented at the ungauged Xerias stream watershed, Volos, Greece. The proposed floodplain mapping uncertainty framework justified through a detailed sensitivity analysis. The results indicate that the proposed framework enables probabilistic flood hazard mapping and may assist the decision-makers to devise better flood risk mitigation strategies for ungauged catchments.

KEYWORDS

Probabilistic flood mapping, uncertainty analysis, Monte Carlo, ungauged streams

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Using cross-over analysis to support water user discussion about investments in water sources for irrigation

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ABSTRACT

Regional long-term water management plans increasingly depend on investments by local water users such as farmers. However, local circumstances and individual situations vary and investment decisions are made under uncertainty. Therefore, the perceived values of costs and benefits may also vary considerably among water users, leading to non-uniform investment decisions. This variation can be explored by examining cross-over points, that is, points of equal preference when comparing alternatives. In a participatory context, cross-over analysis has the potential to structure and strengthen discussions among actors and enhance social learning. This paper presents a framework to use cross-over points in a group setting to support discussions among farmers about strategic investments in irrigation water. The framework is tested in a case study in the Coal River Valley in Tasmania, Australia, where various water sources are available. A discussion workshop is designed to learn from each other's perspectives and investment rationales. Instead of focusing on "what is best", participants engage in a dialogue about when and why a particular water resource is preferable over others for increasing on-farm water availability. These insights can provide valuable background information for investment decisions by other water users, irrigation scheme designers and water managers.

KEYWORDS

Cross-over analysis, Discussion support framework, Personal preference, Investment decisions, Irrigation water

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Simulation and optimization of hydraulic-hydrologic complex system (Case study in Iran)

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ABSTRACT

Water is one of the biggest challenges of this century in the very near future, which may be the source of many of the world's positive and negative developments. Increasing population and a shortage of water resources necessitates the need for proper management of reservoirs. On the other hand in the management of water resources in addition to the issues we face at the same time exploiting reservoirs with hydraulic and water resources were important and both hydraulic and hydrologic modeling flow conditions must be considered together. In this study, three dams and two water transfer tunnels were used for transferring water from Yalan dam to Gokan dam (Yalan-Pashandegan-Gokan Water Transfer (YPGWT) Project). For YPGWT Project simulating and optimizing, at first dynamic programming (forward-moving) was developed, and after solving it, the best diameter and dam height for optimization of water transfer system was determined. Since the water flow through the tunnel is under pressure, increasing dam height will cause the decrease of tunnel diameter for constant water conveyance efficiency. The purpose of this study is transferring 95% of water flow between two basins after supplying the agriculture consumption and environmental needs. The results showed that Yalan and Pashandegan dam with a height of 148.37 and 59.36 m, respectively, and Yalan-Pashandegan and Pashandegan -Gokan tunnel diameter with 2.8 and 2.95 m, respectively, were the most economically optimal combination for water transferring in YPGWT Project.

KEYWORDS

Water Resources Planning, Optimization, Simulation, Hydraulics, Reservoirs, Water Transfer Efficiency, Dynamic Programming

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Evaluation and development of spatial Decision Support System

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ABSTRACT

Studies have been expanded heavily at water networks sector especially at residential areas which including a high density of population. This paper discusses the use of a Geographic Information System (GIS) as a Decision Support System (DSS) generator to create Spatial Decision Support Systems (SDSS) to evaluate the hydraulic situation of the water network. A hydraulic model was used on the small zone of Gaza city (Case study the northern Nasser water network) to get a high accurately results. Calibration and SDSS used to identify the technical problems. The developed SDSS may be used at all zones of Gaza city to improve the network efficiency and effectiveness of operation. In addition, the results of this study will be the base of Supervisory Control and Data Acquisition (SCADA) system to make the system more automated and specify any sudden problem at the system and to give more accurate data. GIS software is recommended to be used in order to better utilize the developed water network database and make the operating and management more effectively. The results indicated that 82% of Zone 2, the water velocity ranged between 0-0.25 m/s while in Zone 1 the percentage is 59%. 70% of the water pressure at Zone 1 has 2 bars while in Zone 2 the percentage is 72% for 1 bar. The low values of the velocities may result from the leakage at the syste.

KEYWORDS

Performance evaluation, Water distribution network, GIS, Water CAD, Gaza City

Integrated Water Resources Management in agro-economy using linear programming: the case of Lake Karla basin, Greece

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ABSTRACT

Several hydrological factors that affect agricultural water use in the Mediterranean region have recently emerged. The financial crisis focuses on production, efficiency and profit, but all these should be achieved under environmental constraints. This requires a shift in policy towards more sustainable and efficient solutions. This research presents optimization problems related to the broader water resources management. The study area is Lake Karla basin (Central Greece). The problems aim to maximize production, productivity, water-use efficiency, net profit, and to minimize irrigation and production costs, by using linear programming in GAMS software. The final goal is to propose to the stakeholders the optimum crop distribution, suggesting different policy options. This approach can be used for further research (e.g. decision-making techniques) in order to combine the economic growth with the protection of the environment.

KEYWORDS

Optimization, Linear Programming, GAMS, Lake Karla Basin, Integrated Water Resources Management, Agro-economy, Policy-making, Data-scarce areas

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A land accounting system for integrated water resources management

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ABSTRACT

Land is a resource that affects all dimensions of the natural environment, as all the human and natural activities occur on it. World development is exerting increasing pressures on the natural systems, such as: urban sprawl and population increase, agricultural expansion and deforestation, new infrastructure and industrial establishments construction. Considering the environmental sustainability targets, land monitoring and management should be treated as one of the main factors delivering all the services for the human welfare by completing the water-food-energy nexus scheme. This research work focuses on the land stocks changes analysis, as part of the System of Environmental and Economic Accounting (SEEA) framework which assesses the interactions among different types of land cover. To this end, coupling the geospatial information from 2001 to 2011 from the United States (US) National Land Cover Database (NLCD) with hydrological and water use data was attempted in the hydrological region of Wabash river covering mainly the state of Indiana. The methodology employed, allows the calculation of new land cover type formation and consumption and land cover type exchanges (flows) among different categories and the calculation of average land intake per category. The main findings of this research work are an accelerating urban sprawl, following up the population increase, against planted and forested areas. The developed areas are steadily expanding, as a signal of a probable future increase in water uses for the public water supply and industrial sectors.

KEYWORDS

Environmental accounting, land accounts, land cover flows, water use, urban sprawl

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Prospects for sustainable water resources management within the river Djetinja catchment

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ABSTRACT

Water resources management that addresses various users' demand at the River Basin scale is the very important topic that involves comprehensive evaluation and consideration of catchment characteristics, and general professional and scientific postulates. Contemporary water management incorporates number of criteria merged in a way to target economic development, social equity, and environmental sustainability. However, the most vital subject is water supply for different users with sufficient amount of water that responds to quality standards. Integrated water resources management principles are incorporated in Republic of Serbia Water Act. Thus, at the river basin and sub basin level allocation among different users and sectors that is sustainable and provides enough water of required quality has to be attained. Due to water management complexity, the potential allocation has to consider natural conditions, water resources quantity, environmental protection, foreseen development, measures, etc. In addition to assessment of natural features (drainage area, topography, land cover, hydrogeology, erosion, etc.), existing water management issues this paper introduces the prospects for improvement of water resources management and allocation among different sectors (drinking water supply, hydropower, agriculture, tourism, etc.) based on planned development within Djetinja River drainage area. Brief overview of natural water retention measures benefits and role of hydrologic ecosystem services that are complementary with existing and foreseen technical measures indicate necessity for their incorporation in decision making process. Selection of measures results from comprehensive analyses and assessment given the complexity of domain. More frequent monitoring and additional data are prerequisite for multipurpose NWRM preference so it can contribute to sustainable and integrated water resources management.

KEYWORDS

Sustainable water resources management, integrated water resources management, water resources allocation, natural water retention measures

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Towards the optimization of water resource use in the Upper Blue Nile river basin

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ABSTRACT

The Nile River is a source of water for millions of people. The continuously growing water demand in combination with the population growth and the lack of water resource management in the basin have led to enormous water scarcity. In order to provide water security, sufficient water resource management is required. For the integrated water resource management of one of the two main Nile sources, the Upper Blue Nile River basin in Ethiopia, the NIMA-NEX project is proposed. The goal is to develop a tool called NIMA-NEX (NIle MAnagement Nexus EXpert tool) to optimize the water resources within the basin. The optimization is achieved in terms of a nexus approach. Thus, water, food and energy are considered as three elements that interact with each other continuously. The present study deals with MA-NEX, the management and optimization module of NIMA-NEX. Within MA-NEX, the system of reservoirs and other projects, as well as the water allocation among the various uses in the Upper Blue Nile River basin are optimized. The study focuses on the maximization of ecological, economic and social benefits, and the political stability. For the simulation and optimization of the system, the model Hydronomeas is used. Various development and management scenarios are investigated and Pareto fronts are proposed for the Upper Blue Nile River basin.

KEYWORDS

Water resources optimization, water resources management, water allocation, Pareto optimization, Hydronomeas

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Indexing vulnerability of an embankment reach against breaching: A remote sensing and hydrodynamic based study

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ABSTRACT

Floods of high magnitude are one of the major problems in the north-eastern region of India. Approximately 4464 km of embankments are being constructed in the Brahmaputra basin itself. The embankments are highly vulnerable to flood and flood disaster for embankment breaching is frequent in Assam. Remote Sensing data of a river system of highly unstable bank has been analyzed in GIS environment for identification of river bank erosion as well as reaches of embankment vulnerable to breaching.

A case study was carried out in the Nona River, a tributary of river Brahmaputra, to identify reaches of embankment vulnerable to breaching during the flood time. Temporal dataset of satellite imagery for several years along with the topographical maps from Survey of India (SOI) were used for mapping the flow channel of river Nona.

Based on the degree of convergence and narrowness between the flow channel and embankment observed from the digitized images of Nona River from 1999 to 2014, some reaches of embankment which are vulnerable to breaching were selected for the study.

Hydrodynamic analysis by MIKE 21C –Curvilinear Flow Model was conducted on those vulnerable reaches in order to validate whether the embankment is going to breach due to change of flow pattern of the river observed from the digitized images of the river.

Results obtained from remote sensing data and flow velocity profile from hydrodynamic analysis were split into different categories ranging from 0 to 10 which indicate the vulnerability of an specific embankment reach against breaching.

KEYWORDS

Vulnerability, Embankment, Breach, Hydrodynamic

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Algiers water issue: Key indicators for a diagnosis of water resources carrying capacity

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ABSTRACT

In Algeria and especially in Algiers the capital city, ensuring inhabitants water requirements remains a critical issue despite huge investments made by the government to secure water supply over the past years. Indeed, in the face of erratic climate conditions with recurrent drought episodes and constantly increasing water demand, due to population growth and economic activity rise, the water supply system is subject to various problems of environmental, economic, technical and managerial nature. This could ultimately affect the water supply of Algiers city. A rigorous and effective management of water resources requires analysis of elements that affect in the long run water resources carrying capacity (WRCC). This latter can be defined as the level of human activity that can be withstood by the available water resources without major degradation of aquatic environments while maintaining an adequate standard of living for the population. Water resources carrying capacity depends mainly onto two major components that are water supply capacity and inhabitants' global water demand. This study aims at proposing key indicators and related thresholds for analysing Algiers water carrying capacity in order to provide a diagnosis tool for policy makers to lay down the foundations of a sustainable water strategy in Algiers city.

KEYWORDS

Algiers water supply, Key indicators, Water system diagnosis, Carrying Capacity

The seismic risk of new and existing dams

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ABSTRACT

The main issues of the design and construction of any dam are undoubtedly the safety and serviceability. It is evident that both of them depend mainly on the capability of the design group (a) to assess realistically all the local site conditions (hydrological, hydraulic, topographical, geological, geotechnical, etc.), (b) to decide the optimum dam shape and type (i.e. embankment dam, concrete gravity dam or arch dam), and (c) to design the dam accordingly in order to withstand all the potential hazards and/or loadings (e.g. gravity, hydrostatic pressure, differential settlements, etc.). Nevertheless, in areas characterized by moderate or high seismicity the design of a dam may be a more challenging and demanding task since both safety and serviceability are directly related to the earthquake-related geohazards and the seismic vulnerability of the dam under consideration. The term "earthquake-related geohazards" is used to describe various geological/geotechnical phenomena, such as strong ground motion, active-fault rupture propagation, earthquake-triggered slope instabilities and soil-liquefaction phenomena. Therefore, the main emphasis of this study is on the seismic risk of new or existing dams. The seismic risk may be estimated by the assessment of the earthquake-related geohazards and the realistic estimation of the seismic distress of a dam. The first part of the study is devoted on the qualitative and quantitative assessment of the main earthquake-related geohazards, while in the second part the main issues related to the seismic response and vulnerability of dams are presented.

KEYWORDS

Dams, geohazards, earthquakes, seismic risk, safety, serviceability, seismic design

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Balancing environmental and socio-economic water demands in the Tagus river headwaters under climatic change

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ABSTRACT

Human-hydrological systems are vulnerable to climate change, particularly due to rigidity in their management strategies. Latest observed figures both in global GHG emissions and global mean temperatures show the growing changes of soon entering in a trajectory of high-end climatic change (HECC) which is likely to have strong negative impacts on Iberian river basins. The headwaters of the Tagus River basin provide a perfect example of a strongly altered human-hydrological system: the natural seasonality of river has been completely eliminated to ensure a constant flow rate throughout the year to serve the expanding water demands imposed by hydropower and agricultural production as well as by water transfer to the Segura catchment. Such water management scheme, stemming from 80-ies, has triggered strong societal debates between the local stakeholders and the Segura beneficiaries and jeopardized the environmental state of the Tagus River. This situation is likely to be exacerbated by projected climate change, as water availability in this area is expected to decrease dramatically. Employing the eco-hydrological model SWIM coupled with a reservoir and water transfer model we aim to assess the vulnerability of the Tagus headwaters system to projected moderate and high-end climate change under present management strategy and a transformative strategy aimed at integral river restoration. Our results show that if increase of coping capacity and restoration of natural variability is aimed, the socio-economic demands, especially related to the water transfer to Segura, should be re-considered and lowered.

KEYWORDS

Sustainable water allocation, Tagus, Tagus-Segura transfer, climate change

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Water, energy and food nexus: The Q-Nexus model

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ABSTRACT

Water, energy and food (WEF) resources are interconnected systems that directly and indirectly affect one another. The water-energy-food nexus perspective as a conceptual framework is highly relevant to model and analyse WEF sectors holistically. Evaluating and analysing interactions across and between water, energy and food systems necessitates suitable methods to promote sustainable and efficient WEF resource use. The Q-Nexus Model is a practical and mathematically-based quantitative WEF nexus assessment framework that serves as platform to quantify, planning, simulate and optimize water, energy and food as an interconnected system of resources that directly and indirectly affect one another. It permits the evaluation of WEF planning scenarios and policy options based on changing demand, technology and resource allocation. This paper reviews the technical features of the Q-Nexus Model and presents method of evaluation of the direct and indirect effects resulted from WEF planning scenarios or policy options. Firstly, the methodological background of the Q-Nexus Model and its ability to simulate water, energy and food nexus systems in response to numerous key drivers is presented. Secondly, procedures of calculating direct and indirect intersectoral use quantities are introduced. At the practical level, a numerical experiment is presented and results are discussed. Lastly, the conclusions and further developments are presented.

KEYWORDS

Water, energy, food, nexus approach, sustainable development

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Small zoned earthfill dam simplified design with 3D solid modeling techniques

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ABSTRACT

The climate of the Mediterranean basin is characterized by an irregular hydrologic regime with low rainfalls during the dry season which necessitates the irrigation of crops. Climate change is expected to exacerbate water shortages in the region, which have intensified in recent years. Thus, is it important to improve water resource management in the area by exploiting surface water resources by constructing dams in river channels. These dams will enable the storage of water that can then be used to meet water deficits. Small earthfill zoned dams are ideal for Mediterranean conditions because of their low cost and fast and relatively easy construction. The objective of this article is to illustrate how the design of small earthfill zoned dams could be further simplified by introducing three-dimensional (3D) solid modeling operations. Additionally, the material quantities necessary for earthfill zoned dam construction are easily computed using the proposed techniques. Finally, these techniques could also be used in order to simplify the design of various hydraulic structures and in different computer aided design software's too.

KEYWORDS

Small zoned earthfill dam, computer aided design, 3D solid modeling, construction materials, AutoCAD

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Different design techniques in determining reservoir capacity

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ABSTRACT

Reservoirs are designed to provide the balance between the flow brought by the river which is high variable in time and volume of water required for some usage purposes of the flow. The storage required on a river to meet a specific demand depends basically on three factors; the magnitude and the variability of the river flows, the size of the demand and the degree of reliability of this demand being met. Several procedures have been proposed to estimate storage requirements. Critical period methods are those in which required reservoir capacity is equated to the difference between the water released from an initially full reservoir and the inflows for periods of low flow. In the presented study reservoir capacity-yield-reliability relationships are investigated for a single reservoir named Sami Soydam Sandalcık Dam. For this purpose, monthly and annual mean flow data observed for a period between 1962-2013, of EIE-811 Suçatı Flow Gauging Station on Dalaman River in West Mediterranean Basin in Turkey are used as case study. The required reservoir capacity is estimated required to meet a prescribed demand for a given model of annual inflows in this study by using mass curve, Dincer, Gould's Gama, McMahon.

KEYWORDS

Reservoir capacity, low flow hydrology, critical period, Dalaman River, Sami Soydam Sandalcık Dam, Turkey

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Geo-Information analysis of the mini hydropower potential in the Liguria region

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ABSTRACT

The present paper deals with the implementation of a GIS-based tool for the definition and spatial evaluation of the mini hydropower potential. The investigation of the mini hydropower potential is performed at the catchment scale by integrating: catchment morphometric analysis; setting criteria for locating the weirs and powerhouses; hydrological modelling; engineering analysis; economic analysis and mapping. Hydropower potential results are synthetized through the synthetic index (MHP) resulting by the economic analysis based on the IRR dynamic method. A simplified understanding of MHP suggests that the investment is strongly recommended (MHP =1.0) when the initial cost equals the revenues occurring during a 10-years period. The integrated approach has been tested on a selected catchment of the Liguria Region (Italy): MHP map is plotted in order to provide an easily visualization of the results in selected catchments. Based on the preliminary results, the study proves that MHP analysis is a powerful tool in order to better support energy management strategies. The determination of MHP indexes in a simplified framework overcomes the typical problem due to the single prediction of hydropower potential for a specific plant configuration. Future perspectives of this research include the analysis of the spatial distribution of the water intakes on different reaches along the same river network in order to limit the aquatic ecosystem disturb and to enhance the sustainable water resource management.

KEYWORDS

Mini hydropower, flow duration curve, GIS-based tool, green energy, sustainable water resource management

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Trade-off between environmental flow policy and run-of-river hydropower generation in Mediterranean climate

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ABSTRACT

Run-of-River Hydropower plants are essential for the sustainable development of renewable energy resources. However, the increase in water demand for energy generation may conflict with the objectives of river conservation according to the Water Framework Directive (WFD). Therefore, the assessment of environmental flow requirements in river basins subjected to water abstractions is a crucial task for the integrity of aquatic ecosystems. The main objective of this contribution is to improve the assessment of interactions between energy generation and instream flow ecological indicators. In this study, we conducted ecological and energy generation analysis for a run-of-river hydropower plant located in the Najerilla River, Ebro basin, Spain. The region under study is characterised by Mediterranean-Continental climate. The analysis was conducted considering 30 years' records of mean daily flow data, net head of the hydropower plant, turbine efficiency, and environmental flow constraints (EFCs). We quantitatively estimated the instream flow alteration (IFA) based on certain hydrological indicators by utilising seven hydrological methods for environmental flow estimation. Subsequently, we compared their implication on hydropower generation and hydrological alteration of the instream flow regime (IFR). The results show that there are significant variations between the seven EFMs. We found that flow regime obtained by applying the 10% Daily method shows similar pattern and magnitude to those of natural flow regime most of the time. We concluded that dynamic approaches (e.g., 10% Daily) concerning the environmental flow estimation are more reliable and feasible regarding energy generation and hydrological alteration-reduction.

KEYWORDS

Run-of-river hydropower plants, flow regime alteration, environmental flow, hydrological alteration

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Effects of crop pattern changes on hydroelectric power generation in Gediz river basin

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ABSTRACT

Due to several socio-economic reasons, crop patterns of a basin may vary over the years. The primary reason generally tends to be on the economic aspect. Such a change has took place in Gediz Basin, Turkey; in between the years 1997-2012, a dramatic transition occurred in crop pattern due to economic pressures. Agricultural communities of Gediz Basin have shifted their main yearly crop from cotton to maize because of forcing benefit/cost ratios. Due to the total and monthly differences between two crops' water requirements, irrigation water demand has also altered throughout the years. The main reservoir Demirkopru has the primary purpose of providing water during the summer season for the lower basin embodying around 110 000 ha of irrigated area. The change in crop patterns has put the effectiveness of the produced energy now in question. Although the power generation contributes negligible amounts versus agricultural production to the gross income in the basin, its cost-effectiveness has become an important issue due to the privatization process of the power plant. In this study, over 20 years of recorded data of Demirkopru reservoir's inflows have been used for the synthetic data generation in order to examine the effects of on-going and future crop pattern changes and operational responses of Demirkopru reservoir. The results of operational studies of reservoir are evaluated in terms of power generation and its cost-effectiveness.

KEYWORDS

Crop pattern, Synthetic data generation, Cost-effectiveness, Electric power generation

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GIS based Analytic Hierarchy Process in determination of suitable site for water storage

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ABSTRACT

The need of the hour is to tap maximum possible water available in the river basin that can be utilized especially during the period of agricultural drought. This can be materialized by creating water storage structures, for this purpose the first task could to be the identification of suitable location for water storage sites. With the advent of remote sensing and GIS techniques, it becomes easier for water resources planner to identify the suitable location of water storage structure within the basin. In the present study an attempt has been made to identify the suitable locations in the upper basin of Sheonath River in Chhattisgarh State, India. Based on the various physical characteristics of the basin, GIS based Multi-Criteria Evaluation technique is being applied to determine the most suitable water storage sites. For this purpose runoff, hydrologic soil group, land use, lineament, slope, stream order and settlement data are used. Raster layers were formed based on the mentioned data; each layer has been given percentage importance. For determining the percentage importance, Analytic Hierarchy Process (AHP) is used. After determining the percentage importance all the layers are overlaid in GIS to produce suitable location for water storage. This mapping helps in selecting potential site for water storage structures.

KEYWORDS

GIS, remote sensing, water storage, runoff, hydrologic soil group, land use, stream order, multi-criteria evaluation, analytic hierarchy process

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Water resources management and lack of water in the Zayandehroud river basin, Iran

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ABSTRACT

Iran is located in Middle East region and is facing a serious water crisis in recent decay, while in the past has been one of the leading countries in the field of water resources management. Zayandehroud river basin which is located in the center of Iran is experiencing different problems due to lack of available water in recent years. Some of the effective factors on the crisis are decreasing the amount of precipitation, changing in type and time of precipitation, declining the groundwater levels and increasing water demands due to population growth. In this study, we investigated the major reasons of the water crisis in Zayandehroud river basin. For this purpose, we create a conceptual model to unravel the effect of different factors on water shortage in this basin. Agriculture, drinking and industry are the main water consumer sectors in the basin, respectively. Although people and Iranian decision makers believe drought and climate change are the main reasons of the water crisis in this basin, the investigations shows that the mismanagement of water resources has more effect on deficiency of water. In addition, water supply is less than real demands. Therefore, it is necessary to follow long-term solutions in order to sustainable water resources management which lead to overcome this problem in the region with ancient civilization.

KEYWORDS

Water crisis, Water resources management, Zayandehroud River, Iran

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Effect of land use change on flood extent in the inflow stream of lake Paralimni, Cyprus

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ABSTRACT

Land use is a crucial factor that influences flood characteristics such as peak discharge, volume, peak water elevation and inundation extent. It is therefore logical that land use change entails changes in these characteristics, thus leading to increased potential harm. In this work the drainage basin of the Inflow Stream of Lake Paralimni, Cyprus (11.5 km2) is investigated, which has undergone significant land use changes, primarily due to the conversion of agricultural land into urban space. At the methodological level, both hydrological and hydraulic modelling is used. Regarding hydrological modelling the SCS method is employed, combined with the synthetic Unit Hydrograph of the Institute of Hydrology of UK and the Muskingum method for river routing. Hydraulic modelling is based on the standard step method for solving the energy equation under 1D steady flow conditions. Software packages such as HEC-HMS, HEC-RAS, HEC-GeoHMS and HEC-GeoRAS are used together with a Geographical Information System. Regarding the input data, observed five-minute precipitation depths from three gauges are used for a historical storm event occurred in February 1988 which is known to have caused inundation. Also, a Digital Elevation Model at the resolution of 1 m is used which is based on Lidar data. Two periods with distinct land uses are examined (1983-2003 and 2006-2016), which allows the assessment of the impact of changes in curve numbers and Manning's roughness coefficients. Significant changes in peak flow rate, flood volume and inundation extent were found when passing from the old to the current land uses.

KEYWORDS

Land use change, flood mapping, Lake Paralimni, Cyprus, HEC-HMS, HEC-RAS

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Robust prioritization for SEA with the missing data

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ABSTRACT

This study investigates how the priority analysis for dam construction sites vary with multi-criteria decision making techniques and generation approaches for incomplete information. Strategic environmental assessment (SEA) seeks to recommend sustainable dam construction sites based on their environmental and ecological impacts in a long-term plan for dam construction (LPDC) in South Korea. However, if specific information is missing, the SEA is less useful for choosing a dam construction site. In this study, we applied Analytical Hierarchy Process (AHP), ELimination Et Choice Translating REality (ELECTRE) III, Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) II and Compromise Programming as multi-criteria decision making techniques, and used binomial and uniform distributions to generate missing information. We considered five dam site selection situations and compared the results as they depended on both multi-criteria decision making techniques and information generation methods. The binomial generation method showed the most obvious priorities. All multi-criteria decision making techniques showed similar priorities in the dam site selection results except for ELECTREE III. The results demonstrate that selecting an appropriate multi-criteria decision making technique is more important than the data generation method. However, using binomial distribution to generate missing information is more effective in providing a robust priority than uniform distribution, which is a commonly used technique.

KEYWORDS

AHP, ELECTRE III, Incomplete information, Multi-criteria decision making, Priority, PROMETHEE II, Strategic environmental assessment

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Research on conjunctive use of surface water and groundwater for managed aquifer recharge (MAR) at the river Nestos delta, Greece

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ABSTRACT

In the framework of the rational water resources management at the eastern part of River Nestos Delta, NE Greece, this paper investigates the potential conjunctive use of surface water and groundwater in order to optimize the exploitation and utilization of the available water recourses from the River Nestos and to confront the continuous groundwater salinization at the coastal part of the study area. The present study targets: (i) to improve the flow conditions through the main water course of the irrigation network of the study area by applying proper technical implementation proposals, and (ii) to design a groundwater artificial recharge pilot project, while assessing the effectiveness of the recharge procedure. Several maps, figures and tables are compiled, indicating the positions and technical details of the proposed interventions based on a topographic survey and a numerical simulation, using the well-known one-dimensional software HEC-RAS. The proposed intersections, tested in the simulation, are distinguished in modifications into the watercourse bed and engineering works concerning the pipeline. Regarding the groundwater artificial recharge pilot project, a system of recharge basins is proposed, as well as the relevant design elements are calculated based on the hydrogeological and hydraulic characteristics of the underlying aquifer system.

KEYWORDS

Conjunctive use of surface water and groundwater, HEC-RAS, Managed aquifer recharge – MAR

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Land accounting perspective on water resources management

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ABSTRACT

Water availability and allocation are connected to various activities (e.g. irrigation, urbanisation, industrial production, recreation), which are taking place on the terrestrial surface. Considering the variation of the driving forces, it is necessary to examine possible patterns and trade-offs between land, water and social welfare. Land cover refers to a set of both natural features and anthropogenic establishments that mainly result from its use. Quantitative and descriptive attributes can be assigned to a land unit providing valuable information about the classification of land cover, the available stocks and flows among different types, the rate at which land cover types and their inherent socio-economic factors depend on water-related processes. Therefore, a total amount of changes that are related to water resources can be observed, recorded and analysed. This research focuses on the implementation of land accounting approach in Greece in order to identify the degree of pressures on water resources over time. Furthermore, the integration of diverse data sources, intends to emphasize the impacts of primary land use activities such as housing and cultivation that are prevalent within the Greek territory. Achieving these goals provides the opportunity to improve decision support tools towards sustainable development.

KEYWORDS

land cover, land accounting

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Environmental flow assessment through integrated approaches

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ABSTRACT

The alteration of river flow regime downstream of artificial dams is known to negatively affect the health of the riparian ecosystems, the geomorphology of the riverbed and riparian zone as well as the quantity and quality of river waters. To avoid such impacts releases from dams are scheduled so as to sustain the so called environmental flow. This work aims at investigating the differences and complementarities of various methods used for the assessment of environmental flow. Firstly, we extended the historical daily flow time series through using a rainfall-runoff model so as to overcome the problem of inadequate length of it. Subsequently, different simple and advanced hydrological methods were applied (Tennant method; minimum monthly flow method; flow duration curve method; the method of basic maintenance flow; the Range of Variability Approach). Also, a hydraulic method (wetted perimeter-discharge technique) was applied using data from several river cross-sections. This method allowed the establishment of an empirical relationship between flow and wetted perimeter. Finally, crucial ecological criteria such as the fish survival requirements under different hydrological and hydraulic regimes were investigated in an effort to formulate an integrated framework for environmental flow assessment. The different approaches were tested on a human modified river with a water supply dam (Mornos), located in the Water District of West Sterea Hellas, Greece.

KEYWORDS

Environmental flow, dam operation, human modified river, Mornos river

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Sustainable management of water resources to safeguarding drinking water – The Water-Guard Project

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ABSTRACT

The purpose of the WATERGUARD Project is the monitoring and protection of the quality of drinking water, as well as the overall qualitative characteristics of the aquifers in Ioannina Basin in Greece, in the Province of Taranto and in the municipality of Gallipoli in southern Italy, through the use of new processes, methodologies and technologies, which combine state-of-the-art integrated geographic information systems, decision support systems, telemetric technologies and knowledge management. This paper focuses on the development, the architecture and the functionalities of the WATERGUARD GIS Platform developed for the Water Association of Ioannina Basin, which is an integrated solution for the management of water supply networks and their infrastructures in a GIS environment. The software augments the functionalities of the existing SCADA system by offering a map centric, user friendly presentation of all the operational information in real time and place and by providing spatial analysis capabilities. The web-based architecture of the application makes it reachable for anyone from anywhere and, moreover, eliminates the need for additional licenses and installation for every user, thus allowing its utilisation by all the personnel with minimum costs. The software also includes an integrated Decision Support System (DSS) with ALERT capabilities, which consists of a set of rules applied in the database level to evaluate the water quality measurements from SCADA or other Operational Measuring Systems. The DSS rules can be easily configured to make possible the extension of the system in the future.

KEYWORDS

WATERGUARD Project, Water Supply Networks Management, GIS, SCADA

IV. Droughts and Water Scarcity

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Drought management and Policy: Changing the paradigm from crisis to risk management

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ABSTRACT

There is increasing concern worldwide about the ineffectiveness of current drought management practices that are largely based on crisis management, i.e., managing disasters. These practices are reactive and, therefore, only treat the symptoms (impacts) of drought rather than the underlying causes for the vulnerabilities associated with impacts. Through the adoption of national drought policies that are focused on risk reduction and complemented by drought mitigation or preparedness plans at various levels of government, the coping capacity of nations to manage droughts can be improved. The time for adopting an approach that emphasizes drought risk reduction, i.e., managing risk, is now, given the spiraling impacts of drought in an ever-increasing number of sectors and the current and projected trends for the increased frequency, severity and duration of drought events in association with a changing climate. This presentation will discuss the principles and objectives of national drought policies and a template for the development of national drought policies for governments as a follow up to the High-level Meeting on National Drought Policies held in Geneva, Switzerland in March 2013. Other follow on activities including the launching of the Integrated Drought Management Programme by the World Meteorological Organization and the Global Water Partnership as well as a series of six regional capacity building workshops on national drought policies will illustrate the widespread adoption of a new paradigm for drought management.

KEYWORDS

Drought policy, drought planning process, impacts of droughts, drought mitigation actions

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Near-real time hydrological drought monitoring in the European Drought Observatory

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ABSTRACT

A near-real time hydrological drought monitoring index, as recently implemented within the European Drought Observatory (EDO, http://edo.jrc.ec.europa.eu) is described. This index takes advantage of daily discharge data simulated by the Lisflood model to capture the dynamic nature of the drought phenomenon. Drought events are defined as prolonged periods in which the discharge values fall below a defined threshold, and the probability of occurrence of the total water deficit, compared to historical events, is used as measure of the severity of the drought. A daily-changing threshold is adopted for each modelling cell in order to account for the different hydrological regimes observed across the European domain. In this paper, the theoretical concept behind the indicator and its operational implementation in the EDO web portal are described. The proposed drought index demonstrated a good capability to capture the major drought events reported in the European Drought Reference (EDR) database (http://www.geo.uio.no/edc/droughtdb/) since 1995, including the most recent drought that occurred during summer 2015 in Central Europe [Cammalleri et al. 2016; Hydrol. Sci. J., doi10.1080/02626667.2016.1240869]. In its current implementation, the index allows for a continuous monitoring of hydrological droughts of the major river basins (drainage area > 1,000 km2) in the pan-European domain.

KEYWORDS

Streamflow drought, Low-flow, Lisflood, EDO

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Modification of the Palmer Drought Severity Index for Mediterranean environments. Model and application

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ABSTRACT

This article describes a modification of the Palmer Drought Severity Index (PDSI) as adapted to Mediterranean conditions, resulting in a new index, the MedPDSI. It differs from the original PDSI because the olives crop, a typical Mediterranean perennial resistant to water stress, is assumed as drought reference crop aiming at the application of the soil water balance. The adopted approach modifies the soil water balance computation, with the actual evapotranspiration computed with the FAO-PM reference ETo and a crop coefficient obtained from the FAO dual Kc approach, Kc = Kcb +Ke. The basal crop coefficient Kcb refers to transpiration and is parameterized at the month scale for a typical rainfed olives grove. The soil evaporation coefficient Ke is estimated every month as a function of soil evaporation, thus depending on monthly precipitation, evaporative atmospheric demand and the soil evaporation characteristics following FAO56. The basic computations of PDSI are kept and self-calibration is adopted. MedPDSI was tested for various soil types and locations across Portugal. Comparing results of the water balance with MedPDSI and PDSI, it is apparent a larger actual ET during the rainy months and smaller in the dry months with MedPDSI; coherently, runoff and percolation decrease. It results, however, relatively similar identification of drought and wetness periods, with the MedPDSI responding quicker to changes in precipitation.

KEYWORDS

PDSI, MedPDSI drought index, soil water balance, rain-fed olives crop, actual evapotranspiration

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Climate change and water valuation in Souss-Massa region: Which management and adaptive measures

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ABSTRACT

Southern part of Morocco is characterized by a semi-arid climate with economy based mainly on tourism, fishery and agriculture. The population and quality life increase in these areas lead to an increase in the domestic and agricultural water demand. The groundwater constitutes the principal resource to satisfy the significant water demand. Water resources overexploitation combined with drought impacts during the last decades caused a depletion of water level in the main aquifers, reduction in water spring flow and deterioration of water and soil quality (increase in salinity, nitrates accumulation, etc). For a better management of this resource under changing conditions, several projects and studies were undertaken in Morocco and particularly in Souss-Massa basin focusing mainly in the renewal of groundwater, improvement of irrigation efficiency and crop adaptation. Since most of the IPCC climate models predict a significant decrease in precipitation in arid zones over the next few decades, water shortage and salinization induced by climate change and human pressure are expected to aggravate the already existing water crisis in these regions. Several studies conducted in Souss-Massa basin aimed to establish adequate management practices, and implement adaptive governance under water scarcity conditions. This report integrates a scientifically-based evaluation of water management scenarios coupled with analysis of institutional adaptation to achieve sustainable use of water resources under water shortage conditions and increasing salinity.

KEYWORDS

Water resources, arid climate, Scarcity, Management, Morocco

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Analysis of drought severity in Seyhan river basin

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ABSTRACT

Drought is one of the most common disasters in the world. Despite being a natural event, environmental changes combining climate and land-use changes increase its impacts. Seyhan river basin in the Mediterranean region of Turkey has great significance since agriculture has the biggest share and IPCC indicates the area among the regions subject to the highest levels of the climate change impacts. In the presented study, drought severity analysis was carried out in terms of both the standardized precipitation index (SPI) and the standardized precipitation evapotranspiration index (SPEI) at multiple time scales (3, 6 and 12 months). In order to quantify both temporal and spatial changes of drought phenomenon, monthly precipitation and temperature data covering the period 1970-2015 were evaluated at meteorological stations in the basin. Data pre-processing which includes missing value estimation and homogeneity analysis was carried out prior to the computation of drought severity indices. Missing data in the recorded series were completed using linear regressions with respective reference series. Standard normal homogeneity test, Buishand range test, Pettitt test and Von Neumann ratio test were used for homogeneity checks on the data set. Precipitation data were also analyzed for trends using the Mann-Kendall non-parametric test. The period 2011-2015 which was the warmest five-year period on record globally was specially analysed as well. Kriging method was additionally used in order to show the spatial distribution of droughts.

KEYWORDS

Drought, SPI, SPEI

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Coastal aquifer response to drought scenarios: The case of Rhodes island

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ABSTRACT

Considerable disagreement exists regarding the definition of drought. However, it is widely accepted that drought is a natural phenomenon caused mainly by a sustained below-average precipitation and high evapotranspiration over a large area. This prolonged water deficiency is propagated through the surface and groundwater systems. Since groundwater is the main reliable water resource in semi-arid areas, it is of interest to investigate the depletion of an aquifer under pumping, caused by the natural decrease in the recharge due to drought. In this study a large-scale groundwater model is developed in an aquifer of Rhodes Island (Greece) to examine its response to drought. The water table decrement and the seawater intrusion extend influence the fresh water volume, which is used as indicator for the coastal aquifer condition. This indicator is calculated based on a transient variable-density groundwater flow model, using SEAWAT numerical code. The pumping rates are selected to cover the actual consumption needs of the study area. The recharge volumes, which are used as input to the seawater intrusion model, are calculated by the Medbasin-M monthly hydrological model. The Reconnaissance Drought Index (RDI), which incorporates precipitation and potential evapotranspiration, both affecting the infiltration and recharge processes, is used to assess meteorological drought severity. The principal objective of the study is to relate the meteorological drought to the available water volumes at a temporal scale.

KEYWORDS

Drought, seawater intrusion, Reconnaissance Drought Index, semi-arid areas, Rhodes island

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Comparison of hedging rule curves depending on available water and current storage in reservoir operation under droughts

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ABSTRACT

Hedging rule for water supply operation of a reservoir allows releases to be curtailed below target levels to avoid potentially more severe shortages later. This paper aims to derive two different hedging rule curves of a reservoir: one rule is based on available water that accompanies prediction of the current period inflow and the other rule is based on the beginning storage alone. The current period inflow was obtained by the ensemble streamflow prediction using historical precipitation data. A mixed integer programming algorithm was used to determine hedging rule curves for water supply operation of Hapcheon Dam, the Republic of Korea for the period from 1990 to 2005 that includes a drought period. Complying the derived hedging rules, reservoir simulation runs for the period from 2006 to 2010 were performed. The derived hedging rule curves based on the beginning storage were placed higher than the curves based on available water and induced earlier rationing of water supply. The rule based on available water included the current period inflow and its simulation resulted in faster recovery to the normal phase of water supply when the drought ended. The simulation results complying the rule based on available water were better in terms of the total water supply deficit. When, however, predicted inflow is not reliable, the hedging rule based on the beginning storage might be worth in practical reservoir operation to avoid more severe shortage resulted from the bad prediction of the inflow.

KEYWORDS

Drought, reservoir, hedging, available water, beginning storage, mixed integer programming

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Monitoring drought in Shiraz, Iran, using Reconnaissance Drought Index and Standardized Precipitation Index

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ABSTRACT

Drought is a significant phenomenon affecting different economic, agricultural, social and environmental sectors. Therefore, monitoring draught in several areas is too important especially those with arid climates. In this study draught was monitored in Shiraz which located in southwest of Iran, between the years 1982 and 2017. Aimed to this purpose RDI and SPI indices was monitored and Due to the RDI annual values, there is near normal and moderately wet condition for all 35 years. According to the SPI values there is extreme dry condition in hydrological years (1983, 2008) and (1993) shows severely dry condition also very wet condition for the years (1992, 1995 and 2004). This research proposes a climatic index the Reconnaissance Drought Index, for drought monitoring particularly in arid and semi-arid area which precipitation amounts are low, evapotranspiration acts as a key factor for monitoring drought, because of using both precipitation and evapotranspiration. It is expected these documents be useful for future decisions and drought monitoring in another area.

KEYWORDS

Drought monitoring. RDI. SPI. Iran. Shiraz

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Regional drought analysis for derivation the drought SAF curve using bivariate copula in the Lake Urmia basin, Iran

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ABSTRACT

Since droughts occur regionally in nature and given this fact that they often affect very large area, it may be concluded that this phenomenon should be studied in the context of regional analysis and a comprehensive assessment must be undertaken thereof. This study aimed to investigate the spatial variations of droughts in terms of monthly SPI using the copula functions so that the drought severity and percent of area under drought might be jointly modeled within the Lake Urmia basin, as one of the Iran's drought-prone basin. Besides, it was attempted to examine the relationships among the aforementioned variables and, consequently, the drought Severity-Area-Frequency (SAF) curve was developed in the region. Accordingly, seven families of copula functions, including Clayton, Gumbel, Frank, Joe, Galambos, Plackett and Normal, were used to model the joint dependence between the aforementioned two drought variables. Given the various assessment criteria, the Frank copula function was selected as the most appropriate copula for drought characteristics. Then, the conditional return periods were determined for the most appropriate copula and, then, the drought SAF curve was developed for the study area. It was indicated that the SAF curve could be of great importance in drought risk analysis in the region.

KEYWORDS

Drought, copulas, SPI, SAF curves

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Assessing the use of SPI in detecting agricultural and hydrological droughts and their temporal cyclicity

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ABSTRACT

One of the most common drought indices used to characterize the droughts is the Standardized Precipitation Index, SPI. This index that can be computed at different time scales uses only rainfall records and aims at detecting meteorological drought triggered by rainfall shortfall. If this deficit is combined with higher than normal evapotranspiration, an agricultural drought may occur. If the period with below average precipitation/above average evapotranspiration persists, the streamflows are affected resulting in a hydrological drought. This paper addresses the capability of the SPI to detect agricultural and hydrological droughts in Eastern Slovakia by comparing its values with those of other indices. Regarding agricultural drought, the comparison considered the Standardized Precipitation Evapotranspiration Index, SPEI. Results show that SPI and SPEI have almost identical performance in agricultural drought detection across the analysed rain gauges. Furthermore, to evaluate the capability of SPI to detect hydrological droughts, the Standardized Streamflow Index, SSI, developed using monthly streamflows and the methods of normalization within the computation of SPI, was applied to a small catchment and compared to the SPI at a rain gauge inside the catchment. This comparison revealed that SPI had a poor performance in detecting hydrological drought. Spectral analysis of the seasonal patterns of the SPI index, using the fast Fourier transform algorithm (FFT), showed that there is a generalized 5-6 year cycle in the agricultural pattern for Autumn and Spring.

KEYWORDS

Slovakia, droughts, SPI, SPEI, SSI, spectral analysis

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Peak drought severity time analysis of Cheongmicheon watershed using meteorological and hydrological drought index

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ABSTRACT

This study analyzed the peak drought severity time of the Cheongmicheon watershed according to evaluation period based on 1) Past (period from 1985 to 2015) and 2) Future Climate Change scenarios (RCP 4.5 & 8.5 period from 2011 to 2100). In order to assess the peak drought severity of lag time and relationships between various drought indices, we used meteorological and hydrological drought index. Standardized Precipitation Index (SPI) was based on precipitation and Standardized Precipitation Evapotranspiration Index(SPEI) was based on precipitation and evapotranspiration, were applied as meteorological drought index. Stream Drought Index (SDI) based on Runoff data was applied as hydrological drought index. In the case of SDI, we use Soil and Water Assessment Tool (SWAT) model for simulation of daily runoff data and SWAT Calibration and Uncertainty Procedures (SWAT-CUP) for optimization of SWAT parameters. In order to analyze the relationship between meteorological drought index and hydrological drought index, SDI was selected in the case of less than -1.5. We compare SPI, SPEI and SDI's peak drought severity time. As a result, in case of RCP 4.5, the difference of peak drought point between SDI and SPI was 0.8 months and SPEI was 0.54 months. In case of RCP 8.5, the difference of peak drought point between SDI and SPI was 0.89 months and SPEI was 0.99 months. And, when duration was increased, the frequency of drought was decreased. This confirmed that, SPEI gives a significant impact on SDI more than SPI.

KEYWORDS

Peak drought severity time, Meteorological drought index, hydrological drought index, SWAT

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Wavelet transform based trend analysis for drought variability over 566 stations in India

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ABSTRACT

Drought, which occurs in all climate zones, is the most complex hydro-meteorological hazard. This paper presents an analysis of the spatial pattern of trends in drought variables carried out at 566 stations spread all across India over 102 years (1901 to 2002). As a measure of drought intensity, standardized precipitation index (SPI) was computed at all stations. Six drought variables namely annual SPI, monsoon SPI, non-monsoon SPI, annual drought severity (ADS), annual drought duration (ADD) and annual drought peak (ADP) were computed at station level. Mann-Kendall (MK) test and Sen's slope were used for trend analysis of drought variables. Discrete wavelet transform (DWT) along with MK test was used to identify the dominant periodic components in trends. Further, continuous wavelet transform (CWT) based global wavelet spectrum (GWS) was used to examine the significant periodic components. The results of the study show an increasing trend in drought for eastern, north-eastern and extreme southern regions, and a decreasing trend for northern and southern regions. Trends were influenced by 2-4 year periodic component in southern India, 4-8 years periodic component in western, eastern and north-eastern India, 8-64 year periodic components in middle India and 32-128 years periodic components in northern India. CWT based GWS shows that most of the periodic components were not significant.

KEYWORDS

Drought trend analysis, Discrete wavelet transform, Continuous wavelet transform, Mann-Kendall test

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Frequency and severity of dry spell phenomenon in Ghezala dam reservoir (Tunisia)

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ABSTRACT

An analysis by event of dry event, according to a predetermined threshold, from series of observations of the daily rainfall was carried out. The approach has been illustrated on a case study of the Ghézala dam localized Northern Tunisia where the average rainfall is 680 mm. The dry events are constituted of a series of dry days framed by the rainfall event. Rainfall events are defined themselves in the form a uninterrupted series of rainfall days understanding at least a day having received a precipitation superior to a threshold of 3.6 mm. The rainfall events are defined by depth and duration, which are found to be correlated. An analysis of the depth per event conditioned on the event duration has been undertaken. The negative binomial distribution appears the best overall fit for the depth per event. The duration of the rainfall event follows a geometric distribution while that the dry event follows the negative binomial distribution. The length of the climatically cycle adjusts to the Incomplete Gamma. This analysis is used to generate a synthetic sequence of rainfall and dry events with correspondent lengths of rainy season for study the water resources management and the impact of climate change.

KEYWORDS

Event-based analysis, dry event, rainfall event, severity

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Drought analysis with SPI index and entropy

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ABSTRACT

Drought is a natural disaster adversely affecting the survival and economy of the living organisms. Drought is related with many factors including climate and regional properties. Many different measures are used to determine drought. The goal of this study is the investigation of the Meteorological drought in Central Anatolian Region in Turkey. In the presented study, the Standard Precipitation Index and the Apportionment Entropy (AE) method are investigated and compared. For this purpose, observations of 13 meteorological stations located in Central Anatolia Region by The Turkish State Meteorological Service (DMİ) are evaluated. The results of the study contributed to the identification of drought parameters and consequently the missing information and data on this subject were completed. The entropy method provided similar results to the results obtained by other methods widely used in the literature regarding the data for the Central Anatolia Region. The entropy method was determined to yield similar results to that of the SPI method as indicated by the comparison of the relative frequencies of the severity of drought in the regional stations. Therefore, the method can be proposed as a method to be used in long-term drought calculations and regional drought calculations. The results of the present study showed that entropy method can be an alternative to be used in the analysis of drought.

KEYWORDS

Drought, Drought parameters, Entropy, SPI index

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Long-term variation of PDSI and SPI computed with reanalysis products

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ABSTRACT

Long-term temporal variation of droughts in Portugal was assessed using the Palmer Drought Severity Index (PDSI) and the Standardized Drought Index (SPI) with a 9 month time scale. Weather data from the NOAA-CIRES Twentieth Century Reanalysis Project version 2c, which spans from 1851 to 2014 with a spatial coverage of 2.0º latitude x 2.0º longitude were used. For PDSI, monthly evapotranspiration was computed using the FAO PM-ETo method. Monthly data from reanalysis products consisted of maximum and minimum air temperature, net radiation, wind speed and relative humidity. Precipitation data was obtained from the same source.

To assess how the long-term climate variability influences the identification of dry events in the drought indices, five different calibration periods were selected to estimate, respectively the potential values of evapotranspiration, runoff, soil moisture recharge and percolation loss of the PDSI water balance and the distribution function parameters of the SPI. Results show that the adopted calibration period have a significant impact of the frequency of extreme events detected in both drought indices. A Fourier analysis was applied to PDSI and SPI time series to search for significant cycles that could relate to return periods of droughts, with North Atlantic Oscillation cycles previously identified for Portugal.

KEYWORDS

PDSI, SPI, long-term variability, 20th century reanalysis

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Water shortage characterisation for surface water systems with storage

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ABSTRACT

From all forms of water appearing in the Earth's hydrological cycle, surface water is known to constitute the largest resource that provides water to human societies and ecosystems. Droughts affecting surface water can considerably reduce water availability for various water uses, which, in turn, may lead to water shortage, depending on water demand. Therefore, information on the balance between water availability and water demand is of vital importance in water resources management. Various indices expressing this balance have been proposed, including the Demand Sensitive Drought Index (DSDI). In this paper we propose a modified form of DSDI, termed 'Surface Water Shortage Index' (SWSI). This can be applied to any spatial unit ranging from a large geographical area to an isolated hydraulic work. Focusing on a single drainage basin with a storage reservoir at its outlet, the variables involved in SWSI are selected to be water volumes for streamflow, demand, withdrawal, storage and spill. The water balance equation for the reservoir is used for formulating the index, which reflects the water demand deficit with respect to water availability by also taking into account a finite water storage capacity. The index is calculated for three-month intervals. An application is presented based on data from the Evinos river basin, Greece. Results are compared to those of a simplified version of SWSI resembling to DSDI and termed 'adjusted DSDI' (DSDIa).

KEYWORDS

Surface water, water shortage characterisation, water demand, water availability, Demand Sensitive Drought Index

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Sustainable management of rainwater harvesting systems: A case study of semi-arid area

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ABSTRACT

In this paper, Erbil province in Iraqi Kurdistan has been chosen as a representative case study for a large number of provinces in semi-arid areas, lacking imbalance between water demands and supply. Climate change is expected to bring higher average temperatures and lower precipitation, which would intensify the pressure on water resources and increase the environmental concerns. A set of fifty-five detention ponds in Erbil were investigated, with storage capacities ranging from nearly 49,000 m3 to 250,000 m3. These ponds were constructed to mainly supply smallholder farms, watering livestock, and for groundwater recharge. The paper seeks to examine the function and necessity of retention ponds, as a sustainable drainage system measure in semi-arid areas, to mitigate the growing combined impacts of a water shortage and inter-annual climate variability. A set of indicators was adopted: (a) the cost of construction; (b) harvested water volume; (c) irrigated farms; (d) the number of beneficiaries; (e) the number of livestock kept; (f) groundwater recharge; (g) recreation activity; and (h) biodiversity, in addition to checking its materialising by concerned authorities and residents. A detention pond application plan has been developed to support the sustainable functioning of Rain Water Harvesting System (RWHS).

KEYWORDS

Detention pond, climate change, supportive strategy, water shortage, integrated water resources management

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The effect of reservoir networks on drought propagation

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ABSTRACT

Human interventions in response to drought can both alleviate and enhance drought. Developments of infrastructure for freshwater storage, groundwater abstraction and irrigation have proved to be effective in overcoming meteorological and agricultural drought in many locations worldwide. At the same time such developments may exacerbate hydrological drought, especially during and following extended periods of (meteorological) drought. In order to effectively manage drought, there is an urgent need to better understand and evaluate the drivers of such events. This means that we need to separate between human and natural factors that affect hydrological processes in basins. In this paper, we demonstrate how the Downstreamness concept can be used for Drought Diagnosis. This is done for a subcatchment of the Jaguaribe basin in Northeast Brazil. Our diagnosis focuses on the propagation of three severe multi-year droughts that have developed during the period 1979-2016. Our study shows how a network of surface water storage reservoirs has affected the propagation of drought. Applying the proposed approach is helpful for the spatiotemporally-explicit assessments of droughts and their propagation. Strategic and operational water (and drought-risk) management relies on valuations of trade-offs between commitments of upstream and downstream uses and technical implementations of upstream and downstream measures. Our study offers valuable insights through the inclusion of sub-basin points of view as an integral part of a river basin perspective. In this way, the effects of anthropogenic processes affecting drought propagation can be better understood.

KEYWORDS

Drought propagation, Downstreamness, Jaguaribe basin, Brazil

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Low flow conditions evaluation within the Western Morava river basin

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ABSTRACT

The largest share of renewable internal fresh water resources in Serbia is located within the Western Morava River basin in central part of Serbia. Despite of the favourable natural conditions and water resources abundance, in last few years noticeable shortage in drinking water supply is detected in some regional water supply systems within the river basin, in particularly during the peak seasons, namely summer and autumn. Thus, like in many other parts of the world, consequences of observed changes in low flow accompanied with significant seasonal fluctuations in precipitation and runoff, emphases necessity for trough evaluation and analyses of the observed precipitation regime, runoff and low flows seasonal fluctuations within the drainage area. Moreover, evaluation of land use, hydrogeology and soil type provides better insight into natural retention capacity of significance for ground and surface water sources. Established correlation among precipitation, runoff, and natural retention capacity as a result of land use practices indicated significant differences of season low flow conditions. The results presented in this paper manifest necessity of comprehensive regional hydrological low flow investigation for future drinking water supply infrastructure and other water management facilities to sustain sustainable water resources management at the watershed level.

KEYWORDS

Low flow conditions, drinking water sources, natural retention capacity, seasonal fluctuations

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Stochastic generation of low stream flow data of Perigiali stream, Kavala city, NE Greece

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ABSTRACT

The present study generates synthetic low stream flow time series of an entire calendar year considering the stream flow data recorded during two certain interval periods of the years 2016 and 2017. We examined the goodness of fit tests of six theoretical probability distributions to low stream flow data acquired at the exit of the Perigiali stream, Kavala city, NE Greece watershed, during part of May, June, July, part of August, part of December 2016 and part of January 2017, using either a combination of a 3-inches U.S.G.S. modified portable Parshall flume in conjunction with a 3-inches Montana portable flume and a combination of a 3-inches conventional portable Parshall flume in conjunction with a 3-inches Montana portable flume and calculated the corresponding probability distributions parameters. The six specific probability distributions used in this study were the following: (1) Gumbel min (Minimum Extreme Value Type 1) distribution, (2) 3-Parameter Log-Normal distribution, (3) Pearson Type 5 distribution, (4) Pearson Type 6 distribution, (5) Two-Parameter Weibull distribution and (6) Wakeby distribution. The Kolmogorov-Smirnov, Anderson-Darling and Chi-Squared, GOF tests were employed to show how well the probability distributions fitted the recorded data and the results were demonstrated through interactive tables providing us the ability to effectively decide which model best fits the observed data.

KEYWORDS

Artificial time series, discrepancy ratio, goodness-of-fit tests low flow data, conventional and modified Parshall flumes

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Crop pattern modification for long term mitigation planning against persisting droughts

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ABSTRACT

Droughts are hazardous phenomena affecting practically all the sectors of the economy. Generally, agriculture is the most vulnerable sector, dependent on both the characteristics of the drought episode and the sensitivity of the crops of the existing crop pattern. Sensitive crops to water deficit (rainfed or irrigated) may lose significant part of their yield in case of an intense and long-lasting phenomenon. To face the drought phenomena and their consequences the responsible authorities devise preparedness plans including strategic long-term and short-term measures. Among the most important long-term mitigation measures is the modification of the crop pattern of the agricultural area which is vulnerable to droughts. The paper evaluates this option using the approach of the annualised drought risk assessment. Drought risk is a metric representing the average annual loss in revenue due to the detrimental activity of the drought hazard. To implement this approach, a long series of drought events should be analysed and the sensitivity of the crops to water deficit should be known. For the demonstration of the proposed procedure a numerical example is presented involving rainfed crop.

KEYWORDS

Crop pattern, agricultural drought, persisting droughts, drought indices, preparedness planning, crop yield modelling, annualised drought risk

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Characterization of drought in Italy applying the Reconnaissance Drought Index

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ABSTRACT

The mitigation of drought impacts is one of the most important challenges in the management of water resources and can only be properly realized through integrated management of this phenomenon. Regional drought analysis is conventionally based on drought indices for the identification of drought intensity, duration and areal extent. The aim of this study is to characterize the impact of the drought phenomena in Italy through the application of the Reconnaissance Drought Index (RDI). The basic form of the index is the ratio of the cumulative precipitation to potential evapotranspiration, for a specified reference period; it represents the intensity of water consumption in a given system, which varies in time and space but is entirely independent of the crops and soil characteristics and is also easily determinable. The Reconnaissance Drought Index (RDI) was considered more appropriate to the case-study examined. The run method is used to determine the characteristics of the drought phenomenon and to identify drought periods. As expected the RDI index shows more frequent events of drought in the Northern regions than in the South of Italy where the droughts is a structural condition. In the South the agricultural system has a more robust coping capacity and is more prepared to deal with water scarcity. This information is extremely useful for the evaluation of drought risk through mitigation measures with the appropriate management of water resources.

KEYWORDS

Agricultural drought, drought indices, Reconnaissance Drought Index (RDI), drought assessment, mediterranean crops, drought mitigation measures

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SPI analysis over Greece using high resolution precipitation gridded datasets

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ABSTRACT

This research work focuses on the analysis of the Standardized Precipitation Index (SPI) over Greece for three time scales; three, six and 12 months (SPI3, SPI6, SPI12; respectively). The SPIi timeseries were calculated using the DrinC open-access software.. The estimation of the index, as well as, its mean values and trends were based on the E-OBS gridded precipitation data v.11.0 for the period 1950 - 2014 with 0.25°x0.25° spatial resolution. Moreover, an analysis concerning the moving average fluctuation within the same period was performed, providing the corresponding patterns. Additionally, five elevation zones were created with the aim of investigating any particular relation between the altitude of a location and the means and trends of SPIi. In order to determine the most severe drought events that have occurred in Greece, the SPIi anomalies were also estimated. It was found that the means of seasonal index present distinct spatial pattern over Greece, while the SPIi trends patters also differ. A systematically high SPIi in the zone of 200-500m is observed, while the maximum negative trends are presented in the zone of the lowest altitudes (0-200m); where the large amount of agricultural activities is located.

KEYWORDS

SPI, means, trends, elevation patterns, Greece

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System based multivariate drought characterisation for surface water

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ABSTRACT

By adopting the systemic approach for drought analysis, the surface water subsystem turns out to be the most critical element of the studied water system due to the fact that the largest part of water abstractions worldwide originates from surface water. Ideally, to characterise drought conditions in this subsystem, all variables involved in its water balance should be conjunctively analysed. In an effort towards this direction, multiple variables are used which are accessible through measurement or are easily estimated. These include precipitation, potential evapotranspiration and streamflow. All three variables are jointly employed in a multivariate drought index constructed using copulas. The univariate normal, Gamma and log-normal distributions serve as the candidate marginal distributions, while elliptical copulas are selected to represent the dependence structure of the three variables. Fitting of marginal distributions and copulas is performed using the maximum likelihood method. Values of the proposed index are compared to those of known indices which are the Streamflow Drought Index (SDI), the Reconnaissance Drought Index (RDI), and the Standardized Precipitation Evapotranspiration Index (SPEI). Time series of annual values are used, while the area is fixed at the surface of a river basin. The analysis is carried out on data from two river basins in western Greece (Mornos and Evinos). Results indicated that the proposed index is a reasonable compromise of existing indices tested.

KEYWORDS

Drought characterisation, copulas, systemic approach, SDI, RDI, SPEI

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Drought identification and trend analysis in Peloponnese, Greece

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ABSTRACT

Drought is one of the worst natural disasters. According to the Emergency Event Database, drought incidents affect more than 25% of all people affected by all types of weather related disasters, even though they represent only 5% of natural disasters worldwide. Identifying drought is, therefore, of major interest, since it is the basis towards assessing the impacts of drought and defining appropriate measures to mitigate their effects. In this paper drought is assessed in the three River Basin Districts of Peloponnese, Greece. Identification is achieved using two well known drought indices, the Standardized Precipitation Index (SPI) and the Reconnaissance Drought Index (RDI). Precipitation data utilised by both indices and temperature data used in RDI calculations through the estimation of potential evapotranspiration, were obtained from a number of stations in the area. Data processing is performed in Geographic Information Systems (GIS). Spatial and geostatistical functions are applied in a model builder tool. Also, mapping tools are employed to create map layouts. Descriptive statistics for each Water Basin are presented using Box and Whisker Plots. Finally, drought trends are detected and their statistical significance is evaluated using the Spearman and Mann-Kendal non-parametric tests. Sen's slope is calculated to present a more accurate estimate of drought trends. Based on the meteorological time series used and the analysis of trends, Peloponnese cannot be considered a drought prone area for the recent past (period 1968 – 2008).

KEYWORDS

Standardized Precipitation Index (SPI), Reconnaissance Drought Index (RDI), Spearman test, Mann-Kendall test

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Recent changes in spatio-temporal trend of drought and precipitation in Xinjiang, northwest China

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ABSTRACT

Analysis of spatiotemporal trends of drought and precipitation require long-term historical data to fully evaluate the characteristics, as well as a single drought index or univariate analysis is hardly exhaustive to reveal the multidimensional characteristics of regional drought. To resolve the above considerations, our research partition spatial domain into cluster with multiple sites, conduct drought and precipitation characteristics from 105 meteorological stations. The NDE, DDE, MDD and MxDD show drought characteristics were not spatially uniform. Focus on the typical site, illustrates a detailed graphical representation: 10-month duration was detected happened twice as the largest drought duration, and drought event was monitored such bulge in special month (e.g. May, June, September, October and November). Cluster analysis share basic statistics and return period of drought at each cluster as a "mainstream" : cluster 1 as a long-duration drought-prone area, cluster 3 has a higher level in short-duration. Precipitation time series all present increasing trends, only cluster 2 increased significantly with early mutation year. Moreover, precipitation concentration and heterogeneity in monthly precipitation were described by precipitation concentration index. Ultimate we describe the spatial pattern of precipitation for more pluvial regions. Also, the average change rate of decennial precipitation and the significance test was computed about 20% of sites change significantly, most (88 in 105) stations present an increasing trend with the highest value of increasing slope (31.06 mm/decade).

KEYWORDS

Cluster analysis, return period, Xinjiang

V. Water Quality and Environmental Processes

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Unusual river turbidity and water quality hysteresis in the most urbanised catchment in the UK

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ABSTRACT

Over 50% of the world's population is now urbanised, and this proportion will rise to 60% by 2020. It is vital, therefore, that we develop understanding of how urban processes and related hydrological changes impact on water resources, water quality and water pollution dynamics. However, little is known of the dynamics of storm-event sediment and pollutant transport in urban rivers.

In many catchments, it is often assumed that polluting fine sediment fluxes are delivered early in the storm, peaking before the flow maximum, i.e. the 'First-Flush' Model (FFM). This paper tests the validity of this First-Flush Model in the most urbanised catchment in the UK: the River Tame, Birmingham, which is 42% urbanised.

The paper presents high-resolution hysteresis analyses of key turbidity and water quality datasets, using very high frequency 15-minute data. Determinands include storm-event river flow, rainfall intensity, turbidity, electrical conductivity and Ammonia.

Crucially, in 90% of storm events, turbidity peaks occurred, unusually, after river flow peaks. This generated anticlockwise hysteresis - contrary to classic 'First-Flush' model predictions. Of 10 explanatory hypotheses tested, three are of special interest, including (a) the impact of Combined Sewer Overflow ingress, (b) delayed bed sediment destabilization effects (with a new BASS model - Biofilm Adhesion of Sediment Supplies); (c) road-derived particulates generated by some of the heaviest traffic loads in Europe. This unusual storm behaviour suggests that urban impacts on water resources are much more significant and complex than thought, as discussed in a 'Senile Cities' model.

KEYWORDS

'First Flush' model, turbidity, suspended sediment, hysteresis, urban river

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Pyrosequencing analysis of ammonia oxidizing bacteria in municipal activated sludge system

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ABSTRACT

Nitrification is a critical step that depends on the physiology and function of nitrifying microbial diversity in the activated sludge treatment systems. Optimum and efficient nitrification hinges on in-depth understanding of the structure and dynamics of the nitrifying community structure within the wastewater treatment systems. In this study, high-throughput pyrosequencing was employed in profiling ammonia-oxidizing bacteria (AOB) in activated sludge system treating municipal waste. During the investigation, the average temperature was 16.5 ± 2.1oC and 22.8 ± 2.7oC during winter and summer respectively. During this study, the dissolved oxygen level in the plant was constantly lower than the optimum (0.6 ± 0.3 and 0.6 ± 0.1 mg/l winter and summer respectively). The plant treated wastewater with influent ammonia concentration between 24.4 and 31.6 mg/l. The average influent flow rate (ML/Day) was 96.81 during this period. The diversity of AOB, the nitrifiers involved in the first and the rate-limiting step of ammonia removal had correlation with nitrification efficiency and temperature. Pyrosequencing revealed significant differences in the AOB population, which was 6 times higher during summer compared to winter. The AOB sequences related to uncultured bacterium and uncultured AOB showed an increase of 133% and 360% respectively when the season changed from winter to summer. This study suggests that vast population of novel, ecologically significant AOB species that remain unexploited, still inhabit the complex activated sludge communities.

KEYWORDS

454-pyrosequencing, AOB, WWTP, Nitrification

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Evaluation of membranes as promising technique for reclamation and reuse of wastewater

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ABSTRACT

In 21st century water is a precious resource and after the emphasis on the water sustainability, its proved to be a challenge for water treatment systems to treat wastewater good enough to make it reusable for different purposes. Studies around the world reported the presence of many organic micropollutants like pharmaceuticals and pesticides in the water treated with conventional treatment processes. These micropollutants pose a serious threat towards the aquatic environment especially in case of antibiotic resistances bacteria. Advance treatment processes are one of the most discussed methods to minimize this treat. But rapid expansion of the population in developing countries caused the existing conventional wastewater treatments plants overloaded and there will be no space available for expansion of the existing treatment plants. This leads towards an attractive option of membrane technology. Plenty of membrane designs and operational setups are available in the market. Efficiencies of membrane technology differs with the types of targeted pollutants presents in wastewater and type of membrane being used. The scope of present study covers the types, mechanisms and constraints of the membrane systems to treat wastewaters for pharmaceuticals. A short review has been presented in which reliability on Nanofiltration is discussed with respect to pharmaceutical removals. It was noticed that drugs can be successfully treated by using NF coupled with other advance treatment methods.

KEYWORDS

Membrane Technology, wastewater reuse, Nanofiltration, pharmaceuticals, micropollutants

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The effect of polymer concentration on electrospun PVDF membranes for desalination by direct contact membrane distillation

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ABSTRACT

Membrane separation technology holds great potential in advancing desalination and water/wastewater treatment to improve the efficiency of impurities removal as well as to augment water supply. Various membrane based technologies are currently being applied for these purposes. Among the current membrane-based technologies, the MD process presents many attractive features compared to others. MD is a low pressure, non-isothermal membrane separation process with a hydrophobic microporous membrane which offers a solution for the treatment of concentrated solutions that are not viable for reverse osmosis. An increasing array of research is being conducted to fabricate novel membranes in order to optimize the performance of the MD process. Different parameters such as pore size, porosity and thickness affect membrane performance during the MD process. Electrospining method for fabrication of membranes allows for controlling of mentioned properties. In this study, by taking into consideration that the polymer concentration has the significant effect on the resultant nanofiber diameter and electrospun nanofibrous membrane (ENM) structure, different Polyvinylidene fluoride (PVDF) membranes with different fiber diameters and physical properties were obtained by varying polymer concentration from 20 to 24.5 wt%. Fabricated membranes were tested for desalination by direct contact membrane distillation (DCMD). The bead-free nanofiber with diameter of 240nm obtained at 20 wt% concentration of polymer solution and increasing PVDF concentration lead to an increase of fiber diameter to 464nm. Results of DCMD operation show that by increasing concentration of polymer solution, the permeate flux decreases. For all membranes the salt rejection ratio was more than 99.9%.

KEYWORDS

PVDF Concentration, Electrospun nano-fiberous membranes, Desalination, Membrane distillation

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Cesium ion partitioning with ionophores in ionic liquid-water biphasic systems

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ABSTRACT

Cesium is an extensive fission product in spent nuclear fuels. The removal from the nuclear wastes forms a key part of waste remediation strategies. We report the molecular dynamics studies on the interfacial behavior of cesium (Cs^+) extraction by bis(2-propyloxy)calix[4]crown-6 (BPC6) and dicyclohexano-18-crown-6 (DCH18C6). For the benchmarking study, the phase separation for [BMIM][Tf_2N]– water was validated. Thereafter, to understand the mechanism of complexation and the behavior of crown ether ligand, crown ether (CE) molecules and $Cs^+NO_3^-$ ions were inserted randomly in the ionic liquid (IL) water biphasic system. It was observed that the Cs^+– CE complex is more stable at the interface. The radial distribution function (RDF), interaction energies and the diffusion coefficient during complexation of Cs^+ cation with BPC6 and DCH18C6 crown ether were also computed. Within the limited sample size of twelve crown ethers and six cesium nitrate molecules, BPC6 and DCH18C6 were able to capture two and one cesium atom(s) respectively towards its crown cavity after a 40 ns simulation time. In case of BPC6 the captured cesium atoms were found to lie towards the IL part of the interface. This work hence summarizes the interface phenomena.

KEYWORDS

Ionic liquids, Interface, Cs^+ ion extraction, Ionophore, Molecular dynamics

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High performance functionalized MWCNT/PES membrane for oil-in-water treatment

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ABSTRACT

Membrane filtration is a promising technology for oily wastewater treatments considering its high separation efficiency along with simplicity and fairly short process time. However, the application of this technology has been limited by severe fouling caused by oil droplets in the oil-in-water separation resulted in less performance. In this study, pure polyethersulfone membrane was modified by two different functionalized multi-walled carbon nanotube, Carboxylated MWCN and Hydroxylated MWCNT, to increase its hydrophilicity and oil resistant. Carboxylated and Hydroxylated MWCNT/PES mixed matrix membranes were manufactured via NIPS method. Nanocomposite/polymer solutions for membrane formation were prepared in DMF with 16 wt% PES and 1 wt% PVP. The functionalized MWCNTs were added to the casting solution in different concentrations (based on the polymer constituents) and dispersed by sonication stirrer. The effect of these functionalized MWCNTs on the performance of PES membranes permeability was investigated in terms of oil water flux via cross-flow flat sheet module. The results indicated that the performance of the membrane was enhanced by blending functionalized MWCNT to the casting solution. Carboxylated MWCNT increased the oil/water flux by 80 percent, however, the hydroxylated MWCNT increased the flux by only 50 percent. Comparison of the flux in different concentrations of MWCNT also showed that membrane has the best permeability at 0.1% of Carboxylated MWCNT and 0.15% of Hydroxylated MWCNT. Higher concentration of MWCNT showed a reverse effect on the permeability and decreased the flux due to the aggregation of the nanoparticles in the membrane matrix.

KEYWORDS

PES membrane, Carboxylated MWCNT, Hydroxylated MWCNT, Membrane performance, Permeate flux

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Purification of humic acids contained simulated wastewater using membrane ultrafiltration

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ABSTRACT

Treatment of water from any industrial effluent can provide valuable profits towards the living environment. The resolution of the treatment of effluent is the minimization of water pollution and reuse of water. Several researches have already been performed to remove natural organic matters from wastewater. In our present work, simulated wastewater was treated using membrane batch ultrafiltration with polyethersulfone membrane. Commercial Humic acids was used as a common natural organic matter present in industrial wastewater. The effects of different transmembrane pressure drops (207, 276 and 345 kPa) on permeate flux and permeate quality were explored using 50 kDa molecular weight cut off membrane. The concentration of Humic acids in water was maintained at 50 mgL-1. In order to overcome compaction effect of the membrane, the module was pressurized with deionized (DI) water for 2 hours at 345 kPa applied transmembrane pressure (TMP) drop. Maximum permeate flux was obtained at 345 kPa TPM drop. The percentage removal of pollutant was 93.8%. Flux decline was analysed using Hermia's pore blocking mechanism and artificial neural network. Apart from this, module performance was characterized by calculating total resistance during purification of synthetic wastewater.

KEYWORDS

Humic acids (HAs), natural organic matters, membrane ultrafiltration, wastewater

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Removal of diclofenac in drinking water with fenton process

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ABSTRACT

Pharmaceutical residues are found in low concentrations (µg/L-ng/L) in aquatic environment. Pharmaceuticals are used to treat human and animal diseases. These drugs and their metabolites are excreted unchanged and they are continuously mixed in wastewaters. The residues of these compounds can be involved in environment in different ways: for example, expired drugs, hospital wastewater, human and animal excretion, pharmaceutical industry. Diclofenac sodium salt is a non-steroidal anti-inflammatory drug (NSAID) and is used commonly in worldwide. Conventional wastewater treatment plants are not sufficient to remove micropollutants, therefore advanced oxidation process have become an emerging solution. Fenton process is a branch of advanced oxidation process. Therefore, fenton process is used to clear out the effectiveness of diclofenac degradation in drinking water. In the present study, under laboratory conditions, coagulation and advance oxidation, with H_2O_2 and $FeSO_4$ (Fenton process) are used to degrade the concentrations of diclofenac from water conducted. To find out, biodegradability of the treated solutions the COD and TOC values of the background constituents in the water matrix are planned to measure. For this purpose, we used 10 mg/l diclofenac sodium salt synthetic solution with selected different parameters as, pH (2-6), $FeSO_4$ and H_2O_2 concentration (30-75-150 mg/l), stirring time (10, 20, 30 minutes), residence time (30, 60, 90 minutes) all in room temperature. These selected parameter are the determined optimal values. After processing, 150 ml of sample is taken out from the upper layers of the solutions to make COD and TOC tests.

KEYWORDS

Diclofenac, Fenton Process, Pharmaceuticals, Water, Wastewater

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CFD-aided modelling for hydrodynamic analysis of biological reactor

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ABSTRACT

The performance testing of treatment plants is of great concern in the field of environmental engineering, especially regarding the management of wastewater plants devoted to treatment and reuse. The efficiency of the treatment process is strictly related to both biological kinetics and hydrodynamics, influencing each other. In fact, the actual hydrodynamic behaviour of a biological reactor can deviate significantly from the design hypotheses, leading to hydraulic defects such as formation of dead volume and bypass. These problems exert a strong influence on the biological process and therefore affect the treatment efficiency of the plant. The Residence Time Distribution (RTD) analysis is commonly adopted for quantifying the type and amount of the functioning deficiencies affecting the process. However, to address the corrective intervention, these deficiencies should be localized by integrating RTD method with Computational Fluid Dynamics (CFD). This paper shows the early studies of a wider research project aiming at developing a standardized method combining RTD and CFD techniques for mitigating or eliminating functioning defects in biological reactors. An application of CFD-aided modelling for assessing hydrodynamic behaviour of an activated sludge (AS) pilot plant is illustrated. The obtained results are compared with experimental results from RTD analysis, showing how the CFD model can help supporting design of new facilities and the optimization or retrofitting of existing facilities for wastewater treatment.

KEYWORDS

Finite volume modelling, RTD analysis, biological reactor, pilot plant, experimental verification, hydrodynamic analysis, functioning defects, dead volume

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Bimetal doping on TiO_2 for photocatalytic water treatment: A green route

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ABSTRACT

Herein, we propose a new and green technique of bio-mediated bimetal doping on TiO_2 ($Zn/Cu/TiO_2$) using the aqueous leaf extract of Chayote plant which is rich in ascorbic acid (354 mg/kg leafs). The proposed method was successful to bring down the band gap of TiO_2 to 2.3 eV for $Zn/Cu/TiO_2$ at 1:1:98. The crystallite size of TiO_2 at higher dopants loading was increased significantly (16.3 to 38.4 nm) because of Cu^{2+} and Zn^{2+} induction into the Ti^{4+} lattice and, there was as high as 12% transformation of the anatase phase to the rutile phase of TiO_2. The increase in the absolute value of zeta-potentials of $Cu/Zn/TiO_2$ was notably faster (5 mV per unit pH increase) at $pH>pH_{zpc}$ which was resulted from the rise in oxygen vacancies and, $Cu/Zn/TiO_2$ were mostly present as a separated non-aggregated unit in water with a polydispersity index of 0.201. $Zn/Cu/TiO_2$ exhibited 98% Congo red dye decolourization compared to 59.3 and 68.7% with Zn/TiO_2 and Cu/TiO_2 under the visible light illumination (17700 Lux). COD reduction was 80.6, 71.2, and 75.9% with $Zn/Cu/TiO_2$, Zn/TiO_2, and Cu/TiO_2 with the quantum efficiency of 23.4, 30.8 and 41.5%, respectively. It was found that $O_2^{\bullet-}$ radicals were mostly caused the dye decomposition as evidenced from the electron spin resonance spectroscopy.

KEYWORDS

Bimetal doped photocatalyst, Band gap reduction, Visible light absorption, Dye degradation

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CFD modelling of wind effect on rectangular settling tanks of water treatment plants

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ABSTRACT

Sedimentation is a simple physical process which is widely applied on conventional water treatment plants; however, the tanks' efficiency depends on numerous factors including the wind action. In the present study, calculations are performed with a VOF model and one-phase model, which uses as an input the location of free surface and the surface velocity which are determined by the VOF model, to investigate the effect of a strong co-current wind (11 m/s) on a rectangular settling tank of a conventional water treatment plant. The results show that: (1) The flow field is highly affected by wind action, i.e. under windy conditions the tank is coved by an extended wind-generated eddy, while the suspended solids' concentration fields are influenced by the corresponding flow fields. (2) Without wind, the tank's removal efficiency is calculated equal to 85.4%, by the VOF model, and equal to 85.3%, by the one-phase model; these values are in satisfactory agreement with the experimentally determined value (86.0±1%). (3) For a co-current wind of 11 m/s, the tank's efficiency decreases to 83.4% (VOF) and 83.6% (one-phase model), which is also in satisfactory agreement with the experimentally determined value (84.0%); however, the wind effect is slight (≈2%). (4) Both the VOF and the one–phase model can predict satisfactorily the tank's removal efficiency; so the one-phase model can be used to assess wind effect on all types of settling tanks, according to the proposed methodology, since it is a significantly less time consuming model compared to the VOF model.

KEYWORDS

Wind effect, settling tank, tank's performance, water treatment plant, CFD

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Investigation of preparation conditions of Nano-SiO_2 embedded PES membranes for producing clean water from wastewater

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ABSTRACT

The goal of this study was to determine the desired preparation conditions of Polyethersulfone (PES) membrane for producing clean water. Membranes were fabricated via a combination of vapor induced phase separation (VIPS) and non-solvent induced phase separation (NIPS) methods. SiO_2 nanoparticle were used as the hydrophilicity modification agent in the casting solutions which led to a negative impacts on the permeate flux in high concentrations due to aggregation. Nowadays one of the biggest problems of most of industries, especially petroleum and petrochemical industries is water pollution with oil materials, hence study of such systems is highly applicable. VIPS and NIPS are two methods for porous membrane fabrication each of which needs some modifications for formation of the membrane with regular pore size distribution and regular structure, so the combination of these two methods is such beneficial that VIPS can help to produce a neat surface pores and NIPS can generalize this surface structure to the whole membrane and then form a membrane with suitable morphology for highly water production. In this study, oil-water separation process has been accomplished for fabricated membranes under the same operating conditions and effects of each preparation factor on permeate flux investigated and amount of rejection has been calculated by COD test and finally the best membrane for this separation was selected.

KEYWORDS

Membrane formation, water purification, vapor induced phase separation, nonsolvent induced phase separation, PES membrane

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Understanding the anaerobic fluidized membrane bioreactor for wastewater treatment

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ABSTRACT

The fluidization of Granular Activated Carbon (GAC) particles is a promising method for mitigating membrane fouling particularly in membrane bioreactors (MBRs). In particular, the fluidized GAC particles confer mechanical scouring and surface shear of the membrane surface, which reduces membrane fouling in the anaerobic fluidized bed - membrane bioreactors (AnFMBRs) for wastewater treatment. This study targeted at understanding the improvement of fine (micron-sized) particle critical flux in the presence of fluidized GAC via the Direct Observation Through the Membrane (DOTM) technique. Results highlight that: (i) fluidized GAC increased the critical flux by an order-of-magnitude relative to that with tangential liquid shear alone; (ii) the overall critical flux expectedly increased with power input, but the relationship between local critical flux and power input depended on the position along the membrane height; and (iii) at the same power input, although the larger GAC particles were more effective locally due to greater particle inertia, the smaller GAC particles were more effective overall due to greater bed expansion enabling scouring of more membrane heights.

KEYWORDS

Membrane fouling mitigation, liquid-solid fluidization, critical flux, direct observation, energy input

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Separation of hexavalent chromium (Cr(VI)) from wastewater through supported liquid membrane using environmentally benign solvent

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ABSTRACT

The main aim of this study is to separate hexavalent chromium (Cr(VI)) using environmentally benign solvent based supported liquid membrane (SLM). With the context of environmentally benign solvent, sunflower oil used as a green solvent and n-methyl-n,n,n-trioctylammonium chloride (aliquat 336) as a carrier, where aliquat 336 showed very good carrier for transport of Cr(VI). Di-sodium ethylene-di-amine-tetraacetic acid (Na2-EDTA) was selected as stripping agent for its affinity towards metal. SLM method has proved very effective method over the other traditional solvent extraction methods. Polyvinylidene fluoride (PVDF) was used as a support in order to hold and contain the membrane liquid in the SLM structure. The size of the pores in the support is 0.22 μm. The transport performance of Cr(VI) was affected by various parameters such as pH of feed phase, pH of strip phase, concentration of strip phase, concentration of carrier, stirring speed and period of operation (i.e. run time). Over 80 % extraction and over 70 % recovery was obtained with following operating conditions: concentration of carrier = 1% (v/v) aliquat 336, pH of feed phase = 4.56, pH of strip phase = 6.5, concentration of strip phase = 0.03 M, stirring speed =120 rpm and run time = 48 h. The results of SLM study can further use to design the three phase hollow fibre membrane (HFM) based separation process.

KEYWORDS

Supported liquid membrane (SLM), environmentally benign solvent, aliquat 336

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Moving towards a water-sustainable chemical industry: novel water recovery processes

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ABSTRACT

A key factor to consider when thinking of a sustainable chemical industry that is using water in its operations (such as the metals and mining industry) is the energy footprint of the applied water recovery technologies. Forward Osmosis (FO) and Freeze Crystallization (FC) are two innovative processes promising to minimize fresh water intakes in the chemical industry at a significantly lower energy input compared to conventional processes, such as Reverse Osmosis (RO), evaporation, or crystallization. FO is a membrane process able to recover water from dilute feed solutions (i.e., industrial process water, high salinity streams), into a concentrated draw solution (CDS). The flow of water into the CDS occurs spontaneously, due to the osmotic pressure gradient generated between the two solutions, diluting the CDS. The draw solutes must then be separated from the resulting dilute draw solution (DDS) to regenerate and recycle the CDS in the process, leaving behind clean water. This step is the main source of energy consumption in the overall FO process, which only requires moderate heating. On the other hand, FC involves processes in which water is removed from an aqueous solution by freezing or freeze-thaw cycling, while the solutes remain in a concentrated aqueous phase from which they can be recovered or contained. The energy advantage is due to the fact that the latent heat of freezing is about 7 times lower than its evaporation analogue. Research advancements in the aforementioned processes are reported.

KEYWORDS

Water recovery, forward osmosis, natural freezing, freeze crystallization

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Treatment of fluoride, iron and arsenic contaminated drinking water

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ABSTRACT

Electrocoagulation (EC) was investigated systematically for the effective removal of fluoride, iron and arsenic from drinking water. The efficiency of the process was estimated in terms of percentage removal of fluoride, iron and arsenic. However, electrocoagulated water was not suitable for the drinking purpose as the solution pH was alkaline along with the agglomerated suspended sludge with size range 10 - 100 μm. In order to make electrocoagulated water drinkable, EC followed by microfiltration (MF) was investigated. Mixture of fluoride, iron and arsenic in contaminated drinking water was treated by EC followed by MF. The mixture was first treated in a batch EC process. The treated water along with the electrocoagulated byproducts was then passed through a MF unit for further treatment. MF membranes were prepared at various sintering temperatures and characterized. It was found that ceramic MF membranes prepared at 950 °C had a sharp pore size distribution with surface porosity of 0.43 and average pore radius of 0.56 μm. Electrocoagulated water was treated in the MF cell in order to separate suspended agglomerate at different transmembrane pressures. Permeate flux and permeate quality was measured and analyzed. It was found that the prepared MF membrane was efficient in retaining the suspended particulates formed during the electrocoagulation process. It was observed that the hybrid technique can successfully remove fluoride, iron and arsenic from contaminated drinking water. The conductivity, TDS and pH of treated water remains within the permissible limit proposed by world health organization (WHO).

KEYWORDS

Electrocoagulation, microfiltration, hybrid technique, conductivity, drinking water, fluoride, iron, arsenic

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Biological treatment of a low strength domestic wastewater in a membrane bioreactor

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ABSTRACT

Apart from facing eutrophication, wastewater treatment is a major environmental issue, due to the exhaustion of human resources and the enforcement of stricter legislation limits. Limited economic resources and land availability as well as the high cost of conventional wastewater treatment plants led us to find alternative sustainable methods to treat wastewater, such as membrane bioreactor technology. In this work, we evaluated the depuration of a low strength domestic wastewater derived from a coagulation-flocculation process.
An MBR system was operated under alternating aeration and periodic feed, where membrane cleaning was achieved by periodic pumping. MBR performance was examined with and without external carbon source addition, whereas either raw urban wastewater or glycerol from the biodiesel production served as the external carbon source. In all cases, BOD5, COD, TKN and NH4+-N removal rates were greater than 86% and their effluent values were below the legislation limits. However, denitrification efficiency was low in the absence of external carbon source or during addition of the raw effluent (<16.9% and 25.6%, respectively) and only glycerol addition as the external carbon source resulted in complete denitrification. In particular, TN removal efficiency was above 85%, with effluent NH4+-N and TN concentrations being below 1.7 and 11.7 mg/L, respectively. Indeed, glycerol addition improved system performance, fulfilling the disposal limits set by the law.

KEYWORDS

Domestic wastewater, low strength, MBR

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Influence of clay lens on contaminant transport in unconfined coastal aquifers

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ABSTRACT

Groundwater serves as the most reliable source of freshwater for domestic, industrial and agricultural purposes in most of the coastal areas of the world. However, the freshwater aquifers hydraulically connected with the sea or ocean has been deteriorating day by day due to different anthropogenic activities. Therefore, a better understanding of contaminant transport processes in coastal aquifers is highly important to prepare and implement proper water resources planning and management policies for coastal environment. The coastal groundwater flow is very complex due to the occurrence of a freshwater-saltwater diffusion zone and the tidal variation of sea level at the seaward end also contributes to the complexity of coastal groundwater flow. In this study, an experimental investigation has been carried out to understand the behavior of contaminant plume in unconfined coastal aquifers under the influence of horizontal clay lens. The laboratory experiment is conducted in a rectangular flow tank filled with glass beads as the porous medium. A constant head was maintained on the freshwater and saltwater boundary using respective chambers during the experiment. A colored dye with the salt solution was used to differentiate the saltwater from the freshwater. This also helps in visualization of the contaminant. The experimental results show that there are two saltwater wedges developed, one at the base of the aquifer and the other one is above the clay lens. Experimental results also show that the contaminant travels slightly along the saltwater wedge towards the seaward boundary. This experimental study helped us to better understanding of contaminant transport processes occurring in coastal aquifers.

KEYWORDS

Contaminant Transport, Unconfined Coastal Aquifer, Laboratory Experiments, Saltwater Interface, Clay Lens

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Application of nanostructured materials in fluoride removal from contaminated groundwater

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ABSTRACT

Fluoride is a water pollutant of great environmental concern due to its wide abundance and devastating effects on human health. Defluoridation of drinking water is one of the effective solutions for mitigating fluoride pollution. Extensive research has been done so far on various methods for removal of fluoride from water and wastewater. Precipitation processes involve the addition of chemicals and formation of fluoride precipitates. Strong base exchange resins remove fluorides either on hydroxyl cycle or chloride cycle along with anions. Researchers had paid their attention on adsorption technology since last two decades for fluoride removal. Adsorption processes are generally more popular because of their efficiency, convenience, simplicity of design and for their eco-friendly nature. Adsorbents used in fluoride removal are bone charcoal, tricalcium phosphate, florex, activated carbon, magnesia, activated alumina, plant materials, limestone, special soils and clay, fly ash etc. Nanomaterials have gained attention recently and have been widely used as sorbents due to properties such as high surface-to-volume ratio and short diffusion route. Hydrous titanium dioxide (TiO2), Aluminum–cerium (Al–Ce) hybrid adsorbent, Aluminium hydroxide impregnated limestone, sulfate-doped Fe3O4/Al2O3 nanoparticles, Fe3O4 nanoparticles were used for fluoride removal. Micro/nano-hierarchal web consisting of activated carbon fibres and carbon nano fibres impregnated with Al used as an adsorbent for fluoride removal from wastewater. The future research should be focused on evaluating the efficiency of adsorbents in terms of cost and feasibility for removal of fluoride.

KEYWORDS

Fluoride, Adsorption, Nanomaterials, Remediation, Groundwater

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Distribution and assessment of heavy metals and physicochemical parameters in riverine basin

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ABSTRACT

Water is the most precious resource to sustain the life on earth. Rapid industrialization and urban development results in inclusion of variety of pollutants into rivers. In the present study, a comparison of characteristics of water quality with respect to heavy metal (Fe, Al, Mn and Se) and their interrelationships with some physiological parameters during different seasons of year 2015 has been investigated flowing through the two geographical regions, namely Kurdistan region (Chamsaghez, Chamkhorkhoreh, Jaghatoo Rivers) and West Azarbaijan Region (Sarough River) , in Zarrineh river basin one of the most important and longest rivers in the Lake Urmia basin in Iran which branches from the mountains of Chehelcheshmeh at the being of Kurdistan province. All observed values of Se in spring, observation of Al in 14 stations, observation of Fe in 11 stations and observation of Mn in 9 stations exceed WHO standard for drinking water. However, all of the observation of Se in winter are found with the standard limit. In the present study, the metals Fe, Al and Mn show negative correlation with pH and also the Mn and Se, show negative correlation with DO. Metals Al and Fe found to have strong positive correlation with each other. Distribution of Al and Se in river Chamsaghez and Al, Se and Mn in river Sarough systems, Al in Jaghatoo river and Fe in Chamkhorkhoreh river during entire study period shows significant difference at 95 % level of significance. Spatially all the metals in different river systems do not show any significant spatial difference in their distribution among different river systems.

KEYWORDS

Pollution, Dissolved heavy metals, spatial distribution, physicochemical parameters

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Determination of longitudinal dispersion coefficient in streams with transient storage

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ABSTRACT

The dispersion is one of the most important pollution transport phenomena, which is used in numerical water quality models. The dispersion rate is described by the value of the dispersion coefficient in the advection – dispersion equation. The most reliable way of determining the value of the dispersion coefficient is the field tracer experiment. The results of the field experiments are affected by various influences, which occur in the real flow conditions - one of them is the occurrence of transient storage zones (dead zones). Paper describes the field tracer experiments for determination of the coefficient of longitudinal dispersion in streams of lowland type (channels with small slopes and velocities) with expected of dead zones and water vegetation occurrence. Tracer experiments were carried out on three different streams in south Slovakia. The evaluation of field measurements confirmed in all cases the presence of mentioned flow deformation, i.e. river sections and regions with the appearance of small velocities that were formed due to the extensive presence of vegetation in the river. These areas capture part of the transported substance (tracer) and then gradually release the substance and incorporated back into the stream, creating a significant distortion of the tracer concentration time course. Strong influence of these impacts raises the question of the adequacy using standard analytical solutions, whether for determining the coefficient of longitudinal dispersion or for modelling the dispersion of pollution or other substances carried by the river.

KEYWORDS

Hydrodynamic dispersion, longitudinal dispersion coefficient, tracer field experiment, tracer, colouring agent

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Desalination and alternative water resources

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ABSTRACT

With water demand increasing due to population growth, life style change, more water for irrigation to feed the increasing population and increasing environmental needs, and water availability remaining the same or reducing due to pollution or droughts and in some parts of the world decreasing because of climate change, the need for additional water in many countries is increasing. With almost all the conventional water resources developed and exploited, the desalination seems to be an alternative water supply. Desalination is now becoming relatively cheaper when compared to the increased cost of developing conventional water resources. This report examines the subject of Desalination, as an Alternative water supply, outlining in general the basic principles that a water entity and engineer must be aware when embarking on the subject. It also outlines the step that a water entity must make for establishing a desalination plant.

KEYWORDS

Desalination, membranes processes, thermal processes, seawater, brackish water, environment, marine works, on land works, product water quality

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Source separation technologies, opportunities for sustainable wastewater management

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ABSTRACT

Recent challenges regarding urban sanitation system require innovative ideas to ensure high quality wastewater management in future. The drive towards sustainable wastewater management is challenging the conventional wastewater treatment method. Source separation sanitation method could be a new approach to minimize the pressure of population and help to improve the sustainability indicators. It is required the information about new ideas; systems and technologies become more readily accessible for addressing wastewater problems in order to reach solutions for environmental, economic and social balance. This comprehensive review focuses on the statues of current source separation sanitation techniques and summarize the efficiency of each type of technology. The method would be in modular descriptions of component and description of alternative wastewater systems, and facilitates evaluating how well each design satisfies the given context. The review shows clearly that a wide range of technique options is available to treat each type of wastewater, but none of these options can meet all the requirements of treatment in one specific technique and a combination of technique is required to treat separated water to reach optimized nutrient recovery and treated water.

KEYWORDS

Source separation sanitation system, greywater, blackwater, yellow water, conventional sanitation system, removal efficiency

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Assessing ecological flow conditions for wetlands fed from ungauged stream reaches

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ABSTRACT

Wetlands, which are greatly associated with intensive ecological services and high rates of biological diversity and ecological reserve, depend very much on prevailing flow conditions and hydrologic alterations in river systems that supply water to the wetland area. Alterations in flow regimes due to changing climatic conditions and/or anthropogenic impacts (e.g., damming, regulated water release, changing land uses, etc.) make diverse and considerable impacts on ecosystem sustainability for wetlands, thus need to be quantified for unfolding the observed (or predicted) degrees of connected changes in ecological flow conditions. This quantification is, however, problematic for stream reaches with inadequate or no records of measured flows. The presented study implements a holistic approach for comparing ecological flow conditions and detecting alterations between subsequent time periods for a number of wetlands along the Mediterranean transect of Turkey, which primarily lack flow measurements in associated stream reaches. In the approach, time series data of monthly flows for ungauged locations, which are selected at stream entrance points for different wetlands, are first generated by employing the logic that is behind the Massachusetts Sustainable-Yield Estimator (MA-SYE) tool and is based on a number of regression relationships with a defined set of catchment characteristics and also between different flow quantiles. Synthetic time series for monthly flows are later used in computing monthly series of environmental flows through a desktop estimation approach. Inter-periodic comparisons for environmental flow series between subsequent and equi-length time periods help display observed alterations in ecological states of the investigated set of Mediterranean wetlands.

KEYWORDS

Stream flow prediction, ungauged sites, wetlands, environmental flows

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Evaluation of streamflow habitat relationships, using habitat suitability curves and HEC-RAS

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ABSTRACT

Habitat Suitability Curves (HSCs) were developed for two freshwater fish species, namely *Salmo pelagonicus* and *Barbus balcanicus*, using microhabitat data obtained at a mountainous stream, in upper Axios River, Greece, for habitat evaluation on the micro scale. Twelve riverine HSCs associating two size classes with three microhabitat parameters (water depth, velocity and substrate) were developed and used. For the hydraulic simulation of the stream, the well-known, one-dimensional HEC-RAS software was implemented. The Weighted Usable Area (WUA) was estimated by combining habitat suitability indices with the output of the hydraulic model, to evaluate the relationship between streamflow and fish habitat availability. For the calibration of the model, water depth and flow velocity measurements were performed on April 2016. In the framework of the calibration phase, an algorithm was developed, to automate this process and to implement a sophisticated optimisation method. For the upstream and the downstream boundary conditions, water velocity and depth measurements were used as well, to reduce the uncertainty propagation due to the model's parameters. The presented approach may provide a better understanding of how flow variability affects fish microhabitats, while it can contribute considerably to the sustainable water management of hydrologically altered rivers and the concomitant conservation of riverine biota.

KEYWORDS

Habitat suitability curves (HSCs), HEC-RAS software, automation, WUA

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Urban impacts on the water quality in river: model case studies Hron and Drava

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ABSTRACT

This paper analyses the influences of urban sewer systems (combined sewer overflows - CSO's), on the receiving water quality, but deals also with various types of storm water management in urban areas. The first case study analyses the impacts of the continuous (wastewater treatment plant in the town Osijek) and discontinuous pollution sources (CSO's in the town Osijek) on the quality of the receiving water – the Drava river (Croatia). The second modelling case study was performed on the river Hron (Slovak Republic). In this study, the impacts on the water quality from combined sewer overflows form the biggest town on Hron River – Banská Bystrica were studied, as well as four feasible alternatives of storm sewer management (different mixing ratio, different size of storm tanks) were analysed. Results of this studies were the concentrations of selected quality parameters (BOD5, dissolved oxygen, temperature, NH4-N, NO3-N, particular and dissolved P) in longitudinal profile along the modelled part of the river. For both case studies, the mathematical simulation model MIKE11 (Danish Hydraulic Institute, DHI) was used. Results of this modelling study show, that such modelling approach can be very useful for modelling of impacts on the water quality in receiving water and can be also very helpful in evaluation of various strategies and management practices focused on the receiving water quality improvement.

KEYWORDS

Modelling water quality, storm water management, urban area, combined sewer overflows

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Simulation of organics and nitrogen removal from wastewater in constructed wetland

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ABSTRACT

Modelling wastewater treatment processes is an effective tool for prediction and analysis of treatment system performance. In this study, removal of organics and nitrogen compounds of municipal wastewater is simulated in a constructed wetland based on system dynamic approach using Stella software. In the developed model, organics are represented by BOD and nitrogen compounds including nitrate, ammonia and organic nitrogen. Removal mechanisms for BOD include microbial degradation, plant absorption, and sedimentation. The mechanisms for nitrogen removal are denitrification, sedimentation and plant absorption. The model was calibrated and validated for a horizontal subsurface flow wetland in Arundel mills, Maryland based on 24 data gathered biweekly during one year. An acceptable R2 and Nash– Sutcliffe coefficient of efficiency between the simulated and observed concentration values were obtained which provides a reliable tool in operation and management of the specified wetland in this case study. Based on the results of the model, overall BOD removal consists of 43% for the share of microbial degradation, 27% plant absorption and 30% for sedimentation. Also from the overall nitrogen removal, the share of sedimentation for organic nitrogen is 22%, plant absorption 14% and denitrification is 45%. According to the results, the developed model can be efficiently used in prediction, design and operation of constructed wetland.

KEYWORDS

Constructed wetland, wastewater treatment, System dynamic model, organics, nitrogen

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Assessing the source of nitrate and heavy metals in groundwater resources of Abarkooh plain, central Iran

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ABSTRACT

Abarkooh alluvial aquifer is located in southwest of Yazd city at the center of Iran. Groundwater is the main source for irrigation and domestic uses, considered as the potential causes of groundwater contamination in this plain. The study was carried out to assess hydrogeochemical properties of groundwater with the aim to find probable sources of major contaminants including nitrate and heavy metals. In this regard 37 water samples were collected and analyzed for major ions (Ca, Mg, Na, K, Cl, HCO3 and SO4), nitrate and heavy metals with environmental priority including arsenic (As), lead (Pb) and cadmium (Cd). Values of electrical conductivity (EC) increase from recharge area at the west to the eastern discharging parts where the playa is present. The abundance of cations and anions vary in the order of Na^{+} >>Mg^{2+} >Ca^{2+} >Ka^{+} and Cl^{-} >>$SO4^{2-}$ >$HCO3^{-}$, respectively. The highest values of Na and Cl are observed at the east where the saline water intrusion is probable due to the intensive abstraction of groundwater which reverses the flow direction. Pb and Cd is highly correlated with Na, Cl and EC, confirm their geogenic source due to saline water intrusion. Nitrate is high at the west where the un-managed application of fertilizers in agricultural lands is so dominant. A geogenic source for As was proposed based on the results of principal component analysis (PCA). The study confirms the main role of anthropogenic processes in contamination of Abarkooh aquifer generally resulted from over-exploitation of the aquifer and agricultural activities.

KEYWORDS

Nitrate, heavy metal, geogenic, anthropogenic, Abarkooh, Iran

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Case studies investigating hydraulic parameters in full-scale constructed wetlands

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ABSTRACT

Constructed wetlands and ponds are increasingly used worldwide for purifying various types of water effluents. The lack of current knowledge on how efficient they are hydraulically and how to maximise their efficiency is still a challenge. As water movement plays key role in the pollutants mitigation, understanding of the hydrodynamic processes and factors related to pollutants removal would improve the estimation of mixing coefficients, influence of vegetation, and system design. The majority of previous research investigating the effects of wetlands' hydrodynamics on mixing and pollutants removal rates, has been conducted either in pilot-scale units under controlled conditions or via computer simulations, which might introduce uncertainties in the establishment of rules, the prediction of coefficients, and in modelling. Empirical data obtained from full-scale studies are required to quantify the effects of hydrodynamic factors on mixing processes and hydraulic performance during a season. This paper presents results from tracer tests conducted during 2015-2016 in six full-scale systems in the UK under different flow regimes, water depths, and in-/outlet conditions. The aim is to quantify their hydraulic performance and mixing characteristics, trying to open the black box. Results indicate that deeper systems controlled from downstream allow for longer residence times and provide greater treatment efficiency, and that retrofitting using baffles in the system significantly improves the hydraulic performance.

KEYWORDS

Constructed Wetlands, Full-Scale, Longitudinal Mixing, Residence Time, Fluorescent Tests

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Modelling of nickel dynamics in vertical subsurface flow constructed wetlands using a System Thinking Environment

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ABSTRACT

The application of modelling approaches for simulating and designing of constructed wetlands is still a challenge in environmental science. A mathematical model was developed in STELLA software to simulate Ni dynamics (adsorption, plant uptake and effluent concentrations) from synthetic wastewaters loaded with Ni 0.5 ppm and treated in vertical subsurface flow constructed wetlands vegetated with Phragmites Karka on gravel beds. Plant and water samples were collected, pre-treated in the laboratory, digested with diacid and their Ni concentrations were determined using atomic absorption spectrophotometer (AAS), after filtrating the samples on Whatman paper No. 42. A graphical model was developed in STELLA and the data recorded from the experiment were used to calibrate and validate the related mathematical model in the software. Results showed a good agreement between experimental and simulated data indicated by the Wilcoxon Signed Ranks Test p values > 0.05 for Ni adsorbed in gravel, uptake in plant and Ni effluent concentrations. The overall removal analysis showed the following distribution pattern: Experimental data (Total Removal Percentage (%): 84.2; adsorption percentage (%):50.6; plant uptake percentage (%): 33.6). Simulated data (Total Removal Percentage (%): 83.5; adsorption percentage (%): 52.8; plant uptake percentage (%): 30.6). Thus the adsorption played a major role the removal of Ni from wastewater compare to plant uptake and the overall constructed wetland showed its high removal performance in eliminating Ni from wastewater.

KEYWORDS

Process-based models, STELLA software, Wilcoxon Signed Ranks Test, Model validation

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Multi-criteria evaluation of wastewater treatment technologies in constructed wetlands

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ABSTRACT

Segmenting constructed wetland for natural wastewater treatment can be considered as multi-criteria decision-making problem because there are conflicts between criteria while assessing alternative orderings of treatment technologies among segments. Criteria such as: size of wetland area, possible economic effects, technical effectiveness, hydraulic conductivity of soil, and plant coverage and growing conditions, are by nature qualitative, quantitative and 'grey'. Alternatives' performance across criteria is difficult to measure because of incommensurate units and inter-dependence between criteria. In this paper the results obtained with different decision-making tools are presented for the problem of selecting best ordering of treatment technologies in wetland segmentation. Methods used are: analytic hierarchy process (AHP), simple additive weighting (SAW), simple product weighting (SPW), technique for order preference by similarity to ideal solution (TOPSIS) and compromise programming (CP). Horizontal flows, vertical flows and shallow gravel ditches are evaluated across criteria in different orderings considering differences in effects that their ordering produce during purification of incoming wastewaters. A decision-making problem is hierarchically structured and the AHP-based pair wise comparisons are used to derive the weights of criteria and local weights of orderings regarding each criterion. With the decision matrix created in this way, the weighting and distance methods are used along with the AHP to declare the best ordering of technologies by segments. The results obtained for a typical wetland in Serbia are presented to illustrate an approach and the results of sensitivity analysis are discussed, indicating advantages and possible drawbacks of combining or parallel using the results from more multi-criteria methods.

KEYWORDS

Wetland segmentation, wastewater treatment technologies, AHP, TOPSIS, CP

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Identification of pollution sources based on on-line monitoring

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ABSTRACT

Water quality modelling is currently very effective and important tool in context of the task to ensure the required quality of water resources, respectively, to achieve (maintain) good water status according the Water Framework Directive (2000/60/EC). Monitoring of water quality is an important tool for integrated water management, planning and protection, which enables to assess the impact of known sources and detecting unknown sources of river pollution. This paper analyses the current status in numerical modelling of pollution dispersion in streams and use of some modelling approaches for the inverse task. Inverse task means a modelling technique, which is focused on the localisation of unknown pollution source (typical common models or equations are rather focused on the pollution spreading simulation, whereas the pollution source location is known). Paper offers an idea of such inverse task solution. It is based on the known pollution concentration time courses or it can be based on the results of the on-line monitoring of the specific water quality parameters as well. For the application of inverse tasks in conditions of real streams and rivers a large number of various requirements and conditions in specific river should be considered, i. a. the river bed non-prismaticity, occurrence of dead zones, dispersion rate etc. Paper also describes the first version of the software for solving inverse tasks and preliminary experiences of using this software.

KEYWORDS

Inverse task, dispersion, pollution, source, localisation, numerical modelling

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Assessment of pollution at mid-Black Sea coast of Turkey for recovery valuable heavy metals from sediments

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ABSTRACT

Rapid industrialization and urbanization has led to the contamination of sediments with heavy metals and organic contaminants and created a pervasive problem worldwide. Major sources of contamination include agricultural and urban lands, industrial activities, spills, and accidents. Arsenic (As), cadmium (Cd), cobalt (Co), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn) are often found in sediments and other areas affected by anthropogenic activities. Sediments containing these contaminants act as secondary sources of contamination, posing significant direct and indirect environmental risks through bioaccumulation in aquatic organisms and incorporation into aquatic food webs that may lead to human exposure. Heavy metal accumulation, bioavailability, and toxicity to sediment-dwelling organisms are largely influenced by the physicochemical conditions and geochemical properties of sediments. Ongoing assessment at mid-Black Sea coast of sediment samples was digested using the 1 ml $HCIO_4$ % 65, 6 ml HNO_3 % 65, 1 ml H_2O_2 % 30 for metal analysis. Digested samples were analyzed at Perkin Elmer Optima 4300DV Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES). Samples were taken from the four stations; S1, S2, S3, S4. The results show us that all metals have the highest value in the sample number S4. These values found for Cr 7.65 mg/l, Cu 3.05 mg/l , Zn 6.40 mg/l, Cd 11 mg/l ,Pb 1.32 mg/l and Al 2120 mg/l . According to these results, valuable heavy metals may also be treated and extracted from for recovery.

KEYWORDS

Heavy metals, Sediments, Recovery, Black Sea, SEF

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Evaluation of clogging in HSF pilot-scale CWs using tracer experiments

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ABSTRACT

The worst operational problem that may occur during the operation of horizontal subsurface flow (HSF) constructed wetlands (CWs) is the clogging of the porous media. Clogging phenomena cause hydraulic malfunction, and therefore, may lead to inadequate performance of HSF-CWs, and finally, to the reduction of their lifetime expectancy. The main objective of the study was the investigation of clogging in HSF-CWs pilot-scale systems, and its influence on the hydraulics of these systems. Additionally, the study also aims at the evaluation of the sustainable operation of HSF-CWs after their long-term use. One HSF pilot-scale CW was used. The experiment was conducted using an impulse tracer test using KBr, which provided residence time distribution (RTD) curves, and generally, information regarding the effect of clogging on flow dynamics (possible short-circuiting, dead volumes, uneven distribution). For the conduction of the experiment, the conservative tracer was introduced at the inlet through the influent distribution system and the monitoring was performed at various points along the wetland bed (i.e., 1/3 and 2/3 of the length, and the outlet). Equations are used to compute, based on the tracer test data, the mean actual HRT, the tracer mass recovery, the normalized variance and the hydraulic efficiency. The results indicate that the unit operated smoothly without serious clogging phenomena. Generally, this system has shown a sustainable and successful long-term operation. The presented method is an effective method to evaluate performance of horizontal subsurface flow constructed wetlands in terms of clogging.

KEYWORDS

Constructed wetlands, Horizontal subsurface flow, Hydraulics, Clogging, Impulse tracer test, Potassium bromide

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Earth observation based monitoring in Natura-2000 sites, providing ecosystem services for their adaptive management

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ABSTRACT

Epanomi and Aggelochori lagoons and their wider coastal-marine zone are situated in the eastern part of Thermaikos Gulf (N. Greece, near to Thessaloniki) and are considered as very important natural sites, because they include priority marine habitat types, according to 92/43/EEC Directive, i.e. 1120* (*Posidonia beds*) and 1150* (*Coastal lagoons*). The implementation of Water Framework Directive requires both lagoons to achieve good ecological Status in these coastal water bodies and to conserve their habitats. The objectives of this work were to develop an innovative monitoring system in order to provide ecosystem services, in almost real time, for the adaptive management and enhancement of conservation status of coastal habitats. The monitoring of water quality included the assessment of biotic and abiotic factors and it was implemented via the combination of destructive (active and passive sampling based on an early warning system, followed by laboratory analysis) and non-destructive methods (earth in situ monitoring, using an Autonomous Water Telemetry Sensing System (AWTSS), employing spectra sensors and space-born remote sensing data). The main objectives of monitoring, in addition to develop an efficient operational monitoring protocol, based on integrated Earth Observation (Earth *in situ* and space-borne) data, include the evaluation of management effectiveness and the establishment of a feedback mechanism, used to provide ecosystem services for the effective adaptive management. In addition, the performed monitoring was able to provide the ecosystem services needed for the adaptive management, proposed for these habitat types, and to serve the relevant stakeholders.

KEYWORDS

Coastal water bodies-habitats, ecosystem services through Earth observation, innovative integrated monitoring system

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Characterization of the quality of Trichonis lake waters on the basis of the behaviour of chlorophyll-A

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ABSTRACT

The areal and vertical variability of Chlorophyll-a is investigated in the Trichonis lake, Greece, waters in relation to physicochemical parameters, such as temperature, conductivity, pH, in an attempt to determine the quality of the waters. For this purpose chlorophyll-A measurements have been carried out along with the above parameters in profiles, at increasing distance from the coast.
On the basis of the vertical variability of the temperature in the water column four water layers can be distinguished: The upper layer, 0-15 m, where the temperature remains constant with depth, the 15-20 m layer, where the temperature decreases with depth, the 20-25 m layer where the temperature decreases more rapidly compared with the previous layer and the layer 25-32 m, where the temperature decreases even more rapidly with depth.
Using the chlorophyll-a eutrophication scale of Sibura et.al. (2005) the water quality of the lake is described as follows : The waters of the upper layer, 0-15m, are characterized as lower mesotrophic, having moderate quality, those of 15-20 m layer, as eutrophic, having bad quality, those of 20-25 as upper mesotrophic, having poor quality and those of 25-32 m, as lower mesotrophic, having good quality.
It is interesting to note that at all stations investigated chlorophyll-a shows a sharp peak at 15-25 m water layer, coinciding with a low or an increase in conductivity.

KEYWORDS

Water quality, Trichonis Lake, Chlorophyll-A, Physicochemical parameters

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Water quality estimation in Greek lakes from Landsat 8 multispectral satellite data

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ABSTRACT

The European Water Framework Directive (WFD) requires that a Good Environmental Status is retained for all water bodies along their constant monitoring. However, the frequent (e.g., weekly, monthly) monitoring of numerous and extensive inland water bodies places several logistic and economic challenges. Remote sensing is considered one of the most cost-effective methods for providing the spatial and temporal environmental data that are necessary for the effective monitoring and implementation of the WFD. In this study the goal was to establish concrete relations between satellite observations and key quality parameters over several permanent lake monitoring stations in Greece. In particular, water quality indicators such as Chlorophyll-a and turbidity through Secchi disk depth were estimated through the analysis of Landsat 8 satellite and in-situ data. The employed multispectral images and in-situ measurements were selected to have a maximum temporal offset of 15 days, while relations were established based on regression models. The experimental validation indicated correlations with R2 values of up to 0.75 for Chl-a (n>160) and 0.70 for turbidity (n>190). These promising results along with a further multi-temporal validation can be employed for the development of operational, remote sensing monitoring systems for the accurate and timely estimation of key water quality indicators.

KEYWORDS

Remote sensing, Water Framework Directive, Earth observation, regression, chlorophyll, turbidity

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Assessment of the environmentally minimum lake level based on morphological features

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ABSTRACT

The determination of environmentally minimum water level in lakes is essential for the protection of their ecosystems. The assessment of minimum water level depends on a number of biotic and abiotic factors of the lake ecosystem; however, in many cases these factors are not easy to collect and assess in their entirety. At the same time, the lakes in many cases consist an important water reserve to meet the requirements arising from economic activities, e.g. industry, agriculture. In this paper, the morphological features in four lakes – Vegoritida, Petron, Cheimaditida and Zazari – of Northern Greece are analysed in order to assess their environmentally minimum water level. The morphological analysis is based on the relationship of the lake surface area and volume with the water level. An optimization method is applied taking into account that the biodiversity is favoured as the surface area covered by the lake is increased and the human water requirements are satisfied to the greatest possible extent by the available water volume of the lake. The environmentally minimum water level determined by the morphological analysis in the four lakes is compared with the minimum water level based on the analysis of the requirements of fish fauna and macrophytes.

KEYWORDS

Minimum ecological lake level, lake morphological analysis, Vegoritida-Petron-Cheimaditida-Zazari

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Critical review of adaptation strategies for the restoration of lake Koronia

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ABSTRACT

Lake Koronia water basin, located in Northern Greece, depicts a characteristic example of non-sustainable water management case in Greece. The irrational pumping for irrigation in the catchment resulted in the overexploitation of groundwater resources and a serious decrease in the runoff to lake Koronia. Furthermore, the reduction of the mean annual precipitation and the increase of the mean annual temperature, and, therefore, the evaporation that were being observed in the area, due to climate change, are expected to further deteriorate the already distributed water balance of the lake. UTHBAL model along with MIKE SHE and MIKE HYDRO BASIN models are utilized in the present study for the calculation of the historical (1970-1999) and future (2020-2049, 2070-2099) water balances of lake Koronia. The water balance of the lake for the long-term time period was found to be negative even after the implementation of the adaptation measures that have been proposed in the most recent revised Master Plan for the restoration of the lake. An assessment of the efficiency of the most important measures that have already been implemented, in terms of decreasing the future water deficit of the lake, is carried out. The paper concludes that even after the implementation of the measures the water balance of lake Koronia still remains negative for the long-term future period and so complementary adaptation measures should be implemented in order to restore the negative water balance of the lake.

KEYWORDS

Lake Koronia, water balance, adaptation measures, climate change, Master plan

Evaluating the ecological restoration of a Mediterranean reservoir

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ABSTRACT

The restoration of Lake's Karla environment and ecosystem is studied through the evaluation of its current status. Its drainage, in 1962, created a series of environmental problems and led to the local economy contraction. The Lake Karla reconstruction project has begun since 2000. The construction of a reservoir at the lowest part of Lake Karla watershed is among the parts of this project, which will be supplied from Pinios River and the runoff of the surrounding mountains. This newly re-established water body is considered a vital aquatic ecosystem as it is listed in the network of Natura 2000 and has been characterized as a Permanent Wildlife Refuge by Greek Law. The results indicate that the delay of implementation of Lake Karla reconstruction project, the violation of Environmental Terms and the lack of environmental policy are the most important cause of pressures.

KEYWORDS

Ecosystem restoration, eco-technology, anthropogenic pressures, biodiversity

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Adaptive management of Koronia ecosystem based on external-internal dynamics

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ABSTRACT

Lake Koronia, a Ramsar and Natura site has a prolonged history of degradation to wetland status due to intensive groundwater use. In 2015 Lake Koronia water-level increased due to restoration works and a favorable hydrologic year. Consequently, Lake Koronia has progressed considerably towards autotrophy and distinct open water and littoral ecosystems and is expected to oscillate around autotrophy-heterotrophy and wetland-lake transitions depending on annual water budget. Lake Koronia, as it has been configured following water volume increase, presents ecological status assessment and management challenges. The purpose of this paper is to develop an integrated management approach combining internal and external system dynamics and an indicator detecting spatial and temporal changes. Internal factor management centers around dissolved oxygen, as it reflects primary production based on nutrient concentrations in water and sediment, exchanges at the sediment-water interface and littoral-open water interactions. The development of a dynamic aeration scheme, based on spatial and temporal ecosystem variability and real time earth insitu monitoring is proposed. External factor management focuses on agriculture, as it contributes greatly to nutrient loading and water budget determination. The eco-hydrological model SWAT assesses the impact of spatial and temporal fertilization and irrigation water application using space born geodata. Proposed agricultural practices effectiveness is evaluated. Adaptive management and ecological status assessment is based on the proposed indicator, which integrates near real time monitoring, developed protocol, and appropriate layers of Earth observation geodata. This indicator addresses water column, littoral zone, sediment and watershed loading, while complimenting the European Water Framework Directive 2000/60/EC.

KEYWORDS

Ecosystem management, watershed interactions, ecosystem functions, integrated indicators, earth observation, WFD

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A comparative study of water quality in a highly frequented seacoast in Albania

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ABSTRACT

The control and monitoring of environment is done not only to guarantee healthy ecosystems but also to put in evidence if they present any risk for humans. The new demographic changes in our country, especially in seacost regions, have increased the interes concerning their negative effects from environmental point of view in these areas.
The objective of this study was to evaluate dynamics of water quality in a highly frequented seacoast in Albania in a ten years period. For this reason, a bacteriological and chemical study was carried out from July 2015 to June 2016 on seacoast of Durrës, and the data collected were compared with those of a similar study during 2005 and 2006.
Seawater samples were taken monthly from six stations evenly distributed on this coast line. Total coliforms, faecal coliforms and intestinal enterococci were estimated using MPN method, while chemical parameters like pH, ammonia, phosphate, nitrite and nitrate where estimated using standard methods.
Our data show that after ten years, in general, bacterial indicators were increased, but at least in one station, where a new system of waste water pipes is built, bacterial parameters are decreased. High concentrations of faecal bacteria were associated with high concentration of nitrite and nitrate.
The results of this study indicate that there is no improvement in the quality of seawater in Durrës, and there is still much work to be done in order that water in this area becomes safe for bathing.

KEYWORDS

Water quality, faecal coliforms, intestinal enterococci, MPN method

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Performance of direct contact membrane distillation for simulated dyeing wastewater treatment

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ABSTRACT

It is highly desirable to develop effective technologies to address the serious environmental issues caused by dyeing wastewater. Herein, a promising direct contact membrane distillation (DCMD) process was developed for the treatment of simulated dyeing wastewater. Commercial polytetrafluoroethylene (PTFE) and polyvinylidene fluoride (PVDF) membranes were comparatively studied with phenol, aniline and sulfanilic acid served as the model foulants of simulated dyeing wastewater. The influence of several important operation parameters including feed temperature, feed flow rate, feed concentration on flux and rejection was systematically investigated. The result indicated that increasing working temperature of feed and cross flow velocity contribute positivelyto flux of DCMD process. Limited rejection for phenol and aniline was achieved due to the effumability of these compounds. Sulfanilic acid at lower concentration presented higher rejection performance at all operating conditions. Furthermore, the PTFE membranes presented higher rejection than that of PVDF membranes, which can be due to the strong negatively charged surface of the PTFE membranes. These promising results suggest that DCMD process could be served as an effective process to recover high purity water from dyeing wastewater in practice.

KEYWORDS

Dyeing wastewater, direct contact membrane distillation, hydrophobic membrane, model foulant

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Water isotopic and hydrochemical characteristics in Tajikistan, arid central Asia

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ABSTRACT

Main ions and hydrogen, oxygen isotopes were measured in lake water, river water and spring water collected in Tajikistan from September to October 2011, in order to analysis the spatial distribution characteristics and their potential environmental significance. The results showed that stable isotopic variations and ions of water reflect the environment character of different area of Tajikistan. Ca2+ and HCO3- are the dominant ions of river water and spring water, which are mainly come from the calcite and dolomite weathering. Few water samples are Ca-SO42- and Na-HCO3- impacted by the evaporation and silicate weathering. The lakes of Tajikistan are most located in the east mountainous area with the quality types of Mg-SO42- and Na-Cl-, impacted by long time evaporation under arid climate condition. The hydrogen and oxygen isotopes of river and spring water in Tajikistan range from -129~-65‰ and -17~-9.3‰, respectively, and enrichment from east to west in space, indicated that the east river and spring water are mainly supplied by glacier, and the west water mainly the precipitation. The relationship between hydrogen and oxygen isotopes of east and west river water are obviously different impacted by the sources of water, which are δD=9.2×δ18O+28.0 and δD=5.5×δ18O-10.7. The correlation between hydrochemical and isotopic variations in lake water mainly reflected the degree of water evaporation.

KEYWORDS

Tajikistan, hydrogen and oxygen isotopes, hydrochemical types, environmental characteristics

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New, energy saving, cleaning procedures in MBR systems

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ABSTRACT

Global climate changes result in serious consequences to ecosystems. Worldwide governments are taking steps to address the challenge in order to find measures to tackle the problem. The UNFCCC in 1992 in Rio de Janeiro and the Kyoto Protocol, were formed the international framework for combating climate change. One of the measures endorsed this protocol was about a sensible use of limited water resources and reuse them. Nowadays, Membrane Bioreactor systems (MBR) are introduced as an appropriate wastewater treatment method, having the advantage to produce effluent at high quality, suitable for reuse. Unfortunately the MBR systems seem to over consume energy due to aeration needs for membrane cleaning. In this study, new membrane cleaning approaches of an MBR pilot plant for a synthetic urban wastewater treatment are examined. These are based on membrane backwashing procedures, using water at increased temperature (up to 28°C), or/and in combination with high frequency powerful vibration (HFPV) on the membrane's module. Using the above procedures fewer backwash cleaning steps are required using higher backwash water temperatures in a certain backwashing period, contributing in energy savings of the backwash system of about 50%. This rate becomes even higher in combination of HFPV with backwash procedures and it reaches a profit in energy consumption of around 90% of the backwash system. In addition the influence of HFPV in combination with backwash procedure on the cleaning efficiency of membrane's module has a result the increase even more the effluent flow, giving an extra profit of the overall system performance.

KEYWORDS

Backwash, vibration, HFPV, wastewater treatment

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Stable isotopes (δD & $\delta^{18}O$) and major ion chemistry of surface waters in Tajikistan, arid central Asia

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ABSTRACT

Major ions and isotopes of hydrogen and oxygen were measured in lake, river and spring water samples collected in Tajikistan from September to October 2011. Stable isotopic values and ion concentrations in waters reflect the environmental conditions in different areas of Tajikistan. Ca^{2+} and HCO_3^- are the dominant ions of river and spring waters, and come mainly from calcite and dolomite weathering. Several water samples are of the Ca-SO_4^{2-} and Na-HCO_3^- type and reflect strong evaporation and silicate weathering. Most lakes of Tajikistan are located in the eastern, mountainous area and are of the Mg-SO_4^{2-} and Na-Cl^- type, reflecting persistent, long-term evaporation under an arid climate. The hydrogen and oxygen isotope values of river and spring water in Tajikistan range from -129 to -65‰ and -17 to -9.3‰, respectively, and display larger values in the west, indicating that river and spring waters in the east are supplied mainly by glaciers, and waters in the west come mainly from precipitation. Relations between hydrogen and oxygen isotopes in waters from the eastern ($\delta D=9.2\times\delta^{18}O+28.0$) and western ($\delta D=5.5\times\delta^{18}O-10.7$) rivers differ as a consequence of different water sources in the two areas. Correlations between hydrochemical and isotope values in lake water mainly reflect the intensity of evaporation.

KEYWORDS

Tajikistan, hydrogen and oxygen isotopes, hydrochemical types, environmental characteristics

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Comparative study of the environmental state of Ohrid and Prespa lakes, Albania

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ABSTRACT

The present study was undertaken to evaluate the environmental situation of Ohrid and Prespa Lakes with regard to heavy metals present in water in relation to different factors controlling metals occurrence in these environments.
A total of 15 water samples, collected at different stations and depths were selected to monitor Ohrid Lake whilst 4 samples were collected at Prespa Lake. Content of heavy metals such as Cr, Ni, Fe, Pb, Cd, Cu was determined in the filtered fraction of water, using the GF-AAS technique whilst chlorophyll "a" content was used as algal content estimation in both lakes. The relative abundance of heavy metals in Ohrid Lake followed the order: Fe>Cr>Ni>Pb>Cu>Cd while in Prespa Lake the metals order changed to Fe>Ni>Cr>Pb>Cu>Cd. Total mean concentration of Fe, Ni and Cr varied significantly (α=0.05) between the lakes whilst the mean concentration of Cu, Pb and Cd exhibited no significant variation.
Variation of metals concentration with regard to different depths was more evident for Fe, assuming that the content of the dissolved fraction of this element was closely related to water parameters such as pH, water oxygenation, redox potential, etc. Cluster analyses confirm that positive correlation existed between stations S1-S3 and S4-S6 as well as between Fe-Cr-Ni, assuming that metals content was closely related to station location. Estimation of the quality state of the lakes was evaluated based on the European Directives of fresh surface waters such as [78/659/EEC] and (EU, 1989). Given the results, it can be concluded that waters of Ohrid and Prespa Lakes fall in Class A1 of waters quality regarding the heavy metals content, whilst low levels of dissolved oxygen, followed by higher levels of chlorophyll "a" classify deep waters of Prespa Lake in Class A2 of surface waters quality.

KEYWORDS

Heavy metals, water column, Ohrid and Prespa Lake, GFAAS

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Water quality in Osumi, Devolli and Shkumbini rivers, using benthic invertebrates

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ABSTRACT

Anthropogenic activities have increased recently affecting among others, the ecological integrity within the aquatic ecosystems in the river waters in Albania. This paper promotes the biological monitoring of water quality, using macro invertebrates as bio indicators and definition of biological indices as a useful method of evaluating the ecological health status of rivers. Water Frame Directive (2000) implementation requires the use of benthic macro invertebrates as biological indicators for monitoring of water quality. The study presents the relation between benthic macro-invertebrate quantity, and the water quality status in Osumi, Devolli and Shkumbini Rivers, south Albania, during the Summer of 2011 through the Spring of 2013. The results obtained from the study refer to a total number of individuals of 4845 (42 families) in Osumi River, 3469 individuals (31 families) in Devolli River and 5991 individuals (34 families) in Shkumbini River. Based on the SWRC-Biotic Index calculations the following results have been obtained: Osumi River; **St.1** (4.31; 5.39; 4.20; 4.61; 4.37; 4.26; 4.23; 4.15): **St.2** (4.77; 5.52; 3.85; 4.12; 4.76; 4.04; 4.03; 4.07): **St.3** (5.57; 5.15; 3.85; 3.99; 5.42; 5.29; 5.09; 4.91). Water quality bio classification has been carried out as well during the study. Based on the results of this study the two first sampling stations at Osumi River are classified as "good" water quality, while the third sampling station is qualified as "fair" water quality. Generally we can conclude that the water quality of the three Rivers in Albania is still good and slightly impacted.

KEYWORDS

Macro-invertebrates, WFD, bio classification, SWRC-Biotic Index

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Assessment of pollution pressure over water bodies in Thessaly region

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ABSTRACT

Water, as an irreplaceable resource for the survival of all living organisms ,health and economic development, has an outstanding role to biodiversity, to vulnerable ecosystems and bio-geological cycles preservation. Especially in the Mediterranean region, on one hand, the observed and the future projected precipitation decreases due to climate changes and on the other hand, the contamination of water bodies due to anthropogenic activities, set in danger water systems balance. The scope of this study is to quantify the effect of pollution pressure, so that to contribute in the environmental protection on the water bodies of Thessaly region. Microbiological, biological and physio-chemical parameters are studied and defined in order to estimate the pollution of Thessaly's water resources, focusing on surface waters of rivers and lakes, underground and rain waters predestined for drinking water. Furthermore, the meteorological conditions along with the back trajectories of air masses during rain events over the wider area of Thessaly are also investigated. As the interest in protection and exploitation of water bodies is increased, the knowledge of the contaminants and the quality changes is important. The results of this research can contribute to the design and taking of appropriate measures to confront the impacts on water bodies.

KEYWORDS

Pinios River, pollution pressure, basin of River, ecological and chemical balance

Study of contamination of the transboundary river Kura in Georgia

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ABSTRACT

In the article is presented pollution study on the River Kura and its surrounding area at background and anthropogenic points - dynamics of the last year. The study covers the Kura river basin with its tributaries from the Turkish border up to the Azerbaijan border in the article is presented the assessment of the pollution distribution from the upstream to downstream taking into account transboundary issues. River Kura environmental assessment on the territory of Georgia was based on physical-chemical and chemical parameters, which are characteristic for the basin. physical-chemical (water temperature, pH, BOD5, biogenic elements, main anions and cations, total petroleum hydrocarbons (TPH), heavy metals and other parameters were measured depending the EU Water Framework Directive. The sampling of the water, conservation, labelling, storage and transportation were produced in the accordance with the International Standard Organization (ISO) methodology. The study was conducted in the accredited laboratory by the ISO 17025 standard. Analyzes were carried out by the atmospheric air, water and soil analyses laboratory of the National Environmental Agency of the Ministry of environment and natural resources protection of Georgia in the following technical and instrumental support: plasma –emission spectrometer (ICP-OES) on the ISO 11885: 2007; Ion chromatography ICP_OES; spectrometers; GC_MS; IC; conductivity meter; pH meter; turbidity meter; DO meter.

KEYWORDS

Anthropogenic impact, pollution transboundary Georgia, Turkey, Azerbaijan, Kura, water quality, pollutants, EU directives

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Biodiversity indices and nutrient load assessment in Ishmi river, Albania, during 2012-2013

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ABSTRACT

Ishmi River basin is located in the central part of Albania crossing inhabited, industrial and agriculture areas. These activities have a direct impact on the aquatic ecosystem and water quality. The catchment area of Ishmi River consists of several tributaries, including the Lana, Tirana, and Tërkuza Rivers which join to create the Gjola Tributary; close to the River Delta, Zezë and Gjola Rivers together with Droja spring join into Ishmi River which flows into Adriatic Sea (Eftimi, 1989). Taking into consideration the River catchment area, its hydrological characteristics and recent rural and urban development's and industrial activities, we have monitored and analysed the water quality by assessing the biodiversity indices of benthic bio indicators and nutrient load in three monitoring stations along the River during 2012 – 2013. Benthic macro invertebrates are sampled seasonally according to Water Framework Directive (WFD) requirements and the Shannon and Simpson Indices were calculated; while nutrient load for each of the water samples was assessed according to Standard Methods for Examination of Water and Wastewater, APHA, 1998. The study' results indicate that the nutrients content as $P\text{-}PO_4^{3-}$, $N\text{-}NO_3^-$, $N\text{-}NH_4^-$, $N\text{-}NO_2^-$, increases due to the high organic pollution load and it causes the decrease of benthic invertebrate taxa and variation of Biodiversity Indices.

KEYWORDS

Shannon Index, Simpson Index, nutrient load, water quality

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Land management, climate, and water quality: Focus on the western lake Erie basin

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ABSTRACT

Land use/land management and climate are typically considered separately yet their interaction suggest the need to look at both concurrently in order to understand their interactions, effectively disaggregate their water quality impacts, and design effective management strategies. This study characterizes land use/land management, climate, and water quality in the Western Lake Erie Basin with a view to discerning prevailing trends and patterns, and providing information to guide future research efforts in the basin. An analysis of land use, land management, and climate is first presented, followed by an assessment of water quality trends at different locations in the basin. Finally, the associations and implications for further work are discussed.

KEYWORDS

Land use/land management, Climate, Water quality

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Modeling of simultaneous heat and mass transfer in solar distillers at low temperatures

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ABSTRACT

Modeling of simultaneous heat and mass transfers natural convection, for distillers with flat or curved covers, is made. It is based on a stagnant and isotherm core within the fluid, surrounded by an active area near the walls. The approach is validated by experimental results, obtained for a solar trapezoidal distiller with flat and semi-cylindrical condensing covers. The results are in agreement.

KEYWORDS

Heat and mass transfer, natural convection, solar distillation, greenhouses, solar drying, transfers in cavities

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Possibility of artificial beach nourishment using crushed limestone aggregate

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ABSTRACT

Beach feeding has become one of the most popular approaches to coastal engineering over the past decade and many see it as the ultimate saviour, both for increased coastal defence and for tourism. There are two aims of this research: to analyze the change of particle size distribution and grains shape after nourishment and to analyze how shape of crushed limestone aggregate can be improved before beach nourishment to become more comfortable. For this purpose, 13 samples from different parts of an artificial hotel's beach located at Split (Adriatic Sea) were taken and analyzed almost two years after filling the beach with the crushed limestone with coarser grains (16 – 31.5 mm) mixed with the same size river pebbles. The particle size distribution and shape index were analysed for all samples. Also, a few samples of the crushed limestone were taken from the quarry, where the material was taken for beach nourishment. In order to improve grains shape, these samples were subjected to abrasion, by mixing in a laboratory pan mixers or in a ball mill. The particle size distribution and shape index were then analyzed and compared with results obtained on samples from the beach. Shape of crushed aggregate can be improved by the methods of abrasion. For the purpose of beach nourishment this could be too expensive, but the power of the waves to create shape of aggregate before beach filling can be useful for this go.

KEYWORDS

Beach renourishment, crushed limestone, shape index, Faury coefficient

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The impact of drinking water on the prevalence of helicobacter pylori in humans in Elbasan, Albania

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ABSTRACT

Many studies are carried out about the Helicobacter pylori in different countries these three last decades, but this is the first one in Albania. In some of them the authors are focused on its biology and in some others on the impact of environmental conditions in the persons affected by it. The aim of this paper is to present the impact of drinking water consumed by humans on the prevalence of Helicobacter pylori in the district of Elbasan in Albania. The study concerns the period from January 2011 to May 2014. In order to find out the presence of this bacteria in these persons, some analyzes based on the "Sandwich Elisa Test "are carried out. During this period of time are analyzed 886 blood samples taken from 886 persons and resulted that 74 % of them were affected by Helicobacter pylori. The data show that there is different number of persons affected by this bacteria based on the different type of drinking water consumed by them. Some other data about the prevalence of Helicobacter pylori regarding the age and their dwelling-place are presented too. In conclusion, some very important recommendations in order to decrease the value of this prevalence are given.

KEYWORDS

Helicobacter pylori, drinking water, dwelling-place, Elbasan

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Groundwater contamination from uninsulated sewage tanks in an eastern Hungarian settlement

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ABSTRACT

In settlements without sewage systems the uninsulated sewage tanks are the most important sources of groundwater contamination. In our specific eastern Hungarian case study, we attempted to demonstrate the effects of wastewater effluent on the groundwater level and the spatial distribution of the organic matter (OM) and Na^+ in the autumn of 2013. In 2012 we established 3 metre deep monitoring wells within a 25 metre radius of a sewage tank, which were sampled, and the level of groundwater was recorded. The results show that the outflow wastewater formed a groundwater dome. The difference between the groundwater levels measured in the monitoring wells was 49 cm. In the immediate environment of the sewage tank we measured a chemical oxygen demand (COD) of more than 24 mg/l. Moving away from the sewage tank the values decreased rapidly; in the farthest monitoring wells we detected COD values of between 4 and 7 mg/l. The high Na^+ content of domestic wastewaters significantly increases the Na^+ content of the groundwater. In the vicinity of the sewage tank, we detected very high concentrations above 450 mg/l, which continuously decreased when moving away from the sewage tank. In the farthest monitoring wells west and southeast from the sewage tank we measured concentrations of Na^+ of 270 mg/l and 159 mg/l.

KEYWORDS

Groundwater salinity, contamination, wastewater, sewage tank, chemical oxygen demand, modelling

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Linkages between physicochemical status and hydromorphology in Greek lakes under WFD policy

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ABSTRACT

The national monitoring network of waters in Greece, in the context of Water Framework Directive, has been operational since 2012. It comprises 50 lake water bodies, both natural and artificial (24 and 26 respectively). The aims of the study are i) to present the main features of Greek lakes; ii) to position them according to hydromorphological and physicochemical data from the first period of monitoring and iii) to investigate how the hydromorphological features influence water quality. Greek lakes are discerned in relation to hydromorphological aspects such as mean depth, volume, surface area, catchment area. Impacted and unimpacted lakes are separated when positioned along physical and chemical attributes, such as Secchi depth, TP and ion concentrations. The dataset covers a gradient of eutrophication, which seems to be the main anthropogenic pressure on lakes in Greece and probably one of the most widespread anthropogenic pressures on lakes across Europe. Catchment areas of the Greek lakes have undergone substantial agricultural, industrial, and urban development over recent years, leading to eutrophication and hydromorphological alterations. Management measures at a catchment scale aiming to control land uses would be needed in order to maintain and/or improve water quality in Greek lakes, supplemented by site-specific measures when appropriate. The monitoring network provides baseline data that will allow the assessment of status and trends of Greek lakes.

KEYWORDS

WFD, Greek lakes, hydromorphology, water quality

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Relationship between water yield and water quality in broadleaf forested watersheds

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ABSTRACT

Forest ecosystems provide fresh water with best quality in sustainable manner but they consume huge amount of water. Researchers apply different forestry practices to increase water yield by minimizing water loss through evapotranspiration and maximizing amount of rainwater reaching soil surface in the watersheds. Studies showed that water yield and nutrient losses increase after clear cutting. High nutrient concentrations in the streamwater cause deterioration in the water quality. Therefore, objectives of this study were to investigate relationship between amount of annual streamflow and nutrient outflux and quantify nutrient losses in three oak-beech mixed forest covered watersheds. The experimental watersheds were located in Istanbul with sizes of 77.4 ha, 71.9 ha, and 17.5 ha. Water samples were collected from the streams of the watersheds on weekly basis and analyzed for pH, electrical conductivity (EC), total suspended sediment (TSS), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), total nitrogen (TN), sodium (Na^+), potassium (K^+), iron (Fe^{3+}), aluminum (Al^{3+}), ammonium nitrogen (NH_4^+ - N), and sulfate $(SO_4)^{2-}$. Regression equations were developed between annual water yields and nutrient outfluxes. Results showed that there were significant relationships between annual water yield and nutrient outflux except for pH and EC and these parameters showed increase with the increase in the streamflow discharge. This means that if the water yield increases after timber harvest then water quality can be deteriorated in the watersheds.

KEYWORDS

Water yield, water quality, forestry activities, nutrient flux

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Water quality model of Alibeyköy watershed and LID implementation

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ABSTRACT

Uncontrolled urbanization causes flood and poor water quality which results in an increase in peak flow rate and in Total Suspended Solid (TSS) concentration. Low Impact Development (LID) is a Best Management Practice (BMP) and land planning method which may be used to manage storm water runoff to reduce flooding as well as simultaneously improve water quality. Preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage, which treats storm water as a resource rather than as a waste product, are intended by implementing LID. There are several LID type of storm water BMPs such as bioretention, vegetated rooftops, rain barrels, vegetative swales and permeable pavements. In this study, the impact of LID implementation on TSS are investigated by developing a water quality model for Alibeyköy Watershed located in Istanbul, Turkey. For this purpose, the calibrated hydrologic model of Alibeyköy Watershed developed by using Environmental Protection Agency Storm Water Management Model (EPA SWMM) is employed. The water quality model is integrated into the hydrological model using EPA SWMM. Then, several LID types such as retention basins, vegetative swales and permeable pavement are incorporated into the water quality model and their impacts on TSS in Alibeyköy Watershed are observed.

KEYWORDS

Storm water treatment, Low Impact Development, Watershed Model, Total Suspended Solid (TSS) concentration

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Change of land use and soil coverage in the area of influence of Natural National Park Los Nevados

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ABSTRACT

The Nevados National Natural Park (NNNP) and its glaciers El Ruiz and Santa Isabel have been affected by different changes during last decades as land use changes, climate change and changes in extreme events, reason why it has been prioritized to understand its impacts in order to counteract these effects or to delay them. The paper focuses on the recent state of glaciers, moorlands and tropical forests and their changes occurred in the area of influence of NNNP during last decades. This project use remote sensing (Landsat Images) and application of geophysics (Mission Grace) to obtain results. The evaluation carried out from the analysis of satellite images show a notorious retreat of the glacier layer and the geophysical approach has been indicating a reduction of its thickness, keeping in mind that land use and soil covers in the area of influence of NNNP are changing. The reduction of moorlands in favour of livestock and potato crop with its impact on social and environmental aspects is a relevant conclusion. All these changes in general comprise the area of influence of NNNP and have affected its initial dynamics. This analysis serves as a tool for decision makers in the water resources planning and land management in their hydric and social part, based on information of free access as remote sensors images.

KEYWORDS

Land use changes, soil cover changes, remote sensing, glacier retreat

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Comparison of two habitat modeling approaches for the determination of the ecological flow

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ABSTRACT

Over the past decades, severe environmental problems have been caused by the inefficient water resources management by humans; in rivers, diversions, dam constructions and water abstractions mainly for irrigation purposes lead to flow-regime alterations and threat river ecosystems mainly during the dry period when the flow is dramatically reduced. To prevent fish extinction and ensure the good ecological status of aquatic ecosystems, the EU Water Framework Directive proposes the definition of a minimum flow rate, commonly called "Ecological Flow", in rivers. In this study, we compare two different approaches for the determination of the Ecological Flow in Sperchios river, Central Greece, for the case of Squalius vardarensis which is the most important species inhabiting this river. The first approach is the habitat model PHABSIM which is an easy-to-use engineering tool utilizing one-dimensional calculations both for hydraulic and habitat modeling. We define Ecological Flow via the calculation of the Weighted Usable Area of the river as a function of discharge. The second approach is an integrated two-dimensional habitat model which was developed in the National Technical University of Athens in cooperation with the Technical University of Munich and the Hellenic Centre for Marine Research; this model is a combination of the hydrodynamic model TELEMAC-2D and a habitat model. The results of the two methods are in reasonable agreement; however, the two-dimensional calculations offer higher accuracy and reliability but require much more detailed input data and computational time compared to the one-dimensional method.

KEYWORDS

Ecological flow, Habitat Modeling, PHABSIM, Telemac-2D, Sperchios river

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Annual sediment yield prediction by means of three soil erosion models at the basin scale

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ABSTRACT

The objective of this study is the estimate of annual sediment yields deriving from soil and streambed erosion, at the outlet of a basin. Continuous simulations of soil and streambed erosion processes are performed in Nestos River basin, on an hourly time basis, for a five-year period. Three different soil erosion models are applied, as part of three Composite Mathematical Models. The first and third Composite Mathematical Models consist of three submodels: a rainfall-runoff submodel, a soil erosion submodel and a sediment transport submodel for streams, whilst the second one does not include a rainfall-runoff submodel and only consists of the soil erosion submodel and of several empirical sediment delivery ratio methods, for the estimation of the final sediment yield at the basin outlet. The rainfall-runoff submodel that is used for the computation of the surface runoff and the streamflow in the sub-basins, is the hydrologic model HEC-HMS 4.2. The first soil erosion submodel, utilized for the estimate of soil erosion in a sub-basin, is based on the relationships of Poesen (1985), the second is the widely known Universal Soil Loss Equation (USLE), while the third is the Modified version of USLE (MUSLE). The sediment routing for the first and third Composite Mathematical Models is achieved by means of the stream sediment transport model of Yang and Stall (1976). The three models are compared as to their ability to realistically predict annual sediment yields at the basin scale.

KEYWORDS

Annual sediment yields, soil erosion, sediment transport, USLE, MUSLE

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Bioavailability of metals in soils irrigated by synthetic wastewater: Metal Speciation

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ABSTRACT

In Lebanon, Bekaa valley is an agricultural zone; during the dry season, water is withdrawn from Litani River for irrigation which is mostly domestic and industrial waste water. Metal mobility, bioavailability, or potential risks can be anticipated by metal speciation in soil and water. The objective of this study was to investigate the speciation of metals in soil and water of upper Litani basin. Soils samples were subjected to a modified BCR sequential extraction technique that operationally extracts metals as acid soluble, reducible, oxidizing, and residual fraction. Metal content in each fraction and total metal in water were determined by AAS and ICP-MS techniques. Sediment pH, Eh and TOC and macro water parameter were determined. Speciation of metals in water was predicted PHREEQC geochemical computer model. Results indicated in non-residual fraction respectively highest average % of total metal are in reducible and acid soluble (Mn: 27 %, 18; Zn: 18 %; Cr: 27%, 34%; As: 28% , 20%); in oxidizing and acid soluble (Cu: 25%, 10%; Ni: 24%, 33%; Cd: 16%, 23%, Hg: 23;%, 12%). Metal speciation variations among sites were related to the levels of TOC and Eh and water BOD. The ICF values indicate a considerable contamination for As, Cd, Cr, Ni; and GCF indicated 50 % of sites of considerable contamination. Speciation in water predicted existence of the toxic free aqua ion (Mn: 6—97%; Zn: 35-89%; Ni: 60-90%; Cd: 35-82 %). These and soil GCF values reflect the high degree of metal bioavailability, toxicity, and potential risk.

KEYWORDS

Wastewater, soil, metal speciation, bioavailability, Upper Litani basin, Lebanon

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Finding a sustainable balance in the water food nexus – socio-economic transformation in an agricultural catchment

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ABSTRACT

Increasingly the competition for water between food production and the environment threatens the viability of agricultural communities. This paper focused on this water-food-environment nexus in the Murrumbidgee River Basin, Australia, and how it contributed to the evolution of the regional economy and changing demographic patterns. Paradoxically, against expectations, changes in water management favouring the environment coincided with falling unemployment and increase in average regional income, despite a decline in agriculture. To understand this, and to explore how the competition for water played out in the Murrumbidgee Basin, we develop and use a socio-hydrologic model that explicitly considers bi-directional feedbacks between human and water systems. The modelling shows that in response to widespread ecosystem degradation, community sentiment forced new water management policies that favoured ecosystems which inevitably led to reductions in agriculture production. In response, the basin economy reorganized through sectoral transformation to the manufacturing and service sectors, improved agricultural practices, and out-migration of basin residents. The sectoral transformation was facilitated by capital available for investment in manufacturing and service sectors with knock-on impacts on population dynamics and unemployment. Collectively these contributed to a sustainable transformation of the basin economy. The study shows how transformation of the basin economy and demographics mitigated potentially adverse economic outcomes and enabled society to cope with water management decisions that favoured the environment. The dynamics outlined here highlight the adaptive capacity of people and movement of capital in a free economy, supported by appropriate strategies and funding, to cope with water stress.

KEYWORDS

Socio-hydrology, irrigation, ecosystems, water management, employment, sectoral transformation

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Assessing the quality of bottled water brands using a new water quality index

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ABSTRACT

The aim of the paper is to present a newly derived water quality index, specifically developed for assessing the quality of bottled water. Several requirements have been set by the European Union through legislation which all the member states are obliged to fulfil for the bottled waters available in their markets. So, the question arises how good these waters are, if the values of the various parameters shown on the labels are close to reality, and how the consumer can easily and quickly evaluate bottled water brands. A total of 79 different bottled water brands available in the Greek market were evaluated and compared using a specially designed bottled water quality index (BWQI). The index combines one microbiological and six physicochemical parameters. The assessment is based on both laboratory analysis results and values on bottle labels. The index calculator was installed at a specially designed webpage which is easily accessible via personal computers or smart phones. According to the results obtained, it is concluded that the majority of the bottled water samples examined were of excellent or very good quality, a small number was characterised as of good quality, and very few samples failed to attain the good quality status. The new water quality index proved to be a quick, sensitive and powerful tool to assess and compare the quality of bottled waters.

KEYWORDS

Bottled waters, water quality, laboratory tests, bottled water quality index (BWQI), multiplicative model

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GIS-based spatial decision support system for the optimum siting of offshore windfarms

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ABSTRACT

The development of Renewable Energy Sources (RES) as an alternative to fossil fuels has gained significant ground in the last years with the EU aiming at 27% energy production from RES until 2030. However, the lack of suitable land based RES sites due to various constrains (aesthetic nuisance, environmental impacts etc.) has led to the development of offshore windfarms sites. Currently available software packages for wind farms siting take into consideration only wind power, cost and potential energy production but they do not give to the users the capability to simultaneously evaluate various candidate sites; instead, the users have to pre-select a site and then analyze the data. Nevertheless, this procedure is complex and crucial factors must be considered (environmental, socio-economic, spatial planning) and a software that would analyze critical data and compare the candidate sites would contribute remarkably to the evolution of offshore windfarms siting. The current study is aiming to the development of a holistic methodology for the optimum siting of offshore windfarms that will be implemented through a web-based GIS software. The whole process could be briefly depicted by the following steps: exclude sites that do not fulfil the criteria, asses the candidate sites through an analytical hierarchical process, form energy scenarios for every candidate site and then select the optimum. This software will be a precious decision support system for the stakeholders.

KEYWORDS

GIS-based software, Offshore Wind Farms, Siting, Analytic Hierarchical Process, Public Participation

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Development of an updated water quality index based on legislation and experts' opinion

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ABSTRACT

Water quality assessment is based on measurements of physical, chemical and biological parameters according to enforced legislation, while water quality characterization is achieved by using water quality indices (WQI) developed during the past decades. These indices transform a plethora of measurement data into a single characterization value. Nevertheless, the results obtained from the application of various water quality indices are not easily comparable because of their different calculation methodologies. Additionally, many water quality monitoring parameters that are prioritized by legislation (pesticides, halogenated hydrocarbons, heavy metals, pathogens, etc) are excluded from the indices´ calculation. This work presents the effort to update the water quality indices, by taking into account additional monitoring parameters that are considered important, and to redefine their weight coefficients. For this purpose, over 1000 questionnaires were send to researchers, institutions, universities, national, European and international organizations, water management authorities, relevant ministries, water supply companies and non-governmental organizations worldwide. From the questionnaires' interpretation a new water quality index, named "ΥΔΩΡ WQI", was created. "ΥΔΩΡ WQI" characterizes water quality in relation to monitoring parameters included in the latest guidelines of European Union, United States Environmental Protection Agency and World Health Organization. The new water quality index was validated using over three years' data from surface water and groundwater of Western Macedonia Region, Greece, and by comparing its results to those obtained from other indices (NSF, Canadian etc.).

KEYWORDS

Water Quality Indices, water quality classification, water quality assessment

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Water management in nuclear power plant using advanced low-temperature systems

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ABSTRACT

Nuclear power plants (NPPs) consume large quantity of water, more than coal-burning plants. Water is used in every-day plant operation for dissipation of large amount of heat produced by nuclear reactors. Big volumes of clean water are needed in emergency situations for decontamination of contaminated buildings, equipment and apparatus. On the other hand, the need for cleaning large amounts of contaminated water in such cases requires appropriate purification systems. Moreover, during regular operation the NPPs produce also some amounts of contaminated liquid effluents that need treatment. Appropriate water management in nuclear power plants reduces water consumption and decreases emission of radioactive pollutants to the environment. In the paper the possibility of using membrane methods for water desalination, which could be coupled with nuclear reactor supplying heat and electricity for operation of membrane installations, is reported. Such processes like reverse osmosis and membrane distillation are low-temperature desalination methods that could be driven using heat from the condenser or from the vapour generator. The main aims to construct the membrane installations in the NPP will be production of large amount of clean water for power plant purposes, as well as wastewater decontamination. The use of nuclear energy for desalination provides number of benefits; such an approach is economic and environment-friendly. Shared facilities, low operational costs and the possibility of optimisation make nuclear desalination competitive and profitable method for production of pure water, as well as rational for low level waste management in the future NPPs.

KEYWORDS

Nuclear desalination, reverse osmosis, membrane distillation, water management

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Two phase equilibrium study of liquid membrane separation process for the removal of As (III) & As (V) from drinking water

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ABSTRACT

For the past two decades arsenic contamination in drinking water around the globe has led to the research and development of several removal technologies due to its high toxicity. The liquid membrane separation technique being highly selective, simple design and requires low energy has been employed here for the removal of arsenic from its aqueous solution for the purification of drinking water. This work is intended to identify environmentally benign organic solvent, receiving phase and extractant for the extraction and recovery of arsenic ions from its aqueous solution through two-phase equilibrium study. Sodium arsenite and sodium arsenate salts have been used for feed phase solutions of As (III) and As (V), respectively. Amongst the conventional organic chemicals and environmentally benign solvents used as liquid membrane, sesame oil with Aliquat as the extractant increased the extraction of arsenic ions from 50% (without extractant) to 90% (with extractant).

KEYWORDS

Arsenic, two-phase equilibrium study, environmentally benign, liquid membrane, extractant

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Productivity analysis based on fuzzy logic on paddy area irrigated by varied water sources

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ABSTRACT

This study aims to determine the quality of water resources used in four paddy areas selected in Meriç-Ergene Basin of Turkey and find out the effects of these waters on soil productivity using Fuzzy Logic which have recently been used both in Turkey and in the world. Primarily, quality parameters of different water resources which are the water from River Ergene, ground water, the water from River Meriç and dam lake water were determined and analyzed in the running of the model. Changes in the properties of water resources are modeled and interpreted in terms of soil productivity with Fuzzy logic. Chemical analysis of samples obtained from water resources examined in the study is done according to standard methods. In the analysis of water samples saltiness (EC, pH, Na), trace element (Mn, Zn, Fe, Cu), and heavy metal (Pb, As, Cd, Ni, Cr, Co) parameters were examined. In the model, these parameters which directly effects soil productivity are considered as input variables, and productivity is considered as output variable. Soil productivity profiles (%) of the region consisting different soil types have been determined by obtaining the fuzzy values related to these parameters. Soil productivity values differ between 40-60%. According to the obtained results; it can be said that Fuzzy Logic model which is used in many sciences should be useful in agricultural field studies.

KEYWORDS

Fuzzy logic, water quality, macro and micro elements, modelling

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Wastewater treatment by solar air gap multi-stage membrane distillation

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ABSTRACT

Scarcity of fresh water and availability of solar irradiation constitute the perfect condition for developing small-scale solar waste water treatment plants. One of the suitable low energy process applicable is Membrane Distillation (MD). MD is a relatively lower temperature process which does not need to operate under high pressure like Reverse Osmosis (RO). A hydrophobic membrane maintains a barrier between hot feed water and coolant flowing outside. The vapour generated due to partial pressure difference crosses the pores of this hydrophobic membrane and travels toward the cooler side to condense and produce distillate. In this paper, performance of a solar assisted multi-stage MD system has been analysed. Our previous experimental multi-stage MD setup gave a hike of 5.6 times in production per kWh of energy input compared to a single stage. In this study, an average annual solar radiation of 1571 kWh/m2 has been incorporated in the multi-stage MD system with a narrow air gap between the coolant and feed. It has been observed that using smaller sized multiple chambers in the process can enhance the production of fresh water compared to a bigger sized chamber with a single large membrane. Association of solar heat into the MD module can contribute to further energy savings and producing up to 220 l/day of freshwater in hot tropical climate.

KEYWORDS

Air Gap Membrane Distillation, Multi-stage Membrane Distillation, Solar Energy, Wastewater Treatment

VI. Urban Water Networks

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Efficient parallel evolutionary optimization algorithm applied to a water distribution system

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ABSTRACT

Water distribution systems are key components of public infrastructure and it is essential to design, manage and rehabilitate them economically without compromising the required performance and regulatory standards. Evolutionary optimization algorithms such as genetic algorithms have become popular in providing optimal and near optimal solutions to various optimisation problems on water distribution systems. However, one of the main challenges associated with genetic algorithms in the optimization of water distribution systems is that they are time consuming when applied to problems on real-world water distribution networks with large numbers of pipes and multiple operating conditions. For example, in the optimisation of large water distribution systems, a single optimisation run may involve millions of hydraulic and water quality simulations that may take many days on modern powerful computers such as workstations. One way to address this difficulty is by utilising parallel computing methods. The aim of the research was to investigate the potential improvement in computational efficiency achievable through parallel computing by optimizing a design based on a real-world water distribution network with a large number of decision variables, large solution space and complex response surface. The results showed that the parallel algorithm developed was practical and found optimal and near-optimal solutions reliably and efficiently, and the solutions achieved were consistently competitive. The average speedup achieved on an eight-core workstation was 15, based on an optimization problem with hundreds of decision variables for a real-world water distribution network with extended period simulation.

KEYWORDS

Water distribution network, penalty-free multiobjective evolutionary optimization, pressure-driven analysis, discrete optimization, demand satisfaction ratio, controller-worker model

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Modeling and optimization control of a hybrid water system

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ABSTRACT

In most deltas, rivers and channels compose to a water network system. Different water conservancy projects, such as pumping stations, sluices, and barriers are constructed in the water system. These water conservancy projects change the natural water flows, i.e. the direction of a water flow is no longer controlled by the natural terrain, but by the difference in the state of the water heads between sluice gates. Even the flow of the rivers is not clear anymore. The water system influenced by a discrete state control has evolved into a complex hybrid water system. The conventional way to manage such a water system is to monitor water level changes and to control different sluice gates based on experience. However, such management is challenging and causes a serious loss of energy and resources. Therefore, a model-based optimal scheduling process is expected in practice. Unfortunately traditional hydrological models are unable to model hybrid water systems totally. Interdisciplinary research is needed, especially inheriting some approaches from the field of automation technology. This paper models a complex hybrid water system with a scheduling optimization approach. The definition "virtual tank" is introduced to solve the bi-directional flow problem of the hybrid water system. Scheduling processes in short or midterm periods are optimized with the Model Predictive Control Method (MPC). The modeling and optimization approaches are demonstrated in a case study – Smart flood control in the hybrid water network area of Jiangyin, PR China.

KEYWORDS

Bi-directional flow, Hybrid water system, MPC-MLD optimisation, Water network modelling

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Using bayesian networks for risk assessment of real losses in water distribution systems

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ABSTRACT

Severe restrictions on water resources and rapidly increasing water demands as well as the threats arising from the design and the operation of water distribution networks (WDN) are unavoidable. Deciding on which alternative to choose amidst conflicting multiple criteria and different interests of stakeholders is a rather challenging task. Therefore, the recognition of major drivers of Non-Revenue Water (NRW) and its components in WDNs is an effective strategy that addresses water scarcity. Real losses are challenging components of NRW and lead to loss of about 10 percent of water inflow; hence it is crucial to identify and reduce the effective factors on them. This paper aims to identify effective factors on real losses and score their level of presence in the pilot through questionnaires. Then it presents a Bayesian Network (BN) to demonstrate the probability relationships between factors influencing real losses. To the authors' knowledge, this is the first attempt to model factors influencing real losses in WDN using BN. The methodology properly handles the unavoidable uncertainties in available information and lack of data. To demonstrate the application of the proposed model, District 4 of Tehran Water and Wastewater Company has been studied. Results indicate that "wrong and non-standard installation of pipes and other devices" and "poor training for workers and experts" have the most influence on real losses, respectively.

KEYWORDS

Bayesian Network - Questionnaire - Real Losses - Water Distribution Networks

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Diagnosis of water pipeline systems by frequency domain analysis

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ABSTRACT

Inverse transient analysis is a tool for the diagnosis of water distribution systems based on the comparison of the results of analytical or numerical models with pressure signals acquired during transients. The needed numerical models can be derived in the time domain or in the frequency domain. The time domain approach is the most followed and lead to the method of characteristics. The traditional models derived in the frequency domain as solutions to the linearized water hammer equations, namely the impulse response and the transfer matrix methods, are efficient in the simulation but are not suited for complex arbitrarily configured networks. An alternative frequency domain formulation is the network admittance matrix method, where the equations are reorganized into a matrix form using graph-theoretic concepts. In this paper the network admittance matrix method is applied to assess its reliability in the diagnosis of water distribution systems. The unsteady-friction term is introduced in the formulation and a numerical case study is used to detect a pipe replacement in a simple system of metallic pipes. The length, the diameter and the position of the pipe replacement are considered as unknowns and estimated by means of a calibration procedure.

KEYWORDS

Transients, frequency domain, unsteady-friction, admittance, diagnosis, water pipe systems

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Reliability-based design of water distribution networks considering mechanical failures

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ABSTRACT

For effective design of Water Distribution Networks (WDNs), it is necessary to consider the reliability of the system subject to mechanical and hydraulic failures. In this paper, a reliability based framework is presented for design of WDNs using self-adaptive differential evolution (SaDE) algorithm. The framework includes three main components: a simulation model, a reliability assessment model and an optimization model. Simulation model uses EPANET toolkit for simulation of flows and pressure distribution in pipe network, and its outputs are used in reliability assessment model to determine the minimum cut sets. Reliability assessment model consists of determination of system and nodal reliabilities based on minimum cut sets. The reliability is estimated in terms of demand satisfaction subject to the mechanical failure of components. The optimization model finds optimal pipe diameters considering minimization of network cost as objective subject to a minimum level of reliability and other constraints, and the model is solved by using SaDE algorithm. The application of model is illustrated by applying it to a hypothetical WDN consisting of 17 pipes, 13 nodes, a supply source and a pump. On comparison of the results of study with previous studies, it is found that the present framework yields in better solutions and saves significant amount of computational time.

KEYWORDS

Water Distribution Network, Reliability based design, Self-Adaptive Differential Evolution Algorithm

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Stochastic gradient methods for the optimization of water supply systems

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ABSTRACT

Reductions of water deficits for users and energy savings are frequently conflicting issues when optimizing large-scale multi-reservoir and multi-user water supply systems. Undoubtedly, a high level of uncertainty due to hydrologic input variability and water demand behaviour characterizes these problems. The aim of this paper is to provide a decision support for the water system authority, in order to realize a robust decision policy, minimizing the risk of wrong future decisions. This has been done through the optimization of emergency and costly water transfer activation. Hence, a cost–risk balancing problem has been modelled to manage this problem, balancing the damages in terms of occurrences of water shortages and energy and cost requirements for emergency transfers. In Napolitano et al. (2016), we dealt with this problem using a scenario analysis approach. The obtained results were appreciable considering a limited amount of scenarios and a short time horizon. Nevertheless, if we have to increase the number of considered scenarios, taking into account the effect of climate and hydrological changes, computational problems arise. Therefore, to solve this kind of problem, it is necessary to apply a specialized approach for optimization under uncertainty. We develop herein a simulation-optimization model using the stochastic gradient methods. The study case is a multi-reservoir and multi-user water supply system in a specific area in south Sardinia (Italy), characterized by Mediterranean climate.

KEYWORDS

Stochastic gradient methods, water schedules optimization, cost–risk balancing problem

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Spectral analysis and topological and energy metrics for water network partitioning of Skiathos island

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ABSTRACT

Water network partitioning (WNP) into supply clusters aims at improving management of the whole system and subsequent definition of District Meter Areas (DMAs), simplifying water budget and pressure management as well as the identification and reduction of water losses. This solution is a strategic option used by water utilities to control and operate their Water Distribution Networks (WDNs). Thus, it is important to design DMAs in optimal way, inserting flow meters and gate valves in boundary pipes. This is a demanding task, since closure of some network links can worsen network performance in terms of hydraulic and topologic redundancy. This paper presents the application of a novel optimization approach, based on network theory and Graph Partitioning (GP), coupled with heuristic optimization techniques. The methodology uses SWANP software to cluster the network and proceeds with a novel approach for the partitioning phase, based on the minimization of a multi-objective function including both energy and spectral metrics. The methodology is tested on Skiathos Island, Greece WDN. We present interesting preliminary results based on the analysis of several performance indices that measure resilience and robustness of the partitioned network. Overall, an adequate solution to the optimal definition of hydraulic districts through DMAs is presented.

KEYWORDS

Water network partitioning, spectrum, topological metrics, optimization, multi-objective function

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Waterloss detection in streaming water flow timeseries using change-point anomaly methods

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ABSTRACT

The work described herein evaluates the utilization of a change-point method for the detection of anomalies in water consumption time series, and its applicability to waterloss detection in water distribution networks. The change-point detection method is based on the Relative unconstrained Least-Squares Importance Fitting (RuLSIF) algorithm and was implemented on a three-month-long hourly water consumption signal, successfully detecting unusual reductions and increases in the water consumption patterns, and classifying them as anomalies. The first water consumption anomaly type related to a discontinuity in the signal (a break in the consumer's water consumption patterns), whereas the second type related to an unusual increase in the signal (two waterloss incidents). Unlike traditional approaches that monitor the average current periodic consumption and compare this average to the one from a corresponding past period, the RuLSIF change-point detection approach is dynamic and sensitive to any change in the time series in study. Even though the proposed analysis does not predict future anomalies, it is suitable for past and near-real-time anomaly detection; an attribute that is sufficient for waterloss management as it allows for a timely detection of anomalies is streaming water flow data. Further, the method dynamically assigns anomaly scores to the detected changes in the signal, thus easing waterloss detection and appraising the severity of each detected incident. The change-point detection method is able to extract knowledge from past consumption patterns (the water flow signal over time) to detect anomalies in the signal, both in the past and in near-real-time, and for both physical and apparent water losses.

KEYWORDS

Waterloss detection, Water-flow anomaly detection, Real-time time-series analysis

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Towards resilient water networks by using resilience key performance indicators

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ABSTRACT

The main objective of a water distribution network (WDN) is to deliver the required amount of water to the customer under a certain threshold of the desired pressure and quality. These networks are critical infrastructures that should face multiple and continuous changes and even abnormal events that alter their normal service provision. Water utility managers require modelling tools to be able to predict how the WDN will perform during disruptive events and understand how the system can better absorb them. Assessing and enhancing resilience in water infrastructures is a crucial step towards more sustainable urban water management. Several resilience key performance indicators (RKPIs) have been suggested to quantify and assessing WDNs resilience. This work proposes a structured classification for measuring and understanding the supply system by means of RKPIs. The proposed classification is based on a three-stage resilience concept which includes absorptive, adaptive, and restorative stages. This classification attempts to provide engineers, modellers, and managers with structured tools which allow a comprehensive analysis of crisis management case studies in order to enhance the WDN resilience. As the resources in supply are usually limited, recovery phases have a crucial role in resilience enhancing, while under sufficient availability of resources, deploying redundancy, making critical components stronger and ensuring a rapid recovery are all effective responses of the system.

KEYWORDS

Resilience, key performance indicators, water distribution networks, critical infrastructures

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Data mining for household water consumption analysis using self-organizing maps

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ABSTRACT

Household water consumption is a part of the human related water cycle that can get into the core of water resources management. Analysis of water consumption data can reveal great potentials of individualized water services planning. Data mining is the process of identifying and extracting potentially useful information from data sets. Self-Organizing Maps (SOMs) is a data mining technique that involves an unsupervised learning method to analyze, cluster, and model various types of large data sets. In this paper, it is presented how the daily water consumption of a household in Sosnowiec can be clustered into days of week, through some features. The features used to discretize the days of water consumption are statistic metrics and time zone consumption metrics. The time zoning is realized in two ways, the first being the typical morning, noon, afternoon, evening and night and the second considering the local working hour time zones of three main working sectors, banks, offices and shops. We use the SOM algorithm in three approaches. In each approach we use some of the selected features. We have managed to get some clusters with specific features that divide the days of this household in weekdays and weekends.

KEYWORDS

Data mining, self-organizing maps, water consumption analysis

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Simulation of sewer overflow volume in Flanders using a global sensitivity analysis

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ABSTRACT

To quantify uncertainty in urban drainage models, it is important to prioritise the model inputs/ parameters based on their contribution towards the variation in the model outputs. Global sensitivity analysis proves to be a stepping stone for uncertainty analyses by serving this purpose. This study uses Morris screening method to identify important input parameters influencing combined sewer overflow (CSO) volume in an urban catchment in the Flanders region of Belgium. The sewer system is modelled in InfoWorks CS and a composite design storm is used in order to reflect the local modelling practice. Despite a low precision threshold applied on variability, stable convergence was achieved with Morris screening with as few as 900 model simulations. Runoff coefficient, weir crest, and Colebrook-White roughness were found to be the most influential input parameters. Except the runoff coefficient and roughness, all the other input parameters displayed a linear relationship with the CSO volume.

KEYWORDS

Combined sewer overflow uncertainty, Global Sensitivity Analysis, InfoWorks CS, Morris screening

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Incorporating uncertainty in the design of water distribution systems

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ABSTRACT

During the design stage of urban water supply and distribution systems several assumptions and projections to future horizons are made. The analysis and design is then based on a deterministic basis in which all the involved parameters have crisp values. In reality however, most of the parameters exhibit significant variability over the life span of the system. The resistance to flow is among the most important parameters exhibiting variability. This is caused by the variability of the friction coefficient of pipes and the variability of internal diameters of the pipes. This study attempts to incorporate these uncertainties in the analysis and design of urban water supply and distribution systems, following a copula approach. Because of the low data availability, fuzzy membership functions are assigned to describe both variability of friction coefficients and variability of internal pipe diameters. Instead of the min intersection, the use of copulas is proposed in order to combine the uncertainties and calculate the fuzziness of the pipe resistance to flow. Thus, the input variables are fuzzy numbers and the problem is to find the output of the system which will consists also of fuzzy quantities. The system itself is described by the set of precise (crisp) nonlinear Q-equations. Finally, the uncertainty analysis concludes to an optimization problem. A numerical example is presented to demonstrate this innovative methodology.

KEYWORDS

Water distribution system, Uncertainties in design, Resistance to flow, Pipe roughness, Copulas, Fuzzy sets, Extension principle

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Pressure dependent analysis for managing contaminant propagation in water supply systems

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ABSTRACT

Since water distribution Network is consisted of different components which are easy to access, they can be contaminated accidentally or deliberately. Therefore, consequence management and withdrawal of contaminant from water distribution network could be a key factor in minimizing the disastrous effects of contaminant propagation on the public health. A number of actions such as contaminant isolation throughout closing valves and opening the hydrants in order to flush out the polluted water were suggested by previous studies to manage the contamination. These response actions lead the network to the critical state which in some nodes, pressure is lower than standard measure. In this situation head driven analysis of water distribution network would be necessary. In this study combination of hydraulic simulation based on head driven analysis method and particle swarm optimization is used for minimizing negative effects of contaminated water to public health as an emergency response after contaminant entrance detection. In addition, the results of consequence management are compared when another kind of hydraulic simulation – demand driven simulation method – is used. The proposed model is applied on network number 3 of EPANET to demonstrate the model applicability in water distribution system and its effectiveness in dealing with contaminant intrusion into the water distribution network.

KEYWORDS

Water Distribution Networks, Pressure Driven Analysis, Particle Swarm Optimization, Contaminant Intrusion, Contaminant Propagation

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Evolution of water supply infrastructures of Thessaloniki city, Hellas, through centuries

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ABSTRACT

Thessaloniki is the second biggest city of Greece, which has been continuously inhabited for about 2,330 years. An important factor that contributed to the choice of location for the founding of Thessaloniki at this specific location but also in the development of the city was the high availability of water. However, the development of Thessaloniki in a big city and the simultaneous increasing population, created an increased need for water, which could not be covered by the water of the wells. Until the 19th century, water needs were met with cisterns, water channels, fountains and water towers in combination with the wells. Moreover, the city was also equipped with large scale water supply projects, which were exploiting the region's water resources in four different places. These projects were transferring water inside the walls and in every case, were of high expertise. These water transfer works were associated with a water distribution system, with terracotta pipes located beneath roads or following the contour lines. Also, people who lived in the Hellenistic, Roman, Byzantine, Ottoman and newer Hellenic periods gave their own perspective in the problems related to water supply in the city. A review of all these techniques through centuries is presented and commented in this paper.

KEYWORDS

Thessaloniki, infrastructures, water supply, Hellenistic, Roman, Byzantine, Ottoman and newer Hellenic periods

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Water demand management in Europe: Reducing household water consumption in four cities from 1995 to 2015

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ABSTRACT

In many cities urban growth has led to intensified water stress, serious pollution of water resources and increased competition between different water users, including domestic households. An effective strategy to increase both quality and quantity of available water is water demand management. This study examines four European cities which have shown notable success in achieving low domestic water consumption, and attempts to identify what policy instruments were most effective in lowering household water demand and increasing water conservation. The four surveyed cities are: Copenhagen, Denmark; Hamburg, Germany; Tallinn, Estonia; and Zaragoza, Spain. A mixed-methods approach was used consisting of a questionnaire, interviews and review of secondary data and sources of information. We find that a variety of policies and measures are attributed to have lowered the domestic water use, with investments in renovation and maintenance of networks and campaigns for the use of water saving technologies as the most important, closely followed by universal installation of water meters, rapid leak detection, awareness (campaigns) for sustainable use of resources, and municipal regulations. Tariff measures are rarely measured as significant. An important lesson of the study is that water managers should closely examine their own specific situation before designing water demand management policies and measures, as what works or not is very context-dependent.

KEYWORDS

Urban water demand management, water policy, household water consumption, water conservation, water quality

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Impact of water pricing policy and climate change on future water demand in Volos, Greece

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ABSTRACT

The aim of this study is the water demand forecasting in the city of Volos and the evaluation of various parameters affecting it, such as water price, temperature and rainfall. Time series data of water consumption levels and the number of water meters from 2007 to 2012 were collected from databases of Water Utility of Volos, while raw data concerning rainfall and temperature were retrieved from weather stations in the city of Volos. Furthermore, the elasticities of the parameters introduced in the scenarios were available from previous survey conducted by the University of Thessaly. Those elasticities indicate the grade each parameter affects the water consumption, such as the water price and climatic conditions (temperature and rainfall). Subsequently, nine scenarios were created by altering one or more parameters and via the proposed forecasting model (prediction equation), using the specific water consumption and the number of water meters. Estimations of future water demand for the years 2013-2024 under different pricing policies and climate change scenarios were performed using the WEAP model. Then, a scenario comparison was conducted in order to export more conclusions referring to the future consumption. The results of this study prove that rational water pricing can lead to remarkable water conservation.

KEYWORDS

Water demand forecasting, elasticity, water consumption, water pricing

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Domestic water demand forecasting for Makkah, Saudi Arabia

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ABSTRACT

The prediction of water demand is important in countries that have less water resources. Water demand forecasts assist water utility managers in taking decisions on additional supply acquisition, treatment infrastructure, water use restrictions, water conservation impacts, price elasticity and demand management. The aim of this paper is to develop an Artificial Neural Network (ANN) models for predicting annual and monthly domestic water demand in Makkah city, Saudi Arabia. The variables that were selected for development the water demand prediction models were: household area (m2), city population, average personal income, average maximum temperature, and average number of visitors. This data between the years 2002 and 2012 were collected from the relevant sources. The number of dataset was eleven on annual basis and 132 on monthly basis. An ANN approach using feed forward backpropagation was developed to predict monthly and annual domestic water demand in relation to the selected variables. The study revealed that the ANN water demand models can predict monthly and annually water demand with a mean square error (MSE) between 0.0006 and 0.0002, and models' efficiency (E) between 0.97348 and 0.94626. In conclusion, it is suggested that a further development of the proposed ANN models are required to generalize and apply the proposed models to other cities in Saudi Arabia.

KEYWORDS

Makkah, water demand, artificial neural network, prediction, domestic water, water consumption

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The role of rainwater harvesting on providing vegetation water requirement in arid and semi-arid regions

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ABSTRACT

Water harvesting Knowledge has an ancient history. From old times, people, specially, occupants of arid lands whose access to water was limited, invent different ways to collect and conserve water. Today, many of these methods are reclaimed and introduced as Indigenous Knowledge. There are many case studies in different branches of water harvesting and new methods based on Indigenous Knowledge have been presented. These studies especially in our country, which is situated in the desert belt, are of importance. Present study was carried out in a watershed near Mashhad in Iran. Given that Mashhad city is situated in a semi-arid zone in Khorasan Razavi, therefore, is in a good situation for this study. Selected area located in Dehbar district, south of Mashhad contains different parts with various slopes. Basic meteorology data were collected and essential soil properties were measured in soil lab. Based on references, experiences and the local characteristics, it was tried to choose the best structures for the area. Negarim microcatchment and absorbing Banequet was chosen for both of slopes. During nine months, after each precipitation, soil sampling was done with six time repeating process. Soil moisture was calculated after each time. Using basic data and soil information, Changing Procedure of soil moisture was studied. Graph analysis showed that in total, both structures performances were 20% better than the control plots. At the end of precipitation period, loosing moisture in control plots is about two times more than the structures, an average of 30%. The acquired results confirm the success of tested structures on utilization of soil moisture.

KEYWORDS

Water Harvesting, Arid lands, Negarim Microcatchment, Absorbing Banquet, soil moisture

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Robustness and vulnerability assessment of water networks by use of centrality metrics

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ABSTRACT

The reliability of a water distribution network (WDN) is a function of several time-invariant and time-dependent factors affecting its components and connectivity, most important of which have been shown to be the network's topology, its operating pressure, the type of key components (such as the diameter, length, material and age of water pipes) and the network's historical performance (such as the number of previously observed failures in the network). In terms of network topology, this attribute even though generally thought as time-invariant it actually is time-dependent, as the paths in a water distribution network change over time based on the hydraulics in the network (water demand and water pressure/flow alter the way water flows in the piping network). The work described herein examines the time-dependent nature of a WDN topology and by means of a betweenness centrality index (BC) method demonstrates the effect of topology on the network's vulnerability / reliability. The importance of the BC index is demonstrated by use of a case-study water distribution network operated under both normal and abnormal conditions. The proposed method is also coupled with spatial mapping to indicate areas of concern in the network, and with a decision support system to assist in prioritizing actions to improve on the network's robustness and resilience.

KEYWORDS

Network robustness, Vulnerability assessment, Pipe breakage

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The role of domestic rainwater harvesting systems in storm water runoff mitigation

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ABSTRACT

The role of Domestic Rainwater Harvesting (DRWH) systems in storm water runoff mitigation is investigated at the urban block scale by implementing a hydrologic-hydraulic model able to predict the outflow hydrographs together with the hydraulic behaviour of the DRWH at high time resolution. The hydrologic behaviour of an urban block equipped with DRWH systems has been continuously simulated over 26-years of rainfall records. The modelling is undertaken using EPA SWMM; the DRWH is implemented in the model by using a storage unit linked to the building water supply system and to the drainage network. In order to quantify the impact of DRWH systems on improving the hydrologic performance of the urban block, the peak and volume reduction are evaluated with respect the "do nothing" scenario. Although the reduction ratios are limited for exceedance rainfall events (high-intensity and short-duration), the installation of DRWH systems at the urban catchment scale contributes to satisfactory increase the hydrologic performance of the storm water drainage network. At the same time, the modelling results point out that the widespread implementation of rainwater harvesting systems at the urban catchment scale noticeably affects the quali-quantity aspects of urban water management; indeed these storage tanks contribute to reduce the use of potable water and to limit overflow discharges and drainage system failures.

KEYWORDS

Rainwater harvesting, storage tank, storm water control, SWMM

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Water efficiency indicators studies and energy applied to real water distribution system of south of Minas Gerais - Brazil

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ABSTRACT

The indicators applied to water distribution systems help in its diagnosis and support the management actions. Hydraulic and energy-related indicators can relate energy consumption, input flow, pressures and demand to identify systems and tools to minimize energy costs and maximize hydraulic reliability. This study was carried out in a real system, in a city of the south of Minas Gerais, Brazil. With the available data, the main water and energy efficiency indicators were calculated based on Alegre al. (2014). Among those main parameters, the value of PH4 - Utilization of pumping capacity, 98.4%, Op23 - Water losses per branch, 55.90 m³ / branch /year, Op 24 - Water losses per pipeline length, 8.57 m³ / km Of conduit/days. Op26 - Apparent water volume loss at system entry, 0.65%. The results indicate that the system as a whole has a reasonable behavior compared to other case studies regarding water and energy efficiency.

KEYWORDS

Water Distribution Systems, Indicator, Leakage, efficiency hydric

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Green roof as tool of solving Košice city urban heat island

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ABSTRACT

People migrating from places where there is no life, carbon footprint being replaced with water footprint, activists forcing politics to make some changes, industries deforesting landscape, sea level rising, lack of water, broken water cycle. Climate change has been a topic number one last years. Scientist are questioning if the climate change can be slowed down. Retaining water in urban areas, lowering city temperature, humidifying air, bringing nature into cities, catching water in the area of rainfall. This research focuses on Košice city in the middle Europe, Slovakia. The paper follows an ongoing dissertation work on the topic of green roofs and their water retention qualities. The main idea of this research is a green roof as a tool of retaining water in microurban area. The paper pictures the map of the Košice city with different air and surface temperatures and research working on defining ideal green roof for each city districts. The main goal of this research is to define certain areas of the Košice city and be able to design "perfect" roof that would be beating climate change in different ways, mostly in retaining water. The outcome of this research is creating map of the urban heat islands in Košice city and the map of the green roofs.

KEYWORDS

Green roof, urban heat

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Relationship between Hazen-William coefficient and Colebrook-White friction factor: Application in water network analysis

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ABSTRACT

Although Darcy-Weisbach (D-W) equation has been accepted as a standard resistance equation in pressurized flow, some researchers and engineers still prefer to utilize Hazen-Williams (H-W) equation for analyzing water distribution networks (WDNs) in practice. The main difference between roughness coefficients of these two resistance equations is that D-W friction factor varies with Reynolds number of flow field while H-W coefficient is usually considered as a fixed value for a specific material. In this paper, discrepancies between solving three pipe networks using these two resistance equations are investigated. These networks were solved using two hydraulic solver named gradient algorithm and finite element method assuming different values for roughness values. In order to compare the results, equivalent friction factors based on these two resistance equations were required to be used. In this regard, several methods for computing equivalent roughness values were selected from the literature. The first category uses Reynolds number and pipe diameter data for converting D-W friction factor to H-W coefficients and vice versa. On the other hand, the second one is exclusively a function of pipe diameter. The obtained results demonstrate that errors of solving networks with H-W coefficients are not significant in comparison with the results obtained by the D-W equation. More importantly, the method, which only exploits pipe diameter for roughness conversion, is appeared to be not reliable for some cases considered in this paper.

KEYWORDS

Resistance equation, Darcy-Weisbach friction factor, Hazen-William coefficient, water distribution system, turbulent flows

VII. Agricultural Water Management

10th WORLD CONGRESS
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Accuracy of daily PM-ET_o estimations with ERA-Interim reanalysis products

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ABSTRACT

This study assesses the accuracy of estimates of FAO Penman-Monteith daily grass reference evapotranspiration (PM-ETo) using ERA-Interim reanalysis products with 0.75ox0.75o spatial resolution. PM-ETo requires daily maximum and minimum air temperature, net radiation or sunshine duration, relative air humidity or dew point temperature, and wind speed data. For that, local ETo estimates from 1979-2013 over 37 weather stations distributed across Continental Portugal were compared with those issued from the nearest reanalysis grid-point to each station. Accuracy was assessed using several statistical indicators. Results show that the PM-ETo computed with raw reanalysis data clearly underestimates (regression slope b0≤1.05) with RMSE exceeding 1.0 mm day-1 in nearly 30% of cases, but with EF generally above 0.50. Using a monthly bias correction improved the performance of estimates, with b0 usually close to 1.00, RMSE rarely exceeding 0.80 mm day-1, and EF generally above 0.80. These results show that when full local data sets are not available, the PM-ETo may accurately be computed using daily reanalysis products, thus keeping the ability for the understanding of the physics processes.

KEYWORDS

Accuracy indicators, FAO Penman-Monteith ETo, raw reanalysis data, meteorological variables, bias correction

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Proving the contribution of a seasonal shallow water table to evapotranspiration

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ABSTRACT

An attempt is made to elaborate on the soil water dynamics in an olive orchard field in Sparta, Laconia. This is a complex process, where soil water moves in all directions, always obeying the appropriate law of flow e.g Darcy's law. Equipped with modern devices and instrumentation we have been able to monitor and detect soil moisture profiles, θ(z,t), during the period of investigation, as well as record all meteorological attributes which could provide the means of estimating atmospheric demands for the olive orchard experimental field. Under certain assumptions, associated with the physical processes of investigation, such as the predominant direction of water flow being the vertical one , the transfer from the moisture profiles' regime to the hydraulic head, h(z,t) field and therefore the subsequent application of Darcy's law, could permit the detection of actual soil water movement, being upwards or downwards , at specific time intervals during the study period. Our basic objective was to investigate the presence of shallow soil water table and moreover its quantitative contribution to the olive trees water needs. The methodology, which could be applied subject to the availability of data, rested on the establishment of two independent conservation principles, the soil surface energy conservation principle and the mass conservation principle of the soil water. It was shown that shallow water table made its presence during the rainy period, and its quantitative contribution to the olive orchard water needs was estimated.

KEYWORDS

Seasonal shallow water table, soil moisture profiles, soil hydraulic head profiles, water table contribution to ETc

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Temporal variation of ET_0 and regional drought estimation using SPEI method for semi-arid Konya closed basin in Turkey

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ABSTRACT

Analysis of temporal variation of reference evapotranspiration (ET_0) is of great importance in arid and semi-arid regions where water resources are limited. In this study, temporal variation of reference evapotranspiration (ET_0) with parametric and non-parametric tests and regional drought analysis using SPEI (Standardized Precipitation Evapotranspiration Index) method with L-moment parameter estimation have been carried out in semi-arid Konya closed basin in Turkey. Reference evapotranspiration of concerning closed basin in the basin has been estimated using Penman-Monteith method and one calendar year has been split up multi-scalar periods as 1 month, 3 months, 6 months, 9 months and 12 months. Temporal variation of reference evapotranspiration according to multi-scalar periods has been analyzed through parametric Augmented Dickey-Fuller (ADF) test and non-parametric Mann-Whitney U (M-W) test. Significant increasing and little trends for reference evapotranspiration (ET_0) have been detected. According to SPEI method for multi-scalar periods, mild drought has been experienced in general, and however there have been also a significant amount of events where moderate and severe droughts occurred in the basin. When compared with another index RDI (Reconnaissance Drought Index) method using evapotranspiration, it can be said that the SPEI method is particularly sensitive to extreme and severe drought estimates. For estimating regional drought pattern with L-moments for SPEI values, one climatologically homogeneous region has been stated using discordancy, heterogeneity and goodness of fit tests. The best suitable regional distributions for the periods have been found 5-parameter Wakeby distribution. According to Wakeby distribution for homogeneous region, probable regional SPEI quantiles have been estimated various return period.

KEYWORDS

Reference evapotranspiration, temporal variation, SPEI, regional drought, Konya closed basin

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Calculation of the irrigation water needs spatial and temporal distribution in Greece

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ABSTRACT

Among the vital economic sectors that compete for the scarce water resources in Greece as well as the Mediterranean area, agriculture holds a special position. Agriculture has a dominant role in sustaining the growth of rural areas and at the same time represents the major water consumer. In order to tackle the aforementioned issues, efficient water resources management plans comprising appropriate solutions, best practices, data, and tools are required. However, this effort becomes even more challenging in the case of poorly gauged regions and especially in countries characterized by vast spatial and temporal variability like Greece. Accordingly, this effort presents a methodology for a large-scale evaluation of agricultural water needs for the entire country. The proposed methodology is using an entirely spatially distributed, continuous hydrological model, in order to estimate the spatial distribution of the hydrological balance components, the monthly and yearly mean streamflow values at every point of the studied region as well as irrigation water needs and plants water stress. The model operates as an extension of the ESRI ArcGIS, a GIS software package, in order to facilitate the fully spatially distributed calculation of the hydrological balance components, and at the same time to make use of the advanced capabilities of ArcGIS in managing (editing, analyzing and visualizing) geographical data. The applied methodology produced valuable information concerning agricultural water management, and may act as an effective assessment tool for the evaluation of land use or climate variation impacts and of related adaptation and mitigation strategies.

KEYWORDS

Water Resources, Water Demand, Irrigation Needs, GIS, Hydrological Model, Water Balance, Water Stress

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Daily transpiration of a single sessile oak measured by the tissue heat balance method

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ABSTRACT

Transpiration is calculated as a component of evapotranspiration for planning water resources in watershed scale. Since the risk of water shortages is quite high for near future because of growing population, this information is important for water conservation and planning studies especially in sub-humid and semi-arid areas of Turkey where vegetation can take up significant amount of water. To present this fact, water consumption of a single full grown sessile oak (Quercus petraea (Matt.) Liebl.) was determined in daily basis by the tissue heat balance method in Belgrad Forest, Istanbul. Study period covered one growing season in 2016. The sample tree was 18.5 m in height, 34.5 cm in diameter at breast height. Mean air temperature, humidity, and precipitation were 17.4˚C, 76.6 (%) and 368 mm respectively, during the study period. The maximum transpiration was 162.4 kg day-1 in July and the minimum was 0.78 kg day-1 in the first day of April. Total amount of water consumption by this single tree in the whole growing season was 18325 kg. Results of this study revealed that water consumption of the vegetation cover should be taken into account for effective water management in addition to increasing water yield and improving water quality.

KEYWORDS

Transpiration, sessile oak, Belgrad Forest, tissue heat balance

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Impact of climate change on water footprint of wheat, rice and potato (Case study: Iran)

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ABSTRACT

The population growth causes unsustainable global agricultural development especially in arid and semi-arid regions. A new and efficient approach named "water footprint" (including green, blue and grey components) is used by researchers world-wide in order to achieve optimum and sustainable utilization of fresh water resources. Hence in the present study, the water footprints of three agricultural crops (wheat, rice and potato) in all provinces of Iran (31 stations) were calculated for the historical period of 1981-2010. Then the climatic parameters were simulated for two future periods: 2011-2030 and 2045-2065 by the use of the HadCM3 model and the water footprints were also estimated for these two future periods under scenario A2. The results illustrated that, among the considered crops the maximum water footprint belonged to rice and wheat and the minimum amount belonged to potato. The evaluation of water footprint variations in the historical period and the simulated scenarios also showed the highest green water footprint variations in tropical stations and the lowest variation in colder areas. This is explained as follows: the maximum amount of rainfall variations for southern and eastern arid stations of Iran took place during January to March and for the colder areas this was during October up to December. During cold months, no crop cultivation occurs in cold regions but crops are cultivated in hot areas in that period. The blue water footprint variations showed completely different trends being highest for Ardabil, Hamedan, Ghazvin and Rasht and lowest for Bandar-Abbas, Ilam and Tehran.

KEYWORDS

Iran, climate change, water footprint, blue water, green water

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Water buyback in agriculture: what can we expect?

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ABSTRACT

The reacquisition or buyback of water is an increasingly accepted approach to restore environmental flows threatened by overallocation. Reacquisitions are operated through purchase tenders that compensate irrigators who decide to surrender (part of) their right to withdraw water. A major concern in water buyback involves information rents and the extent of the compensation: information asymmetries can lead to agency costs that inflate market prices and hinder buyback welfare enhancing opportunities. The accomplishment of water buyback is therefore conditioned to the ability of the principal to place bids consistent with the shadow price of irrigators. However, methods used to inform buyback programmes to date either rely on ex-post trading data that is not readily available in most regions worldwide; or compensate projected foregone income, and thus ignore the effects that buyback may have on other relevant attributes determining utility. The research hypothesis is that since buyback programmes offer management complexity- and risk-free payments to management complexity- and risk-averse farmers, addressing foregone income may overcompensate sellers. This paper uses revealed preference methods to elicit the parameters of a multi-attribute objective function of irrigators in the overexploited Segura River Basin in SE Spain. Objective functions are used in a series of simulations in which water allocation is progressively constrained to reveal the shadow price of irrigation water using two different compensation measures: i) foregone income, a proxy of the shadow price typically used in the literature; and ii) compensating variation that addresses foregone utility. Results show a relevant gap between the two methods.

KEYWORDS

Mathematical programming, water buyback, compensating variation, Spain

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Sustainability assessment of agricultural production through Causal Loop Diagrams

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ABSTRACT

Sustainable management of water resources in agriculture is extremely challenging for both policy-makers and scientists, especially at the local scale, due to multiple, complex, and interconnected loops existing among different issues and actors involved in intensive agricultural system. In such systems, multiple actors are indeed involved in decision-making processes characterized by high complexity of relationships between internal and external factors. Consequently, due to a poor knowledge of the system complexity, management strategies may often be affected by a high uncertain and result ineffective in their impacts. In this context, the proposed work aims at unravelling the complexity behind the sustainability of water use for irrigation purposes. A model based on Causal Loop Diagrams (CLD) was implemented on a reference case study of Southern Italy in order to get a deeper insight into a complex agricultural system. Moreover, a set of sustainability indices based on the concept of "footprint" were implemented in order to quantify the environmental and socio-economic impacts of the agricultural production. The results allow to detect and analyse the feedback mechanisms leading to potential unsustainability and to evaluate the effectiveness of the actions implemented to improve the sustainability.

KEYWORDS

Sustainability assessment, Causal loop diagram, Complex system analysis, index-based approach

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Estimation of crop water requirements using remote sensing for operational water resources management

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ABSTRACT

The overall objective of this work is the development of a District Information System (DIS) which could be used by stakeholders for the purposes of a district day-to-day water management as well as for planning and strategic decision-making. Karla Lake is used in this study, but the overall methodology could be used as a basis for future analysis elsewhere. Surface Energy Balance Algorithm for Land (SEBAL) was used to derive monthly actual evapotranspiration (ET) values from Landsat TM imagery. The methodology was developed using high quality Landsat TM images during 2007 growing season. Monthly ET values are then used as an input to CROPWAT model. Outputs of CROPWAT model are then used as input for WEAP model. The developed scenario is based on the actual situation of the surface irrigation network of the Local Administration of Land Reclamation (LALR) of Pinios for the year of 2007. The DIS is calibrated with observed data of this year and the district parameterization is conducted based on the actual operation of the network. The operation of the surface irrigation network of Pinios LALR is simulated using Technologismiki Works, while the operation of closed pipe irrigation network of Lake Karla LALR is simulated using Watercad. Four alternative scenarios have been tested with the DIS: a) Reduction of channel losses b) Alteration of irrigation methods c) Introduction of greenhouse cultivation and d) Operation of the future Lake Karla network.

KEYWORDS

NDVI, SAVI, EVI, EVI2, Evapotranspiration, Landsat, METRIC

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Economic productivity of irrigation water and the closure of a river basin in Southern Spain

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ABSTRACT

The expansion of irrigated areas in river basins where water resource is scarce usually leads to the closure of the river basin (RB), as a final result of a multiple pressure-response process. This has been the trajectory followed by the Guadalquivir RB, which is the main river in southern Spain. As response to these pressures, farmers have tended to use the resource more efficiently through a modernisation of their irrigation methods and the widespread of deficit irrigation and high-precision techniques. These individual decisions have sought to maximise the economic return to the limited resource (water), provoking changes in crops composition in order to maximize the productivity of irrigated agriculture and the mean productivity per irrigation unit. The analysis carried out in this paper shows a significant increase in irrigation water mean productivity in the period (1989-2005), driven by the creation of new irrigated areas devoted to high value crops and with a dominant use of deficit irrigation strategies, while a second phase (2005-2012) is defined by slower growth in terms of the mean productivity of irrigation water, primarily as a result of a significant reduction in water use per area. Findings show the patterns followed by irrigation water productivity in the analysed case study, which seems to have reached its full capacity.

KEYWORDS

Irrigation water productivity, agricultural water use, irrigation modernization, river basin management

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Parameterization of "canopy resistance" and estimation of hourly latent heat flux over a crop

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ABSTRACT

The objective of this study is to evaluate the estimation of hourly actual evapotranspiration (AET) in olive trees, applying the Penman - Monteith method (PM) either using models which take into account the 'canopy resistance', or its simplified model as proposed by Priestley and Taylor (PT). The evaluation is based on comparisons with experimental measurements of actual evapotranspiration applying the 'Bowen ratio' method (λE). Hourly experimental data, obtained from air temperature, humidity, wind speed and radiation balance measurements, taken at Sparta nearby area (lat 370 04΄ N, log 220 05΄ E), during the period from June 2010 up to July 2014 are used. In order to estimate hourly 'canopy resistance', needed in the PM method, the Katerji-Perrier (KP) and the Todorovic (TD) models are applied over olive trees. Canopy resistance (rc) estimated from KP model is parameterized by a semi-empirical approach which requires a simple calibration procedure, while rc from TD model is parameterized using a theoretical approach (without a calibration procedure taken place). For estimating λE from minimum data (temperature, humidity and radiation balance) the PT model was also employed, since rc is not required and the aerodynamic term of PM was taken into account in the dimensionless empirical parameter a of the model. The results show that λE is slightly underestimated when KP and PT models are used and a very good correlation between predictions and experimental measurements exists. These models can be successfully employed for estimating actual evapotranspiration over olive trees. On the other hand, TD model overestimates λE and this can be attributed to some theory assumptions weakness in the model.

KEYWORDS

Actual evapotranspiration, canopy resistance, Penman-Monteith method, Katerji-Perrier method, Todorovic method, Priestley and Taylor method

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A methodology to determine the productivity-reliability curve as a tool for improving water management in the agricultural sector

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ABSTRACT

Water scarcity problems may intensify in the future because of the impact of climate change. There are many regions were available water resources are nearly fully allocated. In a scenario of reduction of water availability, the reallocation of water resources may be required and those uses with high consumption and low priority, such as agriculture, could be affected. The decision of reallocation of water uses should be based on the maximization of social welfare. To that end, an assessment of the economic implications of lack of reliability in water use is needed. Water productivity is an often-applied indicator within the agricultural sector. There are studies about the determination of the crop production as a function of irrigation amount and also about the economic evaluation of the water productivities at the basin level. However, this information is not directly applicable to the problem of water reallocation because it does not account for supply reliability. A methodology for determining a Productivity-Reliability (P-R) curve and its application in the Guadalquivir basin (Spain) is presented in this work. The P-R curve represents the average expected value of agricultural production as a function of supply reliability. This curve is based on generally available information such as crop distribution and their market value and also on water availability, which depends on hydraulic infrastructure and water management. The P-R curve is obtained by combining the results of performance simulations of the water resources system in different scenarios and the crop production with the satisfied water supplies.

KEYWORDS

Water resources, climate change, agriculture, production, productivity, reliability

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Water footprint for cotton irrigation scenarios utilizing CROPWAT and AquaCrop models

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ABSTRACT

Water Footprint is a recently-introduced theoretical concept, estimating the amount of water needed to produce each of the goods and services we use. In agriculture, water footprint of a given cultivar is estimated by the water volume of plants' potential evapotranspiration per final crop yield unit. Many studies have been conducted to determine the Water Footprint of various crops in different countries, utilizing various models and datasets ranging from national to regional levels. In this study, we used two FAO agronomic models named CROPWAT and AquaCrop to estimate the annual water footprint of cotton cultivation in Northern Greece for the period 2013 to 2016. Field data obtained from a precision irrigation experiment at farm scale level were used. Both models were executed under full and deficit irrigation strategies. Results showed that there exist substantial differences between the estimations produced by the two models regarding the cotton potential evapotranspiration. Differences were also observed in the case of water footprint estimation by the two models. These differences (about 200 m3/tn) were more evident under the full irrigation scenario and almost negligible (about 30 m3/tn) when deficit irrigation was implemented. Lastly, it was confirmed that precision irrigation could contribute significantly to the reduction of cotton water footprint.

KEYWORDS

CROPWAT Model, AquaCrop model, Water footprint, Evapotransipiration

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Mathematical analyses of water management's effects on rice productions: A case study of Mae Kuang Udom Thara dam, Thailand

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ABSTRACT

This research involves an empirical mathematical model on irrigation water management, rice productions and GDP from rice export. The model is constructed based on a system of linear difference equations to represent the dynamic relationship between water inflows and outflows from Mae Kuang Udom Thara dam, rice productions in the irrigation area, and GDP from rice export. The data used to verify the model are the monthly discharge amounts and the amounts of water flowing into Mae Kuang Udom Thara dam, annual rice productions, and GDP from the rice export sector. All data were collected during 2011-2015. Most of the terms contained in the constructed model have correlation coefficients higher than 0.5. Using the nonlinear optimization to find the parameters minimizing the sum squared error between actual data and solutions from the proposed model, correlation coefficients of water inflow, water outflow, main and second rice crops and GDP from the rice exporter sector are 0.8203, 0.8647, 0.9999, 0.9999, and 0.9659 respectively. According to the correlation coefficients, we can conclude that the model created under our hypotheses can be used to predict water inflow, water outflow, rice production and GDP from the rice export sector since the coefficient correlations of the model solution and the corresponding data are all higher than 0.8.

KEYWORDS

Water inflow, water outflow, main rice crop, second rice crop, GDP, difference equation

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Correction and sensitivity analysis of Hargreaves-Samani model in the estimation of the reference evapotranspiration

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ABSTRACT

According to the importance of evapotranspiration in water balance and supplying water requirement of the plant; this research aim to assess the corrective coefficients for Hargreaves-Samani model by using 22 years statistics of meteorological of synoptic station of Gonabad in Iran. The data series containing of 19 years were considered to estimate equations and remaining data (three years) was used to validate equations. Some equations including types of meteorological parameters were estimated by using SPSS software. equations that had better regression results were tested and two equations were selected among them which respectively with root mean squared error of 0.602 and 0.758 and Nash-Sutcliffe coefficient of 0.835 , 0.711 and determination coefficient of 0.858 , 0.776 showed that the close values to FAO Penman-Monteith than the Hargreaves methods. The first equation includes the average, maximum and minimum temperatures, actual hours of sunshine and maximum sunshine hours, the second equation has two parameters of temperature and wind speed in two meters height. In this research the two presented equations were analysed and the results showed that in the first model the evapotranspiration had relatively more sensitivity than the parameters of minimum and maximum temperatures and average temperature and in the second model both parameters of that were sensitive.

KEYWORDS

Sensitivity analysis, evapotranspiration, corrective coefficient, FAO-Penman-Monteith, Gonabad

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Pollution control by agroforestry systems: a short review

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ABSTRACT

Several mitigation techniques have been proposed for the control of pollution to surface and ground water systems from agricultural activities. Agroforestry, which is the common cultivation of crops and trees, is proposed as one such mitigation technique. Alley crop agroforestry systems have the potential to reduce nitrogen and phosphorus originating from fertilizers; recent studies also exhibit the potential for pesticide removal. It has been previously demonstrated that agroforestry alley crop systems have the potential to remove nitrogen and phosphorus originating from fertilizers excess and recent studies exhibit the potential for pesticides removal. In the present study, the efficiency of agroforestry systems in pollutant reduction is reviewed based on a search comprising a significant number of international studies. A search of relevant international literature was conducted using Scopus, Science Direct and Google Scholar scientific literature search engines, using all relevant keywords for agrochemicals pollution abatement using trees. More than 2000 results were found using various combinations of keywords and the most relevant literature has been extensively studied. From the current knowledge, it can be generally demonstrated that tree roots in agroforestry systems, are able to reduce nitrogen and phosphorus residues in soil from 20% up to 100%, and pesticide transport up to 100%.

KEYWORDS

Agroforestry systems, alley cropping, nutrients, fertilizers, herbicides, pesticides, pollution reduction, buffer strips

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Spatial interpolation of potential evapotranspiration for precision irrigation purposes

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ABSTRACT

Precision irrigation constitutes a breakthrough for agricultural water management since it provides means to optimal water use. In recent years several applications of precision irrigation are implemented based on spatial data from different origins, i.e. meteorological stations networks, remote sensing data and in situ measurements. One of the factors affecting optimal irrigation system design and management is the daily potential evapotranspiration (PET). A commonly used approach is to estimate the daily PET for the representative day of each month during the irrigation period. In the present study, the implementation of the recently introduced non-parametric bilinear surface smoothing (BSS) methodology for spatial interpolation of daily PET is presented. The study area was the plain of Arta which is located at the Region of Epirus at the North West Greece. Daily PET was estimated according to the FAO Penman-Monteith methodology with data collected from a network of six agrometeorological stations, installed in early 2015 in selected locations throughout the study area. For exploration purposes, we produced PET maps for the Julian dates: 105, 135, 162, 199, 229 and 259, thus covering the entire irrigation period of 2015. Also, comparison and cross validation against the calculated FAO Penman-Monteith PET for each station, were performed between BSS and a commonly used interpolation method, i.e. inverse distance weighted (IDW). During the leave-one-out cross validation procedure, BSS yielded very good results, outperforming IDW. Given the simplicity of the BSS, its overall performance is satisfactory, providing maps that represent the spatial and temporal variation of daily PET.

KEYWORDS

Irrigation, potential evapotranspiration, agrometeorological stations, bilinear surface smoothing, spatial modelling

The effect of Yazd wastewater on forage quantity and quality of Atriplex lentiformis

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ABSTRACT

Municipal wastewater is a major source of water in arid regions. The study on the production of forage crops using wastewater is very important. In this study examines the effects of municipal wastewater on forage quantity and quality of Atriplex lentiformis. This experiment includes a completely randomized design with 3 irrigation treatments (100% drinking water, 50% drinking water + 50% wastewater, 100% wastewater) in 10 replicates for 4 months. The results showed that 100% wastewater treatment increased leaf fresh and dry weight to stem ratio of Atriplex lentiformis ($p<0.05$), But had no significant effect on height of this plant. In the wastewater treatment, quality characteristics such as percent crude protein increased and decreased total ash. The percentage of NDF and ADF, dry matter digestibility, metabolic energy, crude fiber, digestible energy and total digestible nutrients were not affected by irrigation treatment. According to this survey results, 100% wastewater treatment, is the best treatment for irrigate this species. In total it seems that due to water scarcity in arid region, the use of wastewater not only to compensate for the shortage of water resources to forage production but is also effective in improving forage quality.

KEYWORDS

Atriplex lentiformis, Municipal wastewater, Forage Quantity, Forage Quality

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Spatial and temporal assessment of potential soil erosion over Greece

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ABSTRACT

Soil erosion is considered as one of the most important environmental problems in the Mediterranean region threatening soil and water resources. The main purpose of this study is to investigate the spatial and seasonal distribution of potential soil loss across Greece. The Revised Universal Soil Loss Equation (RUSLE) model is applied at monthly time-step in a geographic information system (GIS) framework using freely available gridded data and remote sensing derived products. The rainfall erosivity (R-factor) is estimated using long-term monthly average precipitation from the CHELSA high-resolution gridded climate data set. The soil erodibility factor (K-factor) is estimated using ISRIC-World Soil Information SoilGrids250m global gridded maps of soil properties and classes. The cover management factor (C-factor) and the topographic factor (LS-factor) are assessed using remote sensing data. Time-series normalized difference vegetation index (NDVI) data from the Moderate Resolution Imaging Spectroradiometer (MODIS) are used for the C-factor and the digital elevation model (DEM) from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is used for the LS-factor. The average annual soil erosion over Greece is estimated at 4.75 t ha-1yr-1. About, 12.33% of the Greek territory is observed with soil erosion rates higher than 10 t ha-1yr-1, mainly located in high relief areas. Autumn and winter months are the most erosive, demonstrating high rainfall erosivity (R-factor) and vegetation cover (C-factor) values. Finally, 4 out of the 46 Greek River Basins (RBs) are found with average soil erosion rates greater than 15 t ha-1yr-1. The results of this study further confirm the seasonality of soil erosion under Mediterranean climate and vegetation conditions.

KEYWORDS

Soil erosion, RUSLE, GIS, Remote sensing, Greece

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Water availability and requirements for precision agriculture in vulnerable agroecosystems

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ABSTRACT

Agriculture is strongly influenced by the availability of water. Crop yields are affected by variations in climatic factors, like temperature and precipitation, and the frequency and severity of extreme events, like droughts. The aim of this paper is to present the water availability and requirements in vulnerable agriculture. This information contributes to precision agriculture for effective crop monitoring and irrigation management. A drought-prone area characterized by vulnerable agriculture is selected, namely Thessaly in central Greece. Water availability is assessed through rainfall frequency analysis for climate variability impacts. Crop water requirements are considered by estimating crop evapotranspiration (ET) through the combined use of WV-2 satellite images with ground-truth data. The satellite-based ETcsat is produced by using the reference ETo from FAO method, meteorological data and Kc extracted from NDVI utilizing the Red and NIR bands. Based on precipitation frequency analysis, evidence of precipitation reductions is shown. The results justify the importance of water availability for vulnerable agriculture and the need for drought monitoring in the Mediterranean basin as part of an integrated climate adaptation strategy. The results also justify the combined use of WV-2 satellite images with ground-truth data for monitoring crop ET and the incorporation into the precision agriculture methodology has proven to be very useful for optimal agricultural production.

KEYWORDS

Water availability, evapotranspiration, vulnerable agriculture, rainfall frequency, drought, precision agriculture

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Modelling sustainable smart islands using harmony search: A water-energy nexus initiative in Greece

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ABSTRACT

The islands of the Aegean Sea in Greece represent a unique example for the water and energy interrelation. A great number of them are not interconnected to the main power grid and independent local grids produce power mainly using imported fossil fuels (e.g. heavy oil, diesel). Equally important, water resources' scarcity is an additional challenge, especially during the high-demand, summer months. Thus, in many arid islands potable water is transported from the mainland by means of sea transport, at a significant cost. This approach apart from the additional cost of fuel and water transport also imposes significant economic and environmental impact to these idyllic touristic locations. Seasonal variability in power demand and drinking water consumption, fuel price volatility as well as a growing touristic development, impose some additional complexity. The present study analyses specific island grids of the Aegean Sea. Selected islands are analysed as case studies over a 20-year period (2016-–2036). The developed energy modelling exercise uses a Harmony Search Algorithm (HSA) in its core. The aim is to investigate whether deployment of renewable energy sources (RES) to existing energy production could lead to a cleaner, sustainable system, decrease the current burden to the government budget and support local resources. The aim is to examine whether increased share of RES, battery storage, desalination and their combination could reduce islands reliability on imports, reduce its cost and potentially eliminate the current non-sustainable and heavily subsidized status quo.

KEYWORDS

Water energy nexus, sustainable development, energy modelling, renewable energy, optimization, harmony search

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Multi-objective optimization for irrigation deficit through cascade reservoirs

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ABSTRACT

Reservoirs play a strategic role in the rapid monetary growth of the world by providing numerous benefits. However, the reduction in appropriate sites along with environmental and social apprehensions has resulted in curtailment of new reservoirs around the world in 21st century. There is a potential of benefits available from existing reservoirs which have not been capitalized. To move forward in this context, the optimized benefits from reservoirs must be attained. Reservoirs operation optimization considering sediment evacuation (RESOOSE), a recently developed model which combines multiple reservoirs operation and sediment evacuation with Genetic Algorithm based optimization module, had been used in the study. The objective function of optimizing the irrigation deficits was developed. The RESOOSE model was then applied to optimize the irrigation deficits of Tarbela and Diamer Basha Reservoirs in Pakistan. The average annual irrigation shortages, sediment evacuation, hydropower and flood damages of existing rule curves had been computed as 6.9 billion m3, 21.534 million m3, 36.9 billion Kw and 616.2 million US$ which were used as constraints. The irrigation shortages had been minimized by optimized rule curves without reducing these benefits from existing values. The optimized operation of the selected multiple reservoirs reduce the irrigation shortages to 5.95 billion m3 (13.7% reduction). The study suggests change in existing operation of Tarbela and Diamer Basha Reservoirs due to enhanced benefits. Reducing irrigation deficits will certainly help in achieving the objective of exploiting the potential benefits of from cascade reservoirs.

KEYWORDS

Tarbela, Diamer Basha, Optimization, Multi-objective, Genetic Algorithm, RESOOSE Model, Irrigation Deficit, Irrigation Shortage

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Irrigation with highly saline water: a new innovative water treatment system evaluated for vegetable production in greenhouse

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ABSTRACT

Good quality irrigation and potable water became items of scarcity in the recent years. In agricultural production, irrigation represents one of the major inputs and challenges for farmers' survival. Recently the deterioration in quality and quantity of water is a major social and economical issue globally for food, feed and other agricultural production ouputs. Modern technological advances offer some possibilities for desalinized water use or reverse osmosis water for irrigation; however, the cost is still very high and not sustainable in large scales. Research projects with alternative systems including, ultrasound and electromagnetic technologies are under evaluation with promising outcomes. A new water treatment system using alternate low frequencies (ultrasounds) was evaluated in long term studies with various plant species, some very salinity sensitive, under greenhouse conditions. This paper presents data from the lettuce and celery only plant species, although results were similar for other vegetable species. The MAXGROW system provided very satisfactory results when used to irrigate a number of vegetable species with high electrical conductivity (ca. 8 to 12 dS/m) irrigation water. Results from long term evaluation have shown that vegetable yield was not affected adversely and in most cases it was increased. The effect of treated saline water by the system on soil properties was not shown to be adverse as compared with regular EC water qualities used in the study.

KEYWORDS

MAXGROW, water treatment, ultrasound, vegetables, saline water, sonication

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Irrigation water pricing in the countries of the OECD – modern trends and critical review: The Greek Case

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ABSTRACT

During the last decades, due to urbanization and rapid industrial development, water demand has increased enormously resulting in a substantial decrease of the annual renewable water resources per citizen. In addition, water prices do not depict the real value of water, thus misleading consumers to underestimate its real value. Hence, the planning of water pricing techniques is a crucial step for water supply companies and local societies, in order to achieve effective allocation of the restricted water resources to the consumers. In the 90's several movements by economists brought up the issue of "setting the price right", as a tool to produce economic motives to the water users. The main cause of the unwise water consumption in the irrigation sector, that represents 70% of the global consumption, is the underpricing of irrigation water, while it is widely accepted that proper pricing policy is the basic factor for the conservation of the operational competence of water irrigation systems. The current study focuses on the modern trends across the countries of the OECD concerning water management in agriculture, the pricing of the irrigation water and also the reforms observed in the pricing policies. In addition, the Greek case is presented, where a new legislative framework is under way, introducing general rules of estimating water costs and water pricing of the water services. In order to manage water in a more efficient way, the OECD countries should adopt strategies that promote sustainable irrigation water management and take into account climate change, implementing policies that should be easily adopted, according to national or local demands.

KEYWORDS

Pricing, water cost, pricing policies, irrigation, OECD, Greece

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Irrigation of walnut trees in the vicinity of Hisareyn-Gölcük/Kocaeli, Turkey

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ABSTRACT

Walnut trees as well as their fruits represent an important sector of the agricultural industry. Walnut is a valuable fruit species and its cultivation contributes significantly to the economy in Turkey. Turkey with its 13.2 billion walnut trees is so important in terms of walnut cultivation among other countries in the world. There are many problems about irrigation during the growing period of walnut. Walnut trees need irrigation during the growing period. Irrigation is a key-factor for walnut cultivation. Generally, application of irrigation is recommended from the beginning of April until the end of October. Irrigation methods change according to orchard's soil characteristic and climatic conditions of the cultivation area. In this study, irrigation methods and water resources were investigated in the walnut orchards located in the vicinity of Hisareyn-Gölcük/Kocaeli in Turkey. Irrigated and non-irrigated walnut orchards were compared. Double ring infiltrometer test has been performed for the purpose of determining the soil infiltration rate. According to physical observations and the determination of soil characteristics, irrigation methods were assessed with the purpose of determining the most suitable ones for walnut orchard irrigation in the area.

KEYWORDS

Infiltration, irrigation, orchards, productivity, walnut

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Soil water electrical conductivity determination based on the salinity index concept

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ABSTRACT

The dielectric devices can provide simultaneously and for the same spot of soil, measurements of the apparent soil dielectric permittivity (ε_s) and bulk soil electrical conductivity (σ_b). For the prediction of the electrical conductivity of the soil solution (σ_p), the method based on the concept of salinity index (X_s) is proposed. In the standard method X_s is defined as the partial derivative of the bulk soil electrical conductivity (σ_b) with respect to the apparent dielectric permittivity (ε_s). The evaluation of this approach is made by measurements with a dielectric sensor (i.e the WET) in different porous media at different levels of electrical conductivity of the moistening KCl-solution (EC_i). From the results it is shown that the relationship between the σ_b and ε_s is strongly linear for σ_p and σ_b values up to 7.4 and 1.74 dS m^{-1} respectively. The salinity index model performance at predicting σ_p values is satisfactory with RMSE values lying between 0.84-2.04 $dS.m^{-1}$ for the maximum electrical conductivity values of the moistening KCl-solution (EC_i).

KEYWORDS

Soil salinity, bulk electrical conductivity, apparent dielectric permittivity, dielectric sensor

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Assessing the vulnerability of water for agricultural use to climate change: The case of Cyprus

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ABSTRACT

Agriculture is an economic sector highly affected by climate change, since it is directly dependent on climatic variables (e.g. precipitation) and the availability of surface and groundwater resources for irrigation. Climate change impacts on hydrological variables can affect agricultural production. Water availability changes and water quality deterioration necessitate the development of adaptation measures. The present study focuses on the quantification of climate change effects on groundwater resources availability in Cyprus. Climate change impacts on agriculture are analysed in terms of groundwater availability (quantity) and quality (salinity) in an important agricultural area of Cyprus, Kiti (Larnaca). Kiti aquifer is a coastal aquifer facing saltwater intrusion. Groundwater pumping for irrigation purposes has caused significant salinization of groundwater resources in the area. In order to assess climate change effects on the availability of freshwater resources, groundwater flow and salinity at Kiti aquifer is estimated using SEAWAT, a 3D variable-density simulator of groundwater flow coupled with solute transport. Available meteorological and hydrogeological data are used to calibrate and validate the numerical model. Further in-situ groundwater elevation and quality measurements have been performed in 2016 to assess the current state of groundwater resources. In order to estimate aquifer's response to climate change, projections for climatic variables, for the period 2006-2100, have been produced using the RCA4 Regional Climate Model of the Swedish Meteorological and Hydrological Institute, forced by the IPCC RCP 4.5 and 8.5 scenarios. The predictions of the climatic model have been used as forcing for the groundwater model to quantify climate change impacts on groundwater availability and quality and to assess the vulnerability of existing agricultural practices to climate change.

KEYWORDS

Water availability, Kiti aquifer, groundwater flow, salt water intrusion, climate change, irrigation, SEAWAT

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Utilizing earth observation systems towards the implementation of nexus approach for achieving sustainable water management at a river basin scale

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ABSTRACT

Information derived from Earth Observation systems can act as a catalyst for an enhanced and holistic understanding of processes in the Earth system, the development and effectiveness of policies and the monitoring of sustainable use of water resources at river basin scale. In this context, they can facilitate the intensification of agricultural production, while taking into account the principles of a low-input sustainable agriculture that can monitor functional properties related to energy and water use efficiency. The current approach puts major emphasis on utilizing existing in situ networks and develop infrastructure strategies, bridging them with new technologies (e.g. unmanned platforms, advanced sensory systems), in order to monitor agro-environmental directives and providing outcomes more efficient and targeted for the implementation of the Sustainable Development Goals, at different temporal and spatial scales and in a holistic fashion.
An approach of integrating water, energy and agricultural production at the watershed level was implemented in the framework of transboundary territorial projects at the Strymon and Nestos watersheds. Via a series of indicators, inputs and outputs to the system were quantified and the efficiency of using energy and water-soil resources as related to food production has been evaluated. The results of those projects indicated the necessity of implementing the Nexus approach in dynamic systems regarding water resources
This necessity is highlighted by existing GEO Initiatives, EO in-situ networks and their data integration with spaceborne data aiming at developing the strategic planning and the road map to implementation of nexus approach on management of natural resources.

KEYWORDS

River basin, nexus approach, Earth Observation, low-input agriculture

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Evaluation of the water footprint and water use efficiency in a high density olive (Olea europea L.) grove system

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ABSTRACT

Modern approaches in sustainable agricultural production management require holistic approaches and evaluation of the water use efficiency and water footprint. The irrigation water scarcity due to overuse and quality deterioration due to increased salinity levels, represent significant obstacles in sustainable agricultural systems. Systems that promote and evaluate less-inputs and more efficient production are strongly considered lately. This study presents results of two years from an olive grove, planted in high density linear systems adapted for mechanical harvesting. The grove was established in 2011 in Thessaloniki, Greece, for long term evaluation of the effects of major production inputs in olive yield and olive oil quantity and quality. The experimental design includes three planting densities (medium, high and super high density; 500, 1000 and 1670 trees/ha, correspondingly), two commonly used worldwide olive oil varieties/clones adapted for mechanical harvesting (Koroneiki and Arbequina), grown under two irrigation levels (conventional and 50% less) and two fertility levels (conventional and 50% less) with a foliar split application in the fertility treatments. Results from the two years (2015 & 2016) on water use efficiency (WUE) and water footprint (WF) are presented in this paper. The results indicated that increase in WUE and decrease in WF was achieved with management approaches such as planting density at least for the measured period and tree age. Additional efforts to minimize water use and increase WUE are in progress.

KEYWORDS

Olive grove, water footprint (WF), water use efficiency (WUE), high density olive

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Regulation and mitigation services of forests as the components of urban resilience

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ABSTRACT

Urbanization has been an unavoidable situation due to human expansion worldwide. However, urban sprawl causes degradation of natural resources and loss of their services. As a consequence of this, urban ecosystems can not be able to adapt themselves rapidly to these changes and create opportunities to face up to new circumstances. Therefore, sustainably managing urban ecosystems for providing important ecosystem services become more crucial to meet several public demands in the context of both human well-being and resilience of urban ecosystems. In this perspective, the role of green areas or forests in urban ecosystems becomes prominent in terms of providing ecosystem services. The objective of this study was to determine the forest contribution to the resilience of Istanbul by providing water quality regulation and flood mitigation services. Kağıthane watershed which is located on the European side of Istanbul was selected as study site where the pressure has been increasing over the years. 11 sub-watersheds were studied and land use types in the watersheds were classified into four groups as forest, rangeland, agricultural and urban areas. Both water quality regulation and flood mitigation services were quantified by using mathematical equations based on field measurement. Additionally, a scoring method was developed to determine the relevant capacity of each land use type. Results revealed that forested sub-watersheds had high potential while urbanized sub-watersheds have low potential for providing these services. Therefore, adaptive management approaches should integrate the ecosystem services into planning in the context of urban resilience.

KEYWORDS

Ecosystem services, water quality regulation, flood mitigation, forests, urban resilience

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Wastewater treatment and reuse for irrigation as alternative resource for water safeguarding in Souss-Massa region, Morocco

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ABSTRACT

The Souss-Massa basin river is an arid area located in Southern Morocco. The region is characterized by a very intensive agriculture. However, water resources overexploitation, succession of drought years and several sources of pollution constitute major challenges for compatibility between securing the existing activity and safeguarding the groundwater. In order to cope with water scarcity and attenuate the impacts on groundwater, policy makers encourage the reuse of treated wastewater as a substitute resource for agricultural practices. In fact, the Biological System in Tiznit based on Anaerobic, facultative and maturation lagoons is an effective treatment technology leading to a good quality effluent that complies with WHO guidelines to be used without restriction for irrigation. This successful practice in the south of Morocco demonstrates that water reuse can be reliable, commercially viable, socially acceptable, environmentally sustainable and safe. In this particular project, cereals, cooked vegetables, fodder crops (namely alfalfa) and fruit trees were irrigated.
In this paper, costs, benefits, and added-value impacts of wastewater treatment reuse as alternative resources are presented. The case of the wastewater treatment plant of Tiznit is presented as a successful experience in the region on wastewater reuse with the irrigation of about 430 ha of several crops.

KEYWORDS

Over pumping, water scarcity, water reuse

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Bioenergy water footprints, comparing first, second and third generation feedstocks for bioenergy supply in 2040

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ABSTRACT

Freshwater is important for energy. Energy scenarios show increasing energy use, combined with increasing bioenergy shares. Bioenergy derives from *first (*food crops*), second (*energy crops or agricultural residues) and *third (*algae*) generation feedstocks*. There is an ongoing debate about the competition between energy and food crops. Energy crops have no direct competition with food, but an indirect one, using the same natural resources, like water. Crop residues seem a good alternative for food or energy crops. This paper gives water footprints (WFs) of first, second and third generation bioenergy (m^3/GJ). Next, it compares WFs of future energy demand using different bioenergy feedstocks. WFs of energy from residues is smallest, WFs of energy crops largest. Bioenergy from algae has the largest blue WF. From a resource-use point of view, impacts of green WFs on the environment are smaller than impacts of blue WFs. Comparing different bioenergy feedstocks, residues are most favorable. With increasing bioenergy production, impacts on freshwater also increase. It is expected that increased production of *first generation biofuels* heavily contributes to global water scarcity. For *third generation bioenergy*, the application of algae would substantially increase the global blue WF. Comparing IEA scenarios, the greenest scenarios have the largest WFs, due to large contribution of bioenergy (especially in the case of energy crops and algae). Feedstocks with a relatively small WF are crop residues. The potential is enormous, but large challenges remain concerning technical possibilities to convert residues into energy carriers in combination with the possibility that not all residues are available for bioenergy.

KEYWORDS

Water footprint, Bioenergy, First second and third generation biofeedstocks

VIII. Groundwater Hydrology and Contamination

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Space-time modelling of aquifer level using novel geostatistical tools

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ABSTRACT

Space-time geostatistical approaches can improve the reliability of dynamic groundwater level models in areas with limited spatial and temporal data. Space-Time Residual-Kriging (STRK) is a reliable method for spatiotemporal interpolation that can incorporate auxiliary information. STRK is applied to combine the estimated trend and interpolated residuals for the final prediction of the groundwater level, while the uncertainty of estimations is determined using the STRK variance. The method though leads to an underestimation of the prediction uncertainty. Therefore, STRK variance is not usually applied for de-trended data that involve complex spatiotemporal trend functions. Spatiotemporal trend is approximated using a combined component based on a physical law that governs groundwater flow in an aquifer under pumping conditions. A Bayesian approach based on the bootstrap idea is employed to determine the uncertainty of the spatiotemporal model parameters (trend and covariance) and estimations. This stochastic modelling approach produce multiple realizations, rank the prediction results with respect to specified criteria, and captures the range of the uncertainty. The interdependence of the spatiotemporal residuals is modelled using a new space-time variogram based on the product-sum approach that involves the hydraulic conductivity anisotropic ratio within the exponential function. The proposed methodology is applied to predict spatiotemporal groundwater level fluctuations and to investigate the uncertainty of estimations at a sparsely gauged basin on the island of Crete, Greece.

KEYWORDS

Space-time geostatistics, space-time variogram, Bayesian analysis, uncertainty, groundwater level

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Artificial neural networks and particle swarm optimization based model for the solution of groundwater management problem

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ABSTRACT

Fulfilling the growing water demand, at domestic, industrial and agriculture level, is the most challenging task and groundwater plays the most important role for achieving this demand. In this scenario, proper management of groundwater resources is the most required act, as unmanaged groundwater extraction may cause shrinking of aquifer, sea water intrusion and water quality problems. The simulation-optimization approach is the most efficient way to solve any ground management problem where complex numerical models simulate the groundwater flow and/or contamination transport. The optimization model employs simulation for achieving the values of the groundwater head, velocity, concentration etc. This repeated use of the flow model increases the computational burden extensively and takes several hours to converge the final solution. In this study, Artificial Neural Network (ANN), Bagged Decision Trees (BDT) and Particle Swarm Optimization (PSO) models were developed and coupled for the management of groundwater resources. The Analytic Element Method (AEM) based flow model was developed and used to generate the dataset for the training and testing of the ANN model. These developed ANN-PSO & BDT-PSO models were applied to minimize the pumping cost of the wells. The results show that the ANN model can reduce the computational burden significantly and it is able to analyze different scenarios as well.

KEYWORDS

Groundwater Modeling, Groundwater management, Artificial Neural Network, Analytic Element Method, Particle Swarm Optimization

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Vulnerability of groundwater to pollution using three different models in Halabja Saidsadiq Basin, Iraq

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ABSTRACT

Halabja Saidsadiq Basin (HSB) is one of a major basin of Iraq in terms of groundwater reservoirs. Intensive agricultural practices and economic revolution are widespread and located close to groundwater wells, which pose imminent threats to these resources. Therefore, the most effective and realistic solution is to prevent the contamination of groundwater through. The present study targets the computation of the vulnerability of groundwater reservoirs of the study area. Three methods have been examined, namely DRASTIC, VLDA and COP to model a map of groundwater vulnerability for contamination. The standard DRASTIC vulnerability maps classified the basin of four vulnerability index zones: very low (34%), low (13%), moderate (48%) and high (5%). The VLDA model also classified the area into four categories as well: low (2%), moderate (44%), high (53%) and very high (1%).Four vulnerability classes were recognized based on COP model including very low, low, moderate and high vulnerability classes with coverage areas of (1%, 37%, 2% and 60%) respectively. After constructing every vulnerability map, it required to be confirmed in order to estimate the validity of the theoretical sympathetic of current hydrogeological conditions. In this study, nitrate concentration analysis was selected as a contamination indicator to validate the result. Considerable variations in nitrate concentration on dry to wet seasons had been renowned. Consequently, it points toward that groundwater in the HSB are capable to receive the contaminant due to suitability of overlies strata in terms of geological and hydrogeological conditions. Based on this confirmation, the result exemplifies that the degree and distribution of vulnerability classes acquired using VLDA model is more sensible.

KEYWORDS

Vulnerability, DRASTIC, VLDA, COP, Nitrate concentration, Halabja Saidsadiq Basin

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Artificial intelligence and regression analysis in predicting ground water levels in public administration

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ABSTRACT

Water level prediction of ground water can be considered as a very important tool in water resources management. This research implements artificial neural network models in order to build the optimal forecasting models for predicting the water levels and regression analysis in order to evaluate the prediction accuracy. In this research, an Artificial Neural Network Perceptron is applied in order to construct forecasting models for predicting water levels of ground water. The developed models are then compared each other in order to find the optimal one according the best performance that will lead to the most accurate predictions. Several topologies were tested in order to discover the best forecasting model. The different predictive models were constructed by implementing different number of the nodes in the hidden layers, also by testing different number of the hidden layers. The results showed an increased prediction accuracy of the developed Artificial Neural Network Models. This research is aiming at providing the scientists and engineers with the optimal prediction models in order to be used for forecasting the water levels of ground water with increased accuracy compared to other prediction techniques and methods. The developed forecasting models can provide accurate predictions of water levels of ground water which can be very valuable for the public administrators and stakeholders in water resources management.

KEYWORDS

Artificial intelligence, Neural networks, Environmental management, Public Administration, Water level prediction

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Ground water risk management using dynamic bayesian networks and PROMETHEE method

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ABSTRACT

The aquifers are considered as the best and most accessible source of fresh water. In recent years, they have been faced with severe water withdrawal in Iran, therefore some plains was considered as forbidden plains that it means the water withdrawal from these aquifers is unauthorized. Given such a critical situation in aquifers, the need for management of groundwater resources in the form of tools such as monitoring the level of the aquifers and developing the restoring scenarios is essential. Then for this purpose, A Decision Support System-DSS has been developed in this paper based on Prediction of groundwater level and Multi Criteria Decision Making methods (MCDM). Due to the flexible and simple structure, a probabilistic Dynamic Bayesian Networks (DBNs) has been used for monthly groundwater level prediction under uncertainties. After analyzing the obtained results, some applicable groundwater management scenarios such as artificial recharge and irrigation system change as well as relative criteria such as economic, social and technical attributes have been defined for decision making procedure. After elicitation of decision makers' opinions about criteria's relative importance and performance, among the MCDM methods, PROMETHEE-II technique has been applied to ranking the scenarios regarding their efficiency in restoring the Birjand aquifer in Iran which has a critical groundwater resource condition. The results show the ability of the proposed DSS in planning and management of groundwater resources, reducing the risk of aquifer level declining by applying short term management scenarios and predict its effects on rehabilitation.

KEYWORDS

Bayesian Networks, Groundwater Management, MCDM, PROMETHEE-II, DSS

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Analytical solutions to groundwater flow around wells using discharge potential

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ABSTRACT

In general, potential flow describes the flow vector field as the gradient of some scalar potential function. Various definitions of potential function have been used in literature. In this study, the discharge potential was used to solve the problem of groundwater flow around wells. The advantage of discharge potential is that it is applicable to combined confined and unconfined groundwater flow. When the discharge potential satisfies Laplace's equation, potential theory is applicable. When two or more discharge potentials each satisfy Laplace's equation, their sum also satisfies it which means that the principle of superposition can be implemented. Using the latter, solutions to various groundwater flow problems were made. One advantage of analytical solution using discharge potentials is that the size of the computation domain does not influence the solution unlike numerical methods such as finite differences in which the entire boundary condition surrounding the computation domain has to be specified. When using the method presented, however, specifying an observed head at one single point is enough to reach a solution in the case of an infinitely large aquifer. For presentation of the results of two-dimensional flow problems, flownets were drawn by interpolation from discrete values of potential function and stream function.

KEYWORDS

Groundwater, potential flow, discharge potential, well

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Management of coastal hydrosystems through the application of free & open source software tool – FREEWAT

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ABSTRACT

FREEWAT is an open source and public domain GIS integrated modelling environment for the simulation of water quantity and quality in surface water and groundwater with an integrated water management and planning module. It involves the integration of: (i) Observation-Analysis Tool (OAT) that combines a number of time-series processing functionalities for statistical analysis of observations and help prepare model input data; (ii) AkvaGIS that involves hydrochemical and hydrogeological Analysis Tools and (iii) Groundwater Flow (MODFLOW-2005) and Transport modeling modules. FREEWAT platform will be applied in a typical Mediterranean environment that hosts a naturally occurring –and today degraded– coastal wetland with the characteristics of a distinct ecosystem linked to a typical coastal hydrogeological system of a semi-arid region; and therefore can serve as a model for similar systems world-wide. The geo-hydrological setting of the area involves a multi-layer aquifer system consisting of (i) an upper un-consolidated formation of depositional unit dominated mostly by fluvial sediments and (ii) the surrounding and underlying karstified marbles; both being linked to the investigated wetland and also subjected to seawater encroachment.

KEYWORDS

Groundwater modelling, Open source public domain GIS integrated GW modelling, Marathon coastal hydrosystem, water resources management

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Modifying SINTACS method to assess groundwater vulnerability and pollution risk to nitrate

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ABSTRACT

Groundwater as a source of water supply and ecological asset has drawn a growing attention in order to meet the increasing demand of water resources due to fast demographic growth and urbanization, and to economic and agricultural activities intensification. In particular, the assessment of agrochemicals losses from cultivated land and the potential of groundwater contamination, especially from nitrogen species, is a serious issue to effectively meet the measures established in the European Water Framework Directive (Directive 2000/60/EC). The use of indices, describing the intrinsic and the specific groundwater vulnerability are widespread methods to characterize areas affected by non-point agricultural sources. In the present study, the SINTACS method was applied in order to estimate the intrinsic vulnerability of the aquifer underlying the Campanian Plain, an intensively cultivated and densely populated coastal plain located in Southern Italy. Nitrogen losses from the top soil were estimated based on climatic, soil and topographic data using LOS indices. By combing the SINTACS and the LOS indices in a GIS environment, the specific vulnerability of the local unconfined aquifer to nitrogen losses was calculated. Results show that the inclusion of an estimate of the potential percolation of nitrogen species below the agricultural fields, can improve the vulnerability classification of the study area allowing a more detailed and targeted management of groundwater resources and a wiser allocation of land use.

KEYWORDS

Vulnerability indices, N leaching, GIS, Non-point source pollution

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Application of Head-guided Zonation method to delineate groundwater vulnerability zones in a data-scarce catchment

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ABSTRACT

Developing a reliable groundwater model which often requires an extensive and costly subsurface profiling is a real challenge in data-scarce. In this study the Head-Guided Zonation (HGZ) methodology was applied on the recharge area of Oemau Spring in Rote Island, Indonesia, which is under potential risk of contamination from land use changes. The methodology involves calibrating a groundwater model using the HGZ method in parameterisation step. Using distribution of hydraulic gradient, HGZ method aims to represent distribution of subsurface parameters, such as hydraulic conductivity and specific yield, in areas where geologic data is scarce. This study shows that the HGZ method can be effectively used to calibrate a physically-based groundwater model. The results from reverse particle-tracking simulation were used to develop vulnerability zones.

KEYWORDS

Vulnerability zones, groundwater contamination, model calibration, particle tracking, karst aquifer

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Impact of land-use change on a multilayer aquifer in south-eastern coast of Caspian sea

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ABSTRACT

Human activities through land-use changes affect different parts of ecosystem such as geo-hydrological processes. Multilayer aquifer of Golestan province in South-eastern coast of Caspian Sea located in an agricultural zone. This paper demonstrates historical land-use changes and evaluates its impact on confined and phreatic layers of the aquifer. In order to trace land-use changes, three land-use maps of 1984, 2005 and 2013 were used. Data recorded in 33 piezometers and 43 monitoring wells were used to study groundwater dynamics in each layer. According to geological formation and groundwater flow direction, recharge areas of confined and phreatic aquifers determined and land-use changes in each one assessed, using GIS software. Results present considerable land-use changes in mountainous area and ignorable changes in the plain. Both domestic and agricultural consumption have significant impact on phreatic layer but only influence of agricultural wells on confined layer approved. Also the results show threat of saltwater intrusion from Caspian Sea and fossil brine from north part of the plain in confined and phreatic layers, respectively, in case of continuing the land-use change trend. In mountainous district, forest and rangeland areas decreased and residential and agricultural areas increased that according to SCS method altogether higher CN value and reduce recharge rate. Mountainous district lost 12 percent of forests and rangelands that totally added to agricultural area. After all the confined aquifer which recharge only in mountainous area, is more affected by changes in land-use.

KEYWORDS

Confined Aquifer, GIS Software, Golestan Province, Phreatic aquifer, SCS method

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Hydrochemical and qualitative assessment of natural water spring in southern Italy

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ABSTRACT

Groundwater represents a natural resource of great socio-economic importance for the entire southern Italy, where it is used for both irrigation and drinking purposes. Knowledge of the complex hydrogeological environment, of the chemical composition of waters and of the interpretation of geochemical maps allows the definition of flow domain, groundwater quality and degradation processes affecting the aquifers. The present paper offers a large qualitative assessment of water springs falling within the Crati river basin in Calabria, southern Italy, which is the largest basin in the region with an area of 2447.7 km^2 and a complex lithology. 190 samples of water springs, located over 300 m a.s.l., were collected and analysed. For each sample, physical (i.e. pH, water temperature, conductivity) and chemical parameters, such as major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and major anions (SO_4^{2-}, Cl^{-}, HCO_3^{-}), were evaluated. The physical and chemical tests allowed the characterization of the hydrochemical facies of the sampled waters by means of the Langelier-Ludwig diagram. Moreover, the relationship between water temperature and altitude of the water springs has been assessed as well as the one between conductivity and altitude. Due to the extension of the basin, the investigated area was split into 5 sub-areas, with different hydrochemical behaviour. Results showed a good quality status of the water springs, where the hydrochemical facies of bicarbonate-alkaline type is predominant, and allow us to identify the chemical and physical behaviour of groundwater in relation with the several lithologies present in the sub-areas.

KEYWORDS

Groundwater, water springs, Langelier-Ludwig diagram, Crati river basin

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Mechanism of controlling seawater intrusion at coastal aquifers using subsurface barrier

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ABSTRACT

One of cases that threaten groundwater in coastal aquifers is seawater intrusion (SWI). Inserting subsurface barrier (SB) is known as a way of preventing SWI. In this study, we attempted to achieve the optimum indexes for SB characteristics including longitudinal position, height, thickness and its hydraulic conductivity. Numerous scenarios have been defined and the finite difference dispersive SEAWAT model has been used. The positive impact of SB is evaluated by measuring the salt wedge toe retrogression, freshwater volume increase and the reduction of trapped salt wedge dimension over time. The results indicated that inserting the SB closer to shoreline control the SWI more efficient due to dilution of larger trapped wedge behind it. The results also illustrated that the more the height of SB approaches to 5% salinity contour the more efficient it will be. It is also shown that changing the thickness of SB had the least effect on SWI controlling but by reducing its permeability, its performance in short term and long term will have an effective improvement. Therewith, analyzing the performance of SB in aquifer with presence of extraction well demonstrate that even though SB can act successfully in reducing the salinity of extracted water, it cannot eradicate it entirely. Turning over of saline flow form above the barrier and reaching the salt wedge behind it, is found to be the reason. Eventually, the results show that constructing a SB is not a short-term method for controlling SWI and its effects are more significant in long period.

KEYWORDS

Coastal aquifer, Seawater intrusion, subsurface barrier, Transition zone

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Long term monitoring of aquifer salinization processes in a physical analog model

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ABSTRACT

A long-term experiment on an unconfined shallow aquifer physical analog model was performed to study the salinization processes in finely graded sandy-silty sediments. The unconfined shallow aquifer was reconstructed within a laboratory large tank (4 x 8 x 1.4 m) equipped with 26 standard piezometers. The sediments (~35 m^3) pertaining to a crevasse splay deposit of the paleo-Po river system, were sourced in March 2004 from an unconfined alluvial aquifer near Ferrara (Northern Italy). In July 2013, 600 l of NaCl saline solution (35 g/l) was injected in the aquifer physical analog model and the fate and transport of the saline solution was monitored since nowadays. The system was subjected to high evaporation rates, which caused the upper soil salinization in presence of saline groundwater. The movement of the saline solution was monitored in time and space with both fully screened piezometers and high resolution multi-level coring (every 5 cm). The results highlighted how the saline front migrated within the aquifer physical model in response to different boundary conditions: lateral input of water from irrigation canals, sprinkler irrigation and evaporation, all in controlled conditions. This study aims to elucidate the processes of soil salinization in reclaimed agricultural lands characterized by highly saline groundwater.

KEYWORDS

Soil salinization, saline groundwater, evaporation, low permeability

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A 3D Modeling Approach to Groundwater Management in Paharpur Canal Command Area, Dera Ismail Khan, Pakistan

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ABSTRACT

The main aim of this study was to analyze the groundwater flow system in Paharpur Canal Command Area, Dera Ismail Khan using 3D numerical groundwater flow modeling. The groundwater flow system in the area was modeled using MODFLOW 4.2. The model was run for both steady and non-steady state conditions. The area was modeled with a grid of 171 columns and 399 rows with three layers assigned on the basis of the varying hydraulic conductivity values. The upper 100 meter of the unconfined aquifer was modeled. The steady state model was simulated and then calibrated for the year 1980 using PEST. Non-steady state simulation was carried out from the year 1980 to 2010 to evaluate the effects of groundwater abstraction on the water table depths and flow direction. The groundwater model developed has resulted in better understanding of the groundwater flow of the study area. Water logged zone have also been identified with the aid of the model. Groundwater management of the area can be effectively carried out with the support of the model developed.

KEYWORDS

Groundwater, modeling, MODFLOW, calibration, water logging

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Hydrogeological and hydrochemical regime of fissured rocks in Pelion massif (E. Thessaly)

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ABSTRACT

The massif of Eastern Thessaly is structured by formations of the Pelagonian zone. There, an extensive nappe of transformed and in places intensely layered formations composting of schists and gneisses with alternating marbles and interference ophiolitic formations, is composed. The aforementioned nappe is characterized by heterogeneity in terms of the permeability of individual formations. The large number of springs, identified and registered in this study, suggests the presence of an underground communication network, which forms preferred flow pathways for the circulation of water through a dense network of tectonic fissures, which in turn follows the directions of the main fractural system (30 ^{O} N- 40 ^{O}E, 30 ^{O}N- 40 ^{O}W). Concerning the way the springs are being expressed, we distinguish those of zonodi development along the slope and then follow the fracture and those that exhibit a linear array along the inclination of the slope. The springs, in their entirety, are characterized by low value electrical conductivity and remarkable seasonal and regional variations in their supplies (5 - 40 m^3 / h), indicating shallow aquifers of limited capacity. The performed hydrochemical analysis of major, trace, and rare earth elements, revealed the host rock. The waters of the Pelion springs are characterized as moderately alkaline and by low TDS values with three dominant hydrochemical types: i. Mg - Ca- HCO_3 (reflecting the effect of gneiss-schistolithic background), ii. Ca -HCO_3 (indicating the effect of carbonate rocks), and iii. Ca - Na - HCO_3 - Cl (revealing the effect of the dissolution of Na-Bearing minerals and transported marine aerosols).

KEYWORDS

Pelagonian, schists, fissured rocks, springs, hydrochemistry, Pelion massif

EWRA
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Updated groundwater vulnerability evaluation at a coastal aquifer system in NE Greece

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ABSTRACT

This paper presents the updated vulnerability assessment of Xilagani - Imeros aquifer system in the coastal plain region of Rhodope Prefecture, NE Greece, in the framework of the groundwater management in the region. Information regarding the geological and geomorphological environment, as well as data concerning the hydrologic and hydrogeological regime of the study area are stated. The paper presents the application of DRASTIC and GALDIT vulnerability indexes procedures and the design of easy to use vulnerability maps in order to identify the parts where there is a serious potential for groundwater resources qualitative degradation due to agricultural pollution (DRASTIC approach) or seawater intrusion (GALDIT approach). The research is based on the results of hydrogeological studies in the study area for the year 2015 compared to the year 2006, including field hydrogeological measurements and chemical analyses in the laboratory, as well as the design of groundwater piezometric maps and hydrochemical maps. It is worth mentioning that DRASTIC index values for the year 2015 do not differ substantially compared to the corresponding values for the year 2006. Instead, increase of GALDIT index values is recorded for the year 2015 indicating worsening of the groundwater salinization status due to seawater intrusion.

KEYWORDS

DRASTIC GALDIT Vulnerability index, Coastal hydrogeology, Groundwater pollution, Seawater intrusion, Coastal aquifer management

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Use of remote sensing and electrical resistivity tomography to determine Tidsi spring recharge and underground drainage

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ABSTRACT

The Souss plain, located in southwestern Morocco, is characterized along its southern edge by the emergence of several springs - Tidsi, Tioute and Tiare springs - flowing from the Calcareous Anti-Atlas Mountains' with low but constant rates despite successive drought years. This study was focused on Tidsi spring and aims to understand its hydrogeological functioning by determining the recharge area and underground drainage coming from Anti-Atlas Mountains. To reach these objectives, a remote sensed image (Landsat TM+) has been processed in order to map the geostructural mega-lineaments passing through the study area in order to better know the regional fracturation. Then, a geophysical investigation using 2D electrical resistivity tomography has been carried out to study the underground relationships between these mega-lineaments to assess their importance in Tidsi spring's recharge. Satellite image processing shows that Anti-Atlas Georgian limestones are well fractured. The lineation follows three corridors. The major lineaments' directions are in order of importance as follows: NW-SE, E-W and rarely NE-SW, respectively. These results were confirmed by field observations which indicate N20°, N50°, N90°, N130°, N160° lineament directions. Tomography pseudosections reveal the existence of two deep subvertical low-resistivity discontinuities. They show also the link of some lineaments with deep fractures leading to recharge of Tidsi spring. These results allow proposing hydrological behaviour of groundwater from Anti-Atlas Mountains which takes into account for both flows through subvertical faults and karstic fractures.

KEYWORDS

Souss plain, Tidsi spring, remote sensing, electrical resistivity tomography, Karstic fractures

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Enviromental impacts of urbanization in hydrogeological systems

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ABSTRACT

The impact of urban areas growth is a rather complex research topic in the field of hydrogeology. Urbanization significantly affects the natural water cycle, both in terms of quantity and quality, recognized as a challenge with scientific approaches which should be extended to different spatial and temporal scales. The analysis and interpretation of these hydrosystems is a difficult and complicated task influenced by many factors. Urban groundwater resources management is an issue of paramount importance that becomes a necessity in the case of Attica, Greece. Urban aquifers are considered very sensitive ecosystems that are subject to several stresses being mainly of anthropogenic origin. Due to the great heterogeneity of the related infrastructures -such as underground structures and water supply/sewage/stormwater systems - the water balance of groundwater may vary greatly in spatial terms within the urban environment, highlighting that the main contributor to recharge and discharge clearly differ from those in natural systems. Buildings, roads, and other surface infrastructure create an impermeable covering that alters all parts of the hydrological cycle. So it is clear, that the investigation of urban hydrosystems and the thorough evaluation of hydrological processes related to the hydrological cycle of urban groundwater, required modern approaches both in terms of developing new modelling approaches (holistic) and new monitoring techniques of hydrological processes with state of the art technologies. The urban aquifer system of Attica can be used as a reference site that incorporates multi-disciplinary environmental problems and highlights the need for an Integrated Urban Water Management (water supply-drainage-sewage systems).

KEYWORDS

Urban Hydrogeology, Urbanization, Groundwater, Monitoring technologies

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A two-dimensional analytical model for tide-induced groundwater fluctuation in leaky aquifers

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ABSTRACT

Tide-induced groundwater head fluctuations in coastal leaky aquifer systems are complicated and difficult to quantify. Yet, the prediction of groundwater fluctuations may be a crucial work in dealing with the problems of groundwater resources management or contamination remediation in coastal aquifers. This study develops a two-dimensional analytical model for describing the groundwater flow in an *L*-shaped leaky aquifer bounded by a river and the ocean with an arbitrary included angle and subject to the effect of tidal fluctuations. The solution of the model is developed in Cartesian coordinates based on the methods of finite sine transform and Hankel transform. On the basis of the analytical solution, the groundwater fluctuations induced by the joint effect of estuarine and oceanic tides are examined. In addition, the influences of physical parameters such as aquitard leakage (L), included angle (Φ), damping coefficient (*Ker*) and separation coefficient (*Kei*) on the groundwater fluctuations in the confined aquifer are investigated and discussed. The analysed results indicate that those parameters have significant impacts on the head fluctuations in the *L*-shaped coastal leaky aquifer system. The results also show that the effect of L on the normalized amplitude and phase lag of the groundwater fluctuations increases with Φ, but the joint effect of *Ker* and *Kei* on both parameters decreases as Φ increases.

KEYWORDS

Analytical model, coastal leaky confined aquifer, groundwater fluctuations, *L*-shaped aquifer

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Pumping optimization in coastal aquifers: comparison of sharp interface and density dependent models

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ABSTRACT

Seawater intrusion in coastal aquifers can be simulated using models of different accuracies, depending on the application and the required approximation level. In the present work, two seawater intrusion models of different complexities are employed to calculate the optimal pumping rates in coastal aquifer management problems. The first model simulates variable-density flow and salt transport processes and utilizes SEAWAT code. It is considered a time-intensive numerical model which hinders the implementation of simulation-optimization routines in coastal aquifer management. The second model coarsely approximates seawater intrusion by considering the sharp interface approach. The sharp interface model is faster compared to the variable density models, yet, it may introduce errors in the prediction of seawater intrusion since it neglects dispersion mechanisms. In this study, we investigate the potential of three sharp interface model variations to produce satisfactory approximations of the variable density based optimization. A pumping optimization problem is solved for an unconfined coastal aquifer with multiple pumping wells. The efficiency and effectiveness of the sharp interface models are compared to the optimal solutions and the computational time from the SEAWAT based optimization, which is used as benchmark. Results are further analysed based on the capability of the sharp interface models to produce feasible solutions for the SEAWAT based optimization.

KEYWORDS

Sharp interface models, SEAWAT, pumping optimization, coastal aquifer, seawater intrusion

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Towards sustainable management of groundwater: A case study of semi-arid area, Iraqi Kurdistan region

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ABSTRACT

In this paper, Erbil province the capital of Iraqi Kurdistan has been chosen as a representative case study for a large number of provinces in semi-arid areas, lacking imbalance between water demands and supply. Climate change is expected to bring adverse impact on water availability, which would intensify the pressure on water resources and increases the environmental concerns. Sustainable water use and prudent management prefer the rational water use and to preserve groundwater exploitation. The study aims to develop a framework considering sustainability aspects. A total of twenty wells have been selected among ninety-nine observation wells across the province along a period of 16 years from 2000 to 2015 to assess water level depression. The groundwater level had been falling nearly by half, this highlights the issues that the groundwater level has been significantly affected by; impacts of the non-sensible usages of groundwater, dry spell periods, mismanagement of water resources, and unsustainable planning. Urban areas and suburbs were more exposed to water insecure than outskirts The results also suggest that the management of water resources and drainage systems would get worse if there was not adoption on a clear policy to manage it by relying on a robust framework based on sustainability concepts.

KEYWORDS

Groundwater depletion, Sustainability, Water Management, Climate change, Framework

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Assessing groundwater use in irrigation districts with multiple resources (MIGRAD)

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ABSTRACT

A water allocation model at farm-scale was developed to interpret water allocation patterns in an intensive agricultural district of Southern Italy, supplied by groundwater and surface waters (from reservoir) with variable costs and distinct management regimes. The model aims at evaluating the impact of farm-scale water costs on water resources management and groundwater conservation at district scale. Semi-structured interviews were carried out involving local stakeholders to define (i) the relationship between irrigation source selection and water tariff applied by the irrigation district, and (ii) the conjunctive use of groundwater based on water cost convenience. It was demonstrated that farmers' choice depends on the ratio between volumetric water tariff and the groundwater pumping cost at farmscale. The results also demonstrated that a restrictive water tariff policy applied during drought periods produced an increase in the groundwater use instead of reducing the water consumption. The model allowed to analyse the drivers influencing farmers' behaviour, thus assessing the effectiveness of water protection policies, specifically those related to water tariff.

KEYWORDS

Water allocation criteria, integrated water management for irrigation, groundwater use, multi-resources water supply system

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Using groundwater flow simulation of the Chania plain area to propose a proper irrigation plan

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ABSTRACT

The objective of this work was the simulation of groundwater flow at the aquifer of the Chania plain area in Crete, Greece. This area is dominated by irrigated olive and citrus trees with high water demands during the dry period. In the present study, the three-dimensional Princeton Transport Code (PTC) model was employed in combination with the pre-post processor model ArgusOne, which has been developed specifically to simulate groundwater flow and solute transport. PTC employs a unique splitting algorithm for solving the fully three-dimensional equations, which significantly reduces the computational burden. For the model calibration, a simulation time of two years (1998 - 2000) was considered. The model was calibrated using hydraulic head data. In order to quantify the accuracy of the calibration process, a statistical analysis was performed between the simulation results and the corresponding groundwater field data. In addition, for the study area, the irrigation needs in a yearly basis were estimated based on a common irrigation amount for olive and citrus trees (period between May to September). Finally, using the simulation results the effects of saltwater intrusion are discussed and a proper irrigation plan is proposed based on crop requirements.

KEYWORDS

Groundwater flow, irrigation wells, PTC model

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Sustainable use of groundwater for irrigated agriculture – A case study of Punjab, Pakistan

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ABSTRACT

Irrigated agriculture in Pakistan contributes 22% to GDP, 66% to foreign exchange, over 90% to food production, employs 45% of country's labor force and ranks the country as 8th largest food producer in the world. Nature has blessed Pakistan with plenty of water resources and specially a large groundwater reservoir of more than 300 m depth. Pakistan is 4th largest user of groundwater after India, USA & China. In Punjab Province, 40 MAF of groundwater are being extracted through 1.2 million tube-wells annually. Groundwater is contributing about 45% crop-water requirements and thus has gained the vital potential in irrigated agriculture. Besides irrigation uses groundwater is the major source of drinking, industrial and commercial requirements and has boosted up the cropping intensity from 60% in 1947 to 160-170% in 2015 to meet ever increasing demand of food and fiber. A monitoring network of about 3000 piezometers has been installed to observe the groundwater potential (quantity and quality) in the Province at grid of 6x6 km. Data so observed since 2006 have been analyzed using latest tools of groundwater modeling and GIS. Under recent study some recommendations have been formulated for sustainable use of groundwater for irrigated agriculture. It has been observed that over all groundwater reservoir is depleting, quality of groundwater is deteriorating reducing the crop yields and fertile land and major source of groundwater recharge is seepage from canal network. Recharge of aquifer using flood water and rainfall harvesting are two major structural interventions for sustainable use of groundwater.

KEYWORDS

Groundwater, Punjab, Pakistan, quality, irrigated agriculture, piezometers, groundwater recharge, flood, salinity

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Physics-based and data-driven surrogate models for pumping optimization of coastal aquifers

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ABSTRACT

Data-driven surrogate models have been widely used in pumping optimization of coastal aquifers. However, their efficacy has not been previously compared to physics-based surrogate modelling techniques. In this work, we utilize a set of sharp interface models of different complexity to investigate the performance of a variable-fidelity optimization framework against a data-driven approach. In particular, the numerical solution of sharp interface flow represents the available high-fidelity seawater intrusion model. Furthermore, several analytical models represent lower-fidelity approximations for simulating seawater intrusion. To statistically assess the performance of the surrogate-based methods against the high-fidelity optimal solution, we utilized a total of 30 independent optimization runs for each approach. The results indicate that the analytical models which poorly approximate the numerical sharp interface model had also limited skills to approximate the high-fidelity optimal solution. On the other hand, the surrogate-based optimization frameworks that were developed by using either the most accurate analytical model or the data-driven surrogate model were in good agreement with the high-fidelity optimization results. It was also observed that the variable-fidelity optimization algorithm required fewer evaluations with the high-fidelity model in order to converge to the optimal solution. Moreover, the set of these seawater intrusion models could be conveniently used for further development and testing of variable-fidelity optimization frameworks in coastal aquifer management.

KEYWORDS

Seawater intrusion, pumping optimization, surrogate modelling, variable-fidelity optimization

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Phreatic/confined flows in polygons: Dupuit-Forchheimer model versus potential solutions

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ABSTRACT

Analytical and numerical (HYDRUS2D and MODFLOW) solutions for steady unconfined Darcian flows with accretion and leakage in a single aquifer is obtained for domains bounded by trigons (in particular common triangles) and polygons that allows modeling catchment-scale groundwater flows. Strack's comprehensive potential obeys the 2-D Poisson equations, which assumes the Dupuit-Forchheimer vertical averaging of the head. Along the lateral boundaries in 2-D flows and leaky layer in 1-D flow, Robin's condition models clogging of river/wadi banks and beds. In a layered aquifer, confined flows are decoupled into two types of analytic elements: highly-low permeable strata with 1-D and essentially 2-D seepage, correspondingly. The conjugation between these fragments is based on a "seepage shear" condition. This leads to a boundary condition along the interfaces between the two types of commingled strata, which is similar to Kirkham-Brock's one. The method of hodograph is used for two types of 2-D potential flow fragments: arbitrary triangles and trapezia. By routines of computer algebra, the complex potential and physical domain are parametrized via an auxiliary variable. Deviation from trivial 1-D approximations in 2-D fragments are found. Implications for groundwater quality, dissolution of the porous skeleton of the strata and soil erosion by suffusion, as triggered by an intricate "winding" of flow paths between the strata, are discussed.

KEYWORDS

Seepage refraction, hodograph, leaky layer, infiltration, numerical simulations

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Comparison of SGD rate between Northern-Southern coastlines of the Persian Gulf using RS

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ABSTRACT

Submarine Groundwater Discharge (SGD) is defined as any subsurface flow of water from the land into the sea. In this research, we have tried to use remote sensing technique to determine the potential areas for SGD in southern coastlines of the Persian Gulf - around Bahrain where submarine freshwater springs have long been known- and a section in northern Persian Gulf coastline opposite to Bahrain. For this purpose, first necessary corrections (atmospheric, radiometric, and geometric) were made on the obtained Landsat 8 data in 2016 across the study area. Then, by mapping sea surface temperature (SST) and standard temperature anomaly (STA), probable anomalous areas caused by SGD into the coastlines of the Persian Gulf were identified and mapped. Results show that although 29 submarine freshwater springs are known to exist around Bahrain, thermal anomalies in northern coastlines of the Persian Gulf are much more than that of the southern coastlines; we could not detect significant thermal anomaly around and near Bahrain. Therefore, it is likely that the rate of SGD into north of the Persian Gulf is considerably high and much more than in the southern Persian Gulf. The approach implemented in this study can be used for any coastal regions that may have an interaction with coastal aquifers especially for other parts of the Persian Gulf coastlines.

KEYWORDS

SGD, Submarine Spring, Remote Sensing, Persian Gulf

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GIS-based AHP technique for identification of groundwater potential and recharge zones

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ABSTRACT

Groundwater potential and recharge zones perform a crucial function in hard rock terrain. The present study was carried out to identify the groundwater potential and recharge zones in Shivganga basin of Western Ghat, India using Remote Sensing (RS) and Geographical Information System (GIS) for augmenting groundwater resources. The thematic layers considered in the present study are geomorphology, geology, land use/ land cover, drainage density, lineament density, slope, soil and rainfall. The Analytical Hierarchical Process (AHP) was used to normalise the weights of different thematic layers and these layers were integrated in ArcGIS for delineation of groundwater potential zones. The resultant map was alienated into four classes based on their influence to groundwater recharge. Results indicate that 15, 18, 37, and 30 % of the area falls under poor, moderate, good and very good groundwater recharge zones, respectively. The resultant potential map is further classified into five zones on the basis of histograms, viz., very poor, poor, good, very good andexcellent. The specific yield data of 23 dug wells are used to verify the resultant map. The results of the study can be used to formulate an efficient groundwater management plan for sustainable utilization of limited groundwater resources.

KEYWORDS

Groundwater potential zone, Groundwaterrecharge zones, GIS, AHP, Western Ghat

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Innovative float shoe or collar enhances the life of deep water wells

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(1) Demonstration paper - Member of ASCE and Member of AAAS

ABSTRACT

Cementing operations of well casing in recent times have become precise and complex. Like most water well operations, cementing procedures keep on changing fast with the development of new technology and sometimes they are seldom available through one source easily. It is difficult to imagine completing deep water well without having mud contamination issues such as losing the cement slurry quality and bonding strength. Newly developed innovative float shoes and collars are the devices attached to the casing that aid in cementing jobs, improving bonding strength over 20% and extending the life of the wells substantially. Therefore, to resolve mud contamination issues concerning deep water wells, it requires the need to utilize the innovative cement shoes and collars while cementing the well casing for higher bonding strengths. Moreover, these newly developed devices not only assist in better placement of cement in a shorter time, but also aid in extending the functional life of the water wells. Field and logging data emphasizes the cement job quality, improved well design and bonding strength with the casing, leading to much higher production performance and an extended life of deep water wells.

KEYWORDS

Deep water wells, casing, cementing, bonding, innovative float shoes and collars, devices, arid regions.

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Groundwater flow simulation in confined aquifer by meshless element free Galerkin method

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ABSTRACT

In groundwater management problems, the flow behaviour of the aquifer system is analysed by solving the governing equations analytically or using numerical techniques. Numerical techniques such as finite difference method (FDM) and finite element method (FEM) are in use for many decades for solving complex flow problems as these cannot be addressed by analytical methods. In the recent years, meshless methods have been effectively used in solving the groundwater problems. These methods do not require mesh formation resulting in lesser computational cost and time as compared to mesh based methods. The element free Galerkin (EFG) method is one of the efficient and accurate meshless method for the complex flow problems. This method uses moving least square (MLS) approximation for obtaining the shape functions which lack the Kronecker delta function property. Therefore, presently the Dirichlet boundary conditions are imposed using the Lagrange multiplier method. The present study simulates the groundwater flow in a hypothetical heterogeneous and anisotropic confined aquifer using EFG method. The aquifer system is imposed with both Dirichlet and Neumann boundary conditions. The numerical outputs of the EFG model in MATLAB are verified with the groundwater head values obtained from the FEM simulation. The satisfactory results of the EFG model shows the efficacy of the present method.

KEYWORDS

Element free Galerkin method, groundwater flow simulation, meshless method, moving least square approximation

IX. Legislation and Policies

10th WORLD CONGRESS
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The first hydraulic culture in Europe: the Bronze Age Motillas of La Mancha (Spain)

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ABSTRACT

Recent studies indicate that motillas (Chalcolithic and Bronze Age settlements in La Mancha, Spain) could have been the most ancient groundwater collection system at regional scale in Europe. There are catalogued only 32 motillas in La Mancha natural region. The Motilla of El Azuer, in Daimiel (Ciudad Real, Spain) is the most thoroughly studied from the archaeological point of view and it has been established that it was occupied for almost a millennium, 2200 – 1350 cal. BC. It is a unique example in the Bronze Abe in relation to the construction of an old well of about 18 m depth. We present here the first hydrogeoarchaeological study at regional level. The research includes boreholes drilling, geophysical techniques and hydrogeological analysis of the territory. The resulting data confirm a relationship between the hydrology and the spatial distribution of the motillas, sited where groundwater was accessible by means of prehistoric technology. They were built during the 4.2 ka cal BP event in a time of environmental stress after a period of severe and prolonged drought. In these environmental conditions, the construction of these wells was a successful solution that lived on for nearly a millennium and played a major part in the processes of change towards a more complex society.

KEYWORDS

Bronze Age, Climate change, motillas, Paleohydrogeology, La Mancha, Las Tablas de Daimiel National Park

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Sustainable restoration of the Urmia lake: History, threats, opportunities and challenges

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ABSTRACT

The natural and human-induced processes are currently major threats to aquatic ecosystems and water bodies, all over the world. Urmia Lake, the world's second largest saline lake, is located in the Northwest of Iran, is being drying up mainly due to the mismanagement of water use in the basin and the reduction of inflow to the lake. The lake water level has rapidly declined since the mid-1990s. Construction of more than fifty dams and diversion structures, along with the effects of climate change, are the main causes. Construction of a 15 km long causeway in the middle of the lake is an additional cause, which eliminates the natural circulation in the lake. The situation has turned to critical over the past two decades, and the need for restoration is an urgent priority for the region. The contribution of the ten principal rivers for flowing water into Urmia Lake is considered an ultimate solution to this crisis. However, the most challenges for any restoration plan are to be public awareness and general knowledge on the environmental values of the lake to local communities. This paper addresses the major causes to the desiccation of Urmia Lake, and presents an overview on the restoration plan and strategies that have been setup for the next years. Major threats and challenges are also highlighted in terms of the public awareness and community benefits in order to secure the feasibility of the plan for preservation of this internationally recognized wetland at a sustainable environmental status.

KEYWORDS

Causeway Urmia Lake, Restoration plan, Water management, Drought, Lake Causeway

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Measuring sustainable delivery of water, sanitation and hygiene services at the household level: does the measure matter?

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ABSTRACT

Water, sanitation and hygiene (WaSH) are at the very core of sustainable development. As we embark on a new round of global goals to follow the 15 year Millennium Development Goals period, namely the Sustainable Development Goals, a top priority is to address a coherent framework for monitoring these services. In coming years, the sector will witness the development of a variety of multidimensional monitoring measures, albeit from different perspectives. This paper reviews three different multidimensional approaches that are increasingly adopted to determine the level of service delivered at the household. At the global level, a ladder approach to monitoring has been promoted by the WHO/UNICEF Joint Monitoring Programme. Alternatively, the use of aggregated indicators is widespread, as they are adequate to capture and simplify the complexity inherent in services delivery. Finally, the Alkire & Foster methodology for multidimensional poverty measurement has been extensively used for pro-poor targeting. We adapt this method to capture a set of direct household-related water and sanitation deprivations that batter a person at the same time. Taking the international post-2015 monitoring framework as a reference point, this article analyses these measures and their outcomes. For illustrative purposes, one small town in Mozambique is selected as initial case study. We conclude that multidimensional measures are needed to provide a complete picture of the context in which the WaSH services are delivered. In consequence, they are useful to report on the SDG monitoring architecture.

KEYWORDS

Sanitation, Sustainable Development Goals, indicator, multidimensional poverty measurement, identification, monitoring

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Determinants of willingness to pay for improved water supply services in rural Kazakhstan

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ABSTRACT

The UN Sustainable development goals declare to provide water, sanitation and hygiene for all. The supply of affordable and safe water is a global priority and there is thus a requirement for a safe drinking water management and management of excreta disposal and wastewater. The current paper assesses the determinants of consumers' willingness to connect and pay (WTP) for the piped water in rural Kazakhstan. The results show that local villagers use water from different sources and at least three quarters of the respondents are willing to connect and use water from the piped water supply. The general defined determinants for WTP should be carefully considered among the different water users. Perceived water quality is a variable that is relevant for all water users. Other variables such as perceived reliability and the time-spent to collect water from the source, in-household treatment of water, and income perception are also significant but differently correlated with the WTP among different water users. Although, piped water is considered to be a safe system if properly managed, still some water users are reluctant to pay for the system and are satisfied with their current water supply and sanitation services. In this case, a proper management for the drinking water and wastewater and safe management of the excreta disposal should be supplied. It is recommended to include local water users´ opinion as regard the willingness to connect and pay for the piped water system. The findings are of particular importance for policy-makers, water managers, engineers, and public health specialists.

KEYWORDS

Willingness to pay, determinants, rural water supply, Kazakhstan

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Water market and its effects on the sustainable management of water resources in Chile

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ABSTRACT

A simple definition of sustainability is that sustainable use of water requires the maintenance of a desired flow of benefits to a particular group or place undiminished over time, without reducing benefits to other users, including ecosystems. Thus water plays an integral role in ecosystem support, economic development, community well-being and cultural values. Water availability is influenced by both, natural and anthropogenic factors, including climatic variability.
Within this framework, the consequences of a private water management system (due to private water rights) crossed by and linked to the market itself is being analyzed and evaluated, focusing on the case of Chile since the 1981 water code was introduced. It shows how water rights since then have evolved in terms of, extraction point, permanency and execution of rights, analyzing not only water allocation issues but also sustainability concepts. Thus, the main question being addressed is: How does the Water Market facilitate or hinder sustainable water management?
Did mobility induced by the water code of 1981 generated territorial development including expansion of agricultural area as well as changes in crop patterns and thus provoked economic development in some areas, but limited water access to others, leading to unsustainable water use?
Preliminary results of two different catchments are being presented: The highly regulated basin of the Limarí River in the semi-arid north of Chile, and the Diguillín River catchment in the south of Chile, with a different climate and diverse management issues, including inter-basin water transfer.

KEYWORDS

Sustainable Water Management, Private Water Rights, Water Markets, Chile, Remote Sensing, Modelling

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Prototype observatory facilitating integrated coastal zone management at municipal level

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ABSTRACT

The ICZM Observatory of Kavala Municipality has been developed within the framework of Mare Nostrum Project to aid the day-to-day operations of the Municipality, aiming to collect, analyze and process historic, present and forecasted ICZM datasets from various sources. The Observatory follows the well-known DPSIR context (Drivers, Pressures, States, Impacts and Responses) of the European Environmental Agency. Municipal geo-spatial data, environmental data from previous reports, EU and national environmental legislation and institutional information, results from coupled operational models and climate change scenarios have been incorporated in the system. Data are presented in a well-structured layer-basis on a web-GIS environment. A well-designed interface allows the user to enter the Observatory and select the following options: a) Land Development and Uses; b) Environmental Datasets; c) Legislative and Institutional Framework; and d) Toolkit for Public Participation. The system is expected to aid decision-makers at Municipal, Regional and National level to formulate policies on ICZM matters; to provide reliable datasets to scientists and engineers, improving the preparation of technical studies and applications; to engage active citizens and the broader public into coastal zone issues, raising their awareness for coastal environmental and landscape protection; to promote the distribution of information among coastal managers, stakeholders and the general public, especially on issues affecting current and future activities and investments.

KEYWORDS

ICZM Observatory, coastal management and planning, web-GIS, operational numerical models, public participation, Kavala Municipality

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The transboundary water issue; conflict or cooperation: Kura-Araks basin case

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ABSTRACT

It is estimated that over 90 per cent of the world population lives in the river and lake basins that shared between two or more countries. Transboundary water bodies create hydrological, social and economic inter-dependencies between societies and play crucial role for economic developments, reducing poverty etc.
There is a growing literature suggesting, that conflicts around shared water resources will increase dramatically in the years to come and may even lead to war in many strategic regions in the world. But the reality is different. Transboundary water river and lake basins provide an opportunity for cooperation and promotion of regional peace and security.
The transboundary issue in Kura-Araks basin concerns all South Caucasus countries. The issue became more vivid after the collapse of Union of Soviet Socialist Republics (USSR). Due to the long-lasting conflict between Armenia and Azerbaijan the transboundary issue in this basin became politicized. In this paper the author identifies how can the cooperation over water resources provide stability in the region and its possible impact on transformation of Nagorno Karabakh long-lasting conflict.

KEYWORDS

Conflict resolution transboundary water, hydro-politics, Kura-Araks basin, Karabakh conflict

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Legislative framework for drinking water (re)sources monitoring in the Adriatic region

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ABSTRACT

The Strategic project Networking for Drinking Water Supply in Adriatic Region (acronym DRINKADRIA) co-financed by the European Union through the program IPA Adriatic CBC 2007–2013 evaluated various aspects for cross-border drinking water resources management and protection in the Adriatic region, e.g., climate and land use change impact, monitoring and protection legal and policy framework, increased demand during touristic season, etc. Seventeen partner institutions from eight countries across the Adriatic region (Italy, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Serbia, Albania and Greece) participated in project implementation. Due to complexity of cross–border drinking water (re)sources management the legal framework pertaining to drinking water sources monitoring at national and regional level is analysed based on data and information provided by partners. All legal acts and descriptions in English are uploaded on the DRINKADRIA project shared platform. This paper provides legal framework evaluation synopsis, underline the identified gaps, and provide comparison of monitoring practices with respect to cross-border drinking water sources in the Adriatic region. Given the differences in national legal framework it is concluded that the protocol for cross-border monitoring of water resources used for human consumption should be defined on bilateral (trilateral) level among countries instead as a unified protocol for the whole Adriatic area. However, the basic framework and common structure of the protocol is proposed.

KEYWORDS

Legal framework, drinking water resources management, cross-border, transboundary, Adriatic region

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Ecological flows and the Water Framework Directive implementation: An effective coevolution?

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ABSTRACT

The Water Framework Directive (WFD) is the first piece of European environmental legislation addressing hydromorphological modifications and impacts on water bodies. Accordingly, in those water bodies where the hydromorphological pressures are having an impact on the ecological status, action is needed to achieve WFD objectives. Ecological flows appeared as one of the answers to this challenge. Due to their importance, Member States (MS) have been looking to integrate ecological flows in the River Basin Management Plans (RBMPs) and Programmes of Measures (PoMs). More than 16 years after WFD adoption, the study aims to provide a systematic review of the use of ecological flows within the WFD implementation and they contribution to the achievement of that environmental objectives. Based on analysis of official documentation reporting the progress of WFD and ecological flows implementation, as well as, the answers of MS contact points and country experts to understand how this topic has been assessed. Even though an evolution on this theme can be perceived, some challenges still arise, namely a clear and common definition and a methodology for ecological flows calculation. These difficulties are related with the lack of a common approach to these issues, since there is no standard solution for the problems present in MS. More efforts are required, namely in the: i) the development of a verifiable link between ecological flow regimes and biological indicators and ii) the implementation of an ecological flow regime and the assessment of its effects in the water bodies status.

KEYWORDS

Water Framework Directive, Ecological flows, Water bodies status

Underground taming of floods in the Ganges basin: technologies, institutions and policies

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ABSTRACT

A technological approach for protecting flood prone locations through using excess flood water for recharge and storage in the depleted aquifers and using it for protecting dry season agriculture has been conceived and termed as under-ground taming of floods for irrigation (UTFI). UTFI as a total package deals with conjunctive water resources management, with specific foci in terms of flood, surface water, groundwater and irrigation management. This paper makes an attempt to assess the institutional and policy options for sustainable UTFI management in the Ram Gaga sub-basin of Ganges in Uttar Pradesh, India where UTFI testing is underway.

While UTFI technically addresses various anomalies at scale, appropriate institutional arrangements are required to address sustainability of the interventions. Absence of any institutional arrangements is identified as one of the constraints for adopting UTFI. There appears to be clear demand for institutional evolution, though it needs to be introduced externally. Given the substantial socio-economic benefits (impacts), public and private sector agencies (banks, CSR initiatives) could support the collective initiatives. This requires strengthening of existing institutions fostered with new ones. Creating appropriate policy environment is critical in this regard. Promotion and strengthening the NGO sector in the region would go a long way in bridging this gap.

KEYWORDS

Floods, Droughts, Resilience, Payments for Environmental Services, Participatory learning, Social regulation, Ganges basin

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Supplying rural Kazakhstan by access to safe drinking water and sanitation: A major SDG challenge

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ABSTRACT

The Sustainable Development Goals (SDGs) call for full drinking water coverage by 2030. This requires a database that most developing countries do not have access to. Thus, the aim of this paper is to examine discrepancies between official statistics and the actual outcome regarding improved access to safe water and sanitation. For this purpose, interviews were made with local villagers in a rural area in northern Kazakhstan. The results display that there are large differences between official data and actual conditions in the region. The majority of the rural population was found to perceive the water supply as important or very important to their household and a large proportion of the population wants to enjoy 24-hour access to potable tap water and pay for this. Further, a majority thinks that the government should take responsibility for the piped water supply system management. Good water service delivery requires reliable data that seem currently to be lacking for rural Kazakhstan. Data and statistics that may exist have not been sufficiently analysed or shared. Thus, achieving SDGs will require investment in data collection as well as more selective and innovative ways to understand, share, and audit the data. The results are important for the planning and fulfilment of the UN SDGs in Kazakhstan.

KEYWORDS

Sustainable Development Goals, rural water supply, Kazakhstan, baseline data

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Understanding the price elasticity of residential water demand in Spain

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ABSTRACT

This paper explores the influence of regional climate variability on the elasticity of price for residential water demand in Spain. The data comes from the Spanish Survey of Family Budget (INE 2012), a national based survey of household living conditions including more than 15,000 observations. The econometric analysis included other determinants of residential water demand in Spain such as income and household characteristics. In line with the broad literature, the demand for water in Spain is found to be inelastic, although price elasticity differs notably when accounting for different climatic regions in the territory. The results have noteworthy policy implications as water pricing is considered an efficient means of long term sustainable planning of water resources management. The results imply that policy makers may have reasons to explore differentiating the impacts of water efficiency measures by region.

KEYWORDS

Residential water demand, water resources management, water pricing, price elasticity, income elasticity, instrumental variables

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Water demand for economic activities. An application to the Spanish industrial sector

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ABSTRACT

Spain is one of the countries with major water scarcity problems in Europe, increasingly aggravated by climate change. Consequently, the proper design of water demand management policies is essential to achieve water conservation. In this context, we need to analyze the effectiveness of prices as a tool to manage water demand. This study estimates industrial water demand, focusing on sectoral and regional differences. We have panel data for the Spanish autonomous communities for the period 1993-2013, with a sectoral breakdown into 11 subsectors. After analyzing the stochastic properties of the model variables to ensure a consistent inference, we jointly estimate the translog cost function and the cost-share equations of inputs capital, labor, water, energy and supplies. The elasticity of the water demand is -0.66, the output elasticity is 1.04 and water and other inputs are substitutes. In addition, there is a strong sectoral and regional heterogeneity. Subsectors with higher water share in total production cost tend to show a greater water demand elasticity, as do regions with a more humid climate and regions with lower water prices. The results indicate that water pricing policy can be effectively used as a tool to encourage water conservation, but it must be complemented with other instruments to ensure the contribution of all subsectors to water consumption goals and its continuity over time.

KEYWORDS

Industrial water demand, elasticities, sectoral and regional analysis, panel data, cointegration

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Environmental crimes in the water sector

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ABSTRACT

Water stress is creating unprecedented tensions between freshwater users, with inter-connected risks (World Bank, 2016). Freshwater, the "blue gold", is becoming an attractive target for criminals, but the attention of Law Enforcement Agencies and criminologists on water within environmental crimes is only recent. Crimes against water remain difficult to assess, detect and prosecute, because legislations and policies on freshwater vary from Country to Country, data are inconsistent and not standardised, water-related crimes are often recoded under other offences – like fraud, corruption, theft, forgery/counterfeiting of documents, terrorism, or other crimes against heath or the environment. Offences range from water pilfering to tampering, from corruption in water services to cyber or terrorist attacks to water physical and digital infrastructures. The probability and impact of these threats can be high, but need to be assessed to develop effective countermeasures. Unlike any other known crime, water crimes are aggravated through their additional cost and impact on the environment and cost to future generations. Being part of a wider study, this paper provides the definitions of water crimes and water related crimes, and a tentative inventory of different offences against water, based on case studies collected in five European Countries, and on UNODC International Classification of Crime for Statistical Purposes (ICCS).

KEYWORDS

Water crime, freshwater, corruption, environmental crimes, risk, threat, criminology

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The determinants of self-supplied water for economic activities in an urban environment

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ABSTRACT

Designing policies to contribute to the sustainability of water resources requires an appropriate understanding of the use of the different water masses and their determining factors. This work analyses the self-supply of water captured underground for productive uses in an urban environment, using the Heckman two-step model. The first step of this model deals with the decision of whether to self-supply, while the second step examines the self-supplied amount. We used microdata for 2012 from 2,893 companies located in the municipality of Zaragoza (Spain). The results show, first, that the probability of resorting to self-supply is higher when the cost of publicly-supplied water is higher, the cost – fixed or variable - of self-supplied water is lower, and the company belongs to the industrial sector. Second, the demand for self-supplied water depends positively on the production level of the companies and the variable cost of publicly-supplied water, allowing us to characterise both types of water as substitutable. This relationship of substitutability draws our attention to the limited effectiveness of pricing policies which focus only on publicly-supplied water when seeking to reduce the pressure on the resource, and confirm the need for integrated water management. The fact that the volume of self-supplied water does not depend on its variable cost is evidence of its low weight in the company's total costs. The lack of a tariff on water intake from aquifers, which would be an essential economic tool for managing this demand, is especially striking.

KEYWORDS

Water demand, self-supply, groundwater, Heckman two-step model

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Grounded theory methodology and public participation in water management

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ABSTRACT

Water resources are under increased the pressure in almost all parts of the world. In such circumstances, it is also common to have conflicts between different water sectors (for instance, tourism vs environmental use; municipal and industrial supply vs agricultural water use, etc.), and interest groups. In most cases, related problems could be efficiently solved through the public participation and involvement of stakeholders. Traditional public participation in water management is mostly focused on the problem solving, rather than on other important contexts such as: stakeholders' understanding of the problem; motivation (willingness) to participate; preferences; understanding the solving methodology; and expectations that participatory process will lead to desired solution(s). Approach that has been proven to successfully take into account most of these concerns in managing water related participatory problems is known as Grounded Theory Methodology (GTM). In this paper authors use GTM to analyse data collected within the previous study of stakeholders' selection and prioritization in managing water resources of the Krivaja River basin in Serbia. Extensive data sets include detail information about stakeholders, description of the catchment characteristics, and perception of public participation provided by questionnaires distributed and collected within six months period. Results obtained by GTM are compared with similar case studies from developing as well developed countries.

KEYWORDS

Public participation, water management, Krivaja River, grounded theory methodology

The Non-conventional water resources (NCWR) programme in North Mediterranean

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ABSTRACT

Water is a key input for life, socio-economic growth and ecosystem stability. The Mediterranean countries face severe water - related challenges, due to pressures on limited fresh water resources, linked to climate change and variability, as well as unsustainable water use and small catchment areas specially encountered in the islands of the region. The use of non conventional water resources can be a solution towards local water security and climate change adaptation as it can cover needs for secondary uses, without putting further stress on the available resources. In this context, the Global Water Partnership – Mediterranean (GWP-Med) developed the multi-stakeholder programme "*The Non-Conventional Water Resources (NCWR) Programme in North Mediterranean"* bringing together, national and local authorities in Greece, Malta, Cyprus and Italy and is supported by The Coca-Cola Foundation. The Programme aims, through an integrated approach, to promote the use of non conventional water resources in insular communities, towards water security and climate change adaptation at community level. The Programme showcases replicable and cost – effective pilot applications of NCWR, through its technical pillar. It also supports educational activities for teachers and students with the use of dedicated material and special trainings for local technicians on the application of modern NCWR systems. Moreover, it raises awareness on smart NCWR applications and efficient water use solutions as well as promotes capacity-building activities for stakeholders, mostly critical for the development of resilient economies. Since 2008, the Programme has implemented more than 90 small and medium scale applications of NCWR systems in 32 islands in 3 Mediterranean countries.

KEYWORDS

Non conventional water resources (NCWR), climate change adaptation, multi-stakeholder partnership, rainwater harvesting, greywater recycling, educational activities, technical trainings, awareness raising, capacity building

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Towards 3D Modelling of public law restrictions in water bodies

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ABSTRACT

Water bodies constitute a vital resource both for human activities and biodiversity. In order to serve public benefit and contribute to the efficient management and protection of water bodies, Public Law imposes restrictions (PLRs) on land which, given the 3D spatial component of the physical attributes related to water bodies, require to be defined and managed taking into account their vertical extent. Physical factors that affect the integrity of a water body include, inter alia, hydrology, geomorphological characteristics, substrate (bottom composition), riparian zones, tidal effects for estuaries. In this paper, a 3D GIS-based model is developed, in order to present 3D PLRs applying to water bodies according to Greek legal framework, based on EU legislation, taking into account regulations such as on waste water, surface or groundwater protection and wetlands. During the analysis, spatial tools are employed in order to transpose literal descriptions, qualitative and quantitative water bodies' characteristics to 3D volumes, while conflicts and malfunctions that depict the complexity of water body related legislation are presented. The outcomes of this research can be used to present the 3D volumes defined by the implementation of water bodies' related PLRs as well as the contribution of 3D PLR modelling in water bodies' protection and efficient management.

KEYWORDS

3D Modelling, Public Law Restrictions (PLRs), Water Basins, GIS

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A road map for resolving conflicts in dam's administration: The case of Peiros -Parapeiros dam in Greece

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ABSTRACT

Conflicts regarding water management pose particular challenge for negotiation. Especially, large scale water development projects, like dams, are often the source of conflict over political, institutional, economic, environmental and many other issues. A negotiation resolution of such a water dispute may face many difficulties because of the great variety and number of positions or/and interests about water resources among stakeholders. The present study aims to present a realistic analysis of conflict experiences which stem from the case study of Peiros - Parapeiros Dam (Greece). It aims to capture the broad spectrum of the possible intentions of the four main users of the Dam; three municipalities and one industrial area. It analyses the dynamics of the users, as well as their strategies and interventions across them and predicts the path of negotiations by creating improved programming that responds to the relations among the four main water users. The analysis is based on graph theory (GT), conflict analysis (CA), data envelopment analysis (DEA), principal component analysis (PCA) and fuzzy logic (FL). The model applied is the Evolutionary Model of Multilateral Negotiations (EMMN). The study intends to help identifying practical solutions via a flexible negotiation support system (NSS). The findings of the model may furnish insights into the resolution of Peiros Parapeiros Dam Conflict and may contribute in reducing negotiating time and cost for decision makers in a broader way.

KEYWORDS

Dam conflicts, water conflict management, negotiations, Asterion reservoir, policy making, decision making

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A perspective to wastewater legislation in European Countries and Turkey

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ABSTRACT

Factors such as intense industrialization, population growth, pollution due to the resulting over-consumption, ill-judged approaches to water policy and water management, inefficient irrigation techniques and global climate change increase the competition for water resources even more day by day. This entails the use of alternative water resources. In many countries, as well as in Turkey, the emphasis placed on the use of treated wastewater is growing. In its worldwide projections until the year 2030, United Nations' water-related goals for sustainable development are to achieve the reuse of water in greater quantities and to increase the use of safe treated wastewater. According to the model developed for the potentials of reusing wastewater of European countries, Turkey ranks as the 4th among 31 countries in the projection for the year 2025. In the relevant legislation in our country, there are parts that encourage the use of treated wastewater in areas as irrigation water. Although there are some serious obstacles against the reuse of water in Europe, European countries have started updating the legislation and seeking ways to increase the safe reuse of wastewater through intense efforts, especially during the years 2014-2016, for it are known that safe and healthy reuse of water can be provided in other areas. In this study, the legal legislation and operation concerning the reuse of wastewater both in our country and in European countries is evaluated. It is aimed to present the approaches toward the reuse of wastewater in both their positive and negative aspects.

KEYWORDS

Legislation, water recycling, water pollution regulations, projections

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Advantages of integrating virtual water in food security policy, case study; Urmia plain, Iran

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ABSTRACT

Increasing water crisis in most parts of the world, especially in developing countries (including Iran) is one of the most important challenges of specialists. Several studies carried out in different parts of the world to provide proper solutions. However, effects of climate change in recent decades and nonuniform distribution of water in the world also the lack of attention to virtual water subject, producing crops with low nutritional value (calories) so that they don't have optimum cropping pattern as other important reasons, water crisis in recent decades increased. Linking between the calorie and water consumption is this research method. This paper takes this method into account for the first time. The objective of the current study is considering the advantages of integrating virtual water in food security policy. In this research cropping pattern in a fertile plain water catchment area of the Urmia Lake modeled to consider different standard water consumption items (for example water consumption per unit of product, water consumption per unit of energy). Thus, virtual water of crops calculated and to model the optimum cropping pattern to save more water we use the linear programming method with considering the following objectives: increase performance of energy (calories) and cultivated area of the year 2012-2013. The Result shows that with optimizing the crops as energy we can save 34% percent of water in this area.

KEYWORDS

Virtual water, food policy, energy, calorie

Index of Authors

Al-Ansari, N.A. 301
Zokaee Ashtiani, F. 170
Abahous, H. 140
Abbà, A. 173
Abbas, S.A. 89
Abdullah, T.O. 301
Abedan Dehkordi, S.M. 170
Abushammala, M.F.M. 255
Adamakis, I-D. 199
Adey, B.T. 45
Afzali, S. Hosein 261
Agathokleous, A. 246, 257
Aghakhani Afshar, A. 93
Ahi, Y. 234, 289, 351
Ahmad, I. 126
Ahmadi, H. 333
Ahmed, S. 28
Ait-Aoudia, M.N. 117
Akbar Karimian, A. 282
Aköz, M.S. 29, 88
Al Hazza, M.H. Faizi 235
Alamanos, A. 112, 254
Alexakis, D. 229, 291
Algin, H.M. 88
Ali, S.S. 301
Al-Maktoumi, A. 324
Almendro-Candel, B. 39
Alrayess, H. 111, 122
Alvarez, P. 336
Amanatidou, E. 231
Ambhore, R.M. 46
Amirataee, B. 145
An, J. 162
Andrade, M.R. 259
Anli, A.S. 267
Ansarifard, S. 144
Antinoro, C. 158
Antonakopoulou, M. 348
Antonopoulos, V. 202
Apostolakis, A. 202, 221
Apostolopoulos, I. 22
Araghinejad, S. 308
Argyrokastritis, I. 266
Arnone, E. 91, 97
Aronica, G.T. 108

Artabe, A. 342
Arulrajah, A. 307
Arumi, J. 335
Arzuaga, I.M. 48
Asl-Rousta, B. 68
Assani, A.A. 75
Attar, N. Fatolahzadeh 351
Avallone, G. 337
Avgeris, L. 57, 130
Awolusi, O.O. 166
Ayala-Cabrera, D. 247
Aydın, B. 234
Ayyıldız, K. 188
Aziz, S. Qarani 319
Azmat, M. 28
Bagus Adityawan, M. 24
Bahar, R. 235
Baid, A. 116
Bajčetić, R. 346
Bakan, G. 197
Bakradze, E. 214
Balla, D. 220
Baltas, E.A. 35, 40, 113, 131, 159
Bami, R. 206
Banerjee, T. 169
Baran, T. 76, 150, 188
Barbaros, F. 76, 188
Barberán, R. 343, 345
Bariamis, G.E. 113, 131
Barjenbruch, M. 187
Bawazir, A.K. 255
Beden, N. 21
Bellos, K. 57, 130
Bellos, V. 60, 64, 66, 189
Benítez de Lugo, L. 331
Benlouali, H. 295
Benssaou, M. 315
Benzaoui, A. 217
Berbel, J. 274
Berezowska-Azzag, E. 117
Bettiga, A. 19
Bezirgiannidis, A. 181
Bhattacharjya, R. Kumar 182
Bhattacharya, S. 183
Bilge, H. 53
Birylo, M. 95, 96
Biswas, R. 169

Bobori, D. 202
Bohorquez, P. 90
Bordi, I. 77
Borhan Armand, S. 168
Borsi, I. 305
Boshrouyeh Ghandashtani, M. 176
Boskidis, I. 133
Bouaakaz, B. 140
Bouchaou, L. 140, 295, 315
Bouhenna, A. 217
Boulos, P.F. 8
Bourazanis, G. 266, 275
Boutaleb, S. 315
Broli, N. 211
Bui, M-D. 225
Burak, S. 53
Busico, G. 306
Buurman, J. 253
Bux, F. 166
Buyukgungor, H. 167, 172
Cadima, J. 265
Cai, N. 56, 240
Callegari, G. 309
Caloiero, T. 98, 309
Camargo, S.A. 224
Cammalleri, C. 138
Cancelliere, A. 72
Caneo, M. 82
Capello, N. 344
Capponi, C. 242
Carbajal, J.P. 64
Caruso, M.F. 72
Caviglia, D. 123
Cecinati, F. 62
Çetinkaya, C.P. 125
Chalimourdas, G. 58
Chamoglou, M. 204
Charchousi, D. 291
Chatziantoniou, A. 102, 302
Chatzikonstantinou, K. 209
Chavez-Jimenez, A. 276
Chew, J.-W. 177
Choukr-Allah, R. 140, 295
Christelis, V. 142, 318, 323
Christodoulou, S.E. 246, 257
Christodoulou, C. 257
Chuang, M-H. 317

Chung, E-S. 147
Clemens, F. 60, 64
Collivignarelli, M.C. 173
Colombani, N. 306, 311
Constantianos, V. 347
Coscarelli, R. 98
Costa, A.C. 154
Crisman, T.L. 205
Cunha, M.C. 86
Cuoco, E. 306
Curry, R.A. 78
Dabanlıa, İ. 74
Dalezios, N.R. 284
Das, C. 171
Das, J. 79
Das, R. 116
Dastorani, M.T. 256
Dave, A. 300
De Paola, F. 34
de Vito, R. 272
Defo, C. 194
Del Moral-Erencia, J.D. 90
Delgado, R. 82
Demir, V. 21
Dercas, N. 284
Dernek, D. 53
Deuerlein, J. 247
Dhanya, C.T. 101
Di Nardo, A. 245
Di Natale, M. 245
Diaconu, D.C. 84
Diamantis, I. 130
Dikarou, E. 313
Dikbas, F. 150
Dikshit, P.K.S. 300
Dimitriadis, P. 22
Dimitriou, E. 189, 225
Ding, L. 207
Dinouli, D. 213
Diwedi, S.B. 300
Dökmen, F. 289
Dokou, Z. 321
Doulgeris, C. 202
Dragičević, N. 44
Duangdai, E. 278
Dugdale, S.J. 78
Duka, S. 211, 215

Dulovičová, R. 55
Dwelle, M. 33
Ebrahim Banihabib, M. 303
Ebrahimi, M. 282
Ebrahimi, E. 303
Ebrahimi, K. 308
Efstratiadis, A. 18, 38
Efstratiadis, A. 281
Ehtiat, M. 68
Eleftheriadou, E. 252, 288
Emami, F. 73
Eminoglou, G. 314
Erdoğan, B.U. 294
Ertl, T. 63
Expósito, A. 274
Ezbakhe, F. 51
Ezgi Diker, G. 30
Fafoutis, C. 254
Faghihi, N. Rasi 241
Fane, A.G. 177
Farcas, C. 202
Farzin, M. 325
Feiznia, S. 325
Feloni, E.G. 40, 159
Ferrante, M. 242
Ferrari, E. 98
Figueiredo, R. 19
Fischer, S. 20
Forestieri, A. 97
Formigo, N. 339
Fouladitajar, A. 168, 170, 176
Francipane, A. 91
Fratino, U. 272
Frongia, S. 17
Funamizu, N. 346
Gaglioti, S. 309
Gaivoronki, A.A. 244
Gala-Georgila, E. 252
Garrote, L. 37, 71, 107, 124, 276
Gaur, S. 300
Georgiou, P. 202
Gerbens-Leenes, P.W. 296
Gertsis, A. 287, 293
Ghermezcheshmeh, B. 23
Ghosh, D. 180
Ghosh, P. 169
Giambastiani, B.M. Sole 311

Giannakopoulos, C. 291
Giannerini, G. 158
Giannopoulou, I. 288
Gikas, G.D. 198, 277
Giné-Garriga, R. 333
Gini, M. 22
Giordano, R. 272, 320
Gironás, J. 82
Gitau, M.W. 80, 216
Giudicianni, C. 245
Giugni, M. 34
Gkesouli, A. 175
Gkiougkis, I. 130, 314
Gnecco, L. 123, 258
Gökbulak, F. 222
Golzar, I. 325
Gómez, I. 39
Gooya, A.S. 310
Gosain, A.K. 101
Goumas, C. 321
Gourgoulios, V. 43
Gracia-de-Rentería, P. 343, 345
Granados, A. 71, 276
Guillaume, J.H.A. 109
Gül, A. 76, 188
Gülbaz, S. 223
Gültaş, H.T. 350
Gümüş, V. 88
Günaçtı, M.C. 125
Guner Bacanli, U. 150
Guo, T. 80
Gupta, A. 300
Gupta, M. 36
Gutiérrez-Martín, C. 271
Hackl, J. 45
Haider, S. Sajjad 286
Halimi, E. 212
Hamidi, S. Ahmad 332
Hamzaraj, E. 206
Harmancioglu, N.B. 4
Hasiotis, Th. 59
Hassan, F. Raza 322
Hassan, G. Zakir 322
Hatiris, G.A. 230
Hattermann, F. 119
Heidarzadeh, R. 241
Heitzler, M. 45

Hernández, E.I. 39
Herrera, M. 247
Herrmann, F. 83
Heuvelink, G.B.M. 65
Hila, N. 219
Hirich, A. 140
Hjorth, P. 341
Hlavatá, H. 84, 146
Hoyos, D. 342
Hrissanthou, V. 54, 57, 226
Hssaisoune, M. 315
Hurni, L. 45
Hussain, E. 28
Iakovidou, F. 231
Ibrahim, S. 235
Iglesias, A. 107
Iliopoulos, E. 41
Imteaz, M. Alam 307
Indrawati, D. 24
Infusino, E. 309
Ioannidou, V.G. 193
Ioannou, A.E. 248
Islam, T. 36
Ivaldi, M. 123
Ivanov, V. 33
Jafari, H. 192
Jafarzadeh, A. 93
Jerković, M. 190
Jin, Y. 143
Jinhyeog, P. 143
Jothiprakash, V. 26
Juradin, S. 218
Kacimov, A.R. 324
Kadam, A. 326
Kaffas, K. 226
Kagalou, I. 204, 221
Kaiafa-Saropoulou, A. 252
Kalavrouziotis, I.K. 200
Kallioras, A. 305, 314, 316
Kampas, G. 31
Kandasamy, J. 228
Kaplakis, V. 337
Karaki, H. 227
Karakostas, G. 49
Karali, A. 291
Karalis, S. 49
Karamanzia, D. 56, 240

Karancsi, G. 220
Karantzalos, K. 201
Karasogiannidis, D. 130
Karatzas, G.P. 299, 316, 321
Karbakhsh, A. 110
Kargas, G. 290
Karimi, M. 168
Karimirad, I. 308
Karleuša, B. 44, 338
Karnib, A. 120
Katopodes, N. 33
Katsios, I. 49
Kazamias, A.P. 283
Kazemi, G.A. 325
Kazezyılmaz-Alhan, C.M. 223
Keçi, E. 212, 215
Kemitzoglou, D. 221
Kerkides, P. 81, 266, 275, 290
Khan, A. 312
Khan, T. 312
Khashei Siuki, A. 93, 279
Khozeymehnezhad, H. 42
Kim, J. 33
Kim, S.H. 147
Kinzel, C. 63
Kitsakis, D. 348
Kitsara, G. 81
Kitsikoudis, V. 54
Kitsos, A. 58
Klaas, D.K.S.Y. 307
Kleidorfer, M. 63
Knutsson, S. 301
Koch, H. 119
Koch, M. 73
Kofinas, D. 245, 248
Kokkos, N. 336
Köksal, D.D. 289
Kolliopoulos, G. 179
Kolokoussis, P. 201
Kolokytha, E. 203
Kontogeorgos, I. 59
Kontopoulou, E. 201
Kontosthenos, P. 58
Kopsiaftis, G. 142, 189, 318
Korfali, S.I. 227
Korkmaz, S. 304
Kotsifakis, K.G. 159

Kougias, I. 285
Kouhzad, B. 256
Koukouvinos, A. 18
Kourgialas, N.N. 321
Kourti, E. 246
Kourtis, I.M. 35, 66
Koussis, A. 22
Koutsoyiannis, D. 22, 92, 281
Kouziokas, G.N. 302
Kretschmer, N. 335
Kroll, S. 249
Krommyda , V. 99
Krysanova, V. 119
Kuchava, G. 214
Kumar Golder, A. 174
Kumar Goyal, M. 148
Kumari, S. 166
Kuriqi, A. 124
Kuzucu, A. 141
Kyriakidis, S. 199
Kyriakou, K. 230
La Barbera, P. 123, 258
La Loggia, G. 91
Lam, J.C. 45
Langeveld, J. 60
Laspidou, C. 245, 248
Latif, M. 286
Lawler, D.M. 165
Lazo, P. 206
Lebdi, F. 149
Lee, S. 143
Leimgruber, J. 63
Leith, P. 109
Leopold, U. 64, 65
Li, F. 207
Li, Q. 208, 210
Liakopoulos, V. 199
Liersch, S. 119
Likasiri, C. 278
Lintzos, L. 209
Liu, Y. 207
Lobanova, A. 119
Lou, M. 207
Loukas, A. 18, 52, 108, 203, 273
Lykou, A. 25
Ma, C. 207
Maalem, M.S. 217

Mahmoodian, M. 64
Maia, R. 10, 339
Majd, N.R. 270
Makropoulos, C. 25
Malamataris, D. 203
Malamis, S. 209
Malamos, N. 281
Mali, S. 219
Malki, M. 140, 295
Mamassis, N. 22
Manasa, M. 26
Manenti, S. 173
Mansir, I. 295
Mansouri, R. 110
Mantoglou, A. 318, 323
Margonis, A. 275
Marial, J. 179
Marinakis, N. 181
Marinou, P.G. 40
Markonis, Y. 18
Martín-Carrasco, F. 71
Martins, D.S. 139, 151, 265
Martins, E.S.P.R. 154
Martzikos, N. 25
Maryam, B. 167
Mastrocicco, M. 306, 311
Mathlouthi, M. 149
Matić, B.B. 114, 155, 339
Mattioli, W. 344
Mavridis, A. 293
Mavromati, E. 221
McCalmont, J.P. 94
Mehan, S. 80
Mehdizadeh, S. Sadjad 310
Meinke, H. 109
Mejías, M. 332
Melendez-Pastor, I. 39
Melidis, P. 181
Mendham, N.J. 109
Menek, N. 21
Meraat, M. 192
Mester, T. 220
Migiros, G. 313
Migliorini, M. 344
Mimikou, M.A. 113
Mirabbasi, R. 127
Mirbagheri, S. Ahmad 184

Mitraki, C. 205
Mitropapas, A. 316
Molinari D. 19
Mondal, S Kumar 178
Montaseri, M. 145, 270, 351
Moreno Rodenas, A. 60, 62
Morianou, G.G. 321
Morlando, F. 245
Mougiou, P. 290
Mousavi, S. Jamshid 68
Moutafis, N. 59
Moutsopoulos, K. 198
Mu, H. 56, 240
Mudai, B. Kumar 182
Mur, J. 343, 345
Musharaf Ali, Sk. 169
Mylopoulos, N. 112, 254
Mylopoulos, I. 203
Myronidis, D. 121
Naghettini, M. 103
Nalbantis, I. 38, 43, 61, 128, 132, 152, 160
Nandi, S. 27
Nanduri, U. 79
Nanekely, M. 153, 319
Napolitano, J. 244
Nastos, P.T. 159, 213
Navarro, G. 48
Navarro-Pedreño, J. 39
Nazif, S. 251
Nghira, A. 140, 295
Niazkar, M. 261
Nikitas, A. 285
Nikkels, M.J. 109
Nikolopoulos, D. 38
Noto, L.V. 91, 97
Noury, M. 184
Ntonou, E. 205
Ntougias, S. 181
O'Connell, E. 9
Obnosov, Yu.V. 324
Ohri, A. 300
Önöz, B. 30
Onuşluel Gül, G. 76
Onuşluel Gül, G. 141
Orta, A.H. 350
Oyarzun, R. 335
Ožanić, N. 44

Özçelik, M. Said 269
Özhan, S. 222
Pagana, V. 22
Pagano, A. 272, 320
Pahl-Wostl, C. 5
Pajak, K. 96
Palla, A. 123, 258
Panagiotidis, T. 156
Panagopoulos, A. 83, 316
Pande, S. 228
Papacharalampous, G.A. 92
Papadaki, C. 189
Papadimos, D. 202
Papadiamantopoulou, E. 58
Papadonikolaki, G. 225
Papadopoulou, M.P. 291
Papaevangelou, V.A. 198
Papageorgaki, I. 61, 100, 161, 348
Papaioannou, G. 18, 81, 108, 275
Papaioannou, A. 213
Papalaskaris, T. 31, 156
Papalexiou, S.-M. 18
Papamichail, D. 202
Papangelakis, V.G. 179
Papanicolaou, P. 22
Paparisto, A. 206, 212, 215
Paredes, P. 139, 265
Park, D. 129
Paschos, G.T. 131
Pathania, T. 328
Patiño Rincón, D.A. 224
Paulo, A. 139
Paulo, A.A. 151
Pavelic, P. 340
Pavlidis, G. 280
Pearson, J.M. 193
Pepa, B. 212, 215
Perakis, K. 302
Perdikaki, M. 305
Pereira, L.S. 6, 77, 139, 151, 265
Peres, D.J. 72
Pérez-Blanco, C.D. 271
Pérez-Foguet, A. 51, 333
Petriki, O. 202
Petropoulos, G.P. 36, 94, 102
Petsetidi, A. 290
Petsiou, A. 22

Piller, O. 247
Pinheiro, A.N. 124
Pires, C. 151, 265
Pisinaras, V. 83, 336
Pius, B. 84
Pliakas, F. 130
Pliakas, F-K. 314
Podimata, M.V. 349
Poorova, Z. 260
Portela, M.M. 84, 85, 103, 146
Portoghese, I. 272, 320
Poshtegal, M. Khalilzadeh 184
Pothier-Champagne, A. 75
Pouliaris, C. 305
Pourreza Bilondi, M. 42, 93, 279
Praveenkumar, C. 26
Psarropoulos, P.N. 118
Psomiadis, E. 102, 284
Pugliese, F. 34
Pumo, D. 91
Purcz, P. 84, 260
Purkait, M.K. 180
Purwo Saputro, D. 24
Qadir, A. 312
Qishlaqi, A. 192
Rad, M. 191
Radice, A. 19
Rahimi Jamnani, M. 67
Raja, N. Amjad 286
Rajković, M. 218
Ramos, V. 339
Rao, V. 174
Rashid, M. Usman 286
Rastogi, A. Kumar 328
Rauch, W. 63
Rauschenbach, T. 56, 240
Ravinder, K. 194
Raziei, T. 77
Reddy, M. Janga 27, 243
Reddy, V. Ratna 340
Reeve, D.E. 89
Regulwar, D.G. 46
Rey, D. 224
Rezaei, M. 23
Rezaie, H. 145
Rico-Ramirez, M.A. 62
Rishi, D.S. 182

Risva, K. 38
Roghani, B. 241
Romano, P. 34
Roobavannan, M. 228
Roozbahani, A. 241, 303
Rosa, R.D. 139
Rossetto, R. 305
Rout, S. Kumar 340
Ruiu, A. 17
Rutschmann, P. 115, 225
Sadeghi Louye, N. 67
Sadeghi-Tabas, S. 32, 42
Saha, S. 171
Saha, P. 178, 233
Sahi, R. Ahmed 327
Said Özçelik, M. 222
Saita, K. 161
Salamon, P. 138
Samadi, S.Z. 32
Samani, A. Nazari 325
Samiotis, G. 231
Sankhua, R.N. 326
Sant´Ana, D.O. 259
Santonastaso, G.F. 245
Santos, A.C. 85
Santos, J.F. 146
Sapountzis, M. 283
Sarailidis, G. 52
Sargsyan, A. 337
Sarkar, S. 233
Sarvari, F. 279
Schaefli, B. 85
Schellart, A. 249
Scholz, M. 153, 319
Schügerl, R. 55
Schumann, A.H. 20
Schutz, G. 64
Scoullos, M. 348
Sechi, G.M. 17, 244
Segato, L. 345
Seif Ennasr, M. 140
Sekaluvu, L. 216
Şena, Z. 74
Şengönül, K. 222
Sepehr, A. 256
Serafeim, A. 57
Serelis, K. 313

Serengil, Y. 222
Seyoum, A.G. 239
Sfyris, S. 254
Shafiee, R. 310
Shamohammadi, S. 50
Shamsnia, S.A. 144
Sharifi, A. 50, 127
Sharma, A. 148
Sharma, B. 182
Shavliashvili, L. 214
Shehu, A. 211
Shucksmith, J. 249
Shum, E. 179
Siddique, I. Jamil 235
Sidiropoulos, E. 47
Sidiropoulos, P. 204
Silva, A.T. 85, 103, 146
Silva, F.G.B 259
Simi, Z. 155
Simić, Z. 114
Simonovic, S.P. 5
Şimşek, O. 29, 88
Şimşek, A. 197
Singh, V.P. 7
Sirna, M. 306
Sirsant, S. 243
Sivapalan, M. 228
Skoufas, G. 199
Soares, F.R. 259
Sofou, G. 58
Sokáč, M. 55, 185, 190, 196
Solomonidou, A. 313
Song, X. 89
Sophocleous, C. 128
Sordo-Ward, Á. 71, 124
Soudi, M. 332
Souidi, F. 217
Soulis, K.X. 268
Sourianos, E. 230
Soydan, N.G. 29, 88
Spanoudaki, K. 291
Spiliotis, M. 37, 54, 250
Spiliotopoulos, M. 273
Spiropoulos, N.V. 284
Spyropoulou, A. 248
Srdjevic, B. 195, 346
Srdjevic, Z. 195, 346

Srivastava, P.K. 36
Sriwastava, A. 249
Stålnacke, P. 112, 202
Stamatis, G. 313
Stamos, A. 231
Stamou, A-T. 115
Stamou, A. 175, 225
Starrett, S.K. 11
Stavenhagen, M. 253
St-Hilaire, A. 78
Stoumboudi, M. 189
Stournaras, K. 58
Suryadi, Y. 24
Suvocarev, K. 195
Sylaios, G. 277, 336
Symeonidis, P. 133
Szabó, Gy. 220
Szabó, S. 285
Tabara, D.J. 119
Tabesh, M. 241, 251
Tagma, T. 315
Taheriyoun, M. 191
Tait, S. 249
Talebbeydokhti, N. 261
Talebi, A. 256
Talukdar, B. 116
Tanyimboh, T.T. 239
Taskaris, S. 133
Taufik, I. 24
Tedesco, D. 306
Tegos, A. 22
Tegos, M. 132
Tegos, A. 132
Tegos, A. 281
Terzopoulou, E. 199
Tesfaye, T.W. 101
Theodoridou, P.G. 299
Theodossiou, N. 285
Tian, Q. 207
Tigkas, D. 41, 58, 100, 142, 157
Todeschini, S. 173
Todini, E. 13
Toli, K. 347
Torabi Pudeh, H. 110
Torres-Matallana, J.A. 65
Tortajada, C. 253
Treesa, A. 79

Trikoilidou, E. 231

Tsakiris, V. 41, 157, 229
Tsakiris, G. 41, 160, 250
Tsakmakis, I.D. 277
Tscheikner-Gratl, F. 63
Tsesmelis, D.E. 268
Tsiaoussi, V. 221
Tsihrintzis, V.A. 12, 35, 66, 113, 198, 205, 229, 280
Tsikritzis, L. 231
Tsiourtis, N.X. 186
Tsirika, A. 199
Tsirogiannis, I.L. 281
Tsoukala, V. 25
Tussupova, K. 334, 341
Tyralis, H. 92
Tzabiras, J. 273
Tzamtzis, N. 209
Tzevelekis, T. 130
Tziolas, N. 199
Tzoraki, O. 40, 59
Ulke, A. 21
Ulke, A. 111, 122
Umair, M. 28
Umrikar, B.N. 326
Ustun, S. 167
Ustun Odabasi, S. 172
Uygur Erdoğan, B. 222
Uzair Qamar, M. 28
Vafakhah, M. 23
Vaheddoost, B. 87
Vallja, L. 211
Van Dorpe, M. 249
van Oel, P.R. 109, 154
Vangelis, H. 41, 100, 142, 157, 161
Vantas, K. 47
Varnavas, S.P. 200
Varouchakis, E.A. 299
Vasiliades, L. 18, 52, 108
Vasjari, M. 211
Vassilopoulos, E. 22
Velegrakis, A. 59
Vélez, J.J. 224
Velísková, Y. 55, 185, 190, 196
Verma, M. Kumar 126
Vieira, J. 86
Vigneswaran, S. 228

Viñes, S.V. 48
Vogt, J. 138
Vranayova, P. 260
Vranješ, M. 218
Vrushi, L. 219
Vryonis, P. 200
Vurro, M. 272, 320
Wang, J. 177
Warnock, A. 33
Wendland, F. 83
Wilhite, D.A. 137
Wriege-Bechtold, A. 187
Wu, J. 208, 210
Xenarios, S. 112
Xia, F. 162
Xiang, L. 162
Xie, P. 162
Xuan, Y. 89
Yaghoobzadeh, M. 93
Yáñez Morroni, G. 82
Yannopoulos, S. 252, 288
Yannopoulos, P.C. 349
Yasi, M. 332
Yeh, H-D. 317
Yenigun, K. 88
Yurtseven, İ. 222
Zafar, M. 312
Zafari, M. 251
Zahabiyoun, B. 32
Zakrzewska - Kołtuniewicz, G. 232
Zalidis, G. 199, 205, 292
Zambrano, J. 224
Zeisl, P. 63
Zeleňáková, M. 84, 146, 260
Zeng, H. 208, 210
Zervas, D. 202
Zeybekoglu, U. 122
Zhang, Y. 162
Zhang, L. 216
Zhao, F. 207
Zinati Shoa, T. 187
Zingaro, D. 320
Zoidou, M. 277
Zokaee Ashtiani, F. 168, 176
Zouboulis, A. 199
Zoukidis, K. 287, 293
Zucaro, R. 158