



# **MEDITERRANEAN FORUM ON WATER RESOURCES**

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## **ABSTRACTS**

## **ORAL CONTRIBUTIONS**

# **ROLE OF INTERNATIONAL ORGANIZATIONS IN WATER MANAGEMENT OF THE NEW CENTURY**

**Ubertini L.**

UNESCO, Water Resources Management and Culture

The water theme is the subject of the widest and most significant set of multidisciplinary scientific researches that are developed by universities, research centers, international organizations and United Nation agencies from the local to the global scale.

The water research framework is very wide and diverse, covering earth and environmental sciences in general but, with specific regard to the hydrology and hydraulics framework, the most relevant scientific actors are the IUGG and IUGS Unions, aggregated in the ICSU, and the United Nations where the FAO and UNESCO play the major role.

In this work the important role of UNESCO in water resource management sector is described with specific regard to the Italian territory and its important cultural heritage. The preservation and valorization of the UNESCO sites is specifically discussed together with the fundamental importance of multidisciplinary water scientific studies for the resilient and safe development and management of our natural, environmental and cultural heritage sites.

## **WATER UNDER CLIMATE CHANGE**

**Gualdi S., Navarra A.**

Centro euroMediterraneo sui Cambiamenti Climatici (CMCC)

The effects of climate change are significantly affecting temperature and precipitation, and thus water availability, over the whole planet. Both the changes observed in the recent past and those projected for the future by climate models exhibit substantial differences across regions and seasons. Furthermore, these changes are detectable not only in the climatological mean values of rainfall, but, more generally, in the distribution of the precipitation regimes, including the extremes values. Changes in the extremes, in turn, might have impacts on the occurrences of floods or droughts, both in terms of frequency and intensity.

This talk will provide an overview of the observed and projected changes in precipitation and water availability. The projections are based on the multi-model climate change simulations performed in the framework of the World Climate Research Programme (WCRP)'s Couple Model Intercomparison Project – Phase 5 (CMIP5; [cmip-pcmdi.llnl.gov/cmip5](http://cmip-pcmdi.llnl.gov/cmip5)) and conducted to inform the Intergovernmental Panel on Climate Change (IPCC) assessments and in support of emerging Climate Service. Beside, the talk will focus on the European continent, presenting observed and projected changes in water availability in Europe, based on several indicators produced and maintained by the European Environment Agency.

# **CLIMATE CHANGE: USING REMOTE SENSING TO REFINE WATER USE ESTIMATES**

**Farid A., M. Bannayan**

University of Arizona, Tucson, USA

Nearly all regions of the world are expected to experience a net negative impact of climate change on water resources and freshwater ecosystems. The intensity and characteristics of the impact, however, can vary significantly from region to region. Some regions are likely to experience water shortages. Coupled with increasing demand, this is likely to result in large increases in the number of people at risk of water scarcity. For a long-term management planning of a region's water resources, e.g., arid and semi-arid regions, in the face of the evolving climate change impacts, it is important that the properties of vegetation and canopy be quantified. Vegetation patterns and associated canopy structure influence landscape functions such as water use, biomass production, and energy cycles.

In this study, small-footprint lidar (light detecting and ranging) data were used to estimate biophysical properties of young, mature, and old cottonwood trees in the Upper San Pedro River Basin, Arizona, USA. Four metrics (tree height, height of median energy, ground return ratio, and canopy return ratio) were derived by synthetically constructing a large footprint lidar waveform from small-footprint lidar data which were compared to ground-based high-resolution Intelligent Laser Ranging and Imaging System (ILRIS) scanner images. These four metrics were incorporated into a stepwise regression procedure to predict field-derived Leaf Area Index (LAI) for different age classes of cottonwoods. This research applied the Penman-Monteith model to estimate transpiration of the cottonwood clusters using lidar-derived canopy metrics. These transpiration estimates compared very well to ground-based sap flux transpiration estimates indicating lidar-derived LAI can be used to refine water use estimates.

# **RESIDUAL HYDROPOWER POTENTIAL: SPATIALLY SMOOTH RECONSTRUCTION IN NON-PRISTINE CATCHMENTS**

**Claps P., Gallo E., Ganora D., Laio F., Masoero A.**

DIATI, Politecnico di Torino, Torino, Italy

Requirements for increased renewable power sources suggest revision of plans of exploitation of water resources, while taking care of the environmental regulations. Mean Annual Flow (MAF) is a key parameter when trying to represent water availability for hydropower purposes. MAF is usually determined in ungauged basins by means of regional statistical analysis. For this study a regional estimation method consistent along-the-river network has been developed for MAF estimation; the method uses a multi-regression approach based on geomorphoclimatic descriptors, and it is applied on 100 gauged basins located in NW Italy. The method has been designed to keep the estimates of mean annual flow congruent at the confluences, by considering only raster-summable explanatory variables.

In regions with mature hydropower development peculiar situations apply. In particular, the influence of human alterations in the regional analysis of MAF has been studied: impact due to the presence of existing hydropower plants has been taken into account, restoring the “natural” value of runoff through analytical corrections.

To exemplify the representation of the assessment of residual hydropower potential, the model has been applied extensively to two specific mountain watersheds, by mapping the estimated mean flow for the basins draining into each pixel of a the DEM-derived river network. Spatial algorithms were developed using the OpenSource Software GRASS GIS and PostgreSQL/PostGIS. The final representation of the hydropower potential is obtained using different hydraulic-head assumptions for each pixel. Final potential indices are represented and mapped through the Google Earth platform, providing a complete and interactive picture of the available potential, useful for planning and regulation purposes.

# OZONATION OF URBAN WASTEWATER EFFLUENTS FOR WATER REUSE

**Esplugas Vidal S.**

Chemical Engineering Dept, University of Barcelona, SPAIN

During the last decades, water scarcity and water quality are issues of major concern. Large amounts of water were continuously contaminated, especially in developed countries. To restore the water quality is essential to avoid higher levels of contamination and to enable its reuse, contributing also to the decrease of potable water consumption (Bixio et al., 2006). Occurrence of micropollutants in the aquatic environment is also nowadays a well-established issue since not all of them are removed through conventional wastewater treatments. While some are effectively removed by conventional biological treatments (e.g. ibuprofen, paracetamol), others (e.g. carbamazepine, diclofenac) are barely affected (Onesios et al., 2009). Their presence in the aquatic environment is a situation of concern since the effects of low-level but long-term exposure over the aquatic life due to their bioactive nature are still largely unknown. Moreover, although there is no evidence of impact on human health, the precautionary principle should be applied in the case indirect potable reuse. Therefore, additional advanced treatment steps have to be considered to reduce the discharge load of pharmaceuticals and other micropollutants into sensitive receiving waters.

Their occurrence made arise two main concerns; the negative impact they have in the biota, specially the hormonally active compounds, and the contamination of the water bodies used for food production as well as for water potabilization and industry usage. The main channels followed by micro pollutants to enter the environment are well identified. Urban or mixed WWTP are one of them. Although the conventional urban WWTP were not designed to specifically eliminate this type of pollutants, a great part of them is removed along the treatment line from the wastewaters. Many studies carried out on urban wastewaters show that Ozone and Advanced Oxidation Processes applied in the secondary effluents as advanced treatments are effective in terms of "organic micro-contaminants" removal.

The present study investigates the removal of a broad range of micropollutants by ozonation in urban WWTP and its simultaneous impact on the organic matter (Domenjoud et al., 2011). According to the experimental results carried out at lab scale, the ozonation is quite effective in removing COD of urban WWTP effluents and small ozone doses (20 mg/L) are effective in removal micropollutants. A strategy is proposed for the next application of ozonation on urban effluents and it is based on process considerations (ozone dose, mass transfer) and organic matter removal (kinetics and oxidation extent).

# **TECHNIQUE OF TREND TEST AND ESTIMATION FOR THE ANALYSIS OF GROUNDWATER QUALITY DATA OF APULIA REGION**

**Verdiani G., Muschitiello C., Rana G.**

CREA, Dept. SCA, Bari

Quality data, measured by the C.R.E.A. – S.C.A. at 23 sampling points of groundwater for irrigation, located in different areas of Apulia region, have been analysed through a territorial analysis and non-parametric statistical procedures.

The original data were filtered through geo-location analysis that related the wells location with some territorial information: land use, groundwater of belonging, flood risk areas, nitrate and salt vulnerability and pluviometric area of belonging. Afterwards, three sampling points located in Conversano (Bari), San Vito dei Normanni (Brindisi) and Lesina (Foggia) were selected for further analyses on the basis of their common characteristics: same main land use (arable crops), common continuous time interval (July 2002 – July 2004) and saline pollution vulnerability.

The methodological approach is described in this work. On these sampling points, quality data concerning four chemical parameters (electric conductivity, chlorides, sodium and pH) and meteorological data (including rain) obtained from a regional network have been analysed, using non-parametric procedures that include: (i) Mann Kendall (MK) trend test, (ii) Seasonal MK Trend test, (iii) modified MK trend test for autocorrelated data, (iv) Theil-Sen's trend slope estimate and (v) Conover trend intercept estimate. The purpose of these analyses is to statistically assess if there is a monotonic upward or downward trend of the variable of interest over time and to estimate this trend. The analysis showed the presence of an increasing trend of sodium in the well of Conversano and a decreasing trend in the values of Electric conductivity and pH for the well located in Lesina. These results demonstrated the high potential of the applied technique in the forecast of hydrological and water quality trends to be used to achieve a sustainable management of groundwater resources.

# FIELD TEST OF A MULTI-FREQUENCY ELECTROMAGNETIC INDUCTION SENSOR FOR SOIL MOISTURE MONITORING

**Calamita G.<sup>1</sup>, Perrone A.<sup>1</sup>, Brocca L.<sup>1</sup>, Onorati B.<sup>2</sup>, Manfreda S.<sup>3</sup>**

<sup>1</sup>CNR-IMAA, Tito, PZ; <sup>2</sup>University of Basilicata, School of Engineering, Potenza;  
<sup>3</sup>University of Basilicata, DICEM, Matera

Soil moisture is a variable of paramount importance for a number of hydrological processes and requires the capacity to be routinely measured at different spatial and temporal scales. The electromagnetic induction (EMI) method may be useful in this regard considered that it does not require contact with the ground, it allows a relatively fast survey, it gives information related not only to the shallow soil and can be easily used in wooded areas. In this study, apparent electrical conductivity (ECa) and soil moisture (SM) measurements were carried out by using a multi-frequency EMI sensor (GEM-300) and a Time Domain Reflectometry (TDR), respectively. The aim was to retrieve SM variations at the hillslope scale over four sites, characterized by different land-soil units, located in a small mountainous catchment in Southern Italy. Repeated measurements of ECa carried out over a fixed point showed that the signal variability of the GEM-300 sensor was negligible. The obtained results highlighted the potential of EMI to provide, in a short time, sufficiently accurate estimate of soil moisture over large areas that are highly needed for hydrological and remote sensing applications.

## **MONITORING OF SEAWATER QUALITY STATUS BY COMBINING IN SITU AND SATELLITE DATA: THE IOSMOS PROJECT**

**Lacava T., Bernini G., E. Ciancia, Coviello I., Di Polito C., Faruolo M., Filizzola C., Madonia A., Marcelli M., Pascucci S., Paciello R., Palombo A., Pergola N., Piermattei V., Pignatti S., Santini F., Satriano V., Tramutoli V., Vallianatos F.**

CNR-IMAA, Tito, PZ

The Basilicata Ionian coast has a high economic relevance for the Basilicata region, especially concerning the touristic sector. This area is a typical complex marine-coastal ecosystem which, due by the co-existence of different natural and anthropic features, is potentially exposed to different phenomena and levels of degradation. Trying to reduce the negative effects which coastal marine waters are subject to, it is fundamental to implement an adequate monitoring system, able to provide reliable and quickly indication about seawater quality status variation.

Remote sensing data offer a relevant contribution in this framework, providing, with a quite good level of accuracy, information about the spatial distribution of seawater constituents (biological or physical) over large areas with high temporal rates and at relatively low costs. On the other hand, in situ measurements are necessary for the calibration of algorithms based on satellite data and for the study of small-scale (temporal or spatial) phenomena.

In this study preliminary achievements carried out by IOSMOS (IONian Sea water quality MONitoring by Satellite data, OP ERDF Basilicata) project will be described. In particular, long series (more than 15 years) of satellite data and products have been combined with in situ and airborne data to define the quality status of the Ionian coastal water. Among the possible bio-optical and physical parameters which could have been analyzed, the Chlorophyll-a (Chl-a), Suspended Solid Material (SSM) and Sea Surface Temperature (SST) ones have been investigated, providing a comprehensive characterization of the investigated area both in terms of multi-year trends and spatiotemporal variations.

# **ANALYSIS OF GROUNDWATER SUPPLY DYNAMICS FOR POROUS AND FRACTURED AQUIFER BY DATA DRIVEN MODELLING**

**Doglioni A., Simeone V.**

Technical University of Bari

The analysis of groundwater supply dynamic is a relevant topic for the protection of and the management groundwater resources. A data mining approach based on the multiobjective evolution approach has used to analyse the response of groundwater levels to rainfall supply. The proposed approach provides explicit equations able to forecast groundwater table dynamics level as a function of rainfall and past values of groundwater levels. This data-driven methodology is successfully applied to two different aquifers in South Italy representative of different hydrogeological environment: a shallow porous aquifer and a deep coastal karst aquifer. The obtained result shown the capability of the methodology to give reliable result and also information about groundwater supply dynamics in both kind of hydrogeological environment.

# **THE SECRINO LAKE. CHEMICAL AND PHYSICAL PROPERTIES OF THE WATER**

**Marrone R.**

University of Modena

The paper focuses on the results of monitoring the quality of the small subalpine glacial lake of Secrino (Italy) in 2013. The lake is considered the less polluted of Europe due to its clean subterranean sources, the absence of surrounding industries and the absence of tourism in the area.

Reaching the right oligo-mesotrophic condition has been one of the maintenance works done in order to improve the quality of water by reducing the contamination of anthropic and agricultural elements.

The monitoring of water has considered the following parameters: transparency, the chlorophyll, oxygen, pH, alkalinity, conductivity, total phosphorus, orthophosphate, total nitrogen, nitric nitrogen, ammonia nitrogen, inorganic nitrogen, organic nitrogen and reactive silica.

Data obtained have been compared with those done previously in 2011-2012 in order to understand the trophic level and the general condition of water, and to verify the efficacy of the interventions done so far to reduce the nutrient load.

# **MONITORING OF PHYSICO-CHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF TREATED WASTEWATER FROM TREATMENT PLANT OF “INDUSTRIAL AREA OF FOGGIA”**

**Tarantino E., Libutti A., Disciglio G., Gatta G.**

University of Foggia

The present investigation was carried out in years 2009 and 2010 to monitor the physico-chemical and microbiological characteristics of the industrial wastewater (IWW) from the secondary treatment plant of the “Industrial Area of Foggia” (Apulia, Southern Italy). The treatment plant released on average about 567,000 m<sup>3</sup>y<sup>-1</sup> of IWW, which distribution was not uniform over the year. The monthly values were about 250,000 m<sup>3</sup> from November to June and about 90,000 m<sup>3</sup> from July to October.

The obtained results revealed that IWW was characterized by low values of Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Electrical Conductivity (EC) and Sodium Absorption Rate (SAR). An occasional presence of heavy metal and high concentration of total phosphorus, total nitrogen, ammoniacal nitrogen and microbial organisms (*Escherichia coli* and *Salmonella*) were observed.

Due to the presence of these pathogenic microorganisms and sometimes of heavy metals, which may raise sanitary and environmental problems in order to the possible irrigation reuse of this IWW, a tertiary treatment of wastewater based on filtration and disinfection in line are recommended.

# **SENSITIVITY ANALYSIS FOR FLOOD DAMAGE MODEL ASSESSMENT ACROSS EUROPE USING THE FLOOD RISK FOSS**

**Craciun I.<sup>1</sup>, Albano R.<sup>2</sup>, Mancusi L.<sup>3</sup>, Sole A.<sup>2</sup>, Ozunu A.<sup>2</sup>**

<sup>1</sup>College of environment science and engineering, Babes-Bolyai University, Cluj-Napoca, Romania; <sup>2</sup>School of Engineering, University of Basilicata, Potenza, Italy; <sup>3</sup>Sustainable Development and Energy Resources Department, Research on Energy Systems SpA, Milano

Flood damage assessment has become an important component in flood risk management. In the recent years interest in risk-oriented models and risk analysis has increased, improving flood risk prevention, cost–benefit analysis, mitigation and resilience. In this context, several flood damage models have been developed in many European countries. Although there has been an increase in empirical and analytical skills and approaches on risk analysis, more knowledge is necessary for the establishment of a harmonized pan-European approach. A first attempt to develop a pan-European damage model has been made on the request of the European Commission Joint Research Centre (Huizinga, 2007). The study produced depth-damage functions for each European country for the assessment of direct damage produced by floods. In this paper a sensitivity analysis for the depth-damage functions proposed by JRC is presented, using the Free and Open Source (FOSS) tool FloodRisk (L. Mancusi et al., 2015), developed in Quantum GIS software environment. We used virtual input data and information provided at the 12th ICOLD International Benchmark Workshop on Numerical Analysis of Dam. In this study we showed that the outcomes are influenced by depth-damage functions and also by maximum damage values, the first one having a greater influence than the second one, this result being conclusive with previous studies (Jongman et al., 2012; De Moel et al., 2011). However, theoretically, for large values of depth water, the maximum damage values have though a stronger effect on the results, depending also on land-use class.

# **FROM DROUGHT MANAGEMENT STRATEGIES TO APPLIED DROUGHT MANAGEMENT POLICIES**

**Karavitis C.**

Agricultural University of Athens

Drought is a complex natural phenomenon that lacks a universally accepted definition, thus it is difficult to confront holistically. Several efforts have been made towards managing the widespread and catastrophic drought impacts. In this quest, the concept of vulnerability to drought seems to offer some significant potential. In the present attempt, a Drought Vulnerability Index (SDVI) is presented, applied, and spatially visualized through geostatistical methods on a country scale, in southeastern Europe and Latin America. In an effort to link drought characteristics to impacts, the index incorporates water supply information, demand data, the state of the relevant water infrastructure and climatic parameters represented by the standardized precipitation index. The index showed potential in portraying various vulnerability states and followed satisfactorily the vulnerability fluctuations in relation to recorded drought hazard dimensions and impacts. The SDVI may be considered as a first step for the emergence of an integrated drought vulnerability index with multi-scalar applications in environmental research and decision-making. It is believed that improving techniques in index formulation may compliment more reasonable and acceptable solutions to water challenges posed by droughts and help avoid a drifting sense of continuous “water crises” .In this context, drought contingency planning and forecasting may also be included in the decision making arsenal in order to also widen existing perceptions of the area’s inherent weaknesses and limited resilience to both anthropogenic and natural hazards, serving at the same time as an early warning mechanism.

# **SOLAR AOPS: OVERVIEW OF PROCESSES AND PHOTOREACTORS**

**Rodríguez S.M.**

CIEMAT- Plataforma Solar de Almería

Advanced oxidation processes (AOPs) most commonly used require UV irradiation with lamps, therefore, research is focused on two AOPs which can be powered by solar radiation: heterogeneous catalysis with UV/TiO<sub>2</sub> and homogeneous catalysis with Fe<sup>2+</sup>/H<sub>2</sub>O<sub>2</sub>/UV, called photo-Fenton. Although application of these processes to waste water treatment have been studied for at least three decades, engineering systems and engineering design methodologies have only been developed recently [1]. Compound Parabolic Collectors (CPCs) are a very good option for solar photocatalytic applications [2] but recently raceway pond reactors have been proposed as simpler and less costly solar photoreactors for certain applications [3]. One of most interesting applications of solar AOPs is disinfection. Recent research on solar photocatalytic disinfection attempts to combine sustainability with low cost, not only for drinking water, but also for irrigation [Keane et al., 2014]. There are aspects that are essential to generate this new technology: (i) optimization of photo-reactors; (ii) development of viable process schemes; (iii) development of process control strategies; (iv) the influence of process parameters; (v) assessment of the influence of the water chemical parameters. Finally, many efforts have been directed to generate hydrogen from renewable resources in recent years. In particular, there are extensive studies on the photocatalytic hydrogen production from water by using a catalyst and sunlight under ambient conditions [4]. Few results of hydrogen generation via solar heterogeneous photocatalysis have been reported at pilot-plant scale but one of them is at PSA [5]. This work summarizes the current status of solar photocatalysis processes, describing the fundamentals and applications but specially focusing on different solar photoreactors.

## **THE MINERAL WATERS OF MOUNT VULTURE AREA (BASILICATA, SOUTHERN ITALY) AND THE INDUSTRIAL EXPLOITATION HISTORY**

**Gizzi F.T.<sup>1</sup>, Delli Santi M.<sup>1</sup>, Masini N.<sup>1</sup>, Potenza M.R.<sup>1</sup>, Zotta C.<sup>1</sup>, Bruno M.C.<sup>2</sup>, Maffei A.<sup>2</sup>, Perillo F.<sup>3</sup>**

<sup>1</sup>IBAM-CNR, Tito, PZ; <sup>2</sup>Basilicata Region–Presidency Department–Geology and Mining Office, Potenza (Italy); <sup>3</sup>GAL (Local Action Group) Development Vulture Alto Bradano, Rionero in Vulture (PZ) (Italy)

The work presents the first results of a research project entitled: “The mineral waters of Mount Vulture area: the industrial exploitation history since the late nineteenth century” conducted by the Institute for Archaeological and Monumental Heritage of the Italian National Research Council in cooperation with the Basilicata Region – Presidency Department – Geology and Mining Office – and GAL (Local Action Group) Development Vulture Alto Bradano which co-finance the project.

The 24-months project looks at the multidisciplinary and interdisciplinary approach proper of the industrial archaeology and it will take advantage of the analysis of the buildings, equipments and infrastructural evidences, as well as of documentary and iconographic sources and other aspects associated with the production and marketing.

The project will pay particular attention to the geological and hydro-geological analyses performed by the technicians in order to exploit the mineral waters, the construction/extension works of the industrial buildings and infrastructures; the change of rules to be kept to market the mineral waters over the time and the adaptation industrial strategies; the equipment and the industrial development over the decades; the statistical data about sales and employments; the trade relationships and the prize awarded from the dealership companies, and so on.

The final aim of the project is to exploit the water resources both in the national and international contexts. Accordingly, such studies will contribute to awaken public opinion and policymakers to protect the environment and the territory where such natural resources are located.

# **EVALUATING THE EFFECTIVE EVAPO-TRANSPIRATION RATE FROM AN EXTENSIVE GREEN ROOF IN MEDITERRANEAN CLIMATE CONDITIONS**

**Garofalo G., Nigro G., Principato F., Piro P**

University of Calabria, Cosenza

In urban environment, the progressive growth of impervious surfaces has generated severe modifications of the natural hydrological cycle, leading to an increase of the runoff volumes delivered into the combined sewer systems. Such volumes may overwhelm the existing urban drainage systems and cause local flooding. In this context, green roofs may represent a sustainable solution to mitigate urban runoff quantity, by retaining and evapo-transpiring a portion of the rainfall volumes.

Several literature studies have investigated the hydrological-hydraulic behavior of green roofs; only few had evaluated the evapo-transpiration (ET) phenomena combined with definition of a ET coefficient based on measured data. The FAO-56 Penman Monteith (PM) method, based on the energy balance and mass transfer principles, represents the most accurate procedure for predicting the potential ET rates. In a situation where meteorological information are completely absent, the Hargreaves formula is commonly used for estimating potential ET, instead of the PM equation due to the ease of calculation, since almost require only air temperature.

This study firstly intends to evaluate the potential ET of an experimental green roof, located at the University of Calabria (Italy) and covered by Mediterranean plant species, by using the PM method. The results, compared with those obtained with other ET estimation methods, revealing that Hargreaves method is nearly as accurate as the PM model. Secondly, the time variation of water content in the substrate, measured in the experimental green roof, is used to quantify the water loss due to the ET. Those measured data are utilized to validate the Hargreaves method through the definition of the seasonal ET coefficients for the specific green roof studied. The findings will represent a basis to more properly model the effective ET rate from an extensive green roof under Mediterranean climate conditions through the use of validated ET coefficients.

# **WATERMELON FROM THE DESERT: WATER SCARCITY AND INTERNATIONAL MARKET IN MOROCCO**

**Campisano C.**

University of Roma Tre, Roma

Morocco, as other countries of the southern shores of the Mediterranean, is a water-scarce country, characterized by depleted groundwater reserves and an economy largely based on agricultural exports, mainly to the Mediterranean market. The global economy in which Morocco is inserted, can directly affect the water scarcity experienced at a local level. This paper, based on an ethnographic fieldwork conducted in 2015 in Zagora, in southern Morocco, aims to highlight the effects of an export oriented market in a context of water scarcity. The Moroccan watermelon is in growing demand throughout Europe and its production has been encouraged by public funds allocated by the Moroccan State within the “Green Morocco Plan” project, supported by the EU. Indeed, in 2014 Morocco exported to EU more than 30,000 tons of watermelons, compared to the 8,000 exported in 2013. The findings in my fieldwork suggest that the rise in watermelon exports led to an overexploitation of local water resources with a serious impact on drinking water supplies and aquifers quality. Through showing this case study, this paper highlights the importance of water management policies and regulation as well as the not always obvious consequences of trade exchanges.

# **A NON-HOMOGENEOUS MARKOV MODEL FOR THE DEFINITION OF CLIMATE CHANGE SCENARIOS FOR COSTAL AREAS: THE CASE OF THE AGRO-PONTINO PLAIN**

**Cioffi F.<sup>2</sup>, Conticello F.<sup>2</sup>, Lall U.<sup>3</sup>, Marotta L.<sup>1</sup>, Telesca V.<sup>1</sup>**

<sup>1</sup>School of Engineering, University of Basilicata, Potenza, Italy;. <sup>2</sup>Dipartimento di Ingegneria Civile Edile Ambientale, Università di Roma 'La Sapienza', Roma, Italy;  
<sup>3</sup>Department of Earth & Environmental Eng., Columbia University, MC New York, NY.

In the last century, the building of climate change scenarios, particularly for critical regions, such as the Mediterranean, is becoming frequent to predict climate change impacts on the physical environments.

In detail, this study addresses to the possible changes in Agro-Pontino rainfall under different global warming scenarios for the 21st century because it is a reclamation region and presents the typical hydro-geological features of Mediterranean coastal environments so climate changes could adversely affect the socio-economic development of the area. Currently, due to the coarse resolution of Global-Circulation- Models, local climate variables simulations for limited size area are not accurate. Nonetheless, GCMs simulations of large-scale upper-air fields are generally considered reliable, therefore to bridge the gap between GCMs and local-scale processes different downscaling techniques are carried out. Here, a Hidden Markov Model and a Non-homogeneous Hidden Markov Model are developed using a 54-years record (1951-2004) of daily rainfall amount at 9 stations in Agro-Pontino-plain and re-analysis fields of atmospheric variables. In HMM and NHMM runs, we directly consider the entire year, rather than an a priori demarcation of seasons. The idea is to identify, directly using the HMM, the seasonal precipitation characteristics which may be related to the temporal sequence of 'hidden states' of atmosphere, subsequently modeled as dependent on appropriate fields of selected atmospheric variables. Daily rainfall variability is described in terms of occurrence of 5 'hidden weather states' identified by the HMM and associated to variables representing the main characteristics of large-scale atmospheric circulation as obtained by re-analysis data, then, using NHMM, calibration and validation tests are made to identify the optimal set of predictors to reproduce better the observed rainfall features on Agro-Pontino-plain.

## **NEW APPROCHES FOR WATER TREATMENT AND RECYCLING**

**Scrano L., Khalaf S., Lelario F., Karaman R., Bufo A.S.**

University of Basilicata, DIMIE

The European Directive 2000/60/CE stresses the need of adopting measures against water pollution in order to achieve a progressive reduction of pollutants and recuperate water for new uses. Many pollutants have been found in the water bodies as pharmaceuticals, pesticides, and household cleaning products, which have raised up a great concern about their potential effects on environment and human health. Some of the adverse health effects caused by these compounds include aquatic toxicity, resistance induced to drugs used to control pathogenic bacteria, genotoxicity and endocrine disruption. It is evident the necessity of improved wastewater treatments aiming at the (i) best environmental protection from pollution and (ii) recovery of alternative sources for fresh water, thus overcoming in part the increased scarcity of water in dry regions.

Filtration and sedimentation by using natural and modified nano-materials coupled with Advanced Oxidation Processes (AOPs) are promising ways to perform the removal of pollutants. In particular AOPs are characterized by the in situ production of hydroxyl radicals, which are highly reactive species capable of oxidizing organic materials in a non-selective way. The specific objective of the European Project "Diffusion of NANOTECHNOLOGY based devices for WATER treatment and recycling" (NANOWAT) was:

- to develop new technologies, based on nano-materials and solar energy,
- to operate pilot transportable and miniaturized equipments for the efficient purification of water by filtration, sedimentation and photo-degradation, improving exchange of technical knowledge, new professionalism and environmental awareness.

Many class of pollutants were tested and the positive results obtained were largely diffused. Several pollutants were totally removed by using the new filtration tool, but the recalcitrant compounds disappeared mostly from the water body combining both the treatments proposed.

# **ECONOMIC ASSESSMENT OF ALTERNATIVE APPROACHES TO WATER AND ENERGY G. CONSERVATION THROUGH ALTERNATIVE IRRIGATION ADVISORY SERVICES •**

**Quaranta G., Salvia R.**

University of Basilicata, DIMIE

The work is based on evidence gathered in two projects developed in the South of Italy (Campania Region) which are aimed at defining and implementing methods able to optimise irrigation practices both in economic and environmental terms.

The first project focuses on differential irrigation, based on the application of different quantities and timetables according to soil type, and allows significant savings in water whilst maintaining yields at competitive levels.

The methods based on remote sensing, being based on soil characteristics directly linked to water balance allow the forecast, simulation and planning of spatial responses which can be repeated and are consistent over time. This is particularly significant for irrigated areas which are fed by aquifers, where the quantity and quality of the underground water resources are closely linked to the local management of irrigation.

The second project, instead, proposes an Irrigation Advisory Service based on the integration of multi spectral satellite images with high-resolution stochastic numerical weather prediction. The objective is to provide a service at competitive prices to all farms, independent of their size or geographic location.

The aim of the paper is to carry out an assessment of the benefits associated with the adoption of these methods in socio-economic terms and in terms of water and energy conservation. In addition, they will be compared with the most diffused IRRIFRAME framework, largely applied in many Italian regions.

The outline of the work includes an initial section describing the performance and limits of the alternatives, both at farm and water distribution organization level, and their specific adaptation to the Mediterranean context, followed by a section evaluating the environmental and socio-economic benefits of the methods and a final section highlighting possible barriers to their application and diffusion. The work is partially funded by PIRAM (CUP B73D14000070006)

## **WATER MANAGEMENT IN THEBAN ARCHAEOLOGY**

**Greco C.**

Direttore Museo Egizio di Torino, Membro del Comitato Tecnico-Scientifico per i Beni Archeologici del MIBACT

After the construction of the Aswan Dam and the formation of Lake Nasser, the hydrogeological system of Egypt has completely changed. There has been a rise of the water table, aggravated by intensive cultivation of sugar cane, which requires constant irrigation. The sandstone temples are suffering a lot. To save time, major dewatering projects were launched, which involved placing pumps inside trenches to bring down the water level. This temporary solution has had a huge impact on an area that has one of the highest archaeological densities in the world. The issue of the sustainability and preservation of the local archaeological heritage has now become extremely urgent. Addressing it will necessarily require a synergy with other disciplines and, above all, a rethinking of agricultural policies.

# **LEGISLATION AND URBAN MANAGEMENT OF THE WATER IN ITALIAN MEDIEVAL CITIES (13TH-14TH CENT.)**

**Bocchi F.**

University of Bologna, Centro "Gina Fasoli"

The report will deal with water management problems in the medieval cities (Comuni), and special attention will be paid to supply of drinkable water, disposal of waste waters, street cleaning by water supply, water as energy source. In particular, will be examined the decisions that were adopted in the communal legislation about the protection of groundwater against pollution by tanning of hides and skins or slaughter of animals. It will be considered the case of cities as Florence, Pisa, Perugia, Bologna, Treviso, Pistoia, for evaluating the level of attention paid by the communal cities to these problems. For example, we know a lot of statutory rules taken by the Commune of Perugia to safeguarding the aqueduct of Montepacciano, that goes to the fountain in the central square made by the sculptors Nicola and Giovanni Pisano and by the venetian hydraulic engineer Boninsegna. The last section of the speech will be devoted to an analyse of the urban sewage systems and the works required for urbanisation of new areas inside the walls. Such issues concern water management, but they are of crucial importance to the modernisation of medieval cities.

## WATER: LIFE, MEMORIES AND SYMBOL

### Teti V.

University of Calabria, Cosenza

Nelle società tradizionali del Sud e del Mediterraneo l'acqua era scarsa o eccessiva: la vita e la mentalità delle popolazioni erano strettamente legate alla bizzarria del clima, ai forti estremi di due sole contrapposte stagioni; all'alternarsi di lunghi di periodi di piogge torrenziali, quando tutta la terra «sembra navigare sulle acque» e «i paesi diventano essi stessi dei torbidi torrenti» e di non meno lunghi periodi di siccità, in cui tutto brucia e arde. Non è difficile immaginare che la geoantropologia del Mediterraneo abbia influenzato il pensiero del mondo antico. Nella più antica dottrina cosmogonica greca (Omero, Esiodo, Platone) l'acqua, in particolare quella del grande pelago oceanico, è indicata come l'elemento primordiale dell'universo, analogamente a quanto suggerisce l'escatologia sumero-accadica. La cosmogonia greca, Oceano, Plutone, gli dei, le ninfe presentano non solo l'acqua che ride, l'acqua chiara e gioiosa che origina la vita in sede mitica, ma anche un'acqua notturna, vischiosa, tenebrosa, squamosa, inafferrabile, mortifera, distruttiva.

Cosmogonie, mitologie, religioni, culti, pratiche ci pongono di fronte a una concezione, a un'immagine, tutt'altro che unilaterale dell'acqua. L'acqua ha rappresentato non soltanto un elemento fondante e vivificante, salvifico e terapeutico, ma anche un elemento di distruzione, di devastazione, di perdita.

L'acqua è concretamente, oltre che simbolicamente, elemento di vita e di morte. L'analogia e la somiglianza dei simboli, la loro ambivalenza e fluidità, la continuità e la discontinuità nella lunga durata e negli stessi luoghi, portano a individuare al tempo stesso la somiglianza e la diversità delle esperienze che hanno conosciuto le società e le culture. Per questa via l'acqua, in quanto elemento dovunque presente (nell'universo, sul pianeta e nel corpo), può costituire anche il luogo per ripensare i nessi tra biologia e cultura, tra quello che chiamiamo natura e quello che chiamiamo storia. L'acqua ci ricorda l'unità biologica dei diversi popoli e dei differenti gruppi umani. Ciò che ci differenzia è la storia, la cultura, i rapporti che abbiamo stabilito con l'ambiente, le risorse, gli altri. L'acqua è l'elemento che indica unità e distinzione. È l'elemento globale, comune, con le maggiori implicazioni e differenziazioni a livello locale.

Il carattere pervasivo, l'intrinseca, necessaria presenza dell'acqua entro ogni forma di vita del mondo – ecco il punto – non è mai uguale, non si ripete con monotona e scontata prevedibilità. Al contrario, l'acqua esplica le sue necessarie funzioni, articola e modella il suo ciclico fluire e rifluire, dando luogo a differenti geografie e storie, modificando, a seconda dei luoghi, dei tempi, delle interazioni con altri fattori fisici e storici – prima di tutto l'azione plasmatrice o distruttrice degli uomini – i suoi modi di essere, le sue presenze materiali, le sue stesse valenze simboliche. L'acqua – come potrebbe mostrare una storia dell'acqua, nei suoi aspetti biologici, materiali, sociali, religiosi e simbolici, destinata necessariamente a percorrere, traversandole, anche le più diverse discipline - è essa stessa elemento trasversale, fluido, mutevole, multiforme, liquido, solido e gassoso (non dimentichino le nevi e i ghiacci, i vapori e l'aria) che si riversa diversamente sulla terra, nella natura e nella storia.

## **AQUA AUGUSTA: A SYSTEM OF AQUEDUCTS FROM FIRST CENTURY B.C. SERVING THE GULF OF NAPLES**

**Linoli A.**

International Commission on Irrigation & Drainage (ICID)

The Aqua Augusta is a complex system of aqueducts, 145 km long including secondary canals, conceived under the rule of the Roman Emperor Augusto. It was built during the second half of the First Century B.C., with the specific purpose to collect waters flowing from the Serino river springs in Campania region, near Benevento (Southern Italy) and convey them, mostly underground, to the small towns scattered along the gulf of Naples. These were ranging from Pompeii down to the harbor of Misenum, where a very important and strategic naval base was settled, because the largest Roman fleet, for that time, was there serving. The final destination of this sophisticated system of canals, underground conduits and bridges, thus built in order to supply drinking water to the vast population of the area, was a reservoir known as the "Piscina Mirabilis" (that would be Magnificent Pool) with a storage capacity of more than 12,000 m<sup>3</sup> and thus capable of giving water to the more than 30.000 people living in the naval base of Misenum and serving the Roman fleet, at that time. Along with a description of the system, the paper makes a brief mention to the main cities served by the aqueduct and, particularly, describes the distribution of water in Pompeii.

## **THERMALISM IN ROMAN ITALY**

**Ghedini F., Zanovello P., Bassani M.**

Dipartimento dei Beni Culturali, Università di Padova

A few years ago, at the University of Padua a group of researchers, coordinated by the undersigned, was formed with the intent of focussing on the study of thermalism in Roman Italy. After a pioneering phase between mid-18th and the end of the 19th century, the interest towards the complex phenomenon of healing waters and their usage among the Roman has gained new energy during the final decade of last century. However, it has not reached a distinct classification yet, because of the inner complexity of the subject, which requires different competences: not only historical, archaeological, epigraphic, topographic ones, but also geological, chemical-physical, therapeutical etc.

Our research team tried to examine in depth the different aspects of the exploitation of thermo-mineral waters, starting from a systematic filing of every healing site in Roman Italy on a georeferenced database.

The contribute that we will present in Matera will show the developed methodology, the reached results and future horizons of the study. The research, in fact, is still ongoing: the areas interested by the filing of thermo-mineral waters have been widened to the north-western provinces of the Roman Empire (in particular Gallia, Germania and Raetia).

Our research also benefited from the opportunity of analysing one of the most famous thermal sites of the antiquity, Aquae Patavinae, on which the next presentation will be focussed.

**PROJECT *AQUAE PATAVINAE* - MONTEGROTTO TERME ( PD ). TO THE  
ARCHAEOLOGICAL PARK OF THE TERME EUGANEE**

**Bressan M., Ghedini F., Zanovello P.**

Dipartimento di Archeologia, Università di Padova

Since ancient times the principal resource of euganean area near Padua is its natural hot springs of healing water.

During the 1st Millennium BC, here was a sacred place; in roman era, especially towards the end of the first century BC, a rich suburban area developed, with villas, thermal pools and other buildings for leisure.

Thanks to *Aquae Patavinae* Project, now in Montegrotto Terme there are three archaeological sites open to the public, one of which covered with a roof created like the original one.

The aim of the Project is to create an “archaeological park”, a full experience for the visitor in the past through the leading presence of thermal water. Therefore, in Montegrotto Terme, the visitor finds a beautiful reception room at the train station with photos and informations about archeological sites, several information boards placed near visible and no more visible archeological sites, three beautiful archaeological sites and in few month, the visitor will find the “Museo del Termalismo” too. All informations about the Project and the sites are available at the website [www.aquaepatavinae.it](http://www.aquaepatavinae.it).

In addition to permanent installations, the development of promotional activities in recent years has been the organization of cultural activities of various kinds, which are using the archaeological sites as real spaces, in which not only approach the ancient material culture, but also relive the immaterial culture, linked to the life and feelings of people.

## **GREENING THE DESERT AT THE SOUTHERN EDGE OF THE EMPIRE: THE IRRIGATION SYSTEM IN THE LATE ROMAN SITE OF UMM AL-DABADIB (KHARGA OASIS, EGYPT)**

**Rossi C., Chirico G.B., Migliozi A., Fassi F., Mandelli A., Achille C., Mazzoleni S.**

University of Napoli Federico II, Centro MUSA, Portici, Napoli

Umm al-Dabadib is a fascinating archaeological site laying at the outskirts of the Kharga Oasis, at about 700 km south-west of Cairo and 250 km west of Luxor. It was founded in IV AD to mark the southern border of the Roman empire and, in a way, still lies along the edge of the inhabited world: there is no proper road, no water, no telephone signal and no electricity.

Since 2012 the MUSA Center (Musei delle Scienze Agrarie, University Federico II of Napoli, Italy) founded Old Agricultural Sites and Irrigation Systems (OASIS), an interdisciplinary project, partially supported by National Geographic, to studying in parallel the built-up areas, the relating hydraulic infrastructure and agricultural fields.

Umm al-Dabadib is a virtually unknown site, extremely well-preserved, that this project will raise to the attention of the international academic community.

Its most peculiar and important aspect is the presence of infrastructures for groundwater exploitation and irrigation that made life in the desert sustainable for the Roman colony.

The site was served by seven underground aqueducts of the type called qanat or manawir, gently sloping subterranean tunnels that conveyed water by gravity to the crop fields. The level of preservation of the ancient cultivations is astonishing: apart from the underground portions of the aqueduct, here we could clearly identify a network of open-air canals, the layout of the fields and even some archaeobotanical remains of cultivated soil and ancient plants.

At first sight, the large, fortified settlement located along the empire's southern frontier, looks like a military outpost. The results of OASIS expeditions demonstrate that the reality was far more complex. Rather than a basis for offensive operations, Umm al-Dabadib appears to have been a defended position where the most important good to be guarded was the food reserve.

## **SACRED WATER IN ANCIENT GREECE**

**Scafuro M.**

University of Salerno, Dep. Scienze del Patrimonio Culturale, Salerno

Water is life, purification, regeneration. This gives rise to many opportunities for development. Immersion in water is a return to basics, with an outcome that generates strength and purity. The potential water are large and innovative. The Pythia, the priestess of Apollo at Delphi, drinking to Castalia fountain, in order to draw inspiration before his prophecies. Pilgrims on their way to the shrine of Delphi had to take a purifying bath in the same source, as a precondition to be able to consult the oracle. The speech will be aimed to analyze the relationship between the water and the rituals in Ancient Greece in sacred contexts as the sanctuaries of Delphi, Sounion, Brauron and Eleusis.

# **KLEIGHENES AND THE KIMOLIAN EARTH. INVESTING IN A BALANEION IN CLASSICAL ATHENS**

**Di Nicuolo C.**

Ministero dei Beni e delle Attività Culturali e del Turismo, Scuola Archeologica Italiana di Atene

From the last two decades of the fifth century BCE investments in building balaneia represented for many Athenians a significant source of income, not only from entrance fees, but also from the production of bathing supplies. In his “Frogs” (706-717) Aristophanes attacked a man named Kleighenes, a really unpleasant person («Kleighenes the monkey»), the wickedest balaneus of all those who provided bathers mixtures of ash and nitre. Nevertheless, available information identifies Kleighenes as one of the protagonists of Athenian politics during the period, who, despite being of foreign origin, reached one of the highest institutional levels. Like other demagogues this “Annoying Monkey” was a foreigner, who became so influential to acquire prestigious positions (Schol. in Ar.R.709-714). The terms used to characterize Kleighenes were meant to present him as a person unsuitable for the position achieved. As for Kleon, portrayed as a vulgar byrsopoles (tanner), as he owned tanneries, from which he obtained considerable revenues, the identification of Kleighenes as a balaneus may be meant to explain the origin of his wealth. The reference to Kleighenes as the smartest among all the lords of kykesitephron pseudolitron (soap) and the Kimolian Earth (Ar.R.711-712), should be most likely understood as an indication of the direct involvement of this demagogue both in the mining process and in commercialization of the resources from the earths of Kimolos. The bentonite of Kimolos, located at approximately 81.57 miles from Piraeus, has specific properties suitable not only for industrial use, but also for the production of therapeutic products aimed at the treatment of dermatological pathologies. In the second half of the fifth century BCE the reference by Aristophanes to Kleighenes and the Kimolian Earth seems to indicate the awareness of the nature of the rock formations at Kimolos, exploited also for the detergents supplies of Athens and its balaneia.

## **THE USES OF WATER IN THE ANCIENT CITY OF POSEIDONIA-PAESTUM**

**Serritella A.**

University of Salerno, Dept.. Scienze del Patrimonio Culturale, Salerno

The presence of water is a fundamental condition for the establishment of an urban community. In the ancient world the water had an important role in the organization of urban spaces, likewise in chora. Poseidonia, one of the centers of Ancient Greece, it is a case in point to understand all aspects of the significance of water. In fact, although it is limited documentation on public and private water supply of the city, like the drainage system, there are numerous testimonies of urban sacred spaces within works related to water. In the chora, the presence of springs located east of the city (at Fonte di Roccaspide, Capodifiume, Getsemani, Acqua che bolle) in sacred places highlights how much importance the community gave to water not only for the life of the community, but also for the control and management of the territory.

## **ACHELOUS AND THE WATERS. ARCHITECTURAL TERRACOTTAS FROM FRATTE**

**Monda P.**

University of Salerno, DISPAC, Salerno

The Literary sources have, always, identified Achelous as a river god, to which many ancient streams owe their existence; almost a symbol of the primordial waters, a god, with a strong healthy value, that improves and brings fertility and life. His presence is known in many Etruscan and Italic centers and of Magna Grecia, and is documented at Fratte by two specimens of acroteria, with bull-like features and a human face, framed by a long, bushy beard. The Acroteria come from the two sacred areas of the site (area of the Case Popolari and the Acropolis), the analysis of which has contributed to highlight the two major aspects of divinity: in the case of the Acropolis, the presence of the deity seems, in fact, to appear when the original hydro geographic order is suddenly overturned, following the construction in the second half of the sixth century. B.C. of a complex and articulated hydraulic system which disrupts the original orography of the area; in the case of the Case Popolari, the deity seems placed inside a sanctuary, in defense of a natural boundary formed by the River Irno.

## **WATER OF ANOINTMENT AND WATER OF DESTRUCTION**

**Brusasco P.**

University of Genova, School of Human Sciences, Genova

The symbolic uses of water in Iraq from the Sumerians to the Islamic State.

In charting the regenerative importance of water in Iraq, the land known as ancient Mesopotamia and the “cradle of civilization” where irrigation and agriculture were first developed, the author deconstructs its polyvalent meanings and uses from the Sumerian period to the contemporary Islamic State. By drawing on examples from mythology such as the Babylonian Epic of Creation (Enuma Elish) in which the world is generated by the mingling together of the primeval waterly powers Apsu (Ocean of Sweet Water) and Tiamat (Ocean of Salt Water), as well as the Assyrian reliefs from Nimrud with ritual scenes of anointments of the sacred tree and related agricultural practices of date palm pollination, it is possible to highlight the beneficial role of water. However, destructive manipulations of water resources both by the ancient Sumerians and contemporary political powers to threaten enemies and dislodge them from their land allow understanding of how water can be viewed not only as a positive ingredient of life and ritual but also as a lethal weapon for erasing cultural differences. An example of the latter is Saddam Hussein’s attack on the Madan, the Marsh Arabs of southern Iraq who saw their wetlands drained as a punishment for their uprising; or the recent instrumental use of dams and canals by Islamic State terrorists to displace communities or deprive them of crucial water supplies. The paper finally shows that in the course of history “water” has always been imbued with symbolic and contradictory meanings, a powerful intermingling of life and death which regulates social dynamics through time.

## DISCOVERING FORMS AND FUNCTION OF HISTORICAL HYDRAULIC ARCHITECTURE

**De Miranda A.**

University of Bologna

This paper aims to evaluate the typology of the water-wheel as an ancient type of water-architecture which has had a fundamental role, over the centuries, in solving the main problem of supplying and carrying water for irrigation. Using the power of the river, this installation raises water to irrigate fields which are at a higher level than the level of the water. The system is composed of a vertical wheel made of wood and an aqueduct made of masonry. The base of the wheel is submerged in the river and turns because of the current. Water is carried to the top of the wheel and is poured into the channel on the top of the aqueduct, and is directed to irrigate the surrounding fields. This construction, whose earliest evidence dates back to at least the 1st century B.C., is widespread in Syria where its technology has not changed. The paper particularly focuses on the Syrian devices built in the Orontes valley, which has been the ideal place for the development of numerous waterwheels. The construction and the use of these installations are allowed by favourable conditions, like the constant speed of the river, the gradual slope of the ground and the absence of consistent floods. In particular the constant speed of the water enables the wheels to move continuously. The structures show unique characteristics in terms of material. Their use of local wood and stone, together with the chemical characteristics of river water, allow a close integration of these installations into the landscape. Syrian devices visually impressive, present shapes which are the results of an accurate and detailed design and are of great historical, environmental and iconographical importance. The earliest examples of these structures in Syria dates back to the Roman times, at least to the 3rd century A.D.. They are not used for irrigation any longer, but are kept in working order as part of Syria's architectural heritage.

# **THERE IS LIFE ONLY WHERE THERE IS WATER: HERITAGE, CONFLICT AND DISPLACEMENT IN HASANKEYF**

**Marilungo F.<sup>1</sup>, Vitali T.<sup>2</sup>**

<sup>1</sup>University of Exeter, Institute of Arab and Islamic Studies, Exeter; <sup>2</sup>Independent  
Researcher and Filmmaker

This paper presents an ethnographic analysis of the enormous-yet-controversial relevance of the Tigris River's waters for the everyday life of the people in the village of Hasankeyf, an historical town of thousands of caves dug in limestone in Southeastern Turkey or Northern Kurdistan. This village, which could easily become part of the UNESCO World Heritage List, is condemned to be covered soon by an 11 billion cubic meter water reservoir.

The study is based on a field-work research (2011-2012) culminated in the documentary film 'This was Hasankeyf'. It examines how the Tigris River dwellers have built their particular relations with the water and the challenges they experience today vis-à-vis the contested construction of the Ilisu Dam and the consequent forced displacement and resettlement. Interpreting water not only as a natural resource claimed and administered within the 'modernization' project carried on by the Turkish state but also as a natural element that belongs to people, we can address local epistemologies that constitute a substantial part of the heritage doomed to disappear. The conceptual relation between the water as substance and the ways in which people experience it and relate to it are strongly entangled with the representational imageries and oral histories that use the river as a metaphor in everyday life and a paradigm to structure economic, geographical and historical narratives.

The ethnography and the ethnographic film about Hasankeyf focus on the local(s') perception and daily relation with the water of the Tigris to then enlarge the vision to the regional (Turkish vs. Kurdish) and global stages (water-control as a soft-power weapon). Looking at the State's futuristic abstractions upon the Tigris's water and the ways they clashes with locals everyday experience and emotional memory of the river, this paper addresses the unique intersection of historical, anthropological and geo-political lines that create the place called Hasankeyf.

# **PRAYING AND DIGGING ACQUEDUCTS: THE RESPONSE OF ANCIENT NASCA TO WATER SHORTAGES**

**Masini N., Lasaponara R.**

CNR-IBAM, Tito, PZ

The desert of Nazca in Southern Peru is one of the most arid areas of the world, due to the confluence of a cold ocean current (the Humboldt) along with other climatic factors.

The lack of water is due to the scarce pluvial precipitations and the (ii) high infiltration capacity, and the consequent yearly significant reduction of the surface water.

Despite the arid and extreme nature of the environment, this region was populated by important civilizations, such as the Nasca, well-known for its refined and colourful pottery and by the huge and mysterious geoglyphs.

In order to practice agriculture, the Nasca developed adequate strategies to cope with hostile environmental factors and water scarcity, constructing wells and underground aqueducts, known with quechua name of puquios.

The effectiveness of the techniques of hydraulic engineering depended on the climate and the weather events that sometimes underwent drastic changes, as results of the cyclical phenomenon of El Niño.

Hence the origin of Nasca religious belief based on the worship of the mountain gods, in charge of the rain, and, therefore, related to the worship of water and fertility, including rituals which took place inside and outside Cahuachi pyramids or on the famous geoglyphs

Therefore, the response of Nasca to make livable the desert was twofold, aimed at addressing the problem in its causes (climate), by ceremonial activities, and in its effects, through the construction of aqueducts.

The paper deals with the results from 3-year scientific investigations of ITACA Mission in Peru of CNR-IBAM and IMAA, in the Rio Nazca drainage basin. By means of the integration of remote sensing, geophysics, GIS and archaeology a number of lost aqueducts has been detected, the knowledge of hydrological aspects has been improved as well as new information on the relationship between the puquios , settlement patterns and geoglyphs have been obtained.

## **AQUILA-ACCULE: WATER MANAGEMENT IN THE TOWN AND ITS HINTERLAND**

**Redi F.**

University of Aquila

The name of the city of L'Aquila instead of deriving from the rapacious, the imperial symbol, comes from "Accule", "Acquili", which means a place rich in water sources. The famous Rivera Fountain or the "99 spouts Fountain", takes advantage indeed of a copious spring located down to the wedge on which the town was built. We discuss the water supply system consisting also in the fourteenth-century aqueduct of Santanza and cisterns tanks of which the main city buildings were equipped for the collection of rainwater and the withdrawal of heavy snowfall. The water provided the city driving force for mills and fulling mills, for the washing of skins and wool, for the dyeing of cloths. The snow was pressed in special facilities for the production of ice, and for the preservation of food.

## **WATER RESOURCES IN THE TALL VOLTURNO VALLEY IN THE MIDDLE AGE**

**Di Rocco G.**

Lumsa University Roma, Dept. Humanities, Campobasso

In this aim we take in examination the relationship among water resources and fortified settlements of a portion of the tall Volturno Valley, in Molise, in the tall Middle Ages.

Through the contained data in the Chronicon Vulturense, has been possible to track the incidence that the courses of water had in the distribution of the population and result clear the importance of the Volturno and its numerous tributaries as principals sources of water provisioning within the process of fortification of the Earth of St. Vincent.

Also the topographical, cartographic and toponomastic study of the area object of this search has allowed, filling in some cases the silence of the sources, to recover a lot of information for a territory, that of north-western Molise, for the most mountainous and tall hilly, characterized by a thick vegetation and, therefore, rich of water.

Different sources and courses of water have been individualized, that, licking up the promontories and the necks on which the villages and the fortifications are planned, had to furnish the necessary water requirement to the resident population, showing, once more, as the binomial man-water, man-natural environment, is tightly connected with the start of every historical trial.

## **THE ANCIENT AQUEDUCT OF MATERA AND ITS FOUNTAIN**

**Doglioni A., Galeandro A., Lionetti G., Simeone V.**

Technical University of Bari, Bari

In the ancient part of the historical town of Matera there are no natural springs and the availability of water was permitted by a complex system of rainfall water collection. The demographic and urbanistic development of the town make it necessary to build up an aqueduct that made it possible water supply also during drought periods.

For this purpose where used the small spring in the upper part of the Lapillo hill that today is known as Castle hill. On the top of the hill it outcrops sand and conglomerated overlying clayey deposit. So rainfall infiltrating in the upper part of the hill create a groundwater volume in sand level in consequence of the presence of the clayey impermeable layers. This groundwater resource even if is not conspicuous in consequence of its small supply basin gives water also during drought period.

This groundwater resource was picked up by a groundwater collection works supplying an aqueduct toward the town. The first aqueduct was built up during the XIV century and repaired during the XVI century. At the beginning of the XIX century (1826-1832) it was built up a new aqueduct with made up by a passable hydraulic tunnel. In the final part of the aqueduct was built a monumental fountain. This fountain was inaugurate in 1832 during the reign of Frederick II Borbone, so it is called Ferdinanda.

During the XX century in consequence of the availability of water due to "Acquedotto Pugliese" the fountain loss a large part of its social function, so in 1949 it was dismantled. During 2009 it was replaced in its original position.

## WERE THERE GIANTS ON THE EARTH IN THOSE DAYS: THE CATCHMENT OF THE ANCIENT TRIGLIO AQUEDUCT (TARANTO, ITALY)

Fidelibus M.D.<sup>1</sup>, Pellicani R.<sup>3</sup>, Canora F.<sup>2</sup>, Spilotro G.<sup>3</sup>, **Elba E.**

<sup>1</sup>Technical University of Bari, Bari; <sup>2</sup>University of Basilicata, School of Engineering;  
<sup>3</sup>Dicem, University of Basilicata, Potenza

Near Taranto (Southern Italy), alongside the deep Triglio canyon and its branches, there is a huge ancient aqueduct. The water intake apparatus is a hypogeum stretch for water interception formed by tunnels converging in a single pipe and spanning about 4 km. Tunnels, mainly dug into calcarenites, drain the surrounding vadose zone fed by delayed infiltration of precipitation, small overlying superficial aquifers at the top of canyon flanks, or alluvial deposits covering the canyon bottom. Early hydrogeologists who designed the intake work were able to select the most permeable levels, only today clearly identified with advanced hydrogeological knowledge. Tunnels and pits, in fact, locate between 130 and 170 m AMSL: this elevation range represents one of the specific elevation ranges recently ascertained in the carbonate platform of Murgia as marks of prolonged sea level stands. There, sea level standstills over a geological time-scale defined groundwater levels, which in turn shaped karst planes inland on platform surface and karstified sub-horizontal levels in subsurface. The sea carved abrasion surfaces on the Adriatic border of carbonate platform and shaped terraces in coarse sediments on the opposite Ionian border, then forming modest aquifers on clayey beds. The geo-archaeological studies highlight the role of early hydrogeologists, forerunners of an environmental culture that led to the construction of an engineering masterpiece. The sophisticated work of Triglio recalls the qanat or foggare, heritage of Persian, Arab and North African culture. The water intake work, currently is ascribed to the Roman period, but it is in the present configuration the sum of several works dating a wide period, probably starting later, from the local Arab period, around 900 AD. The cultural relevance and the ecological efficiency of the work would need new more accurate historical, archaeological and hydrogeological studies.

## **THE THERMAE MUSEUM IN LATRONICO: SPACE OF SOCIAL MEMORY AND SELF-RECOGNITION COMMUNITY**

**Iacovino A., Mirizi F.**

Dicem, University of Basilicata, Potenza

The Thermae Museum of Latronico, housed in a historic building built in 1928, is founded by the municipality of Latronico, in the province of Potenza, and by the Pollino National Park, with the aim to deepening and spreading knowledge on the municipal thermae activity.

The thermae activity has influenced over time the social and urban fabric of Latronico. In fact, thermae, as well as playing an important therapeutic function, over the years they represented a significant gathering space, a place for recreation and a modifier of social habits, so performing an observatory role on the transformation of social local life in the 20th century. The thermal waters, being the main resource for the territory, had a considerable impact on how to define and perceive the landscape of Latronico. Their exploitation is considered a self-recognition factor for the community, a distinguishing feature culminated with the change of name of the Municipality to “Latronico Terme”.

For this important role, in the design intentions the Museum aims to represent a synthesis and a joint for memories and individual experiences, of the community history, of the knowledges and techniques. As such, the museum will tend to offer a real knowledge of the area in the hope of becoming a place of dialogue, of mediation, of communication between the inhabitants of Latronico and thermae's customers and an instrument for the exploitation of resources local.

The exhibition aims to simulate a virtual visit to the contemporary thermae and Latronico for people who attended and met the thermaes and the town in the past years and decades. The thermae and the present town are used in the exhibition as a kind of scenario, which is the background to a past, to which we refer constantly.

# WATER AND FOOD SECURITY: THE CHALLENGES AND THE WAY AHEAD

Ragab R.

Centre for Ecology & Hydrology Wallingford

Water resources sometimes present us with some critical problems. Too much could cause flood, while too little could cause drought, poor distribution could cause famine, poor quality could cause health hazards and poor management could lead to competition and conflicts at national and international levels. The world is facing the challenge of the impact of climate and land use changes on water resources availability and what strategy needs to be adopted to face these changes including the application of the integrated management system and appropriate agricultural practices? The Future challenges by 2050 include, world population grows from 6.3 to 9 billion, food demand to double to feed the extra 3 billion, 30% of irrigated lands are degraded now, will increase further, water use expected to increase by 50%, a global demand for energy may increase by up to 40% and climate change predicted to increase vulnerability of agricultural sector in most developing countries. Satisfying these demands, while maintaining ecosystems, livelihoods, fisheries and biodiversity, is a huge challenge. The combination of possible impacts of climate change and land use requires a proper plan for water resources management and mitigation strategies. There is a delicate balance between water security, food security and energy security when changing the land use from traditional field crops to biofuel. Water resources management needs to be handled with an integrated approach that takes into account: the water resources availability (quantity and quality), the land use, the water demand, and the climate change. Drought events became very frequent and the rainfed agriculture is frequently supported by supplemental irrigation during the water shortage periods. Deficit irrigation and drought tolerant varieties to cope with the water scarcity are possible solutions.

sea level rise due to climate change could cause inundation and results in soil salinization of the vulnerable UK lowland coastal areas that at risk of seawater surge. e.g. Parrett estuary, the wash and Norfolk Broads. This requires a new thinking of possible introduction of salt tolerant crops, fodder and grass. UK imports about 40% of its food from regions that are already water stressed. This food supply from abroad is at risk due to climate change and drought in those regions. Agricultural water use has increased fivefold since 1940 and accounts for almost 70% of world fresh water use for food, feed, fibre, and biofuels. Any modest increase in water use efficiency will result in significant savings of water to produce more food from the same amount of water. New technology to accurately estimate crop water requirement would lead to high water use efficiency, saving fresh water resources and irrigating more lands. Ideally, we need to produce more from less "more crop per drop", and minimize the water footprint. The agriculture sector in different parts of the world searched for alternative water resources sometimes known as non-conventional water resources e.g. re-use of agriculture drainage water, use of brackish water (groundwater), use of seawater and treated waste water. Land management could help in improving water availability and increasing the water productivity. This paper will highlight the issue of water scarcity and food security, the challenges and possible solutions based on recent research investigations.

## **DEMONSTRATION TEST: CHARACTERISTICS AND POTENTIALITY OF SUPER-EXPANDED GRAPHENE FOR TREATMENT OF WATER CONTAMINATED WITH HYDROCARBONS**

**Masi S.<sup>1</sup>, Greco M.<sup>1</sup>, Caniani D.<sup>1</sup>, Pola A.<sup>2</sup>, Giugliano V.<sup>2</sup>, Lofiego S.<sup>3</sup>**

<sup>1</sup>School of Engineering, University of Basilicata, Potenza; <sup>2</sup>Directa Plus SpA; <sup>3</sup>Hydrolab Srl

Nanotechnologies and nanomaterials are the most promising technological frontier in the field of water protection in terms of high efficiency and environmental performance. One of these materials is the "graphene" a quasi-two-dimensional form of carbon atoms arranged reciprocally on the vertices of a regular hexagonal array.

The possibilities of technological applications of graphene are derived from some of its peculiar features such as high specific surface area, exceptional electrical conductivity and electron mobility, which allow us to prospect a high potentiality for use in a wide range of applications.

A particular form of such a material is the "super expanded-graphene" obtained by a patented process able to increase up to three hundred times its volume. Other special features such as hydrophobicity, oleophilicity, high surface area and the presence of macro and meso porosity, create a great attitude to adsorb organic molecules. These properties can be exploited in both air and water treatment.

The contribution will be aimed to demonstrate, in a simple and intuitive way, the performance of graphene for removal of diesel fuel from contaminated water. In the demonstration will be used transparent containers and colored diesel to make visually evident the treatment process.

The activities will be conducted by specialists, having all the necessary equipment, to ensure the absence of any risk to safety and the environment.

## SUSTAINABLE IRRIGATION STRATEGY IN AGRICULTURE

**Dichio B., Montanaro G., Nuzzo V., Laterza D., Mininni A., Amato M., Lovelli S.,  
Perniola M., Xiloyannis C.**

University of Basilicata, DICEM

In arid and semi-arid regions special attention to optimize the management of all components affecting plant water demand and irrigation water supply is required to increase water use efficiency and reduce any possible irrigation-induced environmental impact (e.g. soil salinization, degradation of ground/surface waters).

Currently in most of agricultural land in Southern Italy, due to unsolved issues related to irrigation water (e.g. price, storage and reserves, competition with urban/industrial sectors, restricted use of non-conventional water) the supply of irrigation (volumes and schedule) is empirical. This easily creates a misuse of water resources along with increase of environmental costs and sub-optimal food production.

This paper summarizes interventions towards increased water use efficiency able to save water and maximize yield in fruit tree orchards, vegetable and herbaceous crops.

For example, in early ripening fruit tree orchards application of post-harvest deficit irrigation contributed to save approx.  $1,500 \text{ m}^3 \text{ ha}^{-1}$  irrigation water without affecting yield and fruit quality. Increasing soil organic carbon (mainly through cover crops, compost addition, no-tillage) is beneficial to soil infiltration rate and in turn for higher soil water holding capacity which may be increased up to  $1,000 \text{ m}^3 \text{ ha}^{-1}$  per year (2 m soil depth). In orchards, due to topography of root systems, a proper calculation of daily soil water budget which include water dynamics at deeper soil layers (e.g. 80-90 cm) could support optimal irrigation schedule. Examples on the effectiveness of summer pruning to reduce transpiration of canopy and in turn irrigation water supply in orchards are discussed.

Irrigation strategies based on different degrees of deficit irrigation were compared on the basis of a simulation model to assess irrigation requirements and yield impacts on herbaceous crops in a Mediterranean area. Multi-year weather data were obtained on a daily basis and scenarios were developed for climatic demand conditions representing dry average and wet years. A deficit irrigation strategy corresponding to a replenishment of 65% of the available water allowed to save 13 to 40 % of water with yield reductions of 5 to 13%.

## **PRECISION IRRIGATION: SOIL-BASED APPROACHES AND TECHNOLOGICAL INNOVATION**

**Amato M.<sup>1</sup>, Rossi R.<sup>2</sup>, Bitella G.<sup>1</sup>, Montanaro L.<sup>3</sup>, Dichio B.<sup>3</sup>, Xiloyannis C.<sup>3</sup>, Perniola M.<sup>1</sup>**

<sup>1</sup>Università degli Studi della Basilicata, Scuola di Scienze Agrarie, Forestali, Alimentari ed Ambientali; <sup>2</sup>Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria CREA-ZOE: Unità di ricerca per la zootecnia estensiva; <sup>3</sup>Dipartimento delle culture europee e del Mediterraneo, Università degli Studi della Basilicata.

Precision irrigation has historically covered a range of approaches from the site-specific supply of water according to soil spatial variability to the determination of optimal amounts of water to be applied uniformly over a whole field. It has been shown to be capable of improving water and soil conservation and productivity. In spite of precision irrigation devices being available, the lack of effective decision support systems and the need for correct identification of uniform management zones specific for irrigation purposes still hamper its diffusion.

This work addresses the contribution of technology for soil-based approaches in precision agriculture, based on a perennial forage and fruit tree orchards field case-studies. The use of on-the-go proximal sensing techniques for defining management zones based on soil variability in combination with yield and terrain attributes will be discussed, as well as the role of low-cost technology for monitoring the water status of soil and plants.

## **IRRIMET: AN INNOVATIVE AN INNOVATIVE ADVISORY SERVICE FOR IRRIGATION WATER MANAGEMENT**

**Pelosi A., De Michele C., Villani P., D'Urso G., Medina H., Chirico G.B.**

University of Salerno, C.U.G.RI., Fisciano, Salerno

The EU Common Agricultural Policy, combined with the Water Framework Directive, imposes to farmers and irrigation managers a substantial increase of the efficiency in the use of water in agriculture for the next decade. Among the interventions aimed at this scope, irrigating according to reliable crop water requirement estimates is one of the most convincing solution to decrease water and energy consumption.

Here we present an innovative advanced irrigation advisory service able to predict reliable crop water requirement estimates to be used by both water irrigation managers and farmers for an efficient irrigation scheduling. The service is centered on a stochastic ensemble-based model, which combines ensemble weather forecasts and ensemble crop growth models with data from ground-based automatic weather stations and remote sensing technologies, i.e. VIS-NIR high-resolution multispectral satellite images able to monitor crop growth in real time.

The numerical weather model outputs are those from the European limited area ensemble prediction system, i.e. COSMO-LEPS, which provides daily probabilistic forecasts up to five days with a spatial resolution of seven kilometers. The crop growth model is based on a set of simplified analytical relations, with the aim to assess the biomass and LAI growth with a daily time step. Within the crop growth model, the net primary production (NPP) is modelled according to a light-use efficiency approach and the LAI dynamics is let be governed by temperature and leaf dry matter supply, driven by the development stage of the crop. The assimilation of observed data into weather and crop growth models is then performed by sequential Bayesian techniques.

The advisory service is broadcasted with a simple and intuitive web interface which makes real time irrigation maps and customized weather forecasts accessible from desktop computers, tablets and smartphones.

# **PROMOTING WATER EFFICIENCY AND SUPPORTING THE SHIFT TOWARDS A CLIMATE RESILIENT AGRICULTURE: THE AGROCLIMAWATER LIFE14 PROJECT**

**Xiloyannis C., Montanaro G., Dichio B.**

University of Basilicata, DICEM

The LIFE AgroClimaWater project's main objective is to prepare the agricultural sector to adapt to climate change through the introduction of Water Management Adaptation Strategies (WMAS) in Farmers' Organizations (FORs). More in particular, the proposed project aims to provide farmers in two areas in Crete, Greece and in one area in Basilicata, Italy with a methodology to adapt their orchards (olives, citrus and peaches) and operation in order to ensure the highest possible productivity under minimal or erratic water availability induced by the imminent climate change. This is also expected to help secure the future food supplies and to stabilize and maintain the farmers' income, irrespective of the prevailing weather conditions. Equally significant project's objectives are to save water for the ecosystems function and inform competitive users for the impact of climate change on their economic activities. While, adaptation to climate change often involves new equipment installation and/ or infrastructure investment, the idea here is to provide farmers and FORs with low cost management practices that can be easily adopted and have been proven to increase water efficiency. The project is multi-objective and through the project's actions the project team intends to:

1. establish a WMAS on the FORs' level
  2. determine agricultural practices that increase water efficiency in cultivation of perennial crops
  3. prepare the pilot farms adapt to climate change
  4. build adaptive capacity and promote knowledge transfer to farmers and FORs
  5. achieve a baseline for climate change awareness in the pilot sub-basins
  6. provide a WMAS to be implemented by farmers and FORs in the target areas and areas facing similar climate challenges for the after LIFE period
  7. incorporate project's results in the national environmental, climate change and agricultural policy and legislation, in anticipation of the regulation of water and agriculture.
- Given that adaptation to climate change is in fact of intersectoral significance, another important objective is to trigger public consultation for the development of regional adaptation strategies. Starting from investing on the success of small scale demonstration orchards, the project intends to attract the interest of larger and larger groups of stakeholders, to achieve the scale needed for adaptation efforts that make real sense, i.e. river basin.

## **WATER FOOTPRINT IN AGRICULTURAL SECTOR: CASE OF STUDY**

**Carlucci G., Lardo E., Cerbino D., Scalcione E., Laterza D., Montanaro G., Xiloyannis C., Dichio B.**

Agreenment srl, Matera

Water is a key natural resource that is becoming increasingly scarce and expensive, so its use should be optimized, especially in agricultural sector that share  $\approx 70\%$  of total water consumption. These conditions force to use the resource more efficiently in agricultural production processes through adoption indicators to help optimal use of resources. This is the case of the water footprint (WF) an internationally recognized indicator of the amount of water consumed within the producing process. In addition, WF may support new marketing strategies of horticultural industry to reach increasing environmental friendly consumers.

The work reports the WF determination of some crops (bean, eggplant and pepper) cultivated in Basilicata Region (Southern Italy). The WF indicator was calculated according to ISO 14046 considering the input and output items at field, warehouse, packing and distribution stages. The study considered the major impacts such as the scarcity (expressed in terms of m<sup>3</sup> equivalent), acidification (kg SO<sub>2</sub> eq.), eutrophication (kg P eq.) and ecotoxicity (CTU eq.). Specific actions to improve the efficiency of water use (i.e. reduced WF), are presented.

## **ESTIMATION OF THE ROOT-ZONE SOIL MOISTURE USING PASSIVE MICROWAVE REMOTE SENSING AND SMAR MODEL**

**Faridani F., Farid A., Ansari H., Manfreda S.**

University of Basilicata, DICEM

Root-zone soil moisture in the regional scale has always been a missing element of the hydrological cycle. Knowing its value could be a great help for estimating evapotranspiration, erosion, runoff, permeability, Irrigation need etc. The recently developed Soil Moisture Analytical Relationship (SMAR) can relate the surface soil moisture to the moisture of deeper layer using a physical balance equation. In recent years, development of satellite technologies has provided the opportunity to have an estimation of parameters with temporal and spatial variability. A number of satellites (SSM/I, AMSR-E, TRMM/TMI and SMMR) succeeded in retrieving surface soil moisture using passive microwave remote sensing. Thus, assimilating surface soil moisture satellite data into SMAR seems very promising in estimation of root-zone moisture in the regional or watershed scales. SMAR proved to effectively estimate the root zone soil moisture in the previous studies, yet there is still room for some modifications regarding this topic. For example, the soil water loss function (i.e. deep percolation and evapotranspiration) assumed to be linear in SMAR model. In this regard, the soil moisture profile data from two research sites (AMMA and SCAN) were investigated. The results showed that after a rainfall, soil water losses decrease exponentially until they reach a minimum steady state and knowing this will help to modify SMAR equation.

## **TWO DIETS WITH DIFFERENT WATER CONSUMPTION FOR MILK AND BEEF PRODUCTION**

**Cosentino C., Adduci F., Labella C., Musto M., Paolino R., Freschi P.**

University of Basilicata, SAFE

The water footprint measures the amount of water used to produce each of the goods and services in use. The consumption of animal products contributes to more than one-quarter of the water footprint of humanity. The agriculture account is 92% of the global freshwater footprint whose the 29% is employed in animal husbandry to produce forage, to mix animal feed, to water animals and in the farm activities. In this study, we tested two diets with different water consumption but with the same energy and protein content. Dairy cows and beef calves were divided into two groups to compare the two different diets: standard feeding, with corn silage-based diet; and alternative feeding, with triticale silage-based diet. Despite the lowest water consumption of the triticale silage group, no significant differences were observed between the two groups in terms of production level and chemical composition of milk for dairy cows and in terms of production level (weight gain), feed conversion efficiency for beef calves.

## **SAFEGUARD AND MANAGEMENT OF LARGE DAMS**

**Arcieri M.**

Comitato Nazionale Italiano ICID (ITAL-ICID), Ministero delle Politiche Agricole, Alimentari e Forestali, Roma, Italy.

Dams are fundamental for water resources management in order to create large reservoirs and guarantee adequate supply to crop irrigation, especially in Mediterranean environments. Their safeguard and proper utilization, thus, represent a key issue nowadays. Stability of the structure, sediments' accumulation and other environmental consequences linked to their operational status, such as coastal erosion for example, are only some of the major concerns that affect reservoirs exploitation.

Nevertheless, the risk connected to the utilization of these large infrastructures today can be reduced by means of innovative technologies such as the optic fiber, which can be of great help in the process of constant and effective monitoring, thus enhancing the correct time of intervention in case of critical situations that might be likely to occur. More over, a proper program of operational maintenance and management will result in a longer and safer life span for the structure. A final consideration, which is obviously to be taken into account as last, but definitely not the least, regards environmental protection of the basin and of its slopes. Many of the problems that today affect dams management such as silting of the reservoir, as a matter of fact, can be prevented and/or reduced by adopting sound forest and soil management techniques aimed at the prevention of soil erosion phenomena, which is one of the major causes for sediments' accumulation.

## **AGRONOMIC MANAGEMENT AND SOIL EROSION**

**De Franchi A.S. ,Giuseppe Landi, Enrica De Falco,Piergiorgio Gherbin, Anna Rita Rivelli, Susanna De Maria, Francesco Basso**

University of Basilicata, DICEM

Defence of soil against erosion plays an important role in the safeguard of the environment for stability of sloping agriculture land and because the erosion processes directly contribute to the degradation of soil and environment. Many areas of Southern Italy, characterized by variable soil textures and rainfall concentrated in the autumn-winter period, with also intense or prolonged precipitation events, are markedly affected by soil erosion and slope instability. This framework, in addition to favour the historical susceptibility of soils to erosion, highlights as the management of the agricultural areas, forest lands and infrastructures, influence and control the erosion processes. Therefore, the issue of soil erosion involves aspects of territorial and environmental planning against hydrogeological instability, in which soil surface erosion constitutes a prodromal stage. Researcher of the University of Basilicata for more 30 years conducting several studies in the hilly environments (Guardia Perticara, PZ, 545-720 a.s.l., 750 mm annual rainfall, 16% slope) on water erosion of agricultural slope land evaluating several agronomic practices: contour farming (contour ploughing, cross ploughing and maximum contour lines), soil tillage (no and minimum tillage, ploughing and deeper loosening), evaluation of different cropping system including multiple cropping (cereal-legume, cereal-forage), selection of species and crops (cereal, legume and forage). Soil erosion evaluated throughout a long period of time, in occurrence to extreme rainfall events, exceeded values of  $15 \text{ t ha}^{-1} \text{ year}^{-1}$ . Differences of eroded soil were found between the different crops (2 and  $4 \text{ t ha}^{-1} \text{ year}^{-1}$  with cereal and pulses, respectively). Among the tillage systems, the surface runoff was higher in no-tillage, followed by minimum tillage and ploughing. Soil losses was correlated to surface runoff, even if the runoff turbidity ( $\text{g of dry soil l}^{-1}$ ) was higher always with conventional tillage.

**ABSTRACTS**

**POSTERS**

## **LC-MS-MS - RAPID AND SENSITIVE METHOD FOR DISSOLVED AND INTRACELLULAR ALGAL TOXINS ANALYSIS IN THE WATER OF THE PERTUSILLO LAKE (BASILICATA)**

**Accoto G., Acito E., Palma A.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

The algal bloom due to cyanobacteria such as *Microcystins*, *Anabaena*, and *Planktothrix*, may cause serious environmental problems. Cyanobacteria, also called blue-green algae, can produce a wide spectra of toxins that can have effects on human health and/or on aquatic living organisms.

Blue-green algae is a phenomenon that generally depends on the temperature range, they grow in lakes, ponds, and slow-moving streams when the water is enriched with nutrients like phosphorus or nitrogen. Many different species of blue-green algae occur in water, but the most commonly detected include *Anabaena* sp., *Aphanizomenon* sp., *Microcystins* sp., and *Planktothrix* sp. It is not always the same species that blooms in a given waterbody, and the dominant species present can change over the course of the season. Therefore, it is necessary to have analytical techniques to detect compounds structurally very different from each other.

The aim of this work was to monitor the presence of some comune microcystins like: MC-RR, MC-LR, MC-LA, MC-YR, MC-LW, MC-LF), Nodularin and Anatoxin A in the lake of Pertusillo during the summer of 2014. WHO has set a threshold value for human health for Microcystin extracellular at 1 µg/l as a concentration limit for drinking water.

Toxins were detected with high performance liquid chromatography (HPLC) coupled with LC-MS-MS/ion trap. SPE-on line pre-concentrated method was used for improving analytical sensibility.. The analytical method was validated with commercially available standards and robustness was verified using classical SPE off-line method. The LOQ of this method was 0.01 ug/l for each compound. The Microcystin extracellular concentration in the lake of Pertusillo was never above the LOQ concentration.

## **LC-MS/MS AND GC/MS/MS METHOD FOR SCREENING OF 170 PESTICIDES AT PPT LEVEL IN SURFACE WATERS**

**Accoto G., Acito E., Bochicchio D., Nola V., Loizzo N., Palma A.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

The environmental impact of organic pollutants in aquatic environment has greater importance today's than ever before. One consequence of the widespread use of pesticides in agricultural practice is that residue of these products contaminate ground and/or surface water. Today, many sources of water are contaminated with pesticides and are also used for preparation of drinking water. Our laboratory has developed a rapid, sensitive and robust analytical procedure for determination of pesticides contamination in environmental and drinking water samples. The method was developed for the screening and quantitation of 170 pesticides including the most widely used substances in agriculture practices. Mainly herbicides, as the classical triazine and their main transformation products, as well as fungicides and insecticides are taken in account.

This analytical method was applied to investigate the presence of pesticides in the artificial lake named Pietra del Pertusillo during the years 2013-2014.

## **NOVEL APPROACH TO THE ANALYSIS OF HYDROCARBONS IN ENVIRONMENTAL MATRICES**

**Anzilotta G., Nola V., Baldassarre P., Pipino A., Loizzo N., Palma A.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

The class of hydrocarbons comprises a large number of substances (paraffins, olefins, alkylbenzenes, polycondensates alkylated hydrocarbons, sulfur compounds, etc.) differ in chemical composition, reactivity, structure and thermodynamic properties. All of them are found in nature as a mixture (crude oil) and remain so even after treatment processes that give the gasoline, diesel, mineral oil, tar, etc. For this feature, the methods of measurement of hydrocarbons are constructed for the determination of the amount of total hydrocarbons present rather than the individual compounds. The method developed has the important novelty for the analysis of hydrocarbons of using the triple quadrupole mass spectrometer as a detector instead of the FID. This choice allows analysis more sensitive due to better signal / noise ratio of chromatographic peaks and reduces the possibility of errors in the identification of substances even with respect to a classic single quadrupole.

# **EXPLOITATION AND MANAGEMENT OF WATER RESOURCES IN THE SUBURB OF VITERBO. A MEDIEVAL AND EARLY MODERN COUNTRY HOUSE (CASALE) IN PONTE DELL'ELCE**

**Biscione M., Gaspari F., Masini N., Romagnoli G.**

University of Tuscia, Disbec, Viterbo

The research project on the architectural complex in Ponte dell'Elce near Viterbo started in 2014 thanks to the collaboration between DISBEC (Dipartimento di Scienze dei Beni Culturali, University of Tuscia) and IBAM-CNR (Institute for Archaeological and Monumental Heritage, National Research Council). The aim of this paper is to identify, through the field-survey and the analysis of stratigraphy of buildings, integrated by a systematic analysis of documentary sources, the main stages of an important country house and its topographic context between Middle Ages and early Modern period, focusing on exploitation of water resources. Water was a basic resource for the agriculture, the animal farming and the industrial activities (especially watermills) placed around Viterbo, but also a distinguishing feature of many country residences built in the suburb. The original nucleus of the building in Ponte dell'Elce dates back to late Middle Ages, but it was reshaped during the 16th century. In this period, the country house (casale) was renewed and included into a larger context: the surrounding area was used as hunting reserve (barco) or as a garden but, in any case, it was dedicated to the leisure and relaxation of the owner and his guests. For this purpose, it was embellished with monumental fountains (at least three) working thanks to a complex system of channels and aqueducts. Some sculptures related to the myth of Hercules and Hesione, carved in huge tuff boulders, can be compared to the well-known examples of Villa Lante (Bagnaia), Soriano (Fonte Papacqua), Caprarola (Palazzo Farnese) and Bomarzo (the Sacro Bosco), architectural and artistic masterpieces that supply first elements to understand and explain the ornamental project of Ponte dell'Elce site. In the following stages, it will be developed a multidisciplinary methodology of the suburban landscape study, focusing on diagnostic techniques application, for the good conservation of similar sites.

## **DETERMINATION OF ORGANOCHLORINE PESTICIDES IN AGRÌ'S RIVER SEDIMENTS**

**Bochicchio D., Accoto G., Nola V., Loizzo N., Palma A.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

Organochlorine pesticides are the most persistent organic contaminants in the environment. An example is the DDT, an organochlorine pesticide banned since '70 that today it's still present in river's sediments

DDT is an highly persistent and hydrophobic pesticide that tends to be detected more frequently in sediments than surface waters. Measuring this pesticide in sediment is important for tracking the fate in the environment and evaluating for potential toxicity. Furthermore, many biological species can digest it and to convert in its degradation product: DDE.

Sediment samples are extracted by using a microwaves system and the compounds of interest are separated from co-extracted matrix interferences by passing the extracts through gel-permeation chromatography (GPC). Chromatographic separation, detection, and quantification of the pesticides from the sediment sample extracts are done by using gas chromatography coupled to tandem mass spectrometry (GC/MS/MS).

The aim of this work is to show the presence of DDT and its degradation products in Agri's river sediments.

## **WATER AND NAME PLACES. A TWO-FOLD LENS BY WHICH RE-EXPLORE THE LANDSCAPE OF RAVINES IN BASILICATA AND PUGLIA**

**Colonna A., Dell'Aglio M.**

University of Basilicata, DICEM

Water is an essential element in any territory, and can be read as a sign or matrix of the form of its habitat.

Ideally, for geographical tidiness, there should be a precise relation between territory and people. Starting from name places we have tried to map the pre-contemporary territory formation, the local natural and anthropic characteristics tied to the use of the water resource. The analysis of the territory via toponyms is effective because each toponym brings with it a trace of the characteristics, qualities, relations between different characteristics (humidity of the soil, the dimensions of the farm) from which one can color a small piece of the territory. Furthermore, place names may endure longer than the conditions which originally stimulated them. For this reasons, in spite of the almost complete disappearance of a "surface hydrography", we still have name showing the existence of ravines, "lame", pools, lakes, fountains, torrents, marshes. Usually, the toponim recalls a priority of quality such as the presence of water, the conditions of use, the morphology of the river, and many others related to the place. That is, streams of relationships between elementary elements which in this place come together, and define the specific and punctual qualities. To give just an example, throughout the territory we find name places which recall the presence of "lame", showing an ancient orographic formation and the abundant flowing of surface waters. The slow process of anthropic settlement in the physical environment produced a widespread filling of the LAME, which then became swaths of very fertile soil in the landscape, for the most part destined to the cultivation of trees. The toponyms, in each case, favor relationships in which either prevail the reference to natural phenomena (water, geological, morphological, etc.), or that to anthropic processes (use of resources, genius loci, the creation of infrastructures, etc).

## **ASSESSMENT OF ECOLOGY AND COMPOSITION OF BENTHIC DIATOMS OF THE NOCE RIVER**

**Casamassima M., Longo S., Marraudino A., Festa G., Palma A., Trabace T.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

The aim of this study was to examine the composition of the community and the ecology of benthic diatoms of the Noce River: benthic diatom samples were collected from six sampling sites during the period September 2014 – July 2015.

Diatoms are microscopic unicellular algae of the family *Bacillariophyceae* (Division *Bacillariophyta*) that occur mostly as single cells but some species form colonies.

They are frequently used as bio-indicators; diatoms have assumed a key role in the evaluation of water quality , showing many of the characteristics of biological indicators, such as the ubiquity , the presence of a large number of species with ecological features well-differentiated , the ease of sampling .

# **VULNERABILITY TO DESERTIFICATION IN MEDITERRANEAN DRY LANDS: THE CASE OF BASILICATA REGION**

**Coluzzi R.<sup>1</sup>, Ianfredi M.<sup>1</sup>, Coppola R.<sup>1</sup>, Simonello T.<sup>1</sup>, D'Emilio M.<sup>1</sup>, Imbrenda V.<sup>1</sup>,  
Macchiato M.<sup>2</sup>**

<sup>1</sup>IMAA-CNR (Institute of Methodologies for Environmental Analysis-Italian National Research Council), Tito Scalo (PZ), Italy; <sup>2</sup>Department of Physics, University of Naples Federico II, Monte Sant'Angelo, Naples, Italy.

Desertification is land degradation in drylands, resulting from various factors including climatic variations and human activities. In fragile areas where drylands are widespread and the anthropogenic impact is currently increasing, as occurs in the Mediterranean basin, drought and intense warm periods can imply the long-term imbalance between available water resources and demands. Water scarcity can exacerbate vulnerability to desertification through direct impacts on soil moisture levels, soil quality, soil structure and organic matter content thereby accelerating the loss of vegetation cover. Because of the inherent bio-geographic complexity of the Mediterranean drylands considerable information from diverse disciplines must be collated in order to assess vulnerability and to single out emerging degradation. Numerous case studies showed that new technologies such as satellite observations represent a valuable source to provide useful information for land degradation assessments, especially over large regions and long-term periods. Here, we present some interesting results obtained by applying a methodology based on simple mathematical-statistical tools, which showed to be able to single out critical areas (hotspots) showing clear signs of incoming degradation. We used NDVI maps from Landsat sensors and interpolated air temperature to detect stressed/sparse vegetation cover in atypically warm areas where reduced primary production could be a consequence/cause of complex interactions between stressed land cover and local climate. Rainfall data and aridity maps confirmed the high vulnerability of particularly dry areas in Basilicata region (Southern Italy), which is a good paradigm of Mediterranean drylands. Altogether, these results suggest the need of an additional effort to develop effective strategies and innovative technological solutions to improve the capacity of the affected population in coping with the projected increase of drought and warming.

**RAINWATER HARVESTING FOR REDUCING POTABLE WATER CONSUMPTION IN  
SUSTAINABLE GARDENING OR WC FLUSHING: STUDY ON STABILITY FOR LONG TERM  
STORAGE WATER.**

**Di Gennaro S., Corrado A., Di Crisci C., Fortunato M., Palma A.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

Pollution and scarcity of water resources would be the major emerging issues in the next century, however the method of rain water harvesting has been into practice since ancient times in Matera and in the southern Italy. After dimensional assessment a pilot cistern of 10,000 liters was installed below ground in a residential building of Pisticci (Matera district). Nutrients, metals and contaminants were investigated during storage.

## **GROUNDWATER COLLECTION WORKS IN CLAYEY SLOPES IN BRADANIC FOREDEEP**

**Doglioni A., Graziadei A., Simeone V.**

Technical University of Bari, Bari

On the clayey slope on the right side of Basento river in the campaigns of Ferrandina town in Bradadanc foredeep area are present really large blocks of sands and conglomerates. Their presence in the clayey masses of the slope is due to fall and spreading phenomena of regressive permeable sandy and conglomerates deposits of the upper part of the hill. Rainfall supply made it possible to create a groundwater resources hosted in this permeable masses. The groundwater was exploited by mean of groundwater collection works. Long passable hydraulic tunnel to collect water was built up and still today are used for irrigation purpose. These secondary groundwater resources may play an important role for irrigation of aids in semi-arid climate as that of the Bradanic foredeep. This tunnels that today are used to collect water and has really interesting constructive characters and peculiarity.

## **WATER IN MEDIOLANUM**

### **Frontori I.**

University of Study of Milano, Dept. of Environment and Cultural heritage , Milano

As is widely known, in the early 1900s the city of Milan looked very different than today because of its close relations with water: it had a dense network of canals and natural groundwater springs. The origin of this intricate system dates back to the process of Romanization and the beginnings of planned urban development. Since 49 BC, when Mediolanum's "municipium" was established, the need for new strategies for water supply and defense led to the diversion of some rivers, with the aim of creating a self-sufficient internal water course-network.

The urban stratification of Mediolanum from the Middle Ages to the present day has obscured most of the evidence of this system; however, combining certain archaeological evidence with the study of historical and cartographic sources could lead to a real understanding of the city's hydrographic system. Over the last thirty years, archaeological digs have uncovered the remains of a number of drainage facilities, channels and pipes throughout the city; furthermore, the discovery of some parts of the defensive moat have stimulated a debate about the aspect of the townscape during the Roman period.

In Milan as in other cities of Regio XI Transpadana, Roman urban planning provided for an extensive water regimentation project to sustain public supplies, the transport of goods by inland waterways, and waste-water management. In accordance with this, in the second half of the 1st century BC the River Seveso was diverted near Via Cusani; its water was channeled to the east and west into the defensive moat that ran outside the city wall, to reunite in the western suburban area and flow out into the southern waterways. Recent archaeological investigations by Soprintendenza Archeologia della Lombardia give support to this picture, revealing several evidence relating to this hydrographic system.

## **NEAR SURFACE GEOPHYSICAL TECHNIQUES ON GROUNDWATER AND SUBSOIL CONTAMINATION: LABORATORY EXPERIMENTS**

**Giamapolo V., Capozzoli L., Rizzo E., Lapenna V.**

CNR-IMAA, Tito, PZ

Since hydrocarbons contamination has become a serious environmental problem, because of the increasing number of accidental spills caused by human activities, we focus our attention to the study of hydrocarbon contaminated site by using indirect investigation techniques. The characterization of flow dynamics in vadose and saturated zone is of key importance to assess groundwater contamination processes. Boreholes, the traditional method for accessing the subsurface, are of limited use for aquifer characterization. As a consequence, non-conventional techniques are gaining popularity. Among these, a key role is played by geophysical methods since they provide information on the characteristics of the subsurface spatial structure as well as on the fluid presence and motion. The most commonly applied techniques are: ground penetrating radar (GPR) and electrical resistivity tomography (ERT), both in surface and borehole applications. The key feature of the geophysical approach is the non-invasiveness and repeatability of the methods with a high sampling density and different resolution. This is particularly true if geophysical imaging methods are applied in an automated, time-lapse manner, using modern data acquisition systems and processing techniques. In order to demonstrate the capability of geophysical techniques for mapping changes in contamination distributions with time in a physical system, a 3D controlled laboratory experiment was performed. Different contamination experiments (LNAPL injections and salt tracer intrusion), occurred in porous media monitored by time-lapse ERTs and GPR prospecting methods, in the Hydrogeosite Laboratory of IMAA-CNR (Marsico Nuovo, Italy).

The experiment goals were to identify preferential fluid flow pathways and concentrations space variability and define a physical conceptual model of the investigated medium. The laboratory experiments demonstrate the applicability of this new method and a modeling allows us to reproduce and validate time-space concentration distribution. We conclude that the numerical and real field studies presented here suggest that incorporation of geophysical data with limited hydrological data may provide valuable information about permeability estimates and their spatial correlation structure that is traditionally only obtainable by performing extensive and intrusive hydrological sampling.

## **OUR GRANDSONS WILL CALL US VANDALS". THE CULTURAL SEVERANCE IN MEDITERRANEAN FISHING (1750CA.-1850CA.)**

**Giordano A.**

University of Napoli Federico II, Dept of Human science, Napoli

Starting from the meaning of Cultural Landscape, this paper aims to extend this definition over the sea, particularly to its portions traditionally exploited by fishermen. There has been many self-regulated fishing communities on the coastal settlements all over the world, and somewhere they still are; but the Mediterranean communities, because of the closeness of this sea, have usually needed stricter rules than elsewhere. This essay focuses on the «cultural severance»\* occurred in Mediterranean fishing during the century between 1750 ca. and 1850 ca. and it particularly analyzes the Apulian fishing at that time, when the pair-trawlers – on their boats called paranze – suddenly appeared and took the traditional fishermen's place as fish providers on the public markets. Where did they come from? Why didn't they respect the traditional fishing rules? Were they fishermen? Through an investigation among archival documents, historical records and previous works about connected topics, I try to underline all the clues which could lead to argue that these trawlers hadn't ever been fishermen, but just sailors and traders. Even if our data are still too few to be sure, my hypothesis is that this new technique – and then its heirs until today– has become the most practiced for reasons totally stranger to fishing efficiency, such as the fish brokers' monopolistic power – which used to make them able to control the fish price – and the poor fishermen's financial dependence on them. But are these fishing techniques sustainable? We'll use also the traditional fishermen's voice – from complaint letters to the king of Naples – to analyze that critical century in which marin «'Eco-Cultural' [landscapes], often managed in traditional ways for millennia»\*, started disappearing

## **ASSESSMENT OF EFLOWS IN THE IMPLEMENTATION OF WFD ON LUCANIAN RIVERS**

**Greco M., Anatrone A., Gravino S.**

University of Basilicata, SI, Potenza

According to the WFD, the ecological flow (Eflow) is assumed to be the hydrological regime consistent with the achievement of the environmental objectives of “good quality status” in natural surface water bodies. As well known, the hydrological regime of natural flow plays a primary and crucial role influencing the physical conditions of habitats, which in turn determines the biotic composition and sustainability of aquatic ecosystems. Furthermore, the simple assumption to supply a minimum instream during dry periods is not enough anymore in order to protect the river environment. The recent hydro-ecological knowledge provides that all flow components must be included as operational targets for water quantitative management from base flows (including low flows) to high and flood regimes in terms of magnitude, frequency, duration, timing and rate of change. Several conceptual and numerical codes have been developed and applied on different case studies in order to define common tools to be implemented for the Eflow assessment. In such a frame, the work deals with the application of the Indicators of Hydrologic Alteration methodology (IHA by TNC) to main Lucanian rivers to assess the ecological flow to be assumed in each monitoring cross section. The analyses have been carried on monthly discharge data derived through a simple rainfall-runoff applied at the basin scale and based on the precipitation measurements obtained by the regional rainfall gauge stations.

## **THE IMPACT OF UPDATED CLIMATIC DATA ON THE GRADATION PATTERNS DERIVED FROM ESA MODEL**

**Imbrenda V.<sup>1</sup>, D'Emilio M.<sup>1</sup>, Lanfrediu M.<sup>1</sup>, Coluzzi R.<sup>1</sup>, Ragosta M.<sup>2</sup>, Simonello T.<sup>1</sup>**

<sup>1</sup>IMAA-CNR (Institute of Methodologies for Environmental Analysis-Italian National Research Council), Tito Scalo (PZ), Italy; <sup>2</sup>School of Engineering (SI-UniBas), University of Basilicata, Potenza, Italy

Among phenomena limiting the availability of natural resources on the Earth, a major role is played by land degradation, i.e., the reduction in the capacity of the land to provide ecosystem goods and services and to assure its functions (Nachtergaele et al., 2010). Different methodologies have been developed to study land degradation including the use of indicators considered suitable tools for synthesizing information on complex processes. The well-established ESA (Environmentally Sensitive Areas, Kosmas et al., 1999) model is the most popular indicator-based method that provides an evaluation of land degradation vulnerability (ESAI index) derived from the combination of indices (layers) accounting for climate, soil, vegetation, and management components. We tested this procedure on Southern Italy by introducing one of the most recent data on global aridity (Trabucco and Zomer, 2009). The resulting map shows degradation patterns similar to those previously obtained but significant increases of vulnerability values are observed in some areas denoting a stronger occurrence ( $\approx +10\%$ ) of highly vulnerable sites. Moreover, by using the Main Contributing Factor technique we are able to identify at pixel level the predominant factor driving degradation to recommend specific measures for the mitigation/prevention of degradation processes. Restricting this analysis to the most vulnerable areas, we recognized that the climate component is the main factor of degradation in about 8% of these areas, mostly devoted to agriculture, confirming the increasing impact of the dryness trend predicted by global and regional climate simulations for the Mediterranean Basin (e.g., Fischer and Schär, 2010). The further expected growth of these trends in the future involving areas currently not threatened by degradation phenomena suggests the undelayable need to promote coordinated action based on efficient and sustainable practices, especially those related to water management.

## **THE HUMAN RIGHT TO WATER AND SANITATION**

**Losasso R.**

University of Rome, La Sapienza, International Law, Roma

Approximately 768 million people lack access to improved water sources and more than 2.6 billion people do not have access to improved sanitation as defined by the World Health Organisation and the United Nations Children's Fund in their 2013 Joint Monitoring Programme Report. Moreover, every year, approximately 1.5 million children under 5 years of age die and 443 million school days are lost as a result of water and sanitation related diseases.

On July 28, 2010, the UN General Assembly adopted a non-binding resolution declaring "the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights" and on September 24, 2010, the UN Human Right Council affirmed by consensus, for the first time, the existence of a legally binding human right to water and sanitation. The human right to water entitles everyone access to water that is necessary for personal and domestic uses, by focusing on key substantive component of availability, quality, acceptability, accessibility and affordability. The water supply for each person must be sufficient and continuous to cover personal and domestic uses, which comprise water for drinking, washing clothes, food preparation and personal and household hygiene. Water for personal and domestic uses must be safe and acceptable. It must be free from elements that constitute a threat to a person's health. Water must also be of an acceptable colour, odour and taste to ensure that individuals will not rely on polluted alternatives. Water and sanitation facilities must be physically accessible and within safe reaching places for all sections of the population, taking into account the needs of particular groups including persons with disabilities, women, children and the elderly. Water services must also be affordable to all and no individual or group should be denied access to safe drinking water because they cannot afford to pay.

## **A STOCHASTIC GENERATION OF DAILY PRECIPITATION FOR MEDITERRANEAN AREA**

**Marotta L., Telesca V., Fuggetta P.M.**

School of Engineering, University of Basilicata, Potenza, Italia.

A Weather Generator (WG) produces daily synthetic time series of weather data of unlimited length. Among different WGs, there are those built in a two-step processes, a first-order Markov-chain for occurrence and an exponential distribution for non-zero amounts. Climgen is a widely used as WG that belongs to this kind. But, the main assumption of Climgen is no reliable for the study area (Mediterranean Region) or rather the existence of a linear-relationship between the transitional probabilities and the fraction of wet days per month (with the linear coefficient constant and equal to 0.75). In this work, the capability of a new Daily Precipitation Stochastic Generator (DPSG) based on a multivariate quasi-stationary and weakly depending stochastic process, has been presented. So, the DPSG, that fits climate features including variability in frequency of wet days in a month, has been developed for precipitation generation. The methodology was applied for daily precipitation series (1959-2013) collected at 10 Mediterranean rainfall stations by European Climate Assessment & Dataset project over the Mediterranean Sea. The reconstruction of missing data was carried out by Hidden Markov Model, statistical downscaling technique which relates the occurrence of weather states to local climate according to their synoptic similarity. The quality of all precipitation series was made by Homogeneity Tests ("Test of Runs"). Then, to evaluate the goodness of generated weather data a Validation procedure has been developed. This consists of different graphical analysis evaluating the correspondence of historical and generated data, comparing monthly means and monthly standard deviation of precipitation occurrence. At this moment, the results obtained suggest the capability of the first-order Markov chain in reproducing monthly statistical patterns, particularly, occurrence of wet and dry days, which are required for operational purposes in engineering.

## **APPLICATION OF A BATTERY OF ECOTOXICOLOGICAL TESTS ON THE AGRİ RİVER**

**Marraudino A., Casamassima M., Festa G., Longo S., Palma A., Trabace T.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

In the period between July 2013 and August 2014 on samples of surface water and sediments of the Agri River and its main tributaries it was performed ecotoxicological evaluation in order to assess the sensitivity of the organisms tested on aquatic and sediment matrix.

In surface water samples tested we were highlighted phenomena of bio-stimulation with the application of the test *Vibrio fischeri* and no effect on the test *Daphnia magna*.

In the same stations of investigation, sediment samples have highlighted environmental stress conditions in some stations much with the application of the test *Vibrio fischeri*, as with the application of the phytotoxicity tests with *Lepidium sativum*.

# **ASSESSMENT OF NEW TECHNOLOGY FOR HYDROCARBONS CLEAN UP IN CONTAMINATED WATER: CHARACTERISTICS AND POTENTIALITY OF SUPER-EXPANDED GRAPHENE**

**Masi S.<sup>1</sup>, Greco M.<sup>1</sup>, Pola A.<sup>2</sup>, Giugliano V.<sup>2</sup>, Caniani D.<sup>2</sup>, Lofiego S.<sup>3</sup>**

<sup>1</sup>Engineering School, University of Basilicata (PZ); <sup>2</sup>Directa Plus SpA – Lomazzo (CO);  
<sup>3</sup>Hydrolab-Ferrandina (MT)

Nanotechnologies and nanomaterials are the most promising technological frontier in the field of water protection in terms of high efficiency and environmental performance. One of these materials is the "graphene" a quasi-two-dimensional form of carbon atoms arranged reciprocally on the vertices of a regular hexagonal array.

The possibilities of technological applications of graphene are derived from some of its peculiar features such as high specific surface area, exceptional electrical conductivity and electron mobility, which allow us to prospect a high potentiality for use in a wide range of applications.

A particular form of such a material is the "super expanded-graphene" obtained by a patented process able to increase up to three hundred times its volume. Other special features such as hydrophobicity, oleophilicity, high surface area and the presence of macro and meso porosity, create a great attitude to adsorb organic molecules. These properties can be exploited in both air and water treatment.

The presented work reports the results of several tests conducted in laboratory under different operating conditions and in a reclamation campaign carried on a Romanian basin contaminated by high level of petroleum residues. The most significant results relate to the ability of specific absorption outlining more than 80 units of adsorbed hydrocarbon per unit of graphene employed. In laboratory, the levels of hydrocarbon in water treated with graphene are resulted less than 1 mg/l for initial contamination up to 2000 mg/l depending on the concentration.

## **VULNERABILITY TO POLLUTION EVALUATION AND MAPPING IN SOME LARGE CARBONATE AQUIFERS OF THE MEDITERRANEAN BASIN**

**Parisi S., Pascale S., Sdao F.**

School of Engineering, University of Basilicata, Potenza

Management and protection of groundwater exposed to contamination and to overexploitation in the industrialized world is one of the major issues in modern groundwater resource planning. In the Mediterranean Basin, the occurrence of wide karstic aquifers in limestone rocks allows the accumulation of important amounts of groundwater resources that are often compromised by the wrong use owing to excessive and unplanned withdrawals and to the qualitative degradation processes caused by both point and non-point pollution loads. Due to the geological setting, the karstic aquifers are frequently vulnerable to superficial polluting sources. In the last decades, several methods to evaluate the intrinsic vulnerability of the aquifer system have been developed based on (i) the zonation of homogeneous areas with a similar degree of vulnerability and (ii) the parametric systems separated into a matrix system, a point-count system, a point-count system model and an environmental evaluation system. More recently, for the evaluation of the vulnerability characteristics of the aquifers innovative methods and techniques derived from Artificial Intelligence were also used. This contribution is devoted to the assessment and mapping of the intrinsic vulnerability to pollution for case studies located in the Mediterranean basin and characterized by different densities and overall qualities of basic information. The areas examined are represented by: (1) the carbonate aquifers of the High Basento Valley; (2) the Mount La Spina carbonate aquifer system (Basilicata, southern Italy); (3) the huge and extensively karstic aquifers which constitute the Keritis River basin (north-western Crete, Greece); and (4) the carbonate aquifers located in the central area of the Kerkyra Island (Greece). For all these areas we define conceptual hydrogeological models before applying the more suitable methodological approach to recognize the sectors characterized by the higher degree of pollution risk.

# **THE DISTRIBUTION, BEHAVIOR AND SOURCE OF ARSENIC IN THE VOLCANIC AQUIFER OF THE MT. VULTURE (SOUTHERN ITALY)**

**Paternoster M., Cantalupo M., Dichicco M.C., Panariello S., Rizzo G., Sinisi R., Mongelli G.**

University of Basilicata, Dept. of Science, Potenza

The As occurrence in water, its geochemical mobility and its toxicity when consumed in enhanced doses, make this element one of the most problematic challenges of present water research (National Research Council, 1999). Differently from other toxic species, As pollution in groundwater is mostly natural in origin. The WHO guideline value for As in drinking water was reduced in 1993 from 50 to 10  $\mu\text{g}\cdot\text{l}^{-1}$  and elevated concentrations of arsenic in groundwater have been reported in a wide range of geological environments. However, volcanism and related hydrothermal systems are the potential sources of arsenic in groundwater systems. A geochemical investigation on 40 groundwater samples in the Mt. Vulture volcanic aquifer, one of the most important groundwater resources of the southern Italy, pumped for drinking and irrigation supply, was performed. The present study includes the first data on the abundance, speciation and mobility of As, as well as thermodynamic considerations on water–rock interaction processes in order to evaluate the main geochemical processes that control the As fate in the investigated groundwaters. The results highlight the occurrence of two hydrofacies: bicarbonate alkaline-earth and alkaline water and bicarbonate-sulfate-alkaline water (high-salinity water). Arsenic concentrations in the groundwater range from 1.2 to 66  $\mu\text{g}\cdot\text{l}^{-1}$ , with wide differences between the hydrofacies, and the high-salinity water shows the highest As values. The dissolution of As-bearing sulphides minerals is likely to be the main source of As in these groundwater. In the other water type chemical modeling indicates that groundwater are Fe-oxides and oxyhydroxides saturated, suggesting that the As concentration is controlled by adsorption/desorption processes. Last but not least, some samples have higher values than legal limits for As, likely as a consequence of geogenic contribution.

## **PISA, THE LAGOON CITY: A COMPLEX WATER MANAGEMENT CAUSED BY THE SILTING OF RESERVOIRS AND THE DRAINAGE OF MARSHY LAND**

**Redi F.**

University of Aquila

Pisa is located at the confluence of the two Arno and Auser rivers, which formed a delta and a lagoon bordered to the west by a progressive series of coastal dunes. The hydro-geographical situation encouraged the settlement and the economy of the city that, since the Etruscans, became an important maritime and river sorting port from the Mediterranean towards Florence and Lucca. The two rivers and the ocean currents favoured the formation of the port, but they also marked its slow crisis, with more and more advanced displacements, unto Livorno. The measures attested by written and archaeological sources, which will be discussed in the text widely, were not at all effective, along with the claims of the agricultural reclamation of land and the laborious maintenance works of ditches excavation, embankments and drainage maintenance of the huge deposits caused by silting and floods.

## EVALUATION OF THE SALINITY WATER BY USING CHEMICAL-PHYSICAL ANALYSIS

**Sasso S., Bufo S.A., Scrano L.**

University of Basilicata, Dept. of Science, Potenza

Excess salt content is one of the main problems concerning irrigation water: a high concentration of salts in the water and in the soil negatively affects crop yields and degrade the land. Coast zones should be taken into special consideration because of sea water infiltration, which can increase the risk of water salinity.

In the “Piana del Sele” area (Campania region, Italy) high salt concentrations were found in irrigation water pumped from wells.

The aim of this work was to assess the current quality of irrigation water in the “Piana del Sele” area not too far from Tirrenian sea.

Six samples, four from the wells and two from the irrigation pipes of “Consorzio di Bonifica Destra Sele”, were taken. Water salinity evaluation was determined by chemical-physical analysis based on the electrical conductivity and osmolarity measurements. Using electrical conductivity data, the ionic strength values were calculated as proposed by Polemio et al. (1980). The salinity index used was the ionic strength/osmolarity ratio, since it represents the molar ratio of monovalent ions (as  $\text{Na}^+$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ ) compared to bivalent ions (as  $\text{SO}_4^{2-}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ) present in the water solution.

The choice to proceed through chemical-physical methods avoided the use of more complex procedures such as the determination of the SAR (Sodium Adsorption Ratio) and ESP (Exchangeable Sodium Percentage), which require long, laborious and expensive analytical operations.

Results of water samples collected showed no worrying values of salt contents, with one exception for a well, where a high deviation from the unit of the ionic strength / osmolarity ratio was found. In such a case; it is necessary to avoid the pumping of water from the well in order to prevent the irreversible degradation of crops and soil.

## **IS THE CLIMATIC CHANGE RESPONSABLE OF THE INCREASE OF NON INDIGENOUS SPECIES ALONG SOUTHERN ITALIAN COAST?**

**Telesca V.<sup>1</sup>, Caricato G.<sup>2</sup>**

<sup>1</sup>University of Basilicata, SI, Potenza; <sup>2</sup>ARPAB, Matera

The next Conference of United Nations Climate Change will be held in Paris, from November 30 to December 11 2015. The conference objective is to achieve a legally binding universal agreement on climate, between all the nations because is known that impacts of climatic change on aquatic and marine ecosystems are growing in the world. In this work we studied the effect of climatic change on aquatic and marine ecosystems and fisheries in South Italy, along the area of "Piana di Metaponto", located along the ionian coast. In this area many devastating floods occurred in the last decade. In the same period an increase of the mean atmospheric temperature has been reported compared with values of the previous 40 years. Furthermore, since July 2008 the presence of blue crab (*Callinectes sapidus*) was reported in the Piana of Metaponto in the Agri river mouth. The blue crab is once of the most dangerous alloctonous crustaceous for aquatic fauna, especially in the mugilidae area. Such a specie shows a wide environmental tolerance, it is euryhaline, eurythermal and can tolerate oxygen values lower than 0,08 mg/l: this characteristics confer a high colonization ability to the specie. The blue crab can prey on fish, molluscs and crustaceous, but dead animals and macrophytes can also be part of its diet as well. It can exert a strong effect on the colonized habitats as its alimentary habits can induce great modifications on the environment. The species is also highly prolific as it can produce from 2-8 million eggs per spawn.

This study suggest that the presence of this specie in this area is correlated with the climatic changes due to increase of the mean temperature observed in the last ten years.

This species cause an impact on biodiversity and human activities such as fisheries.

However, further investigations aimed to clarify *Callinectes sapidus* abundance expansion trends and distribution are necessary to improve scientific knowledge on this new invasive species.

## **ASSESSMENT OF THE ECOLOGICAL QUALITY OF THE NOCE RIVER: INDEX BIOLOGICAL IN COMPARISON**

**Trabace, T., Casamassima M., Longo S., Marraudino A., Festa G., Palma A.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

The ecological assessment of water bodies can be achieved through the integration of water quality, morphological, biological and chemicals criteria, as provided for by Directive 2060/CE. The integrated evaluation of the naturalness of the river and the quality status of the river was conducted by comparing indicators of river functionality IFF, macroinvertebrates STAR\_ICMi, diatoms ICMI. This approach allows to identify the effect of the pressures that affect biological elements and the alteration of river habitats and communities associated with it.

## **PRESENCE OF OSTREOPSIS OVATA ALONG THE TYRRHENIAN COAST OF BASILICATA REGION**

**Trabace T., Longo S., Marraudino A., Casamassima M., Festa G., Pipino A., Palma A.**

ARPA BASILICATA - Centro Ricerche di Metaponto, Metaponto (MT)

*Ostreopsis ovata*, potentially toxic is a tropical benthic dinoflagellate species of the *Ostreopsis* genus has colonized waters in temperate zones. When conditions are favorable, in summer months, *Ostreopsis* can proliferate and create massive floating clusters. The toxins are produced by several marine organisms including *Ostreopsis* can accumulate along the food chain. The phenomenon becomes dangerous when contaminated sea spray is inhaled by humans.

In Basilicata was found its presence in the Tyrrhenian coast as early as 2010, 2011 and confirmed in July 2015 in the sampling station of Acquafredda. The number of algal cells found produced no risk to human health.

## LITICS AND WATER: AQUEDUCTS AND BATHS IN THE POLICY OF HADRIAN IN ARGOS

Vitti P.

Architect

It was Homer the first to state that Argos was poor in water. But by the first century CE things had changed. A new set of the water policy of the city was guaranteed by two water conduits, coming from different areas of the mountain side. Water supply to the city was enough as to foster the construction of many bath buildings (15 bath buildings have been discovered) . The paper aims to examine the aqueduct in Argos and highlight the technical and political aspects related to its construction.

The aqueduct was built by Hadrian in occasion of his first visit to Argos, in winter 123-124. Its itinerary from Mavrovouni, northwest of Argos, has been reconstructed in past years. It was nearly 33 km long and crossed many valleys. The remains of the specus and the piers of the Charadros are enough preserved as to show that the construction was done according to the highest standards of Roman building techniques. The remains of the nymphaeum/castellum aquae on the Larisa Hill as well as the statue that was found during the excavation are relevant for the understanding of how this act of evergetism was presented to the citizens of Argos. This construction was built on an artificial platform identified as the kriterion, the local law court, i.e. one of the most significant buildings of the hellenistic period. At the end of the platform, against the hill, in an absolutely panoramic location, Hadrian placed the nymphaeum, a temple-like construction. It is likely that the new building was a landmark both if seen from the city or from the plain. Most significant was the statue of the emperor located in a niche into the nymphaeum, at the very end of a space characterised by water basins, water falls and a rich marble decoration. Hadrian, in heroic nudity, with the winner ribbon around his head, stood where the water was spouting from the rock. He was there, heroic as the most famous heroes of the mythological past recorded in the lyrics of Pindarus.

## **REUSE OF MUNICIPAL WASTEWATER AS ALTERNATIVE SOURCE FOR OLIVE IRRIGATION**

**Xiloyannis C., Palese A.M., Lardo E., Dichio B.**

University of Basilicata, DICEM

Reuse of municipal wastewater as alternative source for olive irrigation. A medium-term experiment was carried out in a mature olive orchard placed in Southern Italy and micro-irrigated with urban wastewater. Wastewater was treated according to low-cost simplified treatment schemes which excluded biological processes for organic matter and nitrogen removal to recover them as fertilizing substances. Annual irrigation volume was on average around  $3500 \text{ m}^{-3} \text{ ha}^{-1}$ . The irrigated olive orchard was managed according to sustainable agricultural techniques based on: a) the recycling of internal carbon sources (pruning material, plant residues coming from a spontaneous ground cover) aimed to increase soil organic matter, to reduce soil erosion; and to improve soil water holding capacity; b) an adequate fertirrigation performed taking into account soil and wastewater chemical analyses and the mineral element balance in the orchard system. Microbiological quality of wastewater, soil and fruits was monitored to evaluate the risk of contamination. Particularly, analyses of total heavy metals and bioavailable fraction were made on samples taken at different soil depths. Yield, merceological features of drupes and olive oil quality were determined. All analysis were carried out also in a rainfed olive orchard managed according to the conventional techniques adopted in the experimental area. An energy, economic and environmental analysis (LCA) was performed and the environmental benefits coming from the application of the sustainable management were examined focusing on  $\text{CO}_2$  stocks in plants and soil, anthropogenic and natural  $\text{CO}_2$  emissions.

