# Protection and Restoration of the Environment XVI

## Book of Abstracts




Kalamata, 5-8 July 2022

Greece

Organized by the Stevens Institute of Technology, USA, and the Department of Civil Engineering of the University of Patras, Greece

## Sponsors

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the Environmental Engineering Laboratory, Department of Civil Engineering, University of Patras

# PREFACE

"Protection and Restoration of the Environment" is a well-known series of international conferences, organized jointly by one American and one Greek University every two years, in Greece. It started in 1992, in Thessaloniki. In 2020, the fifteenth Conference of the series was scheduled to take place in Kalamata, but finally has taken place in Patras without any physical presence of the participants due to the SARS-CoV-2 Pandemic.

The Protection and Restoration of the Environment XVI (PREXVI) conference held at Kalamata at the Elite City Resort during the period of July 5 to 8 2022. It was jointly organized by: a) the Center for Environmental Systems of the Stevens Institute of Technology, USA and b) the Laboratories of the Environmental Engineering and Hydraulic Engineering of the Department of the Civil Engineering of the School of Engineering of the University of Patras, Greece.

The present volume contains the abstracts of the papers presented during the Conference in Kalamata. They have been classified in the following sessions:

- Agricultural practices and environment
- Air quality and contamination control
- Climate change impacts and adaptation measures
- Environmental health  ecotoxicology
- Environmental impact assessment and risk analysis
- Environmental informatics, statistics, law  economics
- Long-term monitoring and ecosystem research
- Natural treatment systems
- Protection and restoration of ecosystems, water governance and conflict resolution for sustainable development
- River  open channel hydraulics
- Smart environmental systems, soft and renewable energy sources
- Solid waste management
- Sustainable architecture, planning and development
- Wastewater treatment and management
- Water resources management and contamination control

The editors would like the to thank the authors of the papers, the invited speakers, the reviewers of the papers for their invaluable assistance, the sponsors of the conference, and all participants for their involvement in the exchange of knowledge and ideas.

The editors

## Acknowledgements

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- The members of the organizing and the scientific committee, for their eager help.
- The reviewers, for ensuring high scientific standards for the presentations.
- The Professors Demetris Koutsoyiannis, Gerasimos Lyberatos, Panos Papanicolaou and Vassilios Tsihrintzis, for their acceptance to be keynote speakers of the Conference.
- The sponsors of the conference for their financial support.
- All conference participants.

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# Contents

# INVITED PAPERS

# Integrated management of municipal wastewater with source collected biowaste

**G. Lyberatos**

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**Abstract**

Historically, the management of municipal solid waste and that of wastewater have evolved as two independent streams, defined by the main phase in each case; solid and liquid, respectively. Of course, liquid effluents contain substantial amounts of solid matter in suspension, while municipal solid wastes, especially food waste, have a very high moisture content (typically 70-80% by weight). An alternative much more sustainable approach, based on the chemical composition, is presented. Source-sorted food waste is dried and shredded, generating a homogeneous, odor-free biomass that may be stored without deterioration for prolonged periods of time and used in alternative ways for the production of biofuels and/or compost. In parallel, the liquid fraction generated from the drying process may be combined with the municipal wastewater stream opening interesting and novel treatment and valorization possibilities



**Prof. Gerasimos Lyberatos** is currently professor in the School of Chemical Engineering, National Technical University of Athens and a collaborating faculty member of the Institute of Chemical Engineering and High Temperature Chemical Processes (Foundation of Research and Technology Hellas). He obtained his B.S. at M.I.T. and his M.S. and Ph.D. at CALTECH (USA). His research interests are in Biochemical Engineering and Environmental Technologies for liquid and solid waste treatment and valorization. He has over 200 publications in International refereed Journals, and over 300 participations in International Conferences, 9 Chapters in books and two books. He has supervised 40 PhD theses. He has organized two International Conferences. Prof. Lyberatos is Editor of the Journal of Hazardous Materials (Elsevier), Associate Editor of Waste and Biomass Valorization (Springer) and is also the Vice President of the Hellenic Water Association, the Greek governing member of IWA.

# Constructed Floating Wetlands

**V.A. Tsihrintzis**

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**Abstract**

Constructed Floating Wetlands (CFWs) are variants of Constructed Wetlands. They are also called 'planted floating system beds', 'artificial or vegetated floating islands' or 'ecological floating beds'. They consist of emergent vegetation which is usually established on a buoyant structure, and so, it floats on the water surface. The vegetation has an upper part above the water surface, and a lower part (roots) which is 'hanging' within the water column, and so, it can uptake nutrients and other pollutants.

We will present and insight on CFWs based on the published current literature. We will discuss several issues, such as application of this technology, description of floating structures and relevant materials, appropriate vegetation species, design parameters, pollutant removal capabilities, operational parameters affecting performance, mathematical modeling. Finally, we will present our experimental results from pilot-scale system application regarding nutrients and agrochemical removals in such systems.

**Keywords:** constructed floating wetlands, natural wastewater treatment, nitrogen, phosphorus, pesticides, removal performance



**Prof. Vassilios A. Tsihrintzis** is Full Professor of Ecological Engineering and Technology at the School of Rural and Surveying Engineering, National Technical University of Athens, Greece. Prof. Tsihrintzis' research interests concentrate, among others, in water resources engineering and management with emphasis on urban and agricultural drainage and non-point source pollution, water quality of aquatic systems and pollution control, ecohydrology and ecohydraulics, and the use of natural treatment systems (i.e., constructed wetlands, stabilization ponds) for runoff and wastewater treatment. His published research work includes more than 170 papers in peer reviewed scientific journals, over 300 papers in conference proceedings, and more than 100 technical reports. He has also authored or coauthored books and book chapters on Hydrology and Water Resources, Constructed Wetlands, Operations Research, Urban Hydrology and Runoff Quality Management, and Natural Wastewater Treatment Systems. He has participated as a PI/coordinator or a team member in

various research projects in the USA, the EU, and Greece. Dr. Tsihrintzis has supervised more than 100 undergraduate and postgraduate student theses and 16 doctoral dissertations. He teaches, among others, Operations Research, Hydraulic Works, Engineering Hydrology, Urban Water Management, Fluid Mechanics, Groundwater Hydraulics, Environmental Engineering, and Natural Wastewater Treatment Systems. He has also served as a Professor and the Head of the Department of Environmental Engineering, Democritus University of Thrace, Greece, for several years, while before he was an Assistant and then Associate Professor of Water Resources Engineering at Florida International University, USA. Finally, Dr. Tsihrintzis has an extensive professional experience as a practicing civil and environmental engineer both in the USA (he was a registered Professional Engineer in California and a Certified Professional Hydrologist by the American Institute of Hydrology) and Greece, having been involved in several land development drainage, hydrology, sediment transport and channel design, water resources management, wetland restoration, and constructed wetlands projects.

# Stochastic modelling of hydrological extremes in a perpetually changing climate

**D. Koutsoyiannis**

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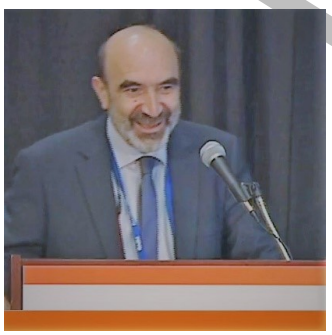
**Abstract**

Current-day scholars have rediscovered change and given particular emphasis on climate change. However change has been well known and well studied on philosophical and scientific grounds since the era of Heraclitus and Aristotle. The omnipresence of change is confirmed by modern-day geological and paleoclimatic studies. These have provided concrete evidence that climate has been perpetually changing. The scientific background to study perpetual change has been developed by the Moscow School of Mathematics and most prominently Kolmogorov, who, among other achievements, laid the axiomatic foundation of probability theory and introduced the concept of stochastic processes. On the other hand, observations on long time series, most prominently by Hurst in Egypt, provided the empirical basis to understand change and its consequences in typical engineering tasks. Based on these lines, a stochastic framework is discussed that can deal with natural extremes under perpetual change, avoiding naïve methodologies which currently prevail.





**Prof. Demetris Koutsoyiannis** is professor of Hydrology and Analysis of Hydrosystems in the National Technical University of Athens. He has served as Dean of the School of Civil Engineering, Head of the Department of Water Resources and Environmental Engineering, and Head of the Laboratory of Hydrology and Water Resources Development. He was Editor of Hydrological Sciences Journal for 12 years (2006-18), and member of the editorial boards of Hydrology and Earth System Sciences, Journal of Hydrology, Water Resources Research, Hydrology and Sci. He has been awarded the International Hydrology Prize–Dooge medal (2014) by the International Association of Hydrological Sciences (IAHS), UNESCO and World Meteorological Organization (WMO), and the Henry Darcy Medal (2009) by the European Geosciences Union (EGU). His distinctions include the Lorenz Lecture of the American Geophysical Union (AGU) (San Francisco, USA, 2014) and the Union Plenary Lecture of the International Union of Geodesy and Geophysics (IUGG) (Melbourne, Australia, 2011). He has served as professor of Hydraulics at the Hellenic Army's Postgraduate School

of Technical Education of Officers Engineers (Athens, 2007-10). He has been visiting academic/professor at the Imperial College (London, 1999-2000), Hydrologic Research Center (San Diego, 2005), Georgia Institute of Technology (Atlanta, 2005-06), University of Bologna (2006 & 2019) and Sapienza University of Rome (2008 & 2019).

# Entrainment and mixing in turbulent buoyant jets

**P. Papanicolaou**

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**Abstract**

Analytical solutions of fully developed, Boussinesq, round and plane vertical buoyant jets (forced plumes) that discharge into an infinite, homogeneous, motionless ambient fluid, can be derived from the momentum conservation equation using a characteristic buoyant jet width parameter Cp, and verified by experiments.

The entrainment coefficient expressed as a function of Cp and the local Richardson number, may take values that are lower than the entrainment coefficient of pure, momentum jets, when the buoyancy acts against the motion (the flow is negatively buoyant). Application of the entrainment coefficient as a function of the local Richardson number to various cases of positively as well as in negatively buoyant jets (fountains), has produced results that are congruent to experiments.



**Prof. Panos Papanicolaou** has received his Diploma in Civil Engineering from the National Technical University of Athens, in 1978. He pursued graduate studies at Caltech from where he has received the degrees M.S. (1979) and Ph.D. (1984).

Worked as a Post Doctoral Fellow and as a Research Engineer at Caltech (1/85-12/86), as a Research Engineer at U.C. San Diego – Institute for Nonlinear Science (1/87-7/90), and USC (8/90-12/90). He was a Researcher at the Chemical Engineering Department of the Aristotle University of Thessaloniki (1/91-2/92), and Managing Director of "HYDROSCOPE – Data Bank of Hydrologic and Meteorological Information", in the Civil Engineering Department of the National Technical University of Athens (3/92-6-94). Adjunct Professor in the Department of Civil Engineering, University of Thessaly, (1/96-1/00), Assistant Professor (2/00-12/08) and Associate Professor (12/08-8/09). Currently he is a Professor at the National Technical University of Athens that he joined in 09/09. He is the author of 80 articles in periodicals and conferences, while his work has been cited 800/1450 times (Scopus/Google Scholar).

His research is focused in the areas of 'Development and Implementation of Experimental Measuring Techniques for Fluid Dynamics', 'Environmental Fluid Mechanics' and 'Hydrologic Transport Processes', including transport phenomena in density stratified flows. He is an expert

in the design, implementation and application of laser-light based techniques for the momentum, mass, and scalar transport measurement in turbulent flows. He has also been a consultant for engineering analysis and design of large-scale, long-term, infrastructure hydraulic projects.

# CONTRIBUTED PAPERS

# A.1 SMART ENVIRONMENTAL SYSTEMS, SOFT AND RENEWABLE ENERGY SOURCES

# Evaluation of polyimide membrane's performance in terms of laboratory-scale $C0_2$ removal from biogas

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**Abstract**

The present study discusses the separation properties of a polyimide membrane module, regarding the optimization of biogas upgrade process by the increased recovery of $CH_4$ (through the $CO_2$ separation/removal). For that purpose, a laboratory pilot-scale membrane set-up was designed and constructed to achieve the production of high purity biomethane (>95%) from a gas mixture, consisting of the main biogas constituents (i.e., $CO_2$ and $CH_4$). The mass flow of inlet streams controlled by a proper mass controller and the feed pressure was controlled by a Back Pressure Regulator (BPR). The applied membrane for this separation was a polyimide hollow fiber (HF) membrane, operating in counter-current flow. The gas streams were analyzed directly (by using a gas analyzer) for the $CH_4$ and $CO_2$ content. The feed concentration consisted from 55-70 vol% $CH_4$ and 45-30 vol% $CO_2$, whereas the influence of applied pressure studied in the range between 5-9 bars, to achieve the desirable CH4 purity levels. The experimental results revealed that the % purity of $CH_4$ in the retentate stream (being the desirable product) exceeds the set limit value of (at least) 95% concentration, applying pressure values over 6 bars. Any further increase of feed pressure leads to even higher CH4 purity on the retentate side, however the retentate mass flow decreases, leading to smaller recovery values for CH4. The $CO_2$ percentage at the permeate stream varies between 50 and 80% and confirms the need to add a supplementary membrane module in order to enhance the $CO_2$ recovery, i.e. for a more successful $CO_2$ separation/capture.

**Keywords:** Biogas upgrade, biomethane, membrane technology, $CO_2$ removal

# Algae biomass-based biogas: pilot study and tea/lca

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**Abstract**

The goal of the study was to construct and operate an algae growth field pilot scale bioreactor system, in a greenhouse environment, at an industrial munitions facility with aim to optimize algae biomass productivity utilizing wastewater streams, specifically industrial wastewater plant influent (IWPI) and ammonium nitrate solution (ANSOL). This system, consisting of two raceway ponds (R1, R2) of 975L capacity and $3.4m^2$ surface area running in parallel, was assembled in the Spring of 2019 and was seeded with an autochthonous algae polyculture consortium.

Over a span of 36 days (end of May to beginning of July) the raceway bioreactors were operated at the facility, while weekly analysis of the samples and the biomass downstream processing were carried out at Stevens Institute of Technology. Harvested algal biomass was subsequently assessed for biogas production via anaerobic digestion.

The initial seeded polyculture grew well and healthy over the duration of the study. The areal biomass productivity obtained for both reactors was quite similar throughout the study, being 23.3 and $24.5g/m^2.day$ for R1 and R2, respectively. This substantial biomass productivity was achieved by using an autochthonous polyculture resilient to grazers and pests. Nutrient levels were controlled (to avoid toxicity) over the length of the run while the harvesting frequency was gradually increased. Since this study was conducted during late spring-early summer, under relatively high ambient temperature and solar radiation conditions, the reported biomass productivity performance may be subject to seasonal variations. The biomethane yield of the polyculture was similar to the values obtained for a monoculture of S. obliquus grown in the laboratory. Moreover, a TEA/LCA study was commissioned using the areal productivity data. Specifically, $20g/m^2.day$ was used as a biomass productivity input value. Two scenarios were modeled. In Scenario 1, the primary product detailed is raw, unpurified biogas. In Scenario 2, raw biogas is upgraded to biomethane (renewable natural gas, RNG) with membrane separation in to improve the TEA results of the proposed facility with RIN credits. Accounting of excess digestate for use as soil amendment, through system boundary expansion, is considered

in both scenarios. Natural gas is less expensive than algae derived biogas due to the facility capital expenses. However, the algae biofuel could be competitive with sufficient environmental valuation and credits (e.g., high RIN credits of $5 or greater). Although the upgraded biogas scenario involves an additional capital and operating expense for membrane separation of CH4, the revenue from D3 RINs (which is not applicable to raw biogas) considerably lowers the net cost.

From an environmental standpoint, the benefits are substantial. The net global warming potential (GWP) of both Scenario 1 and 2 $5.4 gCO_{2eq}/MJ$, $13.1 gCO_{2eq}/MJ$) is far more favorable than for the extraction and processing of U.S. natural gas ($104 gCO_{2eq}/MJ$). This reduction in biogas GWP is due largely to the utilization of waste streams as process inputs – manufacturing wastes and flue gas . The GWP of fossil natural gas is greater than that of biogas. Biogas combustion releases only $CO_2$ that was prevented from entering the atmosphere by algal photosynthetic capture. Thus, biogas combustion does not result in a net increase of $CO_2$ emissions.

**Keywords:** Algae biomass, biogas TEA, LCA

# Evaluation of a hybrid renewable energy system for the supply of a desalination unit for handling salinization

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**Abstract**

Many anhydrous Greek islands are dealing with water scarcity for domestic and agricultural purposes. Especially demands on irrigation water are covered by private irrigation wells, leading to quality and quantity problems of the groundwater. The capability of desalination of abundant seawater can provide a solution to the problem of irrigation water. At the same time, the energy needed for desalination can be exploited from renewable energy sources (RES) in order to reduce the use of conventional fuels and thus reduce carbon emissions. Especially for the Greek islands, the abundant solar potential is worth utilizing through the installation of photovoltaic panels. In this research work, the methodological framework is presented for a Hybrid Renewable Energy System (HRES) consisting of photovoltaic panels (PV), batteries (BT), a desalination unit (DU) for the production of desalinated water for agricultural purposes and a reservoir for the desalinated water (DR). During the winter months, there is no need for irrigation water and the HRES is operating exclusively in order to serve the water needs of the permanent population of the island. The aim of this study is the optimal configuration of the proposed HRES in order to meet all the irrigation and drinking water needs and avoid water drilling for the protection of the natural environment. It is found that for 1 m3 of desalinated water are required 9.33 W of installed PVs and 5.52 g $CO_2$ are eliminated if a proposed HRES is installed for the fulfillment of water demand.

**Keywords:** Desalination, Irrigation, Solar energy, Batteries, HRES

# Development of algal flocculent biomass in synthetic wastewater and secondary effluent

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**Abstract**

The aim of our work was to investigate the formation of photogranules as an efficient method for the treatment of wastewater and harvesting of algal cells. A synthetic substrate (modified Blue Green-11 medium) and the effluent from an activated sludge wastewater treatment plant were used to study the metamorphosis of activated sludge to algal flocs under static and stirring conditions. Algal flocs were observed in all cultures by day 10 and a high chlorophyll concentration was detected in all cases reaching values up to 610 to 630 µg/L at the end of the experiment after 30 days. The size of flocs in all cultures either at static or mixing conditions ranged from 330 to 994 µm, resulting in biomass concentration from 330 to 660 mg/L. The cultures in secondary effluent at static conditions presented the greatest size; the mean diameter on day 10 and 30 was 250 and 994 µm, respectively. The cultures were efficient in nutrient removal and by the end of the experiment nitrates and phosphates were completely consumed.
**Keywords:** Activated sludge, algal flocs, mixing conditions, nutrients removal, granule size

# Wastewater valorization and production of high market value bio products: a methodological approach for the sustainability assessment

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**Abstract**

To accomplish the transition towards a sustainable growth, it is imperative to adopt modern value chain approaches within circular bioeconomy concepts. On this basis, the implementation of a biorefinery approach for wastewater valorization and simultaneous production of high-value market bio-products addresses major global challenges, thus, yielding significant environmental, economic, and social benefits. In this work, a methodological framework for the sustainability assessment of a holistic biorefinery approach for the inclusion of the environmental and socio-economic effects of wastewater valorization into new value chains, processes, and products is introduced. The proposed methodological framework is built upon a Life Cycle Thinking concept and design. More specifically, it includes three distinct pillars: (i) the environmental pillar, that maps the environmental impact of the whole supply chain of wastewater utilization for the production of high added-value products; (ii) the techno-economic that makes provisions for the feasibility and viability of the entire production chain; and (iii) the social pillar, that introduces the social acceptance and understanding to the production and utilization of the proposed solutions. The core outcomes shed light on the potential of circular systems targeting sustainable and efficient wastewater valorization and application of the end-products from an economic, environmental, and social point of view.

**Keywords:** Environmental impact assessment, Life Cycle Thinking, sustainability, techno-economic assessment, social perception, biorefinery, wastewater valorization

# B.1 AGRICULTURAL PRACTICES AND ENVIRONMENT, NATURAL TREATMENT SYSTEMS, PROTECTION AND RESTORATION OF ECOSYSTEMS

# Crop requirements and water losses in collective irrigation Axios river's networks in nothern Greece

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**Abstract**

Water volume consumed for crop irrigation at the plain of Thessaloniki - northern Greece, was estimated and compared against the volume reported by the General Land Reclamation Organisation (G.L.R.O.) of Thessaloniki - Lagada. For the estimation of net crop water requirements, apart from crop evapotanspiration, the contribution of effective precipitation, soil moisture and the phreatic aquifer through capillary elevation were considered. Estimates were performed for all the collective open and pressurized irrigation networks located at the plain of Thessaloniki, and referred to years 2016 to 2019 inclusive. Axios River is the main source of these networks. Results reveal considerable losses of irrigation water that are related to the management, operation and maintenance of the networks by the Local Land Reclamation Organizations (L.L.R.O.). All these reasons will be discussed in the following paper.

**Keywords:** Thessaloniki plain, collective irrigation networks, crop requirements, water losses, network management.

# C storage at planted fields at a Lignite Center for climate change mitigation

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**Abstract**

The COFORMIT research project assesses the contribution of tree plantations at restored areas to the mitigation of climate change. Forests and plantations, through photosynthesis, absorb and store CO2, which is the main greenhouse gas in the atmosphere. Carbon is stored in the above and belowground biomass, the deadwood, the litter and the carbon soil. The studied plantations were established after the mining activity at the Lignite Center of Western Macedonia, at about 2,400 hectares. The COFORMIT project aims to estimate C storage in the plantations of this Lignite Center. The estimation of five-carbon pools in the plantations (aboveground, belowground biomass, deadwood, litter and soil) was performed. The aboveground biomass was estimated using an allometric model for black locust. The deadwood C pool was measured in all plots. The belowground biomass was measured by the direct excavation of coarse roots in five selected trees. Fine roots were measured by soil coring. Indirect methods for estimating the root biomass C pools were applied using the established equations. Litter was collected every two months during a year from the 36 installed litter traps. The soil and forest floor C were measured from samples in 0-30 cm depth. Preliminary results for estimating all five carbon pools of the studied plantations are analyzed.

This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship, and Innovation, under RESEARCH– CREATE–INNOVATE (project: COFORMIT. T1EDK-02521).

**Keywords:** Forest biomass, Carbon sequestration, Robinia pseudoacacia, restoration plantations

# Utilization of earthworm compost sludge instead of peat in olive tree nurseries towards sustainable development and circular economy: feasibility study and effects on growth and nutrition of olive rooted cuttings

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**Abstract**

One of the main goals of horticultural nurseries is the survival of newly-planted seedlings and their successful development after transplanting, including faster plant growth, higher plant quality, greater production and lack of dependence on arable land. Although peat is the most often used amendment in commercial potting substrates, its use involves the exploitation of non-renewable resources and the degradation of valuable ecosystems such as peatlands. In this study the effect of partial and total substitution of peat by vermicompost on the growth and nutrition of olive rooted cuttings was investigated, looking for more environmental-friendly and low-cost practices, recycling and utilizing at the same time sludge from urban wastewater treatment plants. Results proved that earthworm compost sludge could effectively replace peat, enhancing plant growth without added fertilizer. In relation to olive cuttings growing in peat-based substrate, cuttings of the compost-based substrates reached better growth and nutrition, especially when the ratio was 75% compost -25% peat, while it was observed that in the treatments with large percentage of earthworm compost sludge the irrigation doses were significantly reduced, since the water drained at a slower rate. Also, leachates from each treatment were analyzed and the outcomes showed that the concentrations of trace elements and heavy metals were far lower than ranges considered toxic for soil and groundwater. Meanwhile, technical-economic analysis took place, demonstrating the cost reduction for a nursery owner resulting from the replacement of peat with earthworm compost sludge, minimized irrigation need and the non-use of fertilizer during transplanting. Summarizing, the use of earthworm compost sludge constitutes a beneficial alternative to the use of peat in olive tree nurseries due to the observed improvement in plant quality, but also due to the environmental and financial benefits involved.

**Keywords:** Earthworm compost sludge, olive tree nurseries, peat substitution

# Tree bole form simulation through support vector machine modeling. An alternative approach.

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**Abstract**

Prevention of the forest degradation that financial exploitation of man activity can cause, is of vital importance for natural resources sustainable management. A tool to this direction is modeling of features of trees, such as total tree height, diameter reduction factor, tree volume etc.; so that an estimation of the yield of the forest in finance recoverable goods is possible. The diameter of a tree bole generally decreases or tapers from the base to the tip. The way in which this decrease occurs defines the bole form. This taper can occur at different rates and in different ways or shapes. Some general geometric shapes approximate portions of the tree bole, but there are many inflections and points of irregularity.

This paper explores the possibility of applying the Support Vector Machine for regression (SVR) modeling methodology, as possible alternative to non-linear regression models, in order to assess as accurately as possible, the taper of fir tree boles through the accurate prediction of the tree bole diameter reduction factor (a). The knowledge of this coefficient can provide the taper of the tree bole and the size of diameters of the tree trunks above the ground, resulting to reliable tree bole volume estimation. The procedure that should be followed in the development of the SVR models is outlined. Finally, their effectiveness of the model that fitted to the available data, is compared with the results of the best fitted non-linear regression model to our data in hand and evaluated.

**Keywords:** Non-linear regression; support vector regression; fir trees; taper factor; tree bole diameter reduction factor

# A systematic literature review on agricultural waste

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**Abstract**

Agricultural activities have been very important since the first ages of history. Considering that agricultural products are vital for not only human beings but also all livings, agricultural sustainability gains importance because of diminishing natural resources. Furthermore, Covid-19 pandemic, which all countries of the world have been fighting for months, has affected our life cycle and has shown how much agricultural activities are important. While we are still struggling with the pandemic and sustaining our lives with measures, we are also faced with global warming caused by especially greenhouse gases and their consequences. While the combustion of fuels such as oil, coal and natural gas causes an increase in greenhouse gases in the atmosphere, the greenhouse effect also directly results in global warming by increasing the world temperature averages. As the world struggles with global warming, recovery and recycling of agricultural wastes become very vital. In this study, it is aimed to systematically review a literature based on agricultural waste and categorize them under different properties. This study will provide the researchers to see the gap in the literature about agricultural waste topic and provide a perspective about agricultural waste.

**Keywords:** Literature review, sustainability, agricultural waste, recycling

# Optimizing the Water-Ecosystem-Food Nexus in Avocado Plantations: Experimental Design and Initial Results

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**Abstract**

The objective of this work is to conduct studies, collect data and assess the Water-Ecosystem-Food Nexus in Avocado Plantations in a systematic way in order to minimize the environmental footprint and impact of the operation while maximizing the benefits for the farmer and the environment. We will conduct the following two studies:

**Minimize irrigation demand** - Hydrologic and plant monitoring station have been established in an avocado plantation to determine optimal irrigation schemes, the water use efficiency of the trees and ways to improve plant productivity. To optimize the water component of the Nexus, the plants were irrigated the amount estimated by their evapotranspiration needs. In addition, drip irrigation was not applied in a linear fashion in the field, but in a circle with one-meter diameter from the root of the tree. In this way, the amount of irrigation used was only 30% of the typically prescribed irrigation needs for the plants on an aerial basis

**Ecosystem and fertility studies** – The ecosystem and fertility studies involve two aspects. First, biomass production was monitored with the NDVI and PRI cameras in order to estimate the above ground production as well as to identify the conditions that plants were stressed. Second, ten avocado field, half with organic and half with inorganic fertilization were used for soil sampling and analysis for Soil C, N, P, K and micronutrients, Soil bulk density, porosity and sand corrected water stable aggregates, Soil pH and Conductivity, Soil mineralization and respiration and DNA analysis for soil biodiversity. The data will provide indices of soil fertility and soil biodiversity. They will be used to illustrate that organic fertilization results in improved soil fertility, improved soil biodiversity and better ecosystem services

**Keywords:** water, ecosystem, food, irrigation, fertility, biodiversity

# C.1 ENVIRONMENTAL HEALTH & ECOTOXICOLOGY

# Bio-effects of saprolegniasis in salmo trutta larvae

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**Abstract**

Fish disease such as saprolegniasis can results in high mortality and major financial loss in an industry of the global food production. Since the ban of malachite green, an organic dye very efficient at killing the pathogen, Saprolegnia infection re-emerges in aquaculture. Oomycetes secrete toxins, proteinaceous effectors, hydrolytic enzymes, which can act as virulence factors. During this study, in vivo experiment using salmonids was performed to assess bio-effects caused by parasitic oomycetes Saprolegnia parasitica. Salmo trutta at larval stage (endogenous diet) was exposed to 92000 colony-forming units per milliliter (cfu/mL) of S. parasitica for 7 days. Geno- and cytotoxicity were evaluated using nuclear abnormalities and Comet assays. Biological parameters such as heart rate (HR, counts/min) and gill ventilation frequency (GVF, counts/min) were assessed. A significant increase in the comet tail DNA (%) and olive tail moment of the exposed fish blood was observed in comparison to control group. Nuclear abnormalities assay did not show significant differences of geno- and cytotoxicity endpoints frequencies between exposed and control groups.

**Keywords:** Salmonids, cytotoxicity, Comet assay, genotoxicity, toxicity

# Induction of catalase and metallothionein in salmonid fish under multiple stress exposure

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**Abstract**

Global environmental changes along with anthropogenic activity have an impact on the hydroecosystem. Marine and freshwater fish are under a permanence exposure to multiple environmental stressors such as ocean acidification and warming, various chemicals and pathogenic organisms which induce fish diseases. Chemical stressors and pathogen infection can both cause oxidative stress in fish. The results of oxidative damage involve changes of lipids and carbohydrates, protein denaturation, DNA and RNA damage in organism. The aim of the present study was to investigate oxidative stress responses in salmonid fish under multiple stressors scenario: a) after exposure to the landfill leachate as chemical mixture for 14-days, b) after cumulative exposure to pathogenic oomycete Saprolegnia parasitica for 14-days. As biochemical biomarkers of oxidative stress, metallothionein (MT) induction and catalase (CAT) activity were assessed in liver of fish. After 1 and 4 days, sea trout exposed to landfill leachate showed significantly lower CAT activity compared to control group, whereas in brown trout significant changes in CAT activity were not observed. Four days exposure to landfill leachate resulted in significantly elevated levels of MT in brown trout liver, however no significant alterations in MT levels were detected in sea trout. Treatment with S. parasitica did not result in significant changes in the evaluated biomarker responses.

**Keywords:** Sea trouts, brown trouts, metallothionein, catalase, oxidative stress, Saprolegnia parasitica

# Acute toxicity assessment of graphene oxide nanoderivatives on salmo trutta at early development stages

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**Abstract**

Increasing production and application of graphene oxide (GO, a popular carbon nanoderivative), inevitably leads to its release into the aqueous environment. Toxicity of GO to aquatic organisms has been widely discussed, while the effect of GO on fish embryos and larvae remains unclear. We investigated the potential toxicity of GO to *Salmo trutta* at early stages of development. In the present study, embryos and larvae were exposed to 0, 1, 20 and 40 mg/L of GO for 4 days. Our study results proved that GO could accumulate in embryos and larvae. GO exposure was found to cause a significant decrease in the heart rate and the level of malondialdehyde, as well as an increase in the content of metallothionein in fish embryos. However, these effects were not recorded in larvae. Exposure of larvae to GO induced the formation of micronuclei in erythrocytes of larvae. These findings provide new insights into the effects of GO on fish during their embryogenesis. Therefore, it is very important that before subjecting the environment to the widespread GO exposure, the relevant authorities and nanomaterial producers should take into consideration potential risks of nanomaterials to aquatic organisms.

**Keywords:** Graphene oxide, fish embryos and larvae, toxicity, lipid peroxidation, metallothionein

# Nitrocellulose post alkaline hydrolysis liquor: ecotoxicological assessment and nitrogen removal by submerged algal cultures

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**Abstract**
The manufacturing of nitrocellulose (NC) generates wastewater streams laden with this insoluble organic polymer that require physicochemical and/or biological treatment prior to their release into adjacent water bodies under regulatory guidelines. NC fines can be separated from streams and safely and successfully destroyed by means of alkaline hydrolysis. Nitrite and nitrate, the main nitrogen products of NC degradation, are obtained in 3:1 ratio, respectively (Christodoulatos et al. 2001). Yet, the high content of nitrogen species obtained in the digested liquors require further treatment to attain regulatory compliance. In this study, ecotoxicological assessment of the post alkaline hydrolysis (AH) liquors were carried out using Microtox and algal tests (OECD guidelines). Moreover, toxicity evaluation for sole N species such as nitrite or nitrate and combinations with sodium ions were tested to identify the species responsible for toxicity. Results confirmed that nitrite is responsible for the toxicity of the post AH liquors. In fact, solutions containing concentrations higher than 60 mg N/L of nitrite are toxic to freshwater microalgae S. obliquus (ATCC 11477). Subsequently, algal growth tests using two microalgae strains were performed in 24-well microplates using simulated liquors to screen a wide range of nitrite-N:nitrate-N concentrations (keeping a 3:1 ratio), ranging from 20 to 300 mg TN/L. Freshwater microalgae, S. obliquus, grew well in the mixture of nitrite-N:nitrate-N at concentrations lower than 160 mg TN/L. On the contrary, marine water microalgae, N. salina, did not grow well at these nitrogen concentrations. In addition, the N removal rates were calculated for all concentrations tested and were found to increase with increasing the initial amount of N supplied up to a certain concentration. The highest removal rate was 15 mg/L-day for 160 mg TN/L initial N. Once the effective concentrations were identified, scale up experiments were performed in Erlenmeyer flasks of 250 and 1000 mL and actual post AH liquors. Overall, this study demonstrated that the freshwater algae, S. obliquus, assimilates both inorganic nitrogen species converting them into biomass; therefore, the results of this study provide a potential opportunity for recycling nutrients from post AH liquors and a successful two-step chemical and biological treatment of NC. Additionally, the harvested biomass can be further processed to obtain energy and other value-added products.

**Keywords:** wastewater treatment, NC, post alkaline hydrolysis liquors, freshwater and marine microalgae, Nitrogen species removal

**References**

C. Christodoulatos, T.-L. Su and A. Koutsospyros. 2001. Kinetics of the Alkaline Hydrolysis of Nitrocellulose. Water Environment Research 73, No. 2, pp. 185-191.

# Heavy metal contamination of environmental matrix due to illegal electronic-waste management in Nigeria

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**Abstract**

Illegal electronic and electrical importation and poor management of the resultant electronic wastes (e-waste) have caused increase decadence of the Nigerian environment through the release and accumulation of metals. This invariably exposes Nigerians to myriad of health effects caused by toxic metals from the generated e-wastes. This systematic review presents comprehensive information on the ubiquity of metals in the soil, underground and surface water, dust and plants collected within the circumference of the e-waste sites and in blood of occupationally exposed Nigerians to emissions from the e-wastes. The following metals: Pb, Cr, Mn, Cd, Ni, As, Zn, Fe, Cu, and Co, were reported at varying concentrations in the different environmental matrix. They were significantly higher than national and international permissible limits. Health risks associated with accumulation of these metals in the human and wildlife body were discussed. Indiscriminate e-waste disposal in Nigeria is a source of metal discharge into the environment and a threat to public health.

**Keywords:** illegal e-waste disposal, heavy metals, environmental matrix, health risk effects

# Acute and chronic toxicity and oxidative stress by metallic nanoparticles in early life stage fathead minnows (pimephales promelas)

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**Abstract**

The objective of this research was to determine the toxicity of $nZnO$, $nTiO_2$, $nFe_2O_3$, $nCu$ and $nCuO$ to larval *Pimephales promelas* after 96-h and 28-d exposures. Endpoints included survival, growth, spinal curvature, and oxidative stress (total glutathione, GSH, GSSG/GSH, and TBARS [a measure of lipid peroxidation]). The LC50s for $nFe_2O_3$ (28 mg/L) and nCuO, (0.66 mg/L) were greater than those for $Fe^{+3}$ (0.039) and $Cu^{+2}$ ions (0.005), but the LC50 for nCu (0.009 mg/L) was similar to $Cu^{+2}$. There was no evidence of acute toxicity of dissolved ions in the nanoparticle suspensions, nor for $nZnO$ or $nTiO_2$. In chronic exposures, both mortality and growth rate were increased at the lowest concentration of $nFe_2O_3$ (350 µg/L), while mortality and axial spinal curvature was the most sensitive indicator of chronic $nCuO$ toxicity (LOEC=32.5 µg/L for both). The levels of TBARs and glutathione-related parameters suggested that oxidative stress increased in $nFe_2O_3$-exposed fish, but were decreased by $nCuO$ exposure. Because of logistic constraints, chronic tests for $nCu$ were not carried out. The LC10 and LC50 for $nCu$ and LOEC concentrations of $nCuO$ fall within the range of predicted concentrations for high-level exposure scenarios, so these effects may occur at environmentally-relevant concentrations. Differential toxicity of pure nanoparticles vs. commercial formulations is discussed as a possible reason for discrepancies between the present and past works.

**Keywords:** survival, engineered nanomaterials, malformations, hormesis, Darwinian fitness, development

# A.2 WASTEWATER TREATMENT AND MANAGEMENT

# Biosolids stabilization via cold plasma FE-DBD technology: a preliminary study by FTIR-ATR spectroscopy

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**Abstract**

The ever-increasing population leads to the production of immoderate amounts of wastewaters worldwide, which makes apparent the need for their sustainable management and treatment with modern methods of sanitation that are cost and energy effective. Such a method is the emerging technology of FE-DBD cold plasma in ambient air which has been found that can sanitize the biosolids effectively by inactivating completely the biological charge such as Salmonella spp. and other bacteria. Therefore, the need arises for further investigation of the physicochemical properties of biosolids as far as their stabilization is concerned. For this purpose, a preliminary study was made. A biosolid sample was collected from a Waste Water Treatment Plant (WWTP) of a municipality with a population of 100,000 people, in Western Greece. The sample was studied for its physicochemical properties and structural characteristics at molecular level by FTIR-ATR spectroscopy, before and after been treated through the specially designed layout of the cold plasma reactor. The process involves mean electrical power in the range of tens of watts, treatment time in the scale of minutes, and maximum temperature <400 K. The comparative study showed that the plasma dehydrated the sample perfectly and through FTIR-ATR spectroscopy, structural differences were revealed, possibly due to the effect of the free radical mechanisms of the RONS, ions, ozone, low heat, and UV photons that interact during the process. All the above lead to the conclusion that this process worth further study, as the FE-DBD is environmentally friendly, cost effective, efficient and mechanically easy to manage biosolids. This work is a preliminary contribution to the promotion of advanced methods for the pre-ecological management of biosolids, in accordance with European Regulations.

**Keywords:** biosolids, wastewater, treatment and management, FE-DBD, cold plasma, FTIR-ATR spectroscopy

# Fixed bed column removal of heavy metals using supported green nZVI in resin: the effect of contact time

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**Abstract**

The need of clean water resources is becoming a major issue over the years due to overpopulation and to low water quality. The increasing water demands impose the need to treat and reuse wastewater. The effluents of waste water treatment plants (WWTP) consist mainly of water with low concentrations of suspended solids and dissolved organic and inorganic compounds. However, they may contain heavy metals such as arsenic, cadmium, chromium, nickel, copper, lead, mercury, zinc originating from industrial and/or domestic sources. The last decades nanomaterials have been effectively applied for the treatment of contaminated water and wastewater. They combine properties, such as small particle size, high surface area, high reactivity, which make them ideal adsorbing or reactive media. Aim of this study was to evaluate the performance of a nanocomposite material (R-nFe), consisting of nano zero valent iron (nZVI), synthesized by green tea polyphenols and incorporated in a cation exchange resin, for the removal of heavy metals from the effluents of WWT plants. The experimental work involved a series of columns tests. The feed solution originated from Psyttalia WWTP and was spiked with a range of common metal contaminants, such as Cr(VI), As, Ni, Pb, Cu, Cd and Zn, at levels approximately ten times higher than the limits established by the Greek legislation for recycling WWTP effluents in other uses. The solution was introduced in 3 columns with different contact times, namely 2.4, 4.8 and 6.0 minutes. According to the results, the RnFe composite was found to be very efficient for Cr(VI) and As removal. The concentrations in the effluents satisfied the environmental limits, provided that the contact time was higher than 5 minutes. The performance of RnFe was less efficient in the case of divalent metal contaminants, due to the strong competitive effect of calcium, which was present in relative high levels in the effluents.

**Keywords:** nano zero valent iron (nZVI), nanocomposite, fixed bed column, flow conditions, wastewaters, heavy metals removal.

# Determination of main factors influencing arsenate removal from municipal wastewater

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**Abstract**

The effect of phosphate and humic substances on the removal of dissolved and particulate arsenate (As(V)) and iron from synthetic wastewater by ferric chloride was investigated. The treated water samples were filtered through a 0.45 µm filter and centrifuged at 10414 g for 8 min to determine residual dissolved and particulate arsenate and iron concentrations. The species in the filtered samples were considered to be in dissolved form, and the difference between the concentrations of the species in the centrifuged and filtered samples were attributed to particulate form. The results showed that the presence of 1 mg/L and 4 mg/L of phosphate in the wastewater significantly increased the concentration of dissolved As(V) from 1.2 µg/L to 45 µg/L and 56.5 µg/L, respectively. However, phosphate did not increase the particulate As(V) concentration, and it did not have obvious effect on the dissolved and particulate iron, indicating that the increase in dissolved As(V) concentration was due to the competitive adsorption of phosphate and As(V) to the surface sites of ferric hydroxide precipitates. On the other hand, the presence of 10 mg/L FA in wastewater slightly increased concentration of dissolved As(V) and significantly increased the concentration of residual particulate As(V) and iron. Zeta potential analysis determined that when FA concentration increased from 0 to 10 mg/L, the zeta potential of ferric hydroxide precipitates decreased from -12.56 to -22.47 mV due to the adsorption of the negatively charged FA. Meanwhile, the size of the ferric hydroxide flocs decreased from 8.9 to 0.49 µm because of the strong electrostatic repulsion among the highly negatively charged particles. Therefore, the increased particulate As(V) concentration was mainly attributed to the presence of small flocs caused by high concentration of FA.

**Keywords:** ferric chloride, arsenic, fulvic acid, water treatment, filtration, centrifugation

# Assessment of the benefits of aerobic granular sludge in the wastewater treatment facilities in Greece

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**Abstract**

Aerobic granular sludge can be used as an alternative process in biological wastewater treatment to accelerate the simultaneous removal of all the pollutants that are responsible for the eutrophication in the water recipients, such as organic load and compounds of Nitrogen and Phosphorus. During only the last decade, usage of aerobic granular sludge in urban and industrial wastewater treatment plants is gaining ground worldwide, but it is not yet established as a large-scale application compared to the conventional activated sludge process. The latter is still the prevalent method in wastewater treatment in Greece. The suggested aerobic granular sludge method is estimated to have lower energy demands and a smaller installation footprint compared to the existing activated sludge biological treatment method. The fluctuating cost of energy and unexpected population upsurges due to tourism often bring Greek activated sludge installations to their limits which sometimes results in proving the wastewater treatment insufficient. This paper presents the method of aerobic granular sludge, compares it to the conventional activated sludge process, and through the example of an Aegean island's advanced wastewater treatment requirements, identifies the need for further assessment of alternative and promising wastewater treatment methods.

**Keywords:** WWTPs, biological treatment, activated sludge, aerobic granular sludge

# Evaluation of heterotrophic denitrification (HDN) for high strength nitrate wastewater

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**Abstract**

Wastewater steams from production of plastics, nitric acid, fuel additives and in particular, energetic materials are often characterized by high concentrations of nitrate from usage of mixed acids. Treatment of these streams represent a major challenge for physical-chemical technologies such as ion exchange, adsorption and reverse osmosis due to high energy requirements as well as handling and disposal of resulting concentrated brines. Alternatively, heterotrophic denitrification (HDN) as a biological process represents an attractive option, because of lower energy requirements, cost effectiveness, and environment-friendly nature. In HDN, bacteria communities utilize organic carbon sources as electron donors to carry out dissimilatory reduction of oxidized ionic nitrogen (nitrates NO3-, nitrites NO2-) into molecular nitrogen gas (N2). In this work, the efficacy of HDN was evaluated in bench scale experiments for treatment of a synthetic wastewater containing 0.5-2.2 g/L NO3- prepared to simulate nitrate levels in energetic-laden wastewater samples. Exploratory experiments were conducted in a 3.5 L fully automated/controlled fermenter reactor in semi-continuous mode using activated sludge as inoculum and methanol as an electron donor. Several key parameters operating (temperature, pH, DO, ORP, hydraulic/biosolids residence time) and performance parameters (COD removal, biomass concentration, nitrites, nitrates, ammonia, total alkalinity) were monitored systematically. Overall, the system showed resilience in effectively removing the influent nitrate regardless of concentration, with removal efficiencies in the range of 80-90

**Keywords:** denitrification, nitrate, nitrogen removal, sequencing batch reactor (SBR)

# Alkaline hydrolysis of waste nitrocellulose and characterization of post-hydrolysis liquor

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**Abstract**

Nitrocellulose (NC), also known as cellulose nitrate, is a highly flammable compound formed by nitrating cellulose through exposure to a mixture of nitric acid and sulfuric acid; due to its variable degree of nitration, NC can be employed in wide range of products (i.e. paints, lacquers, gunpowder). Although NC's mobility in the environment is limited due to low solubility, industrial facilities producing NC must employ effective and comprehensive treatment methods to eliminate residual undissolved NC fines according to regulatory guidelines prior to disposal. Among all treatments reported for NC, alkaline hydrolysis (AH) has been by far the most commonly applied method that effectively destroys the cellulose backbone of NC into soluble organics, nitrites, and nitrates. In this study, AH was applied to the treatment of highly concentrated NC waste streams, through evaluation and optimization of key parameters such as temperature and caustic strength. In particular, AH batch tests were conducted using both pure NC and waste NC fines to identify operating conditions for degradation of the polymer. Furthermore, a detailed characterization of the post hydrolysis liquor was carried though determination of nitrogen byproducts (i.e. nitrate, nitrite) and carbon content (i.e. COD, BOD).

**Keywords:** nitrocellulose, wastewater, alkaline hydrolysis

# B.2 RIVER & OPEN CHANNEL HYDRAULICS, RURAL AND URBAN HYDROLOGY, SEDIMENT TRANSPORT AND EROSION CONTROL, WATER RESOURCES MANAGEMENT AND CONTAMINATION CONTROL

# Examination of retention ponds design volume and impact in reducing the flood inundation area

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**Abstract**

In this study, a complete hydrological and hydraulic analysis is performed, over a study area located in the upper part of the Pineios Basin, in Thessaly Greece. The hydrological analysis is performed with the aid of the Hydrologic Modeling System (HEC-HMS), while the hydraulic analysis is performed with the use of the HEC River Analysis System (HEC-RAS). First, the extent of the flood is calculated over the designated area, based on a 50-year return period. Then, various scenarios are simulated where the maximum discharge of the 50-year flood hydrograph is limited to a specified value to assess the maximum discharge that can be safely routed over the specified area. Finally, the difference in the generated flood volumes between the 50-year return period flood and the scenarios is calculated, to estimate the total flood volume that should be retained by the retention ponds. Overall, results show that depending on the study area, the construction of multiple retention ponds upstream can be an effective means for flood prevention.

**Keywords:** retention ponds, HEC-HMS, HEC-RAS, rainfall-runoff, Pineios

# Global sensitivity analysis of low impact development input parameters of storm water management model

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**Abstract**
The new trend for urban flood risk management is the use of Low Impact Development (LID) measures (e.g., green roofs, permeable pavements, vegetative swales, bio-retention cells, etc.). However, accurate modeling of LID measures is difficult owing to the large number of parameters that must be estimated and the lack of field studies. As a result, most times, parameters are estimated in a relative coarse manner. The present work presents the results of a Global Sensitivity Analysis (GSA) of the input parameters (e.g., berm height, thickness, roughness, etc.) of Green Roofs (GR) and Permeable Surfaces (PS). Modelling of LID measures (i.e., GR and PS) took place using the Storm Water Management Model (SWMM5.1) of the US Environmental Protection Agency. GSA was carried out using the Morris method. Sensitivity of the parameters was evaluated for a single storm event with regard to the sewer peak discharge. This work revealed that soil conductivity and thickness and surface roughness and berm height, for GR; and pavement permeability, surface roughness and surface slope, for PS, are the most influential parameters of SWMM.
**Keywords:** SWMM, LID practices, global sensitivity analysis, Morris method

# Numerical simulation of local scour at submerged weir structure

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**Abstract**

Weir constructions are frequently used in rivers to control flow depth, to retain specified hydraulic conditions and are often provided for flood defence, habitat improvement and navigation purposes. Such hydraulic structures are usually overtopped during high flood events and local scouring process is developed immediately downstream of the weir. This paper presents a computational fluid dynamics modeling and analysis to numerically predict hydrodynamic and sediment transport parameters downstream of a sharp-crested weir. The three-dimensional Reynolds-averaged Navier-Stokes equations were solved in conjunction with mass balance equation for sediments using finite-volume approximations. Sediment transport and bed level variation were numerically simulated with available bed load transport empirical equations. The maximum local scouring depth, the shape and the area of the local scour hole, downstream from the structure, under clear-water scour conditions, were numerically simulated. Validation of the numerical procedure was applied with available experimental measurements of scour depth variation for different inflow hydrodynamic conditions. Calibration of the applied computational methodology was performed by investigating the appropriate turbulence model and sediment transport parameters. Numerical simulation results of bed level variation downstream of a sharp-crested weir, for different inflow discharges, are adequately compared with experimental data. The comparisons demonstrate the performance of the 3D CFD model in estimating bed level profiles in natural rivers and the proposed numerical procedure results to a substantial methodology for rivers' environmental management.

**Keywords:** 3D turbulent flow, local scour, sharp-crested weir

# Monitoring field campaign in two torrent basins in Eastern Macedonia and Thrace Region

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**Abstract**

The current study takes place within the framework of the "Eye4Water" research project, which aims to enhance water management in Eastern Macedonia and Thrace. During the research project, which will last for approximately 30 months, the water quality of two torrents in the region will be monitored. The two torrents' basins were chosen due to their vulnerability to impairment by substances from point and non-point source pollution. The monitoring scheme involves twelve stations in the Lissos torrent basin and eight stations in the Laspias torrent basin respectively, placed in strategic positions due to their proximity with all sort of human-posed pressures. Specifically, physicochemical properties were measured in-situ (EC, DO, TDS, pH, temperature and salinity), while water samples were collected and transferred to the laboratory for the determination of common pollutants, e.g., organic matter (BOD5 and COD), orthophosphates (OP), total suspended solids (TSS). In this paper, some first results revealing the status during warm, low flow period, are presented in order to extract some conclusions and form an initial assessment of the torrents' water quality. Even though the present paper presents results from the first monitoring campaign, it is obvious that Laspias torrent presents higher pollutant concentrations than Lissos torrent, which can be associated with the variety of point-source pollution (i.e. wastewater treatment plant, landfill animal stock farms), which are located in Laspias watershed.

**Keywords:** water management, monitoring, water quality, pollutants

# Fragmented urban streams: the case of dendropotamos, Thessaloniki, Greece

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**Abstract**

Today, many urban streams are under continuous pressure from human activities which take place in the adjacent built environment. These pressures are related to the change in the quality of the water, the alterations in the geometrical characteristics of the riverbed and the drainage capacity of the stream, while the biodiversity of these open pipelines is also affected. Streams in cities, besides their hydraulic role, may also serve other purposes to benefit the citizens living in nearby neighborhoods. In recent decades, an effort has been made to redefine the role of streams and to reintegrate them into the life of modern cities. The stream of Dendropotamos in the city of Thessaloniki, Greece, is a typical example of a degraded rainwater drainage system, partly converted to closed conduit. However, today the only function it performs is that of the drainage of rainwater, both from its mountainous hydraulic basin and from adjacent urban areas. The part of the stream that passes through a densely built area of Thessaloniki is the most degraded.

In this paper, we present the factors, which have affected and significantly degraded the stream of Dendropotamos. Moreover, we present indicative field measurements regarding the water quality, the geometric characteristics of the stream bed at selected points, as well as of the flow rate close to the stream outlet to the gulf of Thermaikos. In addition, emphasis is placed on the accessibility of the stream and its interaction with the surrounding area, which has also been significantly affected by the continuous degradation of the stream area.

**Keywords:** urban stream, urban area, Dendropotamos, rain water

# Simulation of open channel flow control by Smoothed Particle Hydrodynamics

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**Abstract**

Computer aided design of water-resources projects and flow control hydraulic structures has advanced rapidly in recent years. As a result, there is a demand for effective and computationally efficient simulation methods. Conventional computational methods provide results of acceptable accuracy regarding man-made open channel and river flows. However, for problems with large deformations, conventional numerical tools may face difficulties. To overcome such obstacles, the Smoothed Particle Hydrodynamics (SPH) method is utilized. SPH is a mesh-free method, in which the information associated with the governing partial differential equations (PDEs) is related to "particles" which are used as nodes for solving them. In this work, we investigate the performance of the SPH method by simulating cases of free surface flows in channels with control structures. We study flow systems that include sluice gates and weirs, used in real-life cases for flow control. Emphasis is given to the flow conditions after the sluice gate, hydraulic jump formation and the effectiveness of the flow control, which is the main function of such structures. To verify the accuracy of the simulations and to determine the pros and cons of the SPH method, the calculated results are analyzed and compared with theoretical predictions derived from one-dimensional analysis of the hydraulic jump as well as other algebraic equations retrieved from the scientific literature. This study demonstrates the developed SPH model's utility as a tool for selecting the placement and the operation of hydraulic structures.

**Keywords:** open channel hydraulics, flow control, hydraulic jump, Smoothed Particle Hydrodynamics (SPH).

# C.2 SUSTAINABLE ARCHITECTURE, PLANNING AND DEVELOPMENT

# Green-Connect: an AI-enhanced digital platform to identify and match sustainability projects to funding sources

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**Abstract**

As the transition to a circular economy gains steam, a significant constraint emerges that needs to be addressed. Simply stated, there is no systematic method currently available in the marketplace that automatically connects, in a broad stroke, funding sources and instruments to the best sustainability ideas and projects and vice-versa. The financial industry has failed thus far to produce such platform. The availability of a sophisticated tool, like the one described in this paper, decreases the risk of mismatches and misfires which often result in waste of time, money, and failure to come up with viable solutions. The Green-Connect digital platform uses advanced AI and machine learning techniques such as Natural Language Processing (NLP) for data acquisition and manipulation to provide two critical capabilities. First, it identifies potential sustainability projects by automatically reading text documents on digital media and harvesting relevant data and information across various sustainability domains. Second, it matches prospective projects to user-defined benchmarks and ranks the matches based on pre-defined metrics. In this paper we discuss the architecture and theoretical basis of the Green-Connect platform, the development of a prototype and the results of proof-of-concept applications of the platform.

**Keywords:** sustainability, natural language processing, financing, artificial intelligence

# Audit of forest road-pavement wear using unmanned aircraft and low-cost techniques

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**Abstract**

The road network and its proper maintenance is a crucial part of the protection and sustainable management of forest areas. Road damages often cut off the accessibility of forest areas and therefore it is necessary to repair them immediately, especially before the fire season or the logging period. Auditing road maintenance is a work of the forest services, sometimes it performed by contractors' require validation upon completion. The objectives of this study is to apply an auditing method of forest road pavement wear using low-cost unmanned aerial vehicle (UAVs) in order to extract their geometric features and capture the damages of the road surface. The ability of UAV technology to auditing road wearing having a neutral ecological footprint and as a low cost method is under consideration. The UAV was used to observe a part of the forest road network at University Forest of Taxiarchis in Chalkidiki, Greece. Flights with UAV were carried in order to export orthophoto maps, Thereupon, the forest roads were digitized, and the damages were recorded. Field measurements using conventional methods were applied in order to validate the work that have been done by UAV and foresters. The data analyzed by using ArcGIS and AutoCAD and produced an accurate images data of the UAV whenever to get the percentage of the difference for several wearing features of the road. Comparisons were made between two ways of collecting data (UAV and forest service personnel on field work). Results from the study showed that the covered area by UAV is almost double than the one that covered by foresters in the same timetable. Using UAV as a validation work led us to total saving on auditing road wear costs which can save even the one third of the total cost since it has a neutral ecological footprint once it's not polluting the forest area.

**Keywords:** forest road, audit road wear, unnamed aerial vehicle (UAV), validation, geospatial

# A computer-based model for the design and assessment of stormwater Best Management Practices in existing urban blocks in Greece

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Ioannis Sibetheros, Professor, Katherine Liapi, Professor,



**Abstract**
The shift towards Water Sensitive Urban Design (WSUD) has become a necessity for many cities, including Greek cities, which are still using conventional rainwater management and are adversely affected by extreme rainfall episodes or persistent heatwaves which exacerbate the heat island effect.

In Greece, despite the efforts by individual researchers, the implementation of WSUD is limited and it is not a priority in the design process. However, urban blocks in Greece, due to their characteristics, could become good examples of stormwater Best Management Practices (BMPs) retrofit: they could benefit from the runoff mitigation as well as through the evaporative cooling during summer periods that stormwater BMPs offer.

In this paper, an "architect-friendly" computer-based model developed by the authors is presented, which facilitates the design, implementation and assessment of BMPs in existing urban blocks in Greece. The model serves as a decision support tool, which allows a quantitative comparison of conventional and non-conventional stormwater management strategies in an urban environment, by simulating stormwater runoff volumes and temperature decrease in both cases. Visualization of the results in the graphical interface of the Grasshopper programming environment facilitates the study of the environmental impact of stormwater BMPs and the comparison of different stormwater management scenarios. It provides a structure in the sustainability assessment process, which allows for the examination of the components and interactions within a stormwater management scenario, and enhances communication among architects and other engineers. An overview of the structure and features of the developed model will be presented, while reference will be made to the required dataset (climate data, wind flow simulation data, urban block as-built geometric data including roof, facade, inner block void ground surface areas), the methods that were used for runoff estimation, as well as to the library of BMPs that have been integrated into the model.

**Keywords:** Water Sensitive Urban Design, urban blocks, stormwater best management practices, runoff mitigation, evaporative cooling, decision support tool.

# Air pollution in a school environment under varuing covid-19 related operational conditions

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**Abstract**

Indoor air quality in schools is an important factor of the overall quality of a school environment. It is influenced by several parameters like the overall number of students, the dimensions of the school class, ventilation and air purifier facilities, in-class materials etc., and may influence educational performance and health status for both pupils and teachers. In the current study seven low-cost air quality sensors have been installed in school classes at the Experimental School of the University of Thessaloniki, setting up an internet of things sensor network providing PM10, PM2.5 and CO2 readings continuously. Live data streams are visualized via Grafana to directly reflect air quality in classrooms. In addition, a calendar of hand-recorded activities, via a Citizen Science approach, provides additional information like the opening of windows, use of air purifier, in-class mobility and student activities. The study of both environmental and activity logs provides a unique insight for the development and correlation of air quality in the classrooms with the varying operational conditions of the school community. Moreover, it allows to estimate ventilation performance and therefore indicate whether relevant measures may help in the management of problems like the COVID-19 pandemic and student fatigue.

**Keywords:** indoor air quality, school operational conditions, in-class ventilation

# Spatial changes following forest fire can be point out as a climate change indicator

**A. Stergiadou***, **G. Kolkos**, **A. Kantartzis**, **S. Tampekis and A. Stergioudis**

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**Abstract**

This study aimed at locally investigating the temporal evolution of agroforestry fires and creating hazard charts to prevent and suppress future fires. This work deals with a sensitive problem that mainly afflicts the country but also all other countries that have a similar climate and vegetation with Greece mainly during the summer months and not only the forest fires. We must protect the forest because it is an ecosystem that promotes our living and socioeconomic status, in addition to the valuable lungs of life and as climate stabilization. Purpose of this research is to utilize Forest Cadastre data that can signal spatial changes after a fire and how that can be pointing out as a climate change indicator. Land use over time is shaped by the pressure of anthropogenic activities, especially when adjacent to urban and tourist centers. The historical development of the national cadastre is reported, the contribution of forest maps to the cadastre and the protection of forest wealth is analyzed. The ownership status and land uses in combination with forest fires, as well as the conflicts that arise after them is recorded. The analysis of the causes of land use change in forest areas and to the contribution of remote sensing and GIS in land use coverage. Specifically, there is a report on the creation of land use maps carried out by the process of photo interpretation with ArcGIS software and the results obtained from the contribution of forest maps to the Forest Land Registry are presented in conjunction with the analysis of land use causes. The resulting conclusions are presented as well as proposals for which will contribute catalytically to the solution of the problems that plague the forest area, giving the opportunity to become a source of balance and not a probable indicator of climate change.

**Keywords:** spatial planning, forest Fires, climate change, forest map, Geographical Information Systems

# Expo grounds in sustainable design and planning. The international experience and Thessaloniki' s perspective



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**Abstract**

The paper focuses on expo grounds projects and their contribution to the sustainability of the urban, suburban or natural environment with a resilient perspective in architecture, planning and development. The multidimensional socio-ecological and perceptual approach of landscape architecture is applied in a related PhD research, according to which the concept of sustainability, as the ability to last in time, promotes a resilient and adaptable framework in progress related to the landscape dynamics, physical and cultural ones, and space capability.

Expos are mega-events of certain duration that their implementation initiates large-scale transformations in the host cities or their wider environment. They are directly related to the evolution, history and development of the place in each era, which affect and are influenced by all social, economic, physical and cultural conditions. They involve multiple temporalities, they are perceived as spaces dynamically changing in time: before, during and after the exhibition. As expo grounds we refer to spaces that host an expo and are designed in the urban, suburban or natural environment, always in relation to an urban center. International expo ground design practices are presented that conform with a sustainable perspective both in terms of the spatial footprint of the project, the selection of the appropriate site, the spatial organization, the ecological and social dimension in the design, the impact and the perspective it offers to the place.

The case study of Thessaloniki International Fair is, as above, critically presented. We differently support the project for the city's and its larger area sustainable perspective. We presume further development, both with the creation of the urban metropolitan green and cultural area in the center of the town, as needed and programmed through the town history, and also the emergence of the rich natural suburban areas of the western region.

**Keywords:** Expo grounds; urban design/planning; landscape architecture; sustainability.

# A.3 LONG-TERM ENVIRONMENTAL MONITORING AND ECOSYSTEM RESEARCH 1/2

# Long-Term Ecosystem Research networking in Greece

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**Abstract**

Systematic monitoring of environmental variables at the field and holistic environmental management are key prerequisites to rational sustainable development. This is a task carried out by a synergetic grid of scientists and stakeholders engaged in the long-term environmental, ecological, and socio-economic research in Greece, through dedicated observatories spread across the country. Established in October 2016, the Hellenic Long-Term Ecosystem Research network (LTER-Greece), is the national chapter of the European LTER Europe, and the global network family (ILTER), that counts over 700 members. Currently, the 9 observatories of the network are self-funded through service provision and elaboration of R&D projects where they facilitate piloting needs, supported by the production of high-frequency and long-term biotic and abiotic measurements. The observatories of the network focus on the holistic study of the environment-ecosystem-food-society-energy NEXUS in addressing challenges on climate change, biodiversity loss, pollution, non-sustainable management of soil and water resources, in Greece, in Europe and globally. The network endorses collaborative action and interlinkage of monitoring stations and data bases. It interconnects to the European Strategy Forum on Research Infrastructures (ESFRI) through participation to two emblematic 2020 e-LTER projects that target at the foundation of the official European network of long-term ecological monitoring.

LTER-Greece envisages contributing to the improvement of all citizens' quality of life via the long-term and large-scale research that targets at the conservation, upgrading and sustainable use of ecosystems and their services; Its mission is to offer the community, reliable scientific information and prognostic understanding of the environmental, ecological and socio-economic processes and procedures. Our ambition is to offer services to the State, the stakeholders and the society, and to address the contemporary environmental challenges through a holistic NEXUS approach.

LTER-Greece is soon to become 6 years old. Despite its young age it has succeeded expanding, developing sound foundations, establishing complementarities and interlinkages amongst its members and formulating collaborations. Through its compiled roadmap that shapes its identity and scope, it heads its pathway, already serving the society providing scientifically sound and solid solutions to the real world.
**Keywords:** LTER, monitoring, NEXUS, environment, biotics, abiotics

# The LTER-GR monitoring site in Sani, Chalkidiki: Energy fluxes and gross primary productivity of an Aleppo pine ecosystem.

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**Abstract**
The assessment of forest ecosystems' climate change adaptation and mitigation potential requires long-term monitoring of their carbon and water dynamics, in combination with climate data. Within the eastern Mediterranean region, which is predicted to be heavily impacted by climate change, Aleppo pine ecosystems are widely distributed. In this context, a monitoring site has been established in an Aleppo pine ecosystem in Sani, Chalkidiki, Greece, comprising long-term records of ecosystem $CO_2$, $H_2O$ and energy fluxes with the use of the eddy covariance technique, sap flux densities, meteorological and ecophysiological parameters and remote sensing. In this study we assessed the seasonal fluctuation of ecosystem energy fluxes and gross primary productivity for a two-year period (10/2015 – 10/2017), along with the variation of meteorological parameters and satellite spectral indices and highlighted the optimal and limiting periods of the ecosystem's performance. We also checked the suitability of a satellite gross primary productivity model by comparing its results to the eddy covariance measurements. According to our findings, the optimal period for the fluxes was during spring, while there were some limitations during the summer and winter periods. The model performance is quite sufficient, compared to the eddy covariance measurements, providing a potential for further applications in similar ecosystems in the Mediterranean region.
**Keywords:** LTER-GR, Aleppo pine, long-term monitoring, eddy covariance, GPP, energy fluxes

# Long-term atmospheric research in eastern Mediterranean-The Finokalia observatory

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**Abstract**

The Finokalia environmental research station (35° 20'N, 25° 40'E) is located on the north coast of Crete island (http://finokalia.chemistry.uoc.gr/). The station was established in 1993 and since its launch provides continuously high-quality data for a wide variety of atmospheric research topics. Finokalia is considered representative of maritime background conditions of the eastern Mediterranean as has been extensively documented in the literature. Air masses influenced by human activities and natural processes contribute to the pollutant burdens; anthropogenic pollutants from the industrialized continental Europe and the densely urbanized coastline, desert dust from northern Africa and the Middle East, biomass burning from combustion sources and wild fires and marine emissions, mix under the influence of intent insolation. Finokalia's strategic location at the crossroads of pollutants in the eastern Mediterranean, an area most vulnerable to climate change, makes the observatory an ideal natural laboratory for monitoring climatic perturbations and atmospheric processes in a varying time scale from seconds to decades.

Greenhouse gases concentrations at Finokalia present the same trend as in the Atlantic or the Pacific Ocean for northern hemisphere. The CO2 concentration increasing trend leading to global warming is well captured in the Mediterranean. The long-term operation of the Finokalia station also provides valuable feedback regarding effectiveness of environmental policies regarding air quality and socioeconomic changes impact on the environment. Sulphate concentrations of aerosol particles at Finokalia present two declining periods, reflecting the desulfurization legislation that took effect in 1993 and more recently the economic crisis in Greece and Europe. This decrease in sulphate content affected the acidity of the rainwater, shifting rain pH to higher values. Long-term observations of atmospheric constituents can therefore provide crucial information about the impact of human activities and the effect of environmental protection policies on the atmospheric environment and the climate.

**Keywords:** Atmosphere, Mediterranean, climate change, air quality, Finokalia, aerosols, greenhouse gases

# Learning and action alliances towards the development of nexus based solutions in pinios river basin, Greece: preliminary results

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**Abstract**

Pinios River Basin (PRB) in Central Greece constitutes one of the most productive basins of Greece which, however, encounters several sectoral problems, including water resources depletion and quality degradation, increased energy costs for pumping and nitrate pollution. The non-sustainable natural resources management of the PRB highly prioritize the need for establishing a participatory Nexus-based framework aiming at thoroughly understanding the interrelations between Water-Energy-Food-Climate (WEFC). To achieve this task, the Learning and Action Alliances (LAA) concept is implemented. The aim of the current research is to present the results of the LAA kick-off activities carried out in PRB in the framework of H2020 REXUS project, to identify and investigate the sectoral problems faced and the cross-sectoral interdependencies and conflicts sensed, with the participation of stakeholders covering a wide range of Nexus sectors.

**Keywords:** Learning and Action Alliances, Nexus; Pinios river basin, round-tables, stakeholder mapping; WEFC

# B.3 ENVIRONMENTAL FLUID MECHANICS, ENVIRONMENTAL IMPACT ASSESSMENT AND RISK ANALYSIS, ENVIRONMENTAL INFORMATICS, WATER RESOURCES MANAGEMENT AND CONTAMINATION CONTROL, ENVIRONMENTAL STATISTICS

# Can Environment be damaged by partally working industrial or chemical sites? Case Study: LNG bunkering at a port

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**Abstract**

Modern societal demands for environmental protection have imposed many industries to adopt more environmentally friendly fuels. Liquefied natural gas (LNG) has the potential to replace traditional marine fuels (at least in the short-medium future) and is hence considered as an alternative fuel for the future in the shipping industry. Despite of the benefits LNG offers, it also poses significant hazards to people and assets, in the unlikely event of its release to the environment. This is particularly interesting in the case of a partially (intermittently) working industrial site, such as an LNG bunkering site, where the flow of LNG between the two entities (installation–ship) is not a constant procedure. In this paper, some accident scenarios for ship to ship LNG bunkering are highlighted by exploiting the results of the project "Risk management system for design and operation of installations for LNG refueling" (TRiTON) financed by the Greek government, and the "Sustainability Performance of LNG-based maritime mobility – Plus" (SUPER-LNG Plus) financed by Interreg-Adrion.

**Keywords:** LNG, bunkering, ports, safety, environmental impact

# Assessment of flood hazard at a regional scale based on the couple between DEMATEL and GIS

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**Abstract**

The aim of this research study is to generate Flood hazard, based on a rather qualitative information about the connection among the several factors, that influence the floods. Geographical Information System (GIS) is integrated with Multicriteria Decision Analysis (MCDA) to assess the flood hazard spatially. More specifically, the Decision-Making Trial with the aim of the Evaluation Laboratory (DEMATEL) technique is used to evaluate the inter-relationships among the causes and effects, in order to determine the weights of each factor. Finally, the flood hazard index (FHI) is determined based on an aggregation process among the seven examined factors, namely, flow accumulation, rainfall intensity, distance from the river network, elevation, land use, surface slope, and geology. The initial information is based on the relation between cause and effects with a rather qualitative form. The weights are produced based on the idea of adjacency matrix and total influence matrix (which is an integration of the idea of connectivity), which covers direct and indirect influences. These ideas are included within the DEMATEL technique. The thematic maps of these factors are prepared using ArcMap. By giving weights and dividing them based on the natural breaks (jenks) method into 5 categories, the final hazard map is created showing the total areas subjected to the hazards, as very low, low, medium, high and very high risk zones. Therefore, the hazard zones map of Kosynthos river basin, Greece is produced.

**Keywords:** GIS analysis, DEMATEL, multicriteria, flood hazards, flood prone areas

# Analysis of regional precipitation measurements: The Peloponnese and the Ionian islands case

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**Abstract**

In the present paper a two level clustering approach for time series with a common period for seasonality that may although differ in length or/and contain missing values is proposed. The method is initially briefly discussed and then applied in precipitation time series data from automated weather station across the Peloponnese and the Ionian islands, Greece. Initially, the available precipitation time series are grouped according to their monthly seasonality indices using the principal component analysis and the kmeans algorithm (first level clustering). Then, for each first level cluster, a time series hierarchical clustering using the dynamic time warping method is applied to identify homogeneous regions (second level clustering). The missing values (in the second level clustering) are handled using the seasonally splitted missing value imputation algorithm. The proposed method identifies four large homogeneous regions with common characteristics in the Peloponnese and the Ionian islands.

**Keywords:** hierarchical clustering, imputation, kmeans, seasonality, Thiessen Polygons

# Combining artificial neural networks with knowledge-based numerical modeling and experiments on bubble column reactors to optimize ozonation of oil-drilling cuttings

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**Abstract**

Artificial neural networks (ANN) are currently one of the most important supervised machine learning methods, characterized by the presence of labels (i.e., target values) that can be either numerical data or categorical data. As an effective tool to perform nonlinear input-output mapping, ANN have been used extensively in chemical engineering for various applications such as adaptive control, model-based control, process monitoring, fault detection, dynamic modeling and parameter estimation. Although there are several architectures of neural networks available the feed-forward multilayer perceptron (MLP) ANNs trained with backpropagation algorithm (BP) are consider among the most commonly used networks. The MLP-BP ANNs with only one hidden layer have been reported as universal approximators of any non-linear function and can be sufficient for most important application. In the present study, a feed-forward multilayer perceptron (MLP) ANN trained with backpropagation algorithm (BP) is used to determine the kinetic parameters governing the performance of the oil-drilling cuttings (ODC) ozonation. Ozonation tests of ODC, pre-treated with surfactant (SDS) and diluted with synthetic seawater, are performed on semi-batch bubble flow reactors. The total organic carbon (TOC) is measured with a total carbon analyzer. A dynamic mathematical model is developed to describe the ODC ozonation by combining transport with reactive processes, and minimizing the number of unknown parameters. Numerical simulations for various values of dimensionless parameters generate the datasets that are then employed for the training and validation of the neural network. The trained neural network is then exploited for as an optimization tool for optimal parameter estimation from experimental data of ODC ozonation.

**Keywords:** Artificial Neural Network, numerical simulation, ozonation, parameter estimation

**Acknowledgments:** This research has been co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE (project code: $T2E\Delta K-01447$; project title: "Development of a mobile ozonation unit for the remediation of polluted soils and oil-drilling cuttings").

# Effect of escaping mass coefficient on mean flow and mixing of a round negatively buoyant jet with 30° exit inclination in uniform surroundings

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**Abstract**

This paper uses the integral model, named escaping mass approach (EMA), and predicts several characteristic magnitudes of a turbulent round negatively buoyant jet discharged in a stagnant and uniform surroundings, for 30° exit angle of inclination and Froude number range (4-100), examining the two alternatives: (1) Original EMA with escaping mass coefficient $\Lambda = 0.27$ along all centerline distance; and (2) modified mode of EMA, that $\Lambda$ is assigned to zero in the region after the maximum rise height of the jet centerline. It was found that the predictions of the two alternatives for all magnitudes (vertical and horizontal distances of critical points of the centerline and external convex boundary, as well as bulk dilutions) are practically identical and in very good agreement with the experimental data available in the literature. Consequently, using original EMA is the best practice.

**Keywords:** Escaping mass approach, integral model, maximum rise height, terminal height, return point, dilution

# Viscosity variations of each liquid phase in a three-component cosolvent-NAPL-water system

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**Abstract**

This study investigates the variations of dynamic viscosity of each liquid phase in a two-phase, three-component system comprising a cosolvent, nonaqueous phase liquid (NAPL), and water. The cosolvent selected is isopropanol, and the NAPL is hexane. The experiment starts by mixing a known quantity of isopropanol and hexane in the absence of water, which results in a single-phase mixture. The viscosity value of the solution is then determined. The single-phase experiment repeats with increasing water content until the mixture partitions into a two-phase liquid-liquid system. The viscosity values are then determined for each liquid phase. The two-phase experiment repeats by adding an incremental amount of water until the total water content is near 100%. Determining the viscosity of each liquid phase is not trivial, as each value must be determined while the two liquid phases are in contact and at equilibrium. A commercially available falling-ball viscometer is modified to determine the viscosity of each liquid phase. Results show varying viscosity differences between the two liquid phases at different total water contents. Furthermore, the aqueous phase viscosity can be higher than the range of values set between the three individual components of the mixture.

**Keywords:** groundwater contaminationl hexane, isopropanol, viscosity

# C.3 CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

# Thermal history of a Greek city using Google Earth Engine Imagery

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**Abstract**

Urban Heat Islands (UHI) is among the urban climatology phenomena resulting mainly by the incised population density and the land use/land cover changes inside the boundaries of modern cities. UHIs have permanent thermal occurrence, they are present during all year periods, they act in accumulation with the results of the climate change and their magnitude varies according to the intensity of the urban population activity. In the present study, the UHI evolution of middle size Greek city is presented, using Google Earth Engine as the main analysis platform for the estimation of the phenomenon's spanning area and magnitude during time.

**Keywords:** UHI, rban Heat Islands, Google Earth Engine, remote sensing, urban climatology

# "Green" roof infrastructure can be an adaptation measurement or an inhibitory factor in climate change

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**Abstract**

In the beginning of 21st century, the rapid change of climate by human activities, North Pole movement, earthquakes and other phenomena, lead the scientists to measure every way of human living by using the ecological Footprint. The householders nowadays asked to build a "green house" and part of that action is the reformation of old housing blocks using roof gardens, or wall gardens. Aim of this paper is to describe application of a green roof in a newly built building. The owner of this apartment agreed to measure indicators of: temperature inside and outside the residence walls, humidity, shading, minimizing of rainwater runoff, attenuate noise and a filling of "pure" air. Green roof infrastructure research base on in-situ monitoring to provide rainwater retention, mitigation of urban heat island (UHI) effect, reduction of air pollution, passive energy saving and maybe change local biodiversity. As it proofed by the experiment, even a roof garden of small-scale can mitigate the environment and can be an inhibitory factor in climate change of a city. A small garden on a top of a building can decrease the UHI. The results found that there is a varied effectiveness in ameliorating climate extremes present in the host continents. To have greater impact on climate challenges, whether UHI, pollution, noise or rainwater related, roof garden designers and constructors must study the local climatic conditions and flora. This paper can inspire decision and policymakers regarding the bioclimatic design urban landscape using "green" aesthetics. Comparisons with similar applications in the wider area but also in similar residential cases have led us that the type of garden plays an important role whether it is intensive or extensive. The construction of a suitable garden based on the bio-climatic design and the type of intervention we want to do in a building, leads to a milder or more intense contribution to the differentiation of the micro-climate of the area.

**Keywords:** bioclimatic constructions, green roof infrastructure, climate change, urban landscape, urban heat island (UHI)

# Climate change and transport

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**Abstract**

Transport is an important carbon dioxide emitter accounting for around 1/3 of total CO2 emissions around the world. Thus, a principal target is to reduce CO2 emissions caused by all transport modes. However, it goes without saying that not all transport modes are responsible for the same rates of $CO_2$ emissions by passenger-kilometer. On the other hand, mobility and accessibility are essential factors for economic growth. In the present paper, it is analyzed how regulatory, financial and societal measures can contribute to a shift from more polluting modes to less polluting ones, so as to ascertain sustainable mobility for future generations, while, at the same time, ensuring constant economic growth.

**Keywords:** transport, climate change, carbon dioxide emissions, sustainability, modal shift

# Mitigation and adaptation to climate change through sustainable architectural design and water management

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**Abstract**

This paper focuses on enforcing the principles of mitigation and adaptation to climate change, in an "eco-friendly" private residence in a suburb of Thessaloniki, Greece. These two approaches to climate change are applied through energy efficient and bioclimatic design and water usage optimization for secondary use. The building is constructed using the basic bioclimatic principles which include the orientation of the building and the placement of the windows it includes. Through these, we have accomplished both accessible sunlight and protection from frequent winds during the winter, while during the summer, the living spaces are protected from intense sunlight and cool air can be exploited. Also, as part of the bioclimatic design, part of the building will be below ground level while a planted roof will be installed as a continuum of the planted site, creating more favorable conditions inside and outside the house. In addition, required national energy efficiency regulations and the relevant legislations enforced in Greece have been taken into consideration for the building's design. Furthermore, the rest of the site will consist of a large area of rain gardens that will host horticultural species. Maintenance of the rain gardens will be achieved by using retained rainwater, as well as water from the primary wastewater treatment and, if needed, from the water supply network.

By incorporating these practices into the building, both mitigation and adaptation to climate change are achieved. Through the bioclimatic architectural design and adaption of the building energy performance legislation, significant energy savings are predicted, contributing to the mitigation of the phenomenon. On the contrary, the rain gardens are classified as adaptation measures to climate change due to the reduction of the flooding risk and the efficiency of water usage they offer.

**Keywords:** bioclimatic design, planted roof, rain gardens, sustainable design

# Urban resilience and sustainability:a social research in Thessaloniki

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**Abstract**

This paper presents the results of a social survey conducted in the metropolitan Thessaloniki area, in order to investigate the views of the residents on issues related to the urban environment, climate change, energy crisis and extreme phenomena at three levels: at their home, at their Neighborhood and at their City in general.

At the UN General Assembly in 2015, all member states agreed on seventeen Sustainable Development Goals, eleven of which refer to the pursuit of Sustainable Cities.

If cities are responsible for 70% of energy consumption and 75% of greenhouse gas emissions, but at the same time there are problems with adequate, safe and affordable housing as well as services and necessary facilities, it becomes necessary and imperative to make cities Sustainable and resilient, both for the present and for the challenges of the future.

Although the recent COP26 pointed out the problems of disagreement on common goals by all the countries, the messages that were heard very loudly, made it clear that there is not much wiggle room left - from the high government policy makers all the way down to us, the plain citizens.

The conjecture of the effects of climate change, the energy crisis (which results in a direct economic crisis for the people) and the consequences of the Covid-19 pandemic, create a special reference point from which to explore the views of residents in relation to the present and the future of the urban environment.

The research was conducted from October 2021 to January 2022, and one thousand seventy two (1072) questionnaires were collected, which covered the entire area of metropolitan Thessaloniki.

(Important note: The research was conducted during the period of measures against the Covid-19 pandemic as well as during increased energy costs and some extreme phenomena).

**Keywords:** sustainability, urban environment, climate change, energy crisis, Thessaloniki

# $CO_2$ mineralization: Studying the effect of enzymes and microorganisms

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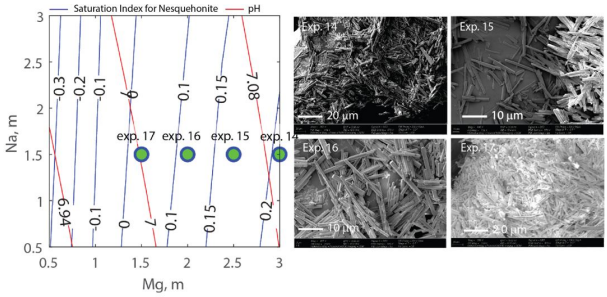
**Abstract**
Carbon dioxide ($CO_2$) mineralization is a carbon storage technology where carbon is bound in thermodynamically stable minerals through an above-ground process. CO2 mineralization has the potential for permanent carbon sequestration at the scale of megatons per year [1, 2, 3]. In comparison to the emerging alternative options of subsurface storage and in situ mineralization [4, 5], it has the advantage to be an above-ground technology that can be monitored and controlled [6, 7]. However, one of the drawbacks is the required high temperature and pressure to complete the reactions within feasible time frames. Therefore, it is envisaged to identify solutions that help lowering the thermodynamic conditions.

Here, we present experimental results from a study on carbonate precipitation in the presence of a enzyme, carbonic anydrase (CA) added directly and through freshwater microalgae, namely, Scenedesmus obliquus and Chlorella vulgaris. Experiments were run using a continuously stirred batch reactor at 25 and 40 °C and at 0.1 and 1 bar of $P_{CO_2}$. Precipitation was performed using the $Mg - Na - Cl$ $CO_2$ aqueous system supersaturated with respect to nesquehonite ($MgCO_3 - 3H_2O$), hydro- magnesite ($M_{g5}(CO_3)_4(OH)_2 - 4H_2O$), and magnesite ($MgCO_3$). The tests were monitored continuously with pressure and temperature probes and the precipitates characterized offline upon washing and separation from the bio-additives. SEM-EDS images show high-purity products and suggest that at given thermodynamic conditions the addition of CA directly or through microalgae allows precipitation and favors the formation of the more stable crystal phase. The figure shows the composition diagram to design the experiments run using S. obliquus at 25 °C and 0.1 bar of $P_{CO_2}$. In all tests $MgCO_3 - 3H_2O$ formed in few minutes. XRD spectra confirm the crystallinity of the carbonates and their stability over time, opening the possibility for their reuse.




**Keywords:** carbon dioxide (CO2), mineralization, carbonates, precipitation

**References**


1. Kirchofer, A., Brandt, A., Krevor, S., Prigiobbe, V., Wilcox, J., "Impact of alkalinity sources on the life-cycle energy efficiency of mineral carbonation for CO2 storage," vol. 5, no. 9, pp. 8631-8641, 2012.

2. Matter, J.M., and Kelemen, P.B., "Permanent storage of carbon dioxide in geological reservoirs by mineral carbonation," Nature Geoscience, vol. 2, p. 837–841, 2009.

3. Sanna, A., Uibu, M., Carmanna, G., Kuusik, R., Maroto-Valer, M.M.„ "A review of mineral carbonation technologies to sequester CO2," Chem Soc Rev, vol. 43, pp. 8049-8080, 2014.

4. IPCC , "Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change," Cambridge Univ. Press, 2005.

5. S. K. White, F. A. Spane, H. T. Schaef, Q. R. S. Miller, M. D. White, J. A. Horner, and B. P. McGrail , "Quantification of CO2 Mineralization at the Wallula Basalt Pilot Project," Environ. Sci. Technol., vol. 54, no. 22, pp. 14609-14616, 2020.

6. S. Krevor, C. Graves, B. Van Gosen, and A. McCarty, "Mapping the mineral resource base for mineral carbon-dioxide sequestration in the conterminous United States: U.S. geological survey digital data series 414, 14 p., 1 plate. 2009.," U.S.G.S., 2009.

7 M. Blondes, M. Merrill, S. Anderson, and C. DeVera, "Carbon dioxide mineralization feasibility in the United States: U.S. geological survey scientific investigations report 2018–5079, 29 p.," U.S.G.S., 2019.

# A.4 LONG-TERM ENVIRONMENTAL MONITORING AND ECOSYSTEM RESEARCH 2/2

# Assessment of microbiological quality of Lissos river, Thrace, Greece

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**Abstract**

Lissos is the Greek ancient name of the river, crossing Rhodope valley in Thrace, Greece. A special feature of Lissos River is that numerous tributaries and streams contribute to the flow of the main river. However, a limited number of studies have been performed until now, focusing mainly on the monitoring of the physicochemical traits of the river quality. On the other hand, microbiological data is restricted to the measurement of conventional indicators, using cultured-dependent techniques. Moreover, no investigation of microbial diversity has been carried out by employing cultured-independent approaches. In this work, the microbiological quality of Lissos River was assessed by performing periodic samplings at key stations of the river, covering their major tributaries and streams. Both surface water and sediment samples were obtained from the selected sampling points and were further analyzed through the implementation of both conventional and next-generation sequencing techniques. This is the first attempt to elucidate the ecological status of a key river of the Thracian valley using advanced microbiological techniques.

**Keywords:** Lissos River, aquatic ecosystem, sediment, microbial diversity, diversity indices

# Reviewing environmental conditions of a minimally disturbed Aegean island – Samothraki, Greece

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**Abstract**

We present a review of our research on Samothraki, one of the last minimally disturbed islands in the Mediterranean, carried out during the past some 20 years focusing on aquatic (hydrology, hydro-morphology, hydro-geochemistry and ecology) and terrestrial ecosystems (vegetation cover and soil erosion). Compared to other Aegean islands, Samothraki presents an exceptional richness in water resources with numerous springs and many streams showing a perennial regime, despite sparse rainfalls in summer and restricted groundwater aquifers. Fog condensation on the mountainous relief may contribute to freshwater resources of the island. Related research is being currently carried out. Spring and stream waters reveal exceptionally low solute concentrations as a result of weathering resistant magmatic bedrock, flashy surface flow, and low ground water residence times. Steep morphology, combined to overgrazing result in high erosion rates. The latter cause forests to be currently classified as of high regeneration priority. As a result of restricted fractured-type groundwater aquifers, overland flow predominates initiating disastrous flash floods. Aquatic quality is high and nutrient levels are consistent with the undisturbed conditions, despite the occurrence of relative high nitrate concentrations, most probably, as a result of atmospheric impact. Related research is ongoing. Stream biological assessment, using benthic fauna, ranged from moderate and poor (in two streams receiving untreated municipal waste waters) to high, with the 70% of the river sites ranked as good and high, while, based on diatoms, it ranged from good to high. Recently, the Samothraki Nature Observatory (founded between HCMR and the Municipality) became a member of the Long-Term Ecological Research Network site (LTER-Greece), whereas the island is a UNESCO's World Network of Biosphere Reserves candidate.

**Keywords:** Samothraki, hydrology, hydro-geochemistry, ecological quality, erosion, LTER, UNESCO Biosphere Reserve

# Establishment of irrigation scheduling services in the Pinios hydrologic observatory

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**Abstract**

Irrigation scheduling support tools can relieve the intense pressure exerted by irrigation on available freshwater resources. In this context, the H2020 funded ATLAS project aims to develop contemporary, robust, reliable and applicable tools to improve EU farmers' management practices. One of the pilots where the development of irrigation scheduling services was tested and is now operationalized, is the area of Pinios Hydrologic Observatory (PHO). Two different web-services were developed: (a) a service for instrumented fields (e.g., weather stations, soil sensors, etc.) and (b) a service for non-instrumented fields. This paper focuses on the former, and presents a brief description of its' data flow and main processing steps, as well as an assessment of its potential contribution to enhance the irrigation scheduling routine of PHO farmers. To this end, climate, soil moisture and water consumption data from an apple orchard divided into four irrigation blocks was used. Results showed that the farmers' empirical irrigation scheduling resulted in significant overirrigation with an excess of 15-50% compared to plants needs throughout the season. Despite such overirrigation, the long time in between weekly irrigation events and the maximum irrigation quantity allowed by the irrigation system resulted in some cases in water depletion within the root zone that could not be efficiently restored. This imposed a water stress to apple trees that can threaten the fruits' final yield and quality. Implementation of instrumented fields service can play a key role in the improvement of farmers' irrigation scheduling process and can mitigate the pressure imposed by the agricultural sector to groundwater resources.

**Keywords:** irrigation scheduling, soil moisture, overirrigation, Pinios Hydrologic Observatory

# How to enhance science-society-policy interactions for achieving sustainability goals. A framework for assessing stakeholder synergies through a System Dynamics approach

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**Abstract**

It is increasingly recognized that, regardless the scale of integration (local to global), to achieve the SDGs and other long-term sustainability goals it is imperative to balance societal, economic and environmental aspects, learn from each other, and work together for our common future. In other words, we need to enhance collaboration and synergies among science, society and policy stakeholders.

COASTAL is a research and innovation project, which builds around a unique multi-actor collaboration of coastal and rural business entrepreneurs, administrations, stakeholders, and natural and social science experts. The four-year project started in 2018 and addresses land-sea interactions based on an approach combining interactive stakeholder engagement and long-term data with systems modelling for six case areas. The aim of the project is to formulate and evaluate business solutions and policy recommendations for improving the coastal-rural synergy in favour of rural and coastal development while preserving the environment.

In this work, we present an overview of the project's approach and methodology, and we reflect on the lessons learned through the lens of the Greek case study, the region of South-West Messina, which was co-coordinated by the Navarino Environmental Observatory (LTER-GR) and the Hellenic Centre of Marine Research. Step-by step, we showcase how to integrate stakeholders' narratives into quantitative SD models, and how these models can be validated and serve for facilitating discussions on how to achieve sustainability goals at a local scale. By doing so, we hope to stimulate other observatories to follow this, or a similar approach, in their case studies.

**Keywords:** stakeholder engagement, participatory modelling, sustainability

# Designing the integrated european ecosystem, critical-zone and socio-ecological research infrastructure

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**Abstract**

holistic approach in investigating ecosystems and socio-ecological systems in the critical zone requires close collaboration among scientific disciplines and communities, but also an integrated observational and experimental design of in-situ facilities (sites, observatories).

eLTER (Integrated European Ecosystem, critical zone and socio-ecological Research Infrastructure, www.eLTER-RI.eu) entered the Roadmap of the European Strategy Forum on Research Infrastructures (ESFRI) in 2018. Two ongoing Horizon2020 projects are dedicated to specifying the requirements of researchers from a wide range of disciplines and other users (eLTER PLUS) and specifying and formalizing the RI according to these needs (eLTER PPP). eLTER RI will consist of a Central Services component and the distributed network of in-situ facilities in >20 countries. It capitalizes on existing LTER networks in 26 countries and >500 eLTER Sites and >50 LTSER Platforms.

We will address major scientific and other users requirements to be met (1) at the scale of individual sites and (2) by a continental scale distributed RI in addressing pressing societal and environmental research challenges, - including such related to ecosystem restauration. One central pillar connecting both scales consists in a set harmonized environmental observations. Such Standard Observations are main drivers of costs in the eLTER RI. Therefore, variables need to be identified, which are of highest relevance across disciplinary user groups, are sensitive to environmental change, represent decisive structural and functional ecosystem components, but are also feasible from a technical and budgetary perspective. Achieving a lasting agreement between research, site operators and funders requires a comprehensive and transparent consultation process.

**Keywords:** research infrastructure eLTER ecosystem critical zone socio-economic studies

# B.4 PROTECTION AND RESTORATION OF ECOSYSTEMS, WATER GOVERNANCE AND CONFLICT RESOLUTION FOR SUSTAINABLE DEVELOPMENT

# Eutrophic water bodies restoration with the application of innovative clay-based materials

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**Abstract**

Eutrophication is a significant source of ecological deterioration in inland and coastal areas worldwide. After the industrial revolution, water bodies' eutrophication and anoxia have become a global concern. Today, human activities such as urbanization, agricultural production, industrialization, mining, and fish farming have resulted in the water pollution and the extinction of species and ecosystems, all of which have lead in the deterioration of the environment. As a result, of the nitrogen and phosphorus-rich industrial and urban wastes, eutrophication and anoxia are formed.

The BLUE-GREENWAY project, financed by the EEA and the Norwegian Grants Fund for Regional Cooperation, intends to deliver best practices for restoring eutrophic water bodies with the application of innovative clay-based materials. This study investigates and reviews the use of sorbent materials for water ecosystems restoration. Sorbent materials regulate phosphorus and nitrogen-containing effluents caused by the ecosystem's pressure points and restore the water column. As a result, clean water will enhance photosynthesis and replenish the water column with greater oxygen concentration. The study adheres to the sustainable design of ecosystems, resulting in a significant ecological restoration against eutrophication and anoxia. Throughout this study, the application of geoengineering materials is assessed to adsorb phosphorus and nitrogen loads.

**Keywords:** eutrophication, anoxia, adsorbent, clays, water, BLUE-GREENWAY

# Operational modeling of North Aegean oil spills forced by high-resolution real-time met-ocean forecasts

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**Abstract**

Oil marine pollution has become a major concern for the health of the world's oceans in recent decades, with significant environmental, social, and economical consequences. The rise in global oil and gas demand, as well as the corresponding expansion in oil and gas production, particularly from coastal and offshore marine reserves, has greatly raised the potential of inadvertent oil leakage into the sea. The oil transportation sector, which uses supertankers and pipelines to transport crude and product oil across oceans, poses similar dangers. The current work deals with the operational simulation of hypothetical scenarios of accidental oil spill releases along the main tanker transportation route in North Aegean Sea. The model applied simulates the transport and weathering of an oil spill, coupled with real-time met-ocean forecasts forced by high-resolution hydrodynamic and wave models. The domain of this study is the North Aegean/Thracian Sea, which has immense marine traffic due to its significant geopolitical location, since it joins the Black Sea with the Aegean Sea through the Dardanelles. The study area is characterized by extremely complex bathymetric and hydrodynamic conditions, such as the Black Sea Water outflow and the formation of the Samothraki Anticyclone and other mesoscale features. The time-period of simulation is 5 days, starting from the time of accidental oil release. Numerical simulations were performed using the OpenOil transport and fate oil spill model, which is a subclass of the OpenDrift, an open-source, python-based, trajectory framework. The model was coupled to the high-resolution hydrodynamic (AEM) and wave models (SWAN), with 1 km × 1 km spatial resolution, downscaling CMEMS operational forecasts model for the area. The oil spill model integrates algorithms simulating several physicochemical processes, such as oil evaporation, emulsification, dispersion and biodegradation, wave entrainment, vertical mixing and resurfacing. Current experimental results focused on the water column stratification/mixing conditions and considered the impact of wind/water circulation and water column stability on the transport of oil droplets, the distribution of oil mass balance, the viscosity and density of oil and the water fraction.

**Keywords:** OpenDrift, OpenOil, oil spill modeling, simulations, met-ocean forecasts, AEM, oil weathering processes.

# A living lab on water management of central Greece: challenges, actions, and expectations from the $3^{rd}$ cycle of the river basin management plans

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**Abstract**

The project "Water for Tomorrow" focuses on the understanding of the water management issues and the actions so far in the Basin District of Thessaly, Central Greece, using a diverse and integrated stakeholder platform. Thessaly is the country's driest region and more intensified agricultural producer. It faces severe problems of water quantity (overexploitation), water quality (diffuse pollution), ambitious production-economic objectives, continuous (historically) drought and flood events, management conflicts, administrative issues of accountability, and economic mismanagement. The stakeholder platform consists of a five-member team (authors), who coordinate the analysis and provide scientific support, and 27 key-stakeholders of the Basin District. These are representatives from Central Government, Prefecture, Local Authorities, experts and experienced professionals, start-ups and technology experts, academics with relevant experience, agricultural co-operations and local agencies of water and agricultural management. The method used for the analysis is a novel framework, the System Innovation Approach. This research presents the three phases of the project and their outcomes: a) How the group initially gets on the same page regarding the understanding of the problems, and the hidden elements governing their interconnectedness. b) A systematic, analytical and detailed evaluation of all existing measures, actions and initiatives. c) How the group acts as a team of co-designers to develop a common vision – an agreeable, scientifically supported, and feasible intervention to tackle the problems from their roots. The findings are expected to be particularly useful for the upcoming Greek River Basin Management Plans ($3^{rd}$ Cycle 2022-2027), the role of the General Water Secretariat, the supported actions and the views of the local stakeholders, as well as for many opportunities for cooperation.

**Keywords:** systems innovation approach, river basin management plans, thessaly, greece, stakeholder analysis, actions evaluation.

# Hydrological simulation of the mediterranean lake system Koronia-Volvi under climate crisis conditions

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**Abstract**

Lakes Koronia and Volvi constitute a significant natural lake system located in Mydgonia basin in northern Greece, facing critical water shortages. The lakes have undergone severe quantitative degradation which is expected to further deteriorate due to climate change conditions. In this study, an integrated hydrological analysis of Lakes Koronia and Volvi for historical and future periods is carried out. Future climate data were derived from Regional Climate Models under different Representative Concentration Pathways to understand and study the lake system water balance under future climate conditions and analyze the respective uncertainty of future predictions. A coupled modelling system including UTHBAL and UTHRL models were developed and applied in the Mygdonia basin for the historical (1970-2000), short-term (2030-2060) and long-term (2070-2100) future periods. The results indicated that water volume, surface and area of both lakes are expected to be further deteriorated in the future periods.

**Keywords:** lake Koronia, lake Volvi, Mygdonia basin, Ccimate change, climate uncertainty

# From water to concrete urban rivers: The case of Ethnikis Aminis Str in Thessaloniki, Greece

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**Abstract**

Without doubt, water resources are essential for the development of civilization. London, Paris, Vienna, Alexandria and many other historical cities emerged around rivers, as the latter provided fresh, drinkable water that could be also used for irrigation, food production, transportation and other activities. Apart from the benefits of living by a river, several risks arise, mainly due to flood events. In some cases, citizens and local authorities applied the necessary adaptation measures, by recognizing the risks and mitigating them through river adjustments or land use restrictions, but in others, no mitigating measures were implemented. This paper focuses on a typical example of urban rivers - streets, Ethnikis Aminis Str. in Thessaloniki, Greece, which is one of the main roads of the city centre and one of the few major vertical axes which connect its hilltop with the seafront. After heavy rainfall during the Winter or the Summer period, Ethnikis Aminis Str. floods, creating several issues to cars, pedestrians and shops alongside the street. This occurs since the street has been built over the watercourse of an existing stream, unfortunately a very common practice even for today.

**Keywords:** resilience, flood, urban hydrology

# C.4 SOLID WASTE MANAGEMENT

# Attitudes towards plastic and microplastic in the Baltic states

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**Abstract**

Plastic and microplastic related environmental and health problems attract a lot of attention recently. Consumers might play an important role by reducing plastic use and pollution and making a pressure for governments and producers. Based on the Eurobarometer survey on environmental attitudes (2020), study aims to analyse attitudes toward marine and microplastic pollution, its reduction, as well as socioeconomic factors of those attitudes in the Baltic states: Lithuania, Latvia, and Estonia. Some 86.8% Estonians totally agree or tend to agree that they are worried about microplastic pollution environmental impacts, correspondingly a little bit less of Latvians (85.7%) and Lithuanians (81.9%) do so. Regression analysis indicate that whose worried significantly more often were female and with higher incomes in Lithuanian case, younger, from larger towns and with higher incomes in Latvian case, and females, from larger towns and bigger households in Estonian case

**Keywords:** plastic pollution, microplastic, attitudes, Baltic states

# Chemical reycling of polymers in the circular economy

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**Abstract**

The two major challenges of humanity today are the fight against the pandemic and the protection of the environment. Concerning the latter, one of the great concerns is the successful management of plastic wastes and particularly plastic packaging. In 2020, from the collected post-consumer plastic packaging (17.8 million tonnes), 42% was recycled 39.5% was used for energy recovery and 18.5% was landfilled. Most of the waste was recycled mechanically, and only very limited volumes (less than 0.1 million tonnes) were treated by chemical recycling processes. To achieve the circular economy for plastics, zero landfilling is needed. Therefore, the amount of polymers recycled should be greatly increased.

The purpose of the study is to investigate the current state of knowledge regarding the chemical recycling of waste plastics. Chemical recycling is used for processing various types of waste plastics, including municipal solid waste, waste packaging and WEEE. The established technologies of chemical recycling of plastics, i.e. chemolysis, pyrolysis, gasification vary in their ability to ensure the circularity of plastics. Pyrolysis and gasification produce by-products and non-reusable residues that need to be disposed of. Both technologies mostly produce intermediates that need further processing to become either chemical products, fuels, or energy, and therefore do not result in circular closed-loop systems for plastics. Both technologies can treat heterogeneous streams of plastic waste, including mixed and contaminated post-consumer plastic waste, and could therefore be complementary to mechanical recycling in dealing with waste streams that otherwise would be landfilled or incinerated. Chemolysis (such as hydrolysis, glycolysis, etc.) is reported to produce monomers of a virgin-grade quality. Usually by-products or residues of chemolysis are not produced. All these issues will be discussed and experimental data will be presented from our lab obtained during the last years.

**Keywords:** lastics recycling, chemical recycling, waste plastics, pyrolysis .

# Thermal and catalytic pyrolysis of plastics originating from waste electric and electronic equipment (WEEE)

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**Abstract**

The rapid economic and technological advances led to an increase in the production and consumption of electric and electronic equipment and so in huge amounts of waste electric and electronic equipment (WEEE). The recycling of such devices is challenging, due to the presence of various materials including glass, metals and plastics (~30% of WEEE). Pyrolysis is often selected as an environmentally friendly method, since secondary valuable materials or monomers can be recovered. In this work various plastic materials coming from WEEE, including televisions, computers, printers, remote controls, were collected from recycling plants and household appliances. After their collection, they were reduced in size and analysed by various techniques. Firstly, they were subjected to FTIR measurements so as to identify the polymers that were present in each device. Their degradation behaviour was investigated via Evolved Gas Analysis (EGA), by heating them from 100 to 700°C with a rate of 20 °C/min. Thermal pyrolysis took place using a pyrolyser coupled with a Gas Chromatographer/Mass Spectrometer, for the determination of pyrolysis products, at the maximum degradation temperature that was received from EGA. Afterwards, catalytic pyrolysis using $Fe/Al_2O_3$ catalyst was carried out, with the aim of estimating its effect on the products distribution. According to EGA analysis, it was found that the thermal degradation in most cases followed a one-step mechanism. From the thermal pyrolysis results, it was revealed that most samples consisted of styrenic polymers, ABS or HIPS, while some of them were blends of ABS/PC. These results were in accordance with those obtained from FTIR. The effect of Fe/Al2O3 catalyst was thoroughly investigated and it was found that during its presence the peaks intensity increased and also, more peaks and so more products were obtained.

**Keywords:** l

# A forecasting approach for construction waste in Istanbul

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**Abstract**

Construction waste becomes more important and crucial considering that Turkey is a country whose construction activities rapidly increase, especially in Istanbul. In that sense, construction waste increases parallel to construction activities, which imply new buildings and constructions are built each and every year. Also, it is obvious that not reused or not recycled materials in constructions result in not only air pollution but also groundwater, soil, land and other pollutions. This type of waste is composed of Excavated soil, Brick-tile, Concrete, Metal and Wood, which can be effectively recyclable and reusable materials and are very vital elements to reuse and recycle. Thus, construction waste becomes a vital topic to investigate in terms of sustainability and waste management. In order to generate policies and take measures in time, forecasting construction waste amount is also major area to handle but it is not always very easy to forecast this type of waste as it includes various parameters and data is not always clear. In this study, it is aimed to forecast construction waste amount, recycle ratios and amount and reuse amount for construction waste by Logistic Regression in Istanbul. This study will provide a forecasting approach for construction waste aiming to improve its reuse and recycling.

**Keywords:** construction waste, logistic regression, forecasting, waste management

# Alternative animal feed production from food waste: development of a methodology for the assessment of potential sources

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**Abstract**

The simultaneous rapid growth of the world population and the automation of the food industry contribute to the production of large amounts of food waste that are generated from the food supply chain, which leads to environmental degradation and is now a factor in climate change. In Greece, the issue of economic viability of the food production sector and in particular meat production is at stake. On the basis of the investigation for the improvement of the environmental and economic performance of the pork production in Greece, the provision of alternative diet to pigs from food waste that is considered unfit for human consumption is examined.

A four-step methodology was developed to compile and assess a list of possible sources of food by-products that may be used to replace the conventional pig diet. Initially, the available categories of food by-products were identified and subsequently the economic and environmental parameters of the value-chain were studied. Three different areas of interest were identified focusing on the location of a potential end-user pig farm in the Region of Central Macedonia, Greece. Sources of collection of available food by-products to be used were mapped and evaluated qualitatively and quantitatively. The preliminary results show that there is a significant food waste potential in the examined area but a complex supply chain has to established for the environmental and economic viability of the operation to be achieved.

**Keywords:** environmental impact, sustainability, techno-economic assessment, food waste, alternative animal feed, bakery meal

# CONTRIBUTED POSTERS

# POSTER SESSION

# Towards more sustainable methods for the development of advance material in environmental remediation

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**Abstract**

In this work, new hybrid polymeric materials were developed. A polymerised sodium silicate base was synthesised and functionalised by adsorption of Fe(II) ions. This iron-dopped material was modified by treatment with a natural reducing biomass extract. The resulting hybrid material was used in Cr(VI) decontamination processes in aqueous medium. The synthesised material can achieve high Cr(VI) removals by a one-step process combining an adsorption with a reduction process. This material can adsorb the two main chromium species (Cr(VI) and Cr(III)) when both are in the same media. High removals are achieved without the generation of nuisance by-products such as sludge. Common problems with nanoparticles, such as agglomeration, are also avoided. The green synthesis approach, i.e., using eucalyptus leaves extract, is key in the preparation of a stable material because the organic matter present in the eucalyptus extract is adsorbed and acts as a capping agent preventing material degradation. Eucalyptus extract has antioxidant activity and high reduction potential ( 222 ± 6 mV respect to an Ag/AgCl 3M reference electrode).

Iron is the element that acts simultaneously as a reductant and adsorbent for chromium. The polymeric base acts only as a supporting material. An adsorption of 24.5 mg Fe(II)·g–1 on the silicate polymeric base was achieved, with an associated adsorption energy of 34.5 kJ·mol–1. For chromium, adsorption values of 153 mg Cr(VI)·g–1 Fe and 279 mg of total chromium (Cr(VI) and Cr(III))·g–1 Fe were observed. Considering the whole reduction and adsorption process, Cr(VI) removal values of 383 mg Cr(VI)·g–1 Fe were achieved.

**Keywords:** Iron dopped material, water treatment, chromium remediation, green development.

# The potential cytotoxic and genotoxic effects of Tetraglyme in human lymphocytes

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**Abstract**

The present study aimed to investigate the cyto-genotoxic effects of tetraglyme in human lymphocytes, thus enriching the existing knowledge about their risk. Tetraglyme working solutions (50 mg $L^{-1}$ and 500 mg $L^{-1}$) were firstly characterized by nuclear magnetic resonance (1H-NMR) for estimating the stability of the chemical substance over time (0 and 24h). In parallel, whole blood samples (almost 5 mL) were collected in heparinized vectors from 3 healthy and non-smoking male donors (20 and 25 years old), previously declared that they were not exposed to radiation, drug treatment or any viral infection in the recent past. Thereafter, lymphocytes were isolated and treated appropriately with different concentrations of Tetraglyme (0.02, 0.1, 0.2, 2 and 20 mg $L^{-1}$). Cell viability, using the Trypan blue exclusion test, was primarily performed, before carrying out the Cytokinesis Block Micronucleus assay (CBMN), using cytochalasin B and the Alkaline Single Cell Gel Electrophoresis procedure (Comet assay). According to the results, the tested concentrations of Tetraglyme, primarily being found to remain stable over the experimental period (0-24h), showed eligible levels of cell death (<10%). However, the CBMN assay showed that Tetraglyme was both cytotoxic (in terms of CBPI index) and genotoxic (in terms of the percentage of micronuclei frequencies observed in treated binucleated cells) at concentrations ranged from 0.1 to 20 mg $L^{-1}$. The latter was further reinforced by the significant levels of DNA damage (in terms of % DNA in tail, Tail and Olive moment) observed in treated lymphocytes, with the higher values to be observed in cells treated with 20 mg $L^{-1}$ of the substance. These findings give rise to the imperative need for assessing the potential environmental and human risk of Tetraglyme, thus reinforcing its rational utilization.

**Keywords:** cytotoxicity, CBMN assay, comet assay, genotoxicity, human lymphocytes, NMR, tetraglyme

# A mobile unit for hybrid energy storage based on $CO_2$ capture and renewable energy sources (RES); comparative study of existing biological methanation systems

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**Abstract**

This study is part of a circular economy programme (LIFE "$CO_{2to}CH_4$"), which aims to develop and demonstrate an innovative, integrated and sustainable industrial process for the simultaneous energy storage and $CO_2$ Capture and Utilization (CCU). The principal idea of LIFE $CO_{2to}CH_4$ involves the construction, operation and demonstration of an autonomous mobile unit for hybrid energy storage, which uses the exhaust gases from a thermo-electric power plant (burning lignite), as well as hydrogen (H2) produced from water electrolysis (by using renewable energy sources) and subsequently, converts them into (bio)methane (CH4), i.e. into an alternative energy source. The mobile unit consists of three fundamental sub-units: (i) the electrolyzer (for the production of H2), (ii) the exhaust waste gases cleaning/purification system, and (iii) the bio-methanation unit. Before the main implementation actions, which include the operation, optimization and demonstration of the prototype mobile unit, a detailed technical preparation design of the integrated process elements (i.e. electrolyzer, cleaning system, bio-methane reactor) was conducted. The present work primarily focuses on the process of biomethanation, which will be implemented in the bio-methane reactor, describes the general operation of the prototype system and provides a brief presentation of the expected results from the LIFE CO2toCH4 programme.

**Keywords:** hybrid energy storage. $CO_2$ capture and utilization (CCU). biological methanation. renewable energy sources. circular economy

# Changes in photosynthetic energy use efficiency of alfalfa due to recurrent heat waves

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**Abstract**

The aim of this study was to investigate the response of chlorophyll a fluorescence parameters of alfalfa (Medicago sativa L.) under regulated environment conditions and recurrent heat waves stress effect. Two 4-day heat waves (35/28 °C day/night temperature) were simulated together with drought (10% soil moisture). Each 4-day heat wave was followed by a 5-day recovery period. Chlorophyll a fluorescence parameters measurements were taken with the Plant Efficiency Analyser with randomly selected youngest fully expanded leaves on the last ($4^{th}$) day of the exposure of each heat wave and after each recovery period. This study highlights that recurrent heat waves had a negative impact on energy use efficiency and growth of alfalfa when plants recovered only partially after regeneration periods. However, the results showed that the effect of the second heat wave on alfalfa chlorophyll a fluorescence parameters was weaker when the losses of the studied parameters were lower.

**Keywords:** recurrent heat wave, alfalfa, chlorophyll fluorescence, forage crops

# Comparison of microalgae lipid conversion into biodiesel with common catalysts and biochars of different origin

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**Abstract**

The aim of this study was to investigate the optimum transesterification method (homogeneous or heterogeneous) for the production of biodiesel by microalgae lipids. A homogeneous process of one-step transesterification process and a two-stage process was employed for biodiesel production by biomass of two microalgae species, *Chlorococcum sp*, and *Scenedesmus rubescesns*. Sulfuric acid and sodium hydroxide catalysts were separately employed employing the basic catalyst followed by the acidic one in the second step was also used. In heterogenous process biochar was used for biodiesel production of *Scenedesmus rubescesns* lipids. Specifically, biochar was from three different materials, malt spent rootlets (MSR), coffee spent grounds (CSG), and olive kernels (OK). In order to examine the effect of pyrolysis temperature the materials were charred at two temperatures (400 and 850 °C). Fatty acid methyl esters (FAMEs) results of this study showed that both microalgae are good candidates for biodiesel production. The quality of the produced biodiesel was strongly determined by the catalyst which was used for the transesterification process. FAMEs produced by *Chlorococcum sp* lipids showed between the two-step process (21.56 mg FAMEs) and one-step with acid (21.585 mg FAMEs), was similar. On the other hand, *Scenedesmus rubescens* the FAMEs of the two-step process (40.51 mg of FAMEs) were higher, compared to one-step methods with acid and base catalysts (9.57 and 22.3 mg of FAMEs, respectively). The results of the comparative study for homogeneous and heterogeneous catalysts showed that homogeneous catalysts (H2SO4 and NaOH) had similar results to the CSG biochar at 400 °C, which was the most productive tested biochar. MSR and CSG biochar, as catalysts, showed that pyrolysis temperatures affected the FAMEs recovery, while with the OK, did not show significant differences.

**Keywords:** microalgae, lipid, transesterification, biochar; FAMEs, biodiesel

# Optimization of electrocoagulation process for biofuels generation using cheese whey

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**Abstract**

Electrocoagulation (EC) is considered as a promising method for the treatment of different wastewaters, offering the advantage of simple equipment requirement, easy operation and short processing times. By this technology, in situ generation of coagulant species is carried out by electrolytic oxidation of anode materials (usually aluminum (Al) or iron (Fe) electrodes), triggered by an electric current applied through the electrodes. The metal ions generated by electrochemical dissolution of a consumable anode spontaneously undergo hydrolysis in water, depending on the pH, forming various coagulant species including hydroxide precipitates (able to remove pollutants by adsorption/settling) and other metallic ion species. In the present study, EC was used as a pretreatment method for bioethanol and biohydrogen production using cheese whey (CW). During EC, a total of three electrodes (two cathodes and one anode) made of Al were used, to pretreat undiluted CW. A Box-Behnken Design was used to optimize the conditions of EC, in response to CW characteristics, such as chemical oxygen demand (COD), sugars and turbidity. Regression equations were obtained, in function of the effective parameters: current (1, 1.5 and 2 A), pH (4, 6, and 8) and treatment time (15, 30 and 45 min). Pretreated CW was forwarded for methane and also for hydrogen production, via mixed microbial consortia.

**Keywords:** electrocoagulation, cheese whey, Box-Behnken design, methane, hydrogen

# On the occurrence and fate of microplastics in the wastewater treatment plants of Greece

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**Abstract**

Plastic pollution is a major issue of global concern and has received ever-increasing attention over the last decade. Microplastics, MPs (plastic fragments < 5 mm) are intentionally manufactured or formed by larger plastics debris breakdown in the environment. Their existence has been reported worldwide and the deleterious effects from their physical accumulation on different organisms have been highlighted. Municipal wastewater treatment plants (WWTPs) have been considered among the main receptors of MPs in industrial and domestic level. It is reported that the MPs removal rate of WWTPs can reach over 90%, meaning that the main part of them are retained during the stage of primary or secondary wastewater treatment. In this work, the fate of MPs in two different WWTPs in Greece, with different capacity and treatment stages, i.e. the WWTP of Patras, a city of 300.000 residents and that of Mytilene with 28.000 residents, was investigated. The analysis was performed in terms of MPs abundance, morphology and chemical composition and was based on the results of optical microscope, Raman and FT-IR spectroscopy. Furthermore, the influence of factors such as population density, economic development level, wastewater source and treatment process were also discussed and correlated to the results obtained.

**Keywords:** Microplastics, wastewater treatment plant, morphology, chemical composition, FTIR, Raman

**Acknowledgements**

This research is co-financed by Greece and the European Union (European Social Fund- ESF) through the Operational Programme «Human Resources Development, Education and Lifelong Learning 2014-2020» in the context of the project "Microplastics in Wastewater Treatment Plants: Occurrence and Fate" (MIS 5048204)»

# Laboratory and pilot-scale cultivation of *Tetraselmis* striata under optimized growth conditions for fish feed production

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**Abstract**

In this work Tetraselmis striata was cultivated in drilling waters (salinity 29 ‰) obtained from the commercial fishery of Plagton S.A.. Previous studies had shown that the microalga displayed optimum growth using 0.2 g $L^{-1}$ of the commercial fertilizer Nutri-Leef (30%-TN, 10%-P, 10%-K) together with 0.18 g $L^{-1}$ of NaHCO3 at a pH value of 8. The effects of temperature, photoperiod and CO2 flow rate on growth and biomass composition of T. striata were also examined in laboratory conditions. The temperatures of 19±1oC, 25±1oC and 28±1oC were studied under continuous illumination (24:0, L (Light): D (Dark)). The highest biomass productivity of 93.7 mg $L^{-1}$ $d^{-1}$ was achieved at 25oC and high protein (49.9%), lipid (23.5%), carbohydrate (19.6%) and pigment contents (5.1%) were also recorded at this temperature. Further experiments were conducted at 25oC studying the photoperiods of 20:4, 18:6, 12:12 L:D. Results revealed that biomass was significantly affected by light absence and biomass productivity gradually reduced as the dark periods lengthened. The metabolic products exhibited higher accumulation rates under continuous illumination which was selected as optimum. The effect of carbon source was also estimated employing pure CO2 at different flow rates (10 mL $min^{-1}$, 20 mL $min^{-1}$, 90 mL $min^{-1}$). T. striata could not tolerate the high flow rate of 90 mL $min^{-1}$ while high biomass productivities (87.5 mg $L^{-1}$ $d^{-1}$) were recorded at 10 and 20 mL $min^{-1}$. Pilot-scale experiments at the optimum growth conditions were conducted in a raceway pond of 40 L capacity. Biomass productivity reached 93.5 mg $L^{-1}$ $d^{-1}$, while protein, carbohydrate, lipid and pigment contents were 48.8%, 21.6%, 28.1%, 4.8% respectively. In both laboratory- and pilot-scale experiments, analysis of amino acids and fatty acids showed that the produced biomass is suitable for incorporation into conventional fish feeds.

**Keywords:** Tetraselmis striata, photoperiod effect, temperature effect, optimization of $CO_2$ flow rate

# Biotreatment of poultry waste and mixture of poultry waste/second cheese whey in suspended and attached growth cyanobacteria-based systems with simultaneous biodiesel production

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**Abstract**
Poultry Litter Extract (PLE) and a mixture of PLE with second cheese whey (SCW) (PLE/SCW) were treated using a microbial consortium dominated by the filamentous cyanobacterium *Leptolyngbya* sp. in synergy with heterotrophic microorganisms indigenous of the wastewaters. Laboratory-scale experiments were conducted under aerobic conditions using suspended and attached growth photobioreactors. The results showed that PLE/SCW was more suitable for the cultivation of the microbial culture leading to higher biomass productivities and organic matter reduction rates in both suspended and attached reactors. Specifically, biomass productivities recorded with PLE/SCW in suspended growth systems ranged from 46.04 to 253.00 mg $L^{-1}d^{-1}$ and from 123.0 to 337.5 mg $L^{-1}d^{-1}$ in the attached growth systems. Using PLE alone, biomass productivities did not surpass 198.9 and 169.6 mg $L^{-1}d^{-1}$ in suspended and attached systems respectively. The PLE/SCW mixture presented high d-COD and total sugars removal in suspended (i.e., up to 94.4% and 96.5%, respectively) and attached growth reactors (i.e., up to 94.0% and 96.4%, respectively). Nitrate nitrogen and orthophosphate assimilation rates were higher in PLE/SCW when using suspended growth systems (i.e., 88.1% and 90.0%, respectively), while high reduction rates were also recorded in the attached systems (i.e., 52.6% and 86.8%, respectively). The biomass produced in the attached reactors of PLE/SCW and PLE contained up to 17.0% and 18.4%, lipids (w/w) on a dry weight basis, while in the suspended reactors lipid contents were recorded as 14.0% and 15.5%, respectively. Lipid analysis revealed that saturated and monounsaturated fatty acids accounted for over 70% of the total fatty acids in experiments applying both PLE/SCW and PLE. The suspended and attached growth systems used in this work could be applied to efficiently treat the above tested wastewaters and simultaneously produce lipids suitable as feedstock for biodiesel production.
**Keywords:** *Leptolyngbya* sp, poultry litter extract, second cheese whey, attached growth, suspended growth

# Water governance for a climate resilient agriculture in Mediterranean countries

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**Abstract**

Effective water governance is the key to achieving water security and sustainable water management. This paper aims to present an integrated water governance scheme, which can be applied at F.ORs level for a more effective implementation of the water management adaptation strategy. The proposed water governance scheme has been adopted by two F.ORs located in Mediterranean areas (in Crete, Greece). The water management system that is developed as a tool for the implementation is presented and the lessons learnt during the implementation are discussed. Experience from the pilot implementation of the proposed strategy in the two F.ORs indicated that systematic monitoring and evaluation of the strategy can increase implementation efficiency and save resources. Moreover, the significance of internal dissemination and transparency was highlighted. Overall, the proposed integrated water governance scheme constitutes a valuable tool for the F.ORs' adaptation to climate change in terms of water efficiency.

**Keywords:** climate resilient agriculture, water management adaptation strategy, Farmers' Organizations, climate change adaptation, agricultural water management

# On the investigation of novel biocatalysts for the production of bioplastics from food wastes

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**Abstract**
For many decades economic growth has been based on a linear model, which results in the inevitable depletion of natural resources and also the production of huge amounts of waste and wastewaters, the accumulation of which leads to a tragic degradation of the natural environment. The understanding, however, of the consequences of such a productive and consuming culture led the European Commission to propose in December 2015 a package of measures aimed at facilitating the transition to a circular economy, based on the reuse and exploitation of waste/wastewater towards their conversion into other useful products. Based on the above, the present study proposes the exploitation of food wastes (FW) as a substrate for the biotechnological production of polyhydroxyalkanoates (PHAs) with adequate properties to be used as food packaging material, into a circular economy concept. PHAs are bioplastics that are accumulated by bacterial cells via the biotransformation of various carbon sources, with the accumulation yields being strongly dependent on the bacterial species used. The selection thus of proper substrates and biocatalysts could contribute greatly to the sustainability of the process. Into this context, the current study investigates the potential of different isolates coming from an enhanced mixed microbial culture (MMC) as biocatalysts for PHAs production from acidified FW. The kinetics of the process were studied and it was shown that the potential of isolates differentiated greatly with the achieved PHAs yields ranging from >1% w/w to <50% w/w (PHAs/CDW). In all cases, though, copolymers of hydroxybutyrate and hydroxyvalerate were produced, with similar thermal properties. The MMC resulted in a PHAs yield of up to 35% w/w, indicating that it constitutes a complex consortium in which hyper-producers co-exist with different bacteria of low potential, and as such the isolation and use of hyper-accumulators could indeed enhance the efficiency of the process.

**Keywords:** polyhydroxyalkanoates, food wastes, circular economy, PHB-HV, thermal properties

**Acknowledgments**
The present study is implemented in the frame of the project "Wastes2Plastics, Development and Demonstration of Key Technologies for Intustrializable Polyhydroxyalkanoates production

from Industrial and Environmental Waste Streams", MIS 5049133" under the Action "Bilateral and Multilateral R&D Cooperation Greece - China", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund)

# Effects of drought on cadmium phytoextraction efficiency by Brassica napus grown under current and future climate conditions in Cd contaminated soil

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**Abstract**

In view of the drastically increased concentration of heavy metals (HMs) in soil over the recent decades, pollution by HM is considered one of the most important environmental problems worldwide. Among all the HMs, Cd has the highest solubility in water, therefore, is one of the most mobile heavy metals in the environment and can be easily taken up by plants. Cd contamination of agricultural soils is, therefore, of particular concern because it reaches the food chain through regular use of Cd-containing phosphate fertilizers, posing a threat to human health. Since HMs are non-degradable and therefore persist for a long time after being introduced into the soil, the most suitable strategy to remediate Cd-contaminated soils is to remove Cd out of the soil. Phytoextraction is such a plant-based technique where plants are used to translocate Cd from soil to plant tissues, which has been considered as a secure, environmentally friendly, and cost-effective approach to remediate Cd-contaminated soils. Like other Brassica species, Brassica napus has many features, such as high biomass production, rapid growth rate and the ability to sequester Cd at a relatively high concentration without impairing its growth or development, that are suitable for the phytomanagement of Cd-contaminated soils. Besides, it is also an emerging biofuel crop that can be used to produce biofuel when grown in degraded soil. Moreover, recent studies have shown that, under warmer climate conditions, especially in conjunction with elevated $CO_2$, B. napus highly increased their above-ground biomass production, indicating an even higher potential for phytoextraction purposes in the future climate. However, as the mobility of Cd in the soil is affected by many factors, its bioavailability may be also affected by climate change-related factors, such as elevated $CO_2$ and temperature. In addition, reduced soil moisture as one of the most significant climate change-related factors also plays an important role in the soil environment and can negate all the advantages gained from the hotter climates. Therefore, the aim of this study was to investigate Cd phytoextraction efficiency by pot grown B. napus under drought conditions (5 vs. 30% of volumetric soil water content) in the current climate (21/14 °C and 400 µmol mol1 $CO_2$) and future climate (25/18

°C and 800 µmol mol$^{-1}$ $CO_2$) conditions. For this, Cd accumulation in B. napus and their photosynthetic performance were evaluated.

**Keywords:** phytoextraction, cadmium, Brassica napus, drought, future climate

**Acknowledgments**

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# Biotechnological exploitation of discarded fruit juices towards bioplastics and microbial lipids

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**Abstract**

Short-live fruit juice has high nutritional value and appealing taste and as such it has a high market demand. However, due its short shelf- life, the need for being processed, packed, transferred and maintained at low temperatures as well as its vulnerability to microbial degradation, large quantities of fruit juice may end up being discarded annually worldwide from cultivation to sale. As a waste, discarded fruit juice has high humidity and organic load, which generates not only economic but also environmental problems. On the other hand due to the same characteristics such a waste might be an ideal substrate for targeted microbial growth and production of high value-added microbial products.

Into this context in the present study, discarded mixed fruit juices were evaluated as substrate for the production of microbial bioplastics i.e. polyhydroxyalkanoates and microbial lipids, via pure and enriched cultures of heterotrophic and autotrophic bacteria (cyanobacteria), respectively. Both of these bio-products are accumulated under non- balanced conditions of nutritional stress and are stored intracellularly as reserves of carbon and energy.

Aiming to the optimization of the yields of bioplastics and lipids, key parameters of their production processes i.e. pH, substrate concentration and the C/N, C/N/P ratios, were studied in small scale batch experiments. After determining the optimal conditions for high yield production, the processes were scaled-up and the final bio-products were recovered from the microbial biomass via solvent extraction and their composition and properties were further studied. The final by-products of both processes, i.e. the extracted biomass and the residual fermentation broths, were further subjected to anaerobic digestion to produce methane, in order to assess the potential for energy recovery from them. This approach makes it possible to exploit the initial waste in the best possible way and into a bio-refinery concept.

**Keywords:** discarded juices, food waste, polyhydroxyalkanoates, microbial lipids

**Acknowledgments**

We acknowledge financial support of this work by the project "Wastes-to-Biopolymers" that implemented under the "Action for the Strategic Development on the Research and Technological Sector",

funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).

# Seismic analysis and design of steel tanks – a review

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**Abstract**

Liquid-containing storage tanks have been widely used all around the globe to cover the need for storing a number of different fluids, from drinking water to liquid fuels, chemicals, liquid wastes, etc. They play a vital role in the stable and continuous operation of both industrial and public life. In case of leakage due to the failure of the tank, the results could be catastrophic both for human lives and the environment. After the introduction, some previous findings concerning the topic are presented. After that, the failure modes of steel tanks are presented, along with the reason that causes them. Two ways of conducting a seismic analysis for tanks are presented, the method of the single degree of freedom model and the Finite Element Method. After that, four of the most used seismic codes are presented. Finally, some conclusions concerning the seismic design and analysis of steel tanks are presented.

**Keywords:** seismic design, seismic analysis, fluid-structure interaction, soil-structure interaction

# International architectural approaches for navigating the COVID-19 pandemic: work-related stress and psychosocial risk

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**Abstract**

This study examines the elimination of work-related stress through specific architectural management strategies in working environments. The threat of infectious diseases such as the Covid-19 pandemic in workplaces increases stress, reduces even more productivity, and damages the financial image of any organization. Psychosocial risks have become a major threat to occupational safety, making imperative need the use of appropriate methods to address them as an organizational issue in combination with the technical details of the building. A structured environment, materials, colors, furniture, artworks, decoration, green elements, resting areas, hybrid workplaces, and other factors are investigated. Parameters such as isolation and privacy, concentration, communication, interaction, teamwork, and spontaneous discussions through architectural approaches are examined. The data collection is achieved by employees from different countries worldwide, through original questionnaires. The research is concluded with the processing of data to conclude statistical analysis as the main tool. The basic target is the development of suitable architectural management strategies that will increase user satisfaction, improve psychosocial conditions, and will overall upgrade the working environment. The results of this study concern every employer and employee and must be seriously taken into account for appropriate future handling.

**Keywords:** architectural approach, work-related stress, occupational safety, work environment, Covid19

# Wastewater Treatment in Constructed Wetlands Augmented with Biochar

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**Abstract**

The aim of this work was to examine the performance of constructed wetland (CW) augmented with biochar for the treatment of secondary effluent. Biochars from eggshells and rice husk pyrolyzed at 800° C were prepared in order examine the effect feedstock type on wetland performance. Five pilot-scale CW of 60-L volume, were constructed and plants belonging to the family of Poaceae. Wetlands were effective for removing organic material and chemical oxygen demand (COD) removal ranged 71 to 100%. The incorporation of biochar to sand layer resulted in higher removal efficiencies. Planted wetlands were more effective for nitrogen removal. More specific, the removal of Total Kjeldahl Nitrogen (TKN) ranged from 72 to 91% compared to 56 and 69% in the unplanned CWs. Phosphorous removal was more effective in unplanted CWs augmented with biochar. Nitrogen removal with rice husk biochar was higher compared to CWs augmented with eggshell biochar. The opposite was observed with phosphorus removal.

**Keywords:** vertical wetland, biochar, eggshells, rice husk, secondary effluent, nutrient removal

**Acknowledgements**

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