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9th International Conference
on Water Resources in the Mediterranean Basin

BOOK OF ABSTRACTS

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Edited by : Laila MANDI

PREFACE

The constraints associated with water management in the Mediterranean are subject to a huge dynamism due to global changes such as climate change that will exasperate extreme phenomena (floods, droughts….) and regional variations such as population and tourism-related pressures in the coastal areas. Mediterranean areas face dramatic changes that will affect the sustainability, quantity, quality, and management of water resources. The differences between territorial gaps, social-economic development and technological progress create the need for different kinds of intervention. So, it becomes necessary to think globally and act locally in the water sector.

It is therefore essential to begin today to design new ways of water management, to ensure greater equity, efficiency and sustainability of resource uses. Integrated water management is one of the pillars of sustainable development.

In this context, the organization of the 9th edition of the International Conference on "Water Resources in the Mediterranean Basin" (WATMED9) aims at bringing together experts in the Mediterranean basin in order to mobilize innovations, knowledge and skills for advancing the cause of water, expanding the exchange of relevant experiences. Also, to up-to-date scientific research results carried out all over the world and allowing to launch new collaborative actions and new networks to better face the challenges and handle the risks for our water resources and human being.

Due to the COVID-19 pandemic which continues to impact people around the world, the WATMED9 program committee decided to organize a fully online conference that was successful.

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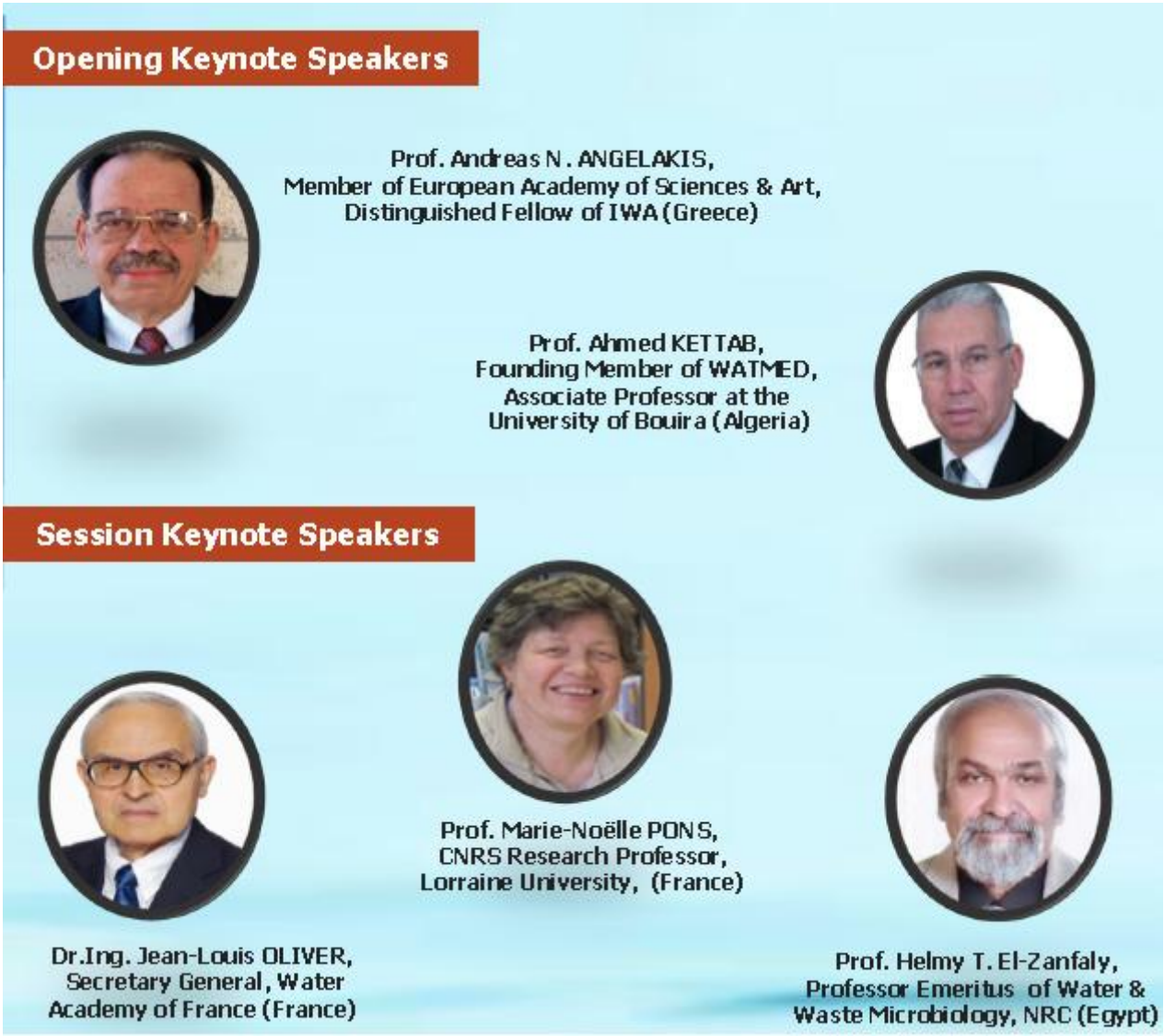

EVOLUTION OF WATER REUSE

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This paper provides a brief overview of the evolution of water reuse over the last 5000 years in all over the world. Wastewater reuse has a long history. It was used for agriculture especially irrigation by prehistoric civilizations (e. g. Mesopotamian, Indus valley, Egyptian, Chinese, and Minoan) since the Bronze Age (ca 3200-1100). Thereafter, wastewater was disposed or used for irrigation and fertilization purposes and these were improved by historians (e. g. Classical and Roman). They were used in areas of surrounding cities (e. g. Athens and Rome). Sanitation practices reemerged in force in the more recent history following the great epidemics in several regions of the world. After the mid of 17th century, the need for sanitation led to the development of effluent application practices, known as "sewage farms" as means to protect public health, to control water pollution and of course to irrigation and fertilization. Wastewater application to the land for disposal and agricultural use was originally operated in European cities and later in the USA. Significant changes in wastewater management occurred since the beginning of 20th century. By understanding the practices and solutions of the past, we are better placed to meet present and future challenges. Today, planning of projects for water reclamation and reuse is significantly increasing in several regions of the world. Also recycled water is used for almost any purpose including potable use. It provides a historical context and links to some of the latest developments in sustainable water reclamation and reuse. Finally, the important role that water reuse will play in the future highly urbanized world is highlighted. In the future, potable reuse will be a critical element in the development of sustainable strategies for water supply, especially in high density urban areas. It should be recognized that withdrawing water from inland areas, transporting it to urban population centers, treating it, using it once, and discharging it to coastal waters is unsustainable. Also, must think of wastewater differently (i.e. a source of water) and the profession must speak with a unified vocabulary.

‘‘DE L'EAU POUR TOUS EN QUALITE ET EN QUANTITE’’ POUR GARANTIR LE DEVELOPPEMENT DURABLE

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L'eau est un produit indispensable et est irremplaçable. A notre connaissance, aucune des technologies de ce nouveau siècle ne nous permet de fabriquer de l'eau et rien ne peut lui être substitué; de plus elle ne peut pas être reproduite. Elle doit donc être protégée par des textes de loi sévères et considérée comme une denrée très précieuse car de plus en plus rare. L’eau, ressource naturelle de plus en plus rare, est une partie du patrimoine d’une nation et de l’Humanité. Sa protection, la mise en valeur et le développement des ressources utilisables dans le cadre des équilibres naturels sont d’un intérêt général pour la nation et le monde. Nous devons veiller au respect de ce noble principe et considérer l’eau comme un bien économique et social et son accès est un droit pour chaque individu. Il est vrai que le droit à l’eau est une nécessité indispensable; notre devoir est de ne pas la polluer, ou la gaspiller. C’est pour cela, que plusieurs organisations internationales telles que l’ONU, le Conseil Mondial de l’eau, l’Union Africaine, l’UNESCO, FAO, OMS, … mènent une réflexion profonde sur les politiques de gestion durable de ressources en eau et sur les règles de sa gouvernance dans le sens d’une pérennité de cette ressource vitale. Il est désormais largement admis que la mise en place d’un développement durable exige de mettre en équation aussi bien les préoccupations sociales et économiques qu’environnementales en tenant compte du facteur essentiel et limite à savoir l’eau. L’eau est devenue un enjeu de taille et seules les nations qui auront su préserver leur capital hydrique pourront survivre. Les pays Africains; considérés pour la plupart comme pauvres en eau seront de plus en plus confrontés à des pénuries d’eau, tant les pressions provenant de l’agriculture, de l’industrie et des populations y sont fortes et croissantes. Dans ce contexte, l’eau a une valeur socio-économique, environnementale et géopolitique particulière. Les solutions techniques et économiques impliquent, de fait, une solidarité entre régions, états. La COP21 tenue en décembre 2015 à Paris-France; et les différentes COP qui on suivi ont montré que les changements climatiques sont une contrainte supplémentaire sur l’eau puisque les problèmes soulevés (inondations, sècheresses, augmentation du niveau de la mer, température ; etc.) et tous les débats sur les changements climatiques sont en fait un débat sur l’eau et son cycle. L’eau est un bien patrimonial commun de l’humanité. La santé individuelle et collective en dépend, l’agriculture, l’industrie et la vie domestique y sont liées. Il n’y a pas d’accès à la production de la richesse sans accès à l’eau. Chaque membre de la communauté humaine, a le droit à l’eau, en particulier à l’eau potable, en quantité et qualité nécessaire et indispensable à la vie et à l’activité économique. L’eau est essentielle à l’Homme en particulier et à la vie en général. Elle a toujours joué un rôle important dans l’Histoire de l’Humanité et de son développement civilisé. Source de vie, elle est aussi source de conflits dans de nombreuses régions du monde. La gestion durable de l’eau doit aussi, avant tout, tenir compte des questions sécuritaires et pour cela un certain nombre d’accords et de conventions sont indispensables. Dans cette conférence seront développés réalités, enjeux; stratégies défis et perspectives au niveau mondial et en Afrique, mais aussi et surtout des recommandations en vue d’un développement durable de l’Afrique à l’horizon 2030/2050 concernant: L’état actuel des ressources en eau, les enjeux et défis futurs à relever. Les divers indicateurs d’évaluation, en notant leur utilité et leurs limites. Les changements climatiques, inondations; sécheresse. Les grands transferts de l’eau : une nécessité ? La politique de

gestion: institution, réglementation, législation Le droit à l'eau et à l'assainissement: mythe ou réalité? La recherche scientifique, la formation, le renforcement des capacités Le traitement des eaux usées et leurs réutilisations Le modèle de consommation: sensibilisation, lutte contre le gaspillage, prix de l'eau, etc. La gestion intégrée des ressources en eau et la bonne gouvernance:tentatives! La gestion des eaux transfrontalières et conflits possibles.

Mots clés : Eau, Monde, Droit à l'eau, Développement durable, Organisation, Stratégies, Enjeux, Conflits.

EAU ET SANTE : DEFIS D'AUJOURD'HUI ET DE DEMAIN

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Avec sa molécule H2O, l'eau possède d'étonnantes propriétés physiques, chimiques et biologiques. Toute matière vivante est ainsi constituée d'eau dans de larges proportions : celle-ci représente 60 à 70% du poids de l'homme, 80% chez l'enfant. La perte de 10% d'eau corporelle entraine des troubles graves et, si elle atteint 20% la mort survient. Ce besoin vital d'eau est très variable selon l'activité physique et la température ambiante, allant de 5 litres par jour pour survivre à 40 ou 50 litres par jour pour les besoins minimaux de l'alimentation et de l'hygiène.

Encore faut-il que l'eau consommée soit saine, sans germes pathogènes ni substances minérale ou toxiques, au de-là de teneurs précises, les normes variant selon les institutions, à commencer par l'OMS.Or presque tous les jours, l'actualité fait état de pollutions d'origines diverses, ponctuelles ou diffuses, accidentelles ou chroniques, susceptibles d'affecter plus ou moins gravement, immédiatement ou à terme, la santé humaine. Ces pollutions sont à la fois d'origine industrielle, agricole ou urbaine. Dans le grand cycle hydrologique, l'eau est inévitablement le réceptacle de tous les produits utilisés et rejetés, qui contiennent, en quantité et diversité rapidement croissantes, des constituants chimiques, leurs métabolites et leurs composés de dégradation, avec une grande variété de caractéristiques physico-chimiques, de transformation biochimique et de dégradabilité.

L'attention s'est portée d'abord sur les micro-organismes (virus, bactéries, parasites, salmonelles, …) à l'origine du choléra, des dysenteries, des hépatites, de la poliomyélite, …Le rythme important de création de molécules nouvelles par les industries chimiques et pharmaceutiques multiplie dorénavant les risques pour la santé humaine même à des doses minimes.C'est le cas des micropolluants et perturbateurs endocriniens ; ces polluants en mélanges interfèrent les uns avec les autres, pénètrent les tissus vivants, perturbent le système hormonal et provoquent des maladies graves souvent à long terme : troubles du développement, de la reproduction, cancers, etc… Enfin d'autres substances, comme les nanoparticules, se développent si récemment que l'on connait encore mal leurs risques potentiels et leur toxicité !Parallèlement, le réchauffement climatique va réduire sensiblement le débit des rivières, notamment en été, accroissant la concentration de la pollution dans les eaux superficielles d'où provient une grande part de l'alimentation en eau potable ; ce dérèglement climatique risque aussi d'introduire dans ces rivières, dans les lacs et dans les réservoirs, des espèces envahissantes provenant de régions tropicales et présentant de nouveaux risques pour la santé humaine comme pour la faune et la flore locales.

OPTICAL METHODS FOR WATER POLLUTION CHARACTERIZATION

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The management of water resources in a context of climate change, which increases the pressure on clean water availability, requires the development of monitoring tools to assess rapidly the quality of water and to characterize its eventual pollution. For several years now, optical methods have been proposed to monitor, without any reagent, different types of water: freshwater (rivers, lakes, etc.), estuarine water, seawater, groundwater, (polluted or not) as well as reclaimed water (which can be used for irrigation, cleaning, etc.), etc. Spectrophotometry and fluorescence spectroscopy can be combined usefully to characterize rapidly the global dissolved organic matter in water resources. Synchronous fluorescence, where the gap between excitation and emission wavelengths, is maintained constant during excitation wavelength scanning, is of particular interest.

The objectives of the presentation are:

- After a summary of the basic principles of synchronous fluorescence, the selection of the optimal gap between excitation and emission wavelengths will be discussed as well as ways to extract information out of the synchronous fluorescence spectra.
- The combined use of synchronous fluorescence and spectrophotometry will be demonstrated using a large sample database covering large rivers (Seine, Danube, Moselle), headstreams (in mountains and plains), rivers suffering from large anthropogenic, agricultural and/or industrial pollution, reclaimed wastewaters, etc. Fig. 1. presents a subset of the database with synchronous fluorescence spectra collected along the Seine River. The characteristics extracted from the spectra will be discussed in function of classical pollution parameters.

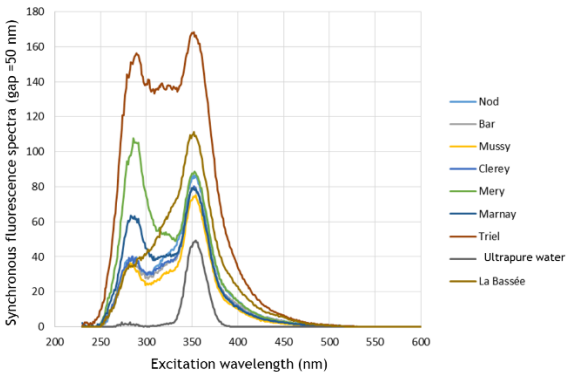

Fig.1: Examples of synchronous fluorescence spectra collected along the Seine River

Keywords: Absorbance, Dissolved organic matter, Humic substances, Spectral deconvolution, Synchronous fluorescence.

MAXIMIZATION THE BENEFITS OF WASTEWATER REUSE FOR AGRICULTURE AS A SOLUTION TO WATER AND FOOD SECURITY

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Replacement of freshwater by treated wastewater is an important conservation strategy contributing to agricultural production. The best way of using treated wastewater is in agriculture, and the use of wastewater for agriculture can definitely relieve a great deal of pressure on freshwater resources. Globally, agriculture is a major consumer of water and in the era of water scarcity replacement of freshwater, even partially, by treated wastewater could be a major alternative source of water. Wastewater reuse has some environment and socio-economic benefits. It helps in conserving natural resources. It is comparatively inexpensive to irrigate crops with wastewater whether compared with cost incurred for irrigating with groundwater from deep wells, especially in case of non-renewable resources, or lifting with diesel pumps from canals, in case of water scarcity. It helps in conserving nutrients, thereby reducing the need for chemical fertilizers; and increase crops yields, crop density and provides a reliable water supply to farmers for new lands even under water scarcity condition. For reusing treated wastewater for irrigation the "wastewater reuse guidelines" are important as wastewater can cause health risk.

The increase in agricultural reuse of treated wastewater is expected to serve goals such as promoting sustainable agriculture, preserving scarce water resources, and maintain environmental quality. Also, irrigation with wastewater may reduce purification levels and chemicals fertilization costs, because soil and crops serve as bio-filters, and wastewater contain essential plant nutrients. Policy decisions regarding the level of treatment and location of agriculture using wastewater should consider multifarious aspects including costs, hazards and benefits of agricultural reuse of wastewater. Developed countries have established conventionally low-risk guidelines based on a high technology/high-cost approach, while in developing countries the strategy is to adapt to a low technology/low-cost approach.

Choosing the most appropriate technology for wastewater treatment should based on two bases which are affordability and appropriateness that relates to the economic conditions of the community and to the environmental and social conditions, respectively. Population density and location and the efficiency of the technology as compared to the cost should be considered. The community should be able to finance the implementation, operation and maintenance of the system. For a system to be environmentally sustainable, it should ensure the protection of environmental quality, conservation of resources, and the reuse of water. Social aspect mainly relates to factors that can directly affect the operation and maintenance of a certain system. These include the local community habits, and life style, public health protection, government policy and regulations as well as public acceptance. Generally, the main driving forces for the selection of a treatment technology are performance requirements, site conditions, and wastewater characterization. Properly managing a system helps in protecting public health and local water resources, and avoiding expensive repairs. While there are many impediments and challenges concerning wastewater management in developing countries, these

can be overcome by suitable planning and policy implementation. For widening the base of wastewater reuse in agriculture and to reach the requirements for unrestricted irrigation, there are needs for optimizing wastewater treatment plants performance with a correction program as well as the low cost technology transfer .Egypt falls in the category of high water stress, where the Nile is the only surface source of renewable fresh water in Egypt.The main increase in availability can be gained by re-use and increase efficiency- demand management. Thus on the national level, re-use and efficient water utilization have the highest priority. Treated domestic wastewater re-use in agriculture represent one approach to cover water scarcity and at the same time protection of our environment from one of the main sources of pollution. The experience of large scale and organized reuse of treated wastewater effluent is still limited in Egypt. However, there are a number of large scale pilot projects, mostly irrigated trees beside some field crops. This situation is changing rapidly in the major cities of Egypt due to the installation of modern wastewater treatment plants that provide tertiary or at least secondary treatment that offer an opportunity for widening the scope of wastewater re-use in agriculture. The physical properties and the chemical and biological constituents of wastewater are important parameters that should be considered in the practice of wastewater re-use in agriculture. The Egyptian Code that regulate the application of wastewater in agriculture provide a list for classifications for plants and crops that allowed to be irrigated with treated municipal wastewater and put them in groups according to the treatment degree. Shortly, the Egyptian Practice Code, which will be discussed, prohibit the application of treated wastewater, with any level of treatment, to irrigate vegetables that eaten fresh or after cooking and fruit trees that eaten without peeling. . In addition it is prohibited to use treated wastewater for exported crops, medicinal and aromatic plants, schools and children gardens irrigation. No local epidemiological or risk assessment studies were undertaken which represent the main stone in determining the application of wastewater re-use in agriculture. Further discussion for the code will be presented through the presentation.

The use of wastewater in agriculture is a possible strategy for addressing water scarcity and nutrient deficiency in agricultural systems, beside environmental protection. Municipal wastewater composition varies over time, sites and regions. In addition, socio-economic levels of the residential communities and number and types of industrial and commercial units also have implications for environmental health protection. Various municipal wastewater treatment technologies are available and developed to efficiently treat the waste. Treatment objectives and properties as well as the available investment resources have to be considered in the choice of the appropriate technology. The marginal costs of wastewater treatments required to comply with the microbial health guidelines for unrestricted irrigation are very high especially in many low-income developing countries in the Mediterranean region. Decisions about wastewater management strategies are a process of balancing costs and effectiveness across these two objectives. For example, we have two main international guidelines for the bacteriological quality of wastewater allowed to be used for unrestricted irrigation, the WHO (not > 1000 fecal coliforms/100 ml) and the USEPA (no detectable fecal coliforms/100 ml). In order to have an answer for the question of which health guideline is appropriate for wastewater reuse, a study aimed at developing risk assessment/cost-effective approach based on mathematical models and experimental data is necessary. The additional health benefit that might result from further risk reduction gained by adhering to the more restrictive regulations should be significant in relation to the major additional costs associated with the expensive technology required to treat effluent to such a rigorous standards.

The technological, economical and health aspects as well as the legal framework have to be considered. Therefore reuse of water is an interdisciplinary challenge for the present and for the future.The planning and management of agricultural reuse projects need to consider institutional and legal, socio-economic, financial, environmental, technical and physical aspects. Most of the aspects have still to be studied in more detail since they require the development of appropriate strategies and qualified bodies for local management of treatment and reuse projects.

ORAL PRESENTATIONS

Session 1

Management of water resources

STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX BASED SPATIOTEMPORAL ANALYSIS FOR DROUGHT MONITORING IN MOROCCO FROM 1979 TO 2019

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Morocco is a vulnerable region to climate change, it will experience droughts with an increasing demand for water; this will mainly affect agriculture and food security. Furthermore, Drought frequency and severity are expected to increase due to climate change. So, a performant drought monitoring is needed to contribute to the adaptation of more efficient measures to mitigate the opposite impacts. Morocco has been experiencing more frequent droughts over the past three decades. However, a universal definition of drought is still missing; this makes the drought monitoring and the assessment of their severity more difficult. The goal of this study is to assess the spatial and temporal patterns of drought using The Standardized Precipitation Evapotranspiration Index (SPEI) in order to establish a near-real-time drought monitoring under climate change. The monitoring of the drought is commonly presented by the use of drought indices, which are constructed based on different climatic and hydrological variables that can reflect different aspects of drought. The Standardized Precipitation-Evapotranspiration Index is a combination of the advantages of two drought indices, The Palmer Drought Severity Index (PDSI), it was a landmark in the development of drought indices. However, it cannot be flexibly analyzed at different temporal scales. To address temporal scale problems, present in the PDSI, the multi-scalar nature of droughts developed the Standardized Precipitation Index (SPI) by means of a precipitation probabilistic approach. Nevertheless, the main criticism of the SPI is that its calculation is only on the basis of precipitation data and without consideration of the effect of evapotranspiration. The Standardized Precipitation Evapotranspiration Index combines the sensitivity of the PDSI to the changes in evapotranspiration demand caused by air temperature fluctuations and the multi-temporal nature of the SPI.

In this study, the monthly SPEI data for whole Morocco is calculatedUsing ERA5 Reanalysis data relies on air temperature and precipitation for the time scale of 6 months, It depends on accumulated water balance for the six previous months, The main advantage of this data, that they are reasonably good in terms of temporal and spatial coverage, and they are useful for the monitoring and assessment of drought in a real time. However, their accuracy has to be evaluated and compared with ground measurements. Firstly, this study assesses an Inter-comparison of ERA5 Reanalysis and observational data from 20 meteorological stations during the period 1979-2019. Understanding the strengths and weaknesses of ERA5 Reanalysis, lead us to choose it as an alternative source of information with acceptable accuracy. This study offers a spatiotemporal analysis and the tendency of drought obtained by plotting maps and graphs showing the monthly and annual variability of drought. The results illustrate that the drought appears in Morocco but in an irregular manner and that it is possible to distinguished clearly drought years by using the SPEI, for example, the drought has been visited Morocco in the agricultural years 2000–2001 and 2006–2007, this drought conditions required the country to import millions tons of wheat. We found that the results obtained are well confirmed. In addition, the Moroccan climate experienced a significant drying tendency, concurrently consecutive drought events have also increased across Morocco. This work can be viewed as a promising first step of a near real-time warning system for drought monitoring to bridge the gap between climate information and the practical needs of end-users.

Keywords: Drought, climate change, water, SPEI, Agriculture.

APPORT DE LA MODELISATION DES RESEAUX D'ASSAINISSEMENT POUR LA GESTION DES CRISES D'INONDATIONS EN MILIEU URBAIN.

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L'extension spatiale des villes sur les espaces ruraux voisins est une caractéristique majeure de l'urbanisation des quarante dernières années à l'échelle Mondiale. L'urbanisation croissante et l'imperméabilisation des sols qui en découle augmentent le risque d'inondation en milieu urbain. Les réseaux d'assainissement devront donc faire face à un accroissement des débits qui dépassent leur capacité d'évacuation. Cette insuffisance augmente et devient plus importante notamment lors d'un événement pluvieux exceptionnel caractérisant de plus en plus la région méditerranéenne. Face à ce défi changeant, la mise en place d'un outil de suivi et de gestion des débordements des réseaux d'assainissement permettant une gestion efficace et opérationnelle devient incontournable pour optimiser les interventions et limiter les dégâts des inondations en milieu urbain.

L'outil d'aide à la décision élaboré combine l'acquisition et la remontée de l'information des interventions de terrain avec le modèle de simulation numérique des réseaux. Les données des interventions sur terrain, les mesures en réseau, les mesures de la pluie alimentent cette base de données d'une façon continue permettant d'affiner le calage du modèle, d'anticiper les débordements, d'instaurer un système de prévention et d'alerte et de proposer des solutions optimisées. La validation du modèle, élaboré sous Mike Urban, s'est faite sur la base d'une campagne de mesure des débits par temps de pluie complétée par les constats de terrain pour plusieurs événements pluvieux significatifs. Les résultats obtenus permettent de confirmer et de caractériser les débordements constatés par l'exploitant. Le modèle de modélisation validé permet de caractériser les différentes insuffisances constatées : insuffisances aval, manque d'ouvrages d'avalement, problèmes d'apports extérieurs et problèmes d'exploitation localisés. Différentes solutions sont proposées sur la base de ce modèle de simulation : renforcements aval, renforcement des équipements d'avalement, tests de délestage entre collecteurs et ajustement des déversoirs d'orage. Des cartes d'inondation sont élaborées permettant de caractériser le dégrée d'insuffisance de chaque collecteur et l'intensité de pluie minimale provoquant son débordement. L'ensemble des points noirs sont surveillés en fonction de l'événement pluvieux attendu. Les moyens d'intervention à affecter dépendront de l'ampleur de l'événement prévu et de la sensibilité de la zone concernée. Cet outil permet également de tester des événements pluvieux majeurs, de plus en plus fréquent vu que les prévisions futures en relation avec les changements climatiques, tablent sur l'augmentation des phénomènes climatiques exceptionnels.

La méthodologie mise en place dans cet article permet donc de disposer d'un outil de gestion des débordements d'eaux pluviales avec une procédure d'auto-amélioration continue de la connaissance du risque, des modèles et des méthodes d'intervention et de gestion de ces débordements. Le modèle de simulation hydraulique permet de suivre l'évolution spatio-temporelle de la zone en fonction de l'accroissement de l'imperméabilisation des sols. Cet outil peut être complété par l'acquisition des données météorologiques et la mesure en temps réel dans les réseaux structurants. Un système central de contrôle permettant de visualiser la circulation des flux en temps réel et d'opérer d'une manière instantanée pourra être mis au point. C'est là un outil de gestion incontournable pour garantir la durabilité et la pérennité du fonctionnement du système en préservant des vies humaines et des biens matériels des riverains.

Keywords : Urbanisation, inondation urbaine, modélisation des réseaux d'assainissement, gestion des crises d'inondation.

SALINITY IMPACTS ON WATER QUALITY AND BENTHIC DIATOMS COMMUNITIES IN THE ARID DRAA RIVER BASIN (SOUTH OF MOROCCO)

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Over many arid areas of the world, salinization affects the functional processes and trophic chain interactions by endangering biodiversity in aquatic ecosystems. It also endangers human well-being by reducing ecosystem services as drinking water quality and agricultural yields. Currently, this issue is amplified through anthropic activities (anthropogenic salinity), socio-environmental constraints and climate change. Draa river basin in Southern Morocco (henceforth Desert River) is one of the most important desert river basins in North Africa. It suffers from overuse water resources and climate change leading to increasing salinization and degradation of water quality. This salinization may act firstly on primary producers that are mainly represented by benthic diatoms. These siliceous microalgae were usually used as an ideal tool for monitoring environmental impacts on aquatic ecosystems. This study aims to assess the salinity effects on the composition and structure of benthic diatoms communities in the Draa River. The water physico-chemical measurements (conductivity, dissolved oxygen, major ions,..) and sampling of benthic diatoms was performed in March 2018 at seven sites in the upper and middle Draa river. The results of water conductivity and major ions analyses showed a growing salinity gradient, especially downstream of the Mansour Eddahbi dam. The conductivity is ranged from 385,5 to 7090 µs/cm. The intermittent tributary oued El Mellah has the highest conductivity while the Iriri stream has the lowest value. The conductivity of these upper tributaries of Draa river vary due to the influence of natural (rock chemistry) and anthropogenic factors. A total of 81 diatom taxa belonging to 26 genera were recorded in all prospected sites. Among 26 genera observed, *Navicula* and *Nitzschia* genera represent alone 40% of the species. The saltwater of El Mellah stream was characterized by the abundance of halophilic species, namely *Nitzschia frustulum*, *Amphora coffeaeformis* and *Navicula ignota*. In some brackish water sites of the middle Draa, other euryhaline species *Navicymbula pusilla*, *Navicula duerrenbergiana*, *Mastogloia smithii* and *Mastogloia elliptica* are dominating. Whereas in the other sites in the middle Draa river, different diatoms with variable affinity and tolerance to salinity (mesohalobe and oligohalobes species) are dominating and are more common such as *Diatoma moniliformis*, *Achnanthidium minutissimum*, *Caloneis amphisbaena*, *Cyclotella meneghiniana*, *Cymbella microcephala*, *Fragilaria ulna*, *Gomphonema angustum* and *Gomphonema parvulum*. Benthic microalgae biomass expressed in density, dry weight and chlorophyll a showed that the unregulated natural tributaries of the upper Draa were little productive, compared to regulated main channel of the middle Draa (downstream of ME dam). Shannon's diversity (ISH) and Pielou's equitability (EQ) indices showed a lower diversity and structural stability within the diatom communities of the Draa river with a specific composition to saline sites.

Keywords: Draa River, Salinity, Water Quality, Benthic diatom, Diversity, Impact.

AN INPUT OUTPUT FRAMEWORK FOR WATER REALLOCATION: EMPIRICAL APPLICATION TO MOROCCO WATER USES

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With the continuous socioeconomic development of Morocco, water resources are being depleted rapidly whereas water demand is largely increasing. This situation has led to a structural unbalance in water resources budget with a continuous trend to worsen over time.
Questions have arisen about how water should be allocated and which criteria should be applied to ensure not only social equity but also economic efficiency. The present study has been triggered by this situation. Indeed, there is a pressing need to assess water reallocation between different economic parties to meet each sector final demand.
Policy makers, however, aim to concurrently improve water resources allocation efficiency and balance both economic and ecological goals in order to achieve a sustainable development.
The present work addresses to this problematic by considering a Moroccan water input-output model framework to evaluate how water is reallocated within the economy in response to exogenous changes in water final demand. An adaptation of the conventional Leontief model to enable water reallocation representation within the economy in the short-run is carried out with a particular focus on water distribution changes driven by exogenous shocks in final water demand.
This empirical study is based on official 2010 data records considered to be the most recent in terms of data availability of desegregated water uses by sectors (HCP, AQUASTAT). At first, a presentation of the Input-Output (I-O) model of water uses by economic sectors will be given. Next, the decomposition path analysis method related to the I-O framework will be used to model relative water uses, water distribution and water reallocation matrix. This method shows how water distribution is modified by changes in both sectoral demand and technical water requirements. The results show that the water distribution in the Moroccan economy is highly asymmetric.

Keywords: Water Input-Output model, Water reallocation, Water distribution, Final demand.

TOOLS FOR THE ECONOMIC EVALUATION OF WASTEWATER RECLAMATION AND REUSE

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The economic evaluation is basic for any wastewater (reclaimed water) reuse project. Nevertheless, the calculation tools for this evaluation are scarcely been developed due to the lack of application of the existing models. The authors develop a comprehensive tool, comprising several steps, as follows.

Step 1. Analysis of the basics

-Engineering

-Description of the initially scheduled and future reuse practices, including the applicable rules and regulations

-Description of the projected activities and actions in the area

-Initial budget

-Positive externalities (advantages expected from the project implementation)

Step 2. Socioeconomic characterization

-Identification of the population affected

-Inventory of the socioeconomic environment (population that will obtain benefits and/or suffer the changes of the scheduled activity): changes on the economy, uses of services, urban landscape, agronomic activity or use of the land.

Step 3. Building, operation and maintenance

-Major works: reclamation facilities

-Minor works: e.g. distribution network, new roads

Up to this point the evaluation is relatively simple, because is dealing with elements that can be directly valuated using market certainties (labour costs, acquisition of the machinery, permits, etc.).

It is useful to know if in those first steps, negative externalities can be raised (noise, changes in the traffic patterns, etc.). Those externalities will vary depending on the possible affectations to the inhabitants, like the time employed for journeys, etc. In each case, a different valuation measure will be necessary.For the operation and maintenance steps, all the previously indicated for the building phase is suitable.

Step 4. Evaluation of the positive and negative externalities

Sanitary quality of water and environment

-No direct effects on the health of people, if the reclaimed water is not used for supply

-Positive and negative impacts on the water bodies (quality, flow increase or decrease)

-Increase of carbon retention, reduction of atmospheric pollution, influence on local climate

-Water/aquifer reconnection

-Changes in flora and fauna

Interaction with the social environment

-Positive and negative effects on the neighbouring population quality of life, incidences on the local commerce.

-The flow of people visiting the area and the importance of the measures changing the water flows can be economically valuated following the cost of travel classical method.

Landscape changes

- Can have positive or negative effects on the inhabitants of the area

Positive: on the quality of life (more economic assets)
Negative: due to the increase of the pressures over the infrastructures and the capacity of charge of the area

- The hedonic prize can be used for the valuation of the systemic ecoservices, which affect the residential properties prize

Quality of life:

-The valuation of quality is performed using the method of the willingness to pay. There are two approaches: the methods based on the questionnaires and the ones based in the revealed preferences.

-Also, the economic valuation must be done by the method of avoided costs, supposing that the costs which avoid certain damages to the environment and the services will provide estimations of its value. It is supposed that the individuals are disposed to change their behaviour and invest money to avoid negative impacts on the environment.

This method will be applied to a specific case in Catalonia, where several reuse facilities will be evaluated.

Keywords: Economic evaluation, Wastewater reclamation and reuse.

CONTESTABILITE SOCIALE BASEE SUR LE « COUT-VERITE DE L'EAU » : LE CAS D'ETUDE DES ASSOCIATIONS D'USAGERS DE RESEAUX D'EAU POTABLE (ASUREP) A KINSHASA, REPUBLIQUE DEMOCRATIQUE DU CONGO

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Kinshasa, capitale de la RD Congo connaît une périurbanisation accélérée et déséquilibrée. Malheureusement cette extension des tissus urbains et périurbains ne s'est pas accompagnée d'un développement adéquat des infrastructures de distribution d'eau, ce qui se traduit par des contraintes importantes dans l'accès à l'eau potable. La REGIDESO qui était censée assurer la fourniture du service de l'eau sur l'ensemble de la ville n'était pas en mesure d'amener de l'eau dans les quartiers périphériques. Dans ce contexte, des logiques d'acteurs se mettent en place autour des services d'eau avec une diversité des modes de gestion. Parmi ces acteurs, nous avons les ASUREP. Mais, dans un contexte de pauvreté urbaine, comment les consommateurs perçoivent-ils le prix pratiqué par l'ASUREP?

L'ASUREP repose sur des principes de fonctionnement définit dans le cadre de la coopération au développement. L'utilisation du coût-vérité pour déterminer la tarification à appliquer est l'un de ceux-ci.Cependant, pour tous les distributeurs d'eau potable dans le monde, le prix de l'eau potable est le motif le plus fréquent de contestation sociale visant les distributeurs (« trop élevé pour la qualité », « pas transparent ». La question du juste prix est fréquemment posée au sein des ASUREP.

Cet article analyse les déterminants de la contestabilité sociale basée sur le « coût-vérité de l'eau ». Le développement du modèle ASUREP en RD Congo ne doit pas donc rien à la contestabilité sociale, mais elles doivent à present y faire face.Pour atteindre cet objectif, une méthodologie s'appuyant à la fois sur une recherche documentaire et d'enquête de terrain et, complétée par des observations directes a été adoptée. Un jeu de question est réservé (1) à la compréhension/ perception de la notion de coût-vérité de l'eau, (2) appropriation du coût-vérité de l'eau et (3) réaction adoptée face au prix pratiqué par l'ASUREP. Une série d'items est proposée: pour les ménages, l'autorité locale et l'équipe de gestion l'ASUREP.

Mots clés: ASUREP, Coût-vérité de l'eau, Marchés de l'eau, Contestabilité sociale, Prix de l'eau.

THE USE OF SEAWEEDS AND ABIOTIC PARAMETERS FOR THE BIOMONITORING OF MOROCCAN COASTAL AREAS: CASE STUDY OF SAFI CITY

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The present work intended to evaluate the quality of Safi city coastline waters (Moroccan Atlantic coast), by using seaweeds and abiotic parameters. The correlation between physico-chemical parameters (nitrogen and phosphorus compounds, dissolved oxygen, temperature, conductivity, pH) and thebiotic indiceswere carried out during four seasons between January and October 2018. This study aims to apply biotic indices in order to assess the capacity of algal communities to reflect the quality of the aquatic ecosystem in the coast of thiscity.

We considered three stations for the present study (S1, S2 and S3), from 32°54'N-9°27'W (S1) to 32°18'N-9°26'W (S3). Four sampling campaigns were conducted during the year 2018.A total of 164 phytobenthos taxa were inventoried including 108 Rhodophyta, 29 Chlorophyta and 27 Pheophyta. However, a remarkable degradation of algal diversity has been noticed from the station S1 (Beddouza) to the two urban stations S2 (Industrial district) and S3 (phosphate complex) where more than 50% of the species have disappeared.The study of the algal stands structure evolution, and the content of proline accumulated in the algal thallus, indicates instability in this macroalgal ecosystem. The levels of the chlorophyllian pigments in four dominant algales species (*Osmundea pinnatifida*, *Fucus spiralis*, *Ulva lactuca* and *Codium elongatum*), indicate an important stress, especially in stations S2 and S3.The results show that the toxic metal contents of seewead (especially Cd, Cu, Pb and Zn) and the concentration of phosphorus are correlated with stress physiological parameters, and inversely correlated with pigment contents.The physicochemical changes of the coastal waters observed in the impacted sites would be due to the anthropogenic pollutants resulting from the intense urban and industrial activities that characterize this industrial city. Indeed, the values of the specific diversity indices of shannon (H') and Equitability (E) show an increase in pollution at stations S2 and S3, the industrial station and the phosphate station respectively, compared to the reference station S1 of Beddouza. This observation illustrates the interest of phytobenthos in the biomonitoring and bioassessment of coastal marine ecosystems.

Keywords: Atlantic coastline of Morocco, biomonitoring, physicochemical parameters, biotic indices, seaweed.

POTENTIAL PHARMACOLOGICAL AND BIOLOGICAL APPLICATIONS OF TWO BROWN ALGAE ORGANIC EXTRACTS: *CARPODESMIA TAMARISCIFOLIA* AND *BIFURCARIA BIFURCATA*

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Marine algae constitute an enormous reservoir of potentially active natural molecules, whose their antibiotic, anti-tumor, antiviral and anti-inflammatory properties give them an appreciated value in pharmacy and medicine applications. Our study aims to evaluate the antibacterial activity of extracts of two brown algae species collected from Sidi Bouzid coast (El Jadida, Morocco): *Carpodesmia tamariscifolia* and *Bifurcaria bifurcata* against three humans pathogenic bacteria responsible for food poisoning and nosocomial infections: *Escherichia coli, Staphylococcus aureus and Bacillus cereus.*

The results of the dichloromethanolic extracts showed antibacterial activity against the *Staphylococcus aureus* strain, producing interesting zones of inhibition. We have also observed that the extract of *C. tamariscifolia* is active against *Escherichia coli*, and inactive against *Bacillus cereus*, while the extract of *Bifurcaria bifurcata* has no activity against *Escherichia coli*, On the other hand, it has significant antibacterial activity against *Bacillus cereus*.

The inhibitory activity of algae on bacteria activity varies depending on the amount of the extract. The high amount of the dichloromethanolic extract of the *C. tamariscifolia* algae (0.32 g) against *S. aureus* had given significant antibacterial activity with an inhibition diameter of (10.5 ± 0.28) mm. The medium amount (0.16 g) had given a medium activity (7.5 ± 0.28) mm, while for the low amount (0.08 mg) no antibacterial activity was recorded. Against *E. coli*, the medium (0.16 g) and the high (0.32 g) quantity of the total extract apply an important activity, expressed by an inhibition diameter which varies between (8.75 ± 0.70) mm for the medium quantity, and (10.87 ± 1.45) mm for the high quantity. While the low amount (0.08g) did not exert any inhibitory action. However, dichloromethanolic extract of *Bifurcaria bifurcata* showed an important and very significant antibacterial activity in comparison to *C. tamariscifolia* against *B. cereus* and *S. aureus.*

This survey would provide with resourceful drug candidates for pharmacological purposes based on brown algae organic extracts.

Keywords: Brownalgae, *Carpodesmia tamariscifolia*, *Bifurcaria bifurcata*, Dichloromethanolic extract, Antibacterial activity, Pathogenic microorganism, Morocco.

Session 2

Water quality and pollution

ASSESSMENT OF HUMAN EXPOSURE TO DISSOLVED URANIUM AND RADON IN GROUNDWATER IN COASTAL ABDA REGION OF MOROCCO

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Naturally occurring radionuclides enter the human body mainly by inhalation of air particulates and by ingestion of food and water. Urban population in Morocco has potable water supplies derived from dams, springs and wells. These drinking waters contain radioisotopes dissolved from rocks and soils and so present a source for radiation dose exposure. It is necessary to measure the radionuclide content of ground water samples to assess potential radiation doses and, if necessary, to take action to avoid the exposure of consumers to radiation. Radon (^{222}Rn) is a chemically inert and very mobile gaseous decay product of uranium (^{238}U) which is found in all rocks and soils. Radon is very soluble in water. The uranium (^{238}U) and radon (^{222}Rn) concentration measurements have been carried out in groundwater samples collected from coastal ABDA region of Morocco, by using a solids state nuclear track detectors LR-115 type. The ^{238}U and ^{222}Rn concentrations in these samples are found in the range of 0.003 and 0.015 µg/l and 0.15 to 0.57 Bq/l respectively. The measured values of ^{238}U and ^{222}Rn concentration are below the limits recommended by the World Health Organization (WHO) which are 100 Bq/l and 0.015 mg/l, respectively [1]. The annual effective doses are also observed to be below the prescribed dose limit of 0.1 mSv/year recommended by WHO [2].

Keywords: Radioactivity, Groundwater, Uranium, Radon, Health, Environment.

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EFFECTS OF ANTHROPOGENIC FACTORS ON GROUNDWATER ECOSYSTEM INZAGORA REGION

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The depletion of aquifer systems in arid and semiarid regions worldwide is causing acute water scarcity and quality degradation, and leading to extensive ecosystem damages. Groundwater is exposed to a variety of anthropic water pollution as raw wastewater disposal in the Draa wadi and the use of septic tanks. In this respect a study performed in some wells of Zagora (South-east Morocco) aimed at both the discovering of the main components of the aquatic subterranean fauna unknown up to now in this area, and the potential relationships between this fauna and the well water quality. For this purpose more than 50 groundwater wells were first surveyed occasionally.

Then the principal physico-chemical characteristics of water from wells were measured regularly at 16 selected wells. From the physico-chemical side, the Fazouata groundwater is distinguished by its high salinity. In many stations, water was hard and saline with an increasing gradient from upstream to downstream. The aquatic fauna present in these 16 stations was also monthly sampled during seven-month. These wells were selected considering their fauna and their position with respect to the pollution sources known in surface.

The results of this survey showed a rich and diverse aquatic fauna including 8 species and one genera new to Science. In the protected wells which are situated far from the pollution sources. The fauna population was dominated by the Amphipodes métacrangonctydae, Stenasellidae, Cirolanides, Thermosbaenacea and ground gasteropodes.

On the other hand, in the less protected well, close to the pollution sources, the fauna population is made of species such as insect larva Culicidae and chironomideae. The analysis of both water quality and biodiversity shows that the latter decreases with increasing groundwater pollution. It is the stygocenose species that diminish and vanish in case of acute pollution.

Keywords: Groundwater pollution, Stygoby funa, biodiversity, Zagora, Water physicochemistry.

ETUDE COMPARATIVE DE LA QUALITE DES EAUX DE SURFACE ET DES EAUX DE MER DANS LA REGION DE SAFI

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Les ressources en eau dans la région de la ville de Safi sont soumises à l'effet de plusieurs facteurs anthropiques favorisant la dégradation de leur qualité. L'objectif de ce travail est de faire une étude comparative de la qualité physicochimique, bactériologique et du niveau de contamination par le Cu et le Pd des eaux de surface au niveau de plusieurs sites dans la Ville de Safi. La stratégie d'échantillonnage adoptée a permis de choisir quatre sites de prélèvement. Les prélèvements des eaux de surface ont été effectués dans deux sites au niveau de la zone du barrage Sidi Abderrahmane (Site 1 et 2). Les prélèvements des eaux de mer ont été effectués au niveau de la plage de la ville de Safi (Site 3) et au niveau du Jorf situé au sud de la ville de Safi (Site 4). Ces échantillons ont été comparés par rapport aux eaux de robinet du secteur Sidi Bouzid (Site 5) et aux normes marocaines en vigueur. Les analyses physicochimiques, les analyses bactériologiques ont été réalisés selon les méthodes communes. Le dosage du Pb et du Cu a été effectué par Spectroscopie d'absorption Atomique (AAS).

Les résultats des analyses physicochimiques montrent que le pH le plus élevé a été observé dans les eaux prélevées au niveau du Site (1) (8.6). Les eaux étudiées dans les différents sites sont caractérisées par une salinité et dureté très élevées à celle de l'eau potable (site 5) et qui dépassent les normes marocaines adoptées essentiellement pour les eaux destinées à l'irrigation. Les propriétés microbiologiques montrent que les eaux de surface prélevées dans les sites (1) et (2) sont les plus contaminées par les coliformes totaux. Ces eaux de surface sont également les plus contaminées par les coliformes fécaux et qui dépassent les normes marocaines en vigueur. Les teneurs en Pb et en Cu mesurées dans les eaux étudiées montrent que les eaux de Jorf situé au sud de la ville de Safi sont les plus contaminées (0.315 $mg.L^{-1}$ de Pb et 0.344 $mg.L^{-1}$ de Cu), suivis par les eaux de surface prélevées dans le site (2) qui présentent 0.25 $mg.L^{-1}$ de Pb et 0.314 $mg.L^{-1}$ de Cu. Selon les normes de qualité adoptée au Maroc pour les eaux destinées à l'irrigation ou pour les eaux de baignade, les eaux de surface étudiée (Eaux prélevées au niveau de la zone du barrage Sidi Abderrahmane) sont impropres à l'utilisation dans ces conditions. Concernant les eaux de mer étudiées (Site 3 et 4), elles peuvent être classées dans la catégorie B, conforme à la baignade selon la classification marocaine, en se basant sur leurs propriétés microbiologiques. Cependant, leur niveau de contamination par le Pb et le Cu présente un risque potentiel, essentiellement pour les eaux de Jorf situé au sud de la ville de Safi nécessitant, par conséquent, une intervention urgente dans le cadre d'une stratégie de développement durable.

Mots Clés: Etude comparative, Eaux de surface, Eaux de mer, Physicochimie, Bactériologie, Contamination Métallique.

MODELISATION DU DEVENIR DES REJETS DE LA STEP DE KENITRA AU NIVEAU L'ESTUAIRE DE LA RIVIERE SEBOU

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Les rejets d'eaux usées de la ville de Kénitra ne cessent d'augmenter suite à l'accroissement démographique de la ville. Avant 2020, ses eaux étaient rejetées sans traitement préalable au moyen de six collecteurs dans l'estuaire de la rivière Sebou, l'océan Atlantique et le lac Fouarate, causant des risques sanitaires et environnementaux. La construction de la station d'épuration des eaux usées (STEP) de la ville de Kénitra a visé l'évacuation de tous les rejets vers la STEP avant leur traitement. La STEP est devenue ainsi le seul point de rejet au niveau de l'estuaire de Sebou (60 Km).
L'objectif de cette étude est la modélisation de la qualité des eaux de l'estuaire de l'estuaire de la rivière Sebou et de simuler le devenir dans l'estuaire des rejets issus de la STEP (située à 19.4 km à l'amont de l'embouchure).
Comme la qualité de l'eau est fortement liée au régime hydraulique, on a utilisé le modèle HEC-RAS pour modéliser le régime hydraulique de l'estuaire. Le module hydraulique a été calibré et validé en une importante base de données hydraulique et morphologique. L'évolution spatiotemporelle des variables hydrauliques (vitesse, niveau d'eau…) calculées par le module hydraulique a été injectée dans le module qualité des eaux pour simuler deux paramètres : l'oxygène dissous (OD) et la demande biochimique en oxygène (DBO5). Deux scénarios ont été testés : simulation d'un un rejet non traité, simulation d'un rejet après traitement dans la STEP. Les simulations montrent l'influence du cycle de la marée et des apports d'eau douce (venant de m'amont) sur le devenir des rejets. Les résultats ont mis en évidence l'impact positif du traitement des rejets sur la concentration de l'oxygène dissout et de la DBO5. Dans le cas où le rejet est traité, la concentration d'oxygène dissout dans les eaux de l'estuaire a tendance à augmenter, alors que la concentration en DBO5 est fortement réduite (Fig. 1). Les simulations ont apporté d'autres éléments de réponse tel que la dispersion du rejet et son temps de séjours dans l'estuaire. Le modèle développé a mis en évidence, sans aucun doute, les avantages de la construction de STEP de Kénitra.
La modélisation de la qualité des eaux de l'estuaire Sebou a visé l'étude du devenir des rejets de la STEP de Kénitra et de montrer les avantages du traitement des eaux usées de la ville de Kénitra sur l'amélioration de la qualité des eaux du milieu récepteur.

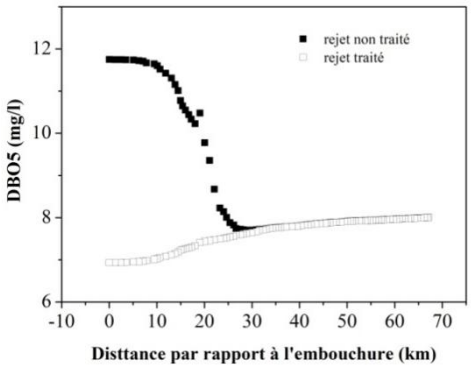

Fig.1 Evolution de la DBO5 avec rejet de la STEP traité et non traité

Mots clés: Estuaire Sebou, Qualité des eaux, modélisation, HEC-RAS, Oxygène, DBO5

FLOOD HAZARD ASSESSMENT OF MOUNTAINOUS WATERSHED USING THE SWAT MODEL: CASE STUDY OF N'FIS CATCHMENT MOROCCO

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A flash flood is defined as an extreme and sudden event that might occur after a heavy rainfall, a massive ice meltdown or a failure of natural or man-made reservoirs. Flash floods frequently cause tremendous economic, environmental and social damages. In mountainous areas, the impact of flash floods is even greater. Their magnitude is influenced by the extreme hydrological events (rainfall, snow...etc.), the steep slope, the poorly developed land cover and the specific geological properties. These are all factors that affect the flow discharge and velocity in these areas particularly which exacerbate their vulnerability to flash floods. The aim of this study is to assess flood risk in the N'fis sub-basin, which is a mountainous catchment located in the high Atlas of Morocco that drains a total area of 1270 km². The N'fis watershed is characterized by an arid to semi-arid climate in plains and sub-humid in mountains. The flood risk estimation in this watershed is a complicated process and a true challenge due to the poor database. To overcome this complexity, we utilized the SWAT (Soil and Water Assessment Tool) which is a physically based, computationally efficient and, capable of continuous simulation over long time periods. This hydrological model help simplifies the complexity of the basin by simulating and reproducing the hydrological behavior of the N'fis upstream. The following statistical criteria were used for evaluating the SWAT model results: Nash-Sutcliffe efficiency (NSE), percent bias (PBIAS), and ratio of the mean square error to the standard deviation of measured data (RSR), in addition to the graphical techniques, were used in the model's evaluation. The forecast is a major stake of the problematic of natural risks management, especially in the field of flooding. A forecast, both reliable and intervene early enough, may limit, the aftereffects of such events at economic, social and human. Therefore the outputs of the SWAT model are used for the flood forecast in particular rain events. One of the most common techniques to estimate the recurrence the flood with high magnitude is the Flood frequency analysis. Statistical methods; namely Gumbel Normal and Log Pearson III were applied to the daily flood frequency generated by SWAT simulation which can produce results of hourly frequency. The analysis is done for different year return periods by using annual maximum discharge data from 1982 to 2018 (37 year), From this procedure, we are able to evaluate two of most commonly used distribution methods, Gumbel and Log Pearson type III .

Key words: Flood, High Atlas, Hydrological modeling, SWAT (Soil and Water Assessment Tool), Flood Frequency Analysis, Gumble, Log Pearson III, Nash-Sutcliffe efficiency, Flood forecast, watershed.

ECOTOXICOLOGICAL DIAGNOSIS AND MARINE POLLUTION OF ESSAOUIRA COAST (MOROCCO): *ELLISOLANDIA ELONGATA* AS BIOINDICATOR SPECIES OF WATER QUALITY

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Globally, marine coastal areas are continually exposed to human aggression and diverse anthropogenic activities, through domestic and industrial discharges often without pretreatment, these wastes sources as well as habitat destruction have a substantial impact on the ecological integrity on their communities such as decrease of their number, disappearance of some species, or physiological disorders. Biological indicators like seaweeds have been used globally in water quality assessments. The use of the calcareous red alga, *Ellisolandia elongata*, for this purpose and for the first time in Morocco is highlighted in the present work in order to evaluate the pollution degree in the coastal area of Essaouira city (Morocco). In this study, three sites were chosen: Moulay Bouzerktoune station (S1) as a reference station, Bab Doukkala station (S2), and the port station (S3) as polluted ones. The seasonal study of algal biodiversity, physiological parameters of *E. elongata* as well as the abiotic parameters was analyzed. They showed that Bab Doukkala S2 and the port S3 stations, where the wastewater from the city of Essaouira pours without any pretreatment and where the algal biodiversity is low, the concentrations of suspended matter (SM), electrical conductivity (EC), Biological Demand of Oxygen (BOD), Chemical Demand of Oxygen (COD), ammonium ($NH4^{+}$), and orthophosphates (PO_4^{3-}) are higher. While the station of My Bouzerktoune S1 record the highest values of dissolved oxygen (DO) and nitrates (NO_3^{-}). On the other side, the concentrations of heavy metals in *E. elongata*, was non-detectable for Cadmium (Cd), Lead (Pb), Nickel (Ni) and Chromium (Cr), but show a high level for Zinc (Zn) and Copper (Cu), in the polluted areas.

For physiological parameters, the results pointed that the concentrations of proline, Glycine Betaine (GB) and Total phenolic compounds (TPC) contents are significantly higher in the studied alga in the polluted areas S2 and S3, whereas, Chlorophyll a (Chla), and axis length values are higher in S1. The stressful conditions have been proved by these results. Also, it reflects the anthropogenic impact threat in this coastal area. Thus, the use of algal parameters in identifying various types of water degradation is essential and complementary to the other environmental indicators to monitor the pollution in the seawater.

Keywords: Seaweeds, physiological parameters, Physico-chemical parameters, Heavy metals, Pollution, Essaouira coast.

STUDY OF THE FATE OF MICROPLASTICS IN DIFFERENT WASTEWATER TREATMENT PLANTS

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The global production of plastics has been increasing for several decades; their multiple properties have allowed these polymers to conquer the domestic domain as well as the industrial field leading to the contamination of aquatic ecosystems. Micro-plastics (MP) are polymers with a size inferior to 5 mm they are classified under two main categories according to their origins. Primary MP which are directly discharged into the environment in the form of small particles generally produced by synthetic products, the secondary ones result from the fragmentation of large plastic. Micro-plastics sweep a wide range of size and density which allows them to occupy the entire water column and subsequently ingested by marine species and therefore end up in the food chain. These particles often adsorb additives and agents which can be harmful to humans, animals and soil.

In our research we study MP that are present in wastewater through the wastewater treatment plants (WWTP) while following a protocol to highlight them (sampling, preparation, identification) and finally take stock of the contribution of WWTP in the elimination of MP.

In this sense the Stabilization pond of Sidi Mokhtar (Marrakech-Safi region, Morocco) has been chosen as pilot, and a 24 hours composite sampling is carried out in this WWTP (natural lagooning), of which a volume of 10l is collected at the level of the entrance and at the outlet of the WWTP. The samples that have been collected passed through three sieves in series which were washed in turn in a glass bottles before their preparation for visualization under a stereomicroscope (Leica M80). The imagery was processed with Gryphax software which also allowed measuring the particle size.

A drawdown around 77% of the identified micro-particles has been recorded between the outlet and the entry of the WWTP. Particles that have been identified are ranged between 0.107 and 3.82 mm in size at the entrance of WWTP unlike the outletwhose particles do not exceed 1.5 mm. Their shape varies between fibers and debris with different colors (Red, blue, transparent, yellow…). The amount of micro-particles identified at the entrance is 4 times more than those found at the outlet where the particles size does not exceed 1.5 mm.

The results obtained have shown that the WWTP can contribute to the reduction of MP present in wastewater even with a simple treatment (lagooning), but the mechanisms of fate of MP in the WWTP is yet to be studied in the future researches. The protocol followed in this study, can be extended and applied to study MP fate in other type of WWTPinthe region.

Keywords: Microplastics, Wastewater, WWTP,Sampling, Characterization methods, fate.

SUSTAINABLE MANAGEMENT OF ABANDONED MINING SITES

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Many mining sites are abandoned in Morocco without any treatment, resulting in a large amount of mining waste. These discharges, rich in metallic trace elements, generate acid mine drainage. This is the case of the Kettara mine located 32 km north of Marrakech and 120 km from Safi. Between 1964 -1981, it produced more than 5.2 million tonnes of mining wastes, which today constitutes an environmental problem. To remediate at this problem, the chemical immobilization process will be use to stabilize heavy metals. Thus, this study aims to use inorganic and organic amendments for the adsorption of heavy metals. It involves using some substances like lime, marble, snail shell and manure to neutralize and fix the soil, thereby reducing the solubility and mobility of contaminants; then the acidity and concentrations of heavy metals will decrease in the soil. The materials will be applied at 5% and 10% on 1 kg of residue in column tests. As expected results, the mixture of mine tailings and amendments such as lime, marble and snail shell will increase the pH of the tailings. The manure will play a key role in the fertility of the soil by adding organic matter to the soil. The preliminary results of the physicochemical characterization showed a very acid soil for the mining residues (pH around 1). The pH of lime, marble, snail shell and manure was between 8 and 13. The conductivity of mine tailings was high (more than 4,000 µS cm^{-1}), hence it justified the mobility of metallic trace elements in the soil. A low level of carbonate (10.47 mg) and organic matter (0.425 %) in these mine tailings was observed. the granulometric analysis of the soil showed a sandy texture (45.45 % of sand). The concentrations of heavy metals in mine tailings were:Cu (1273 mg kg^{-1}), Zn (128 mg kg^{-1}), As (118.5 mg kg^{-1}), Pb (100 mg kg^{-1}). These amendments of soil could be durable solutions for the rehabilitation of mine sites contaminated by metallic trace elements.

Keywords: Mining sites, Mining tailings, Metallic trace elements, Acid mine drainage, Amendments, Chemical immobilization.

ELABORATION DE NOUVEAUX PHOTOCATALYSEURS $Y_3Al_5O_{12}:Ce^{3+}$@ZnO CŒUR/COQUILLE ACTIFS SOUS LUMIERE DU JOUR POUR L'ELIMINATION DES ANTIBIOTIQUES DES EAUX USEES

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L'introduction de substances pharmaceutiques telles que les antibiotiques dans l'environnement et les écosystèmes aquatiques a été identifiée comme l'un des problèmes environnementaux et sanitaires majeurs au cours des deux dernières décennies [1].
La présence de sulfathiazole (STZ), qui est une molécule largement utilisée comme antibiotique, dans les écosystèmes aquatique, est due en grande partie à l'impossibilité de parvenir à une élimination complète pendant le traitement des eaux usées [2]. Cette situation rende nécessaire le développement de techniques et de matériaux efficaces pour éliminer ces nouveaux polluants émergents. Dans ce contexte, la photocatalyse est considérée comme l'une des technologies de décontamination les plus prometteuses [3]. L'oxyde de zinc (ZnO) est l'un des photocatalyseurs à semi-conducteurs les plus utilisés dans la décontamination de l'eau. Cependant, le ZnO est un matériau qui ne peut être activé que par une lumière ultraviolette (UV) qui ne représente qu'environ 5% de la lumière solaire [3]. Par conséquent, pour améliorer la performance photocatalytique des semiconducteurs et exploiter efficacement l'énergie solaire et rendre le procédé photocatalytique de décontamination plus efficace, les photocatalyseurs doivent être actifs sur un domaine plus large tel que la lumière visible (Vis). Pour atteindre cet objectif la stratégie utilisé dans notre travail consiste à coupler les photocatalyseurs semi-conducteurs avec des matériaux photoluminescents, a récemment été développée par la faculté des sciences de Tétouan en collaboration avec l'Institut de Chimie de Clermont Ferrand [4,5]. Cette approche permet de coupler le semiconducteur ZnO avec des matériaux luminescents de type ''down-conversion'' (capable d'absorber la lumière visibel) tel que $Y_3Al_5O_{12}$: Ce^{3+} (YAG) pour synthétiser des photocatalyseurs de type cœur@coquille (luminophores@ZnO) par le procédé sol-gel. Les résultats ont montré que les photocatalyseurs $Y_3Al_5O_{12}$: Ce^{3+} @ ZnO [4] ont une meilleure absorption dans le domaine de visible et capable de produire plus des radicaux hydroxyles comparés au semi-conducteur ZnO seul.
Les résultats ont montré aussi que la dégradation photocatalytique de nos matériaux bien supérieure à celle de ZnO pur, qui attient jusqu'à 98% et 80% de dégradation sous UV-visible et visible, respectivement, contre seulement 70% et 50% sous UV-visible et lumière visible.
Notre approche s'est avérée très prometteuse pour développer de nouveaux matériaux photocatalytiques actifs sous la lumière du jour pour l'élimination des antibiotiques des eaux contaminées par ces substances, en particulier, et pour le traitement des eaux usées d'une manière générale.

Keywords : Eaux usées, Antibiotiques, Photocatalyse solaire, Nanostrucrures, Luminophore.

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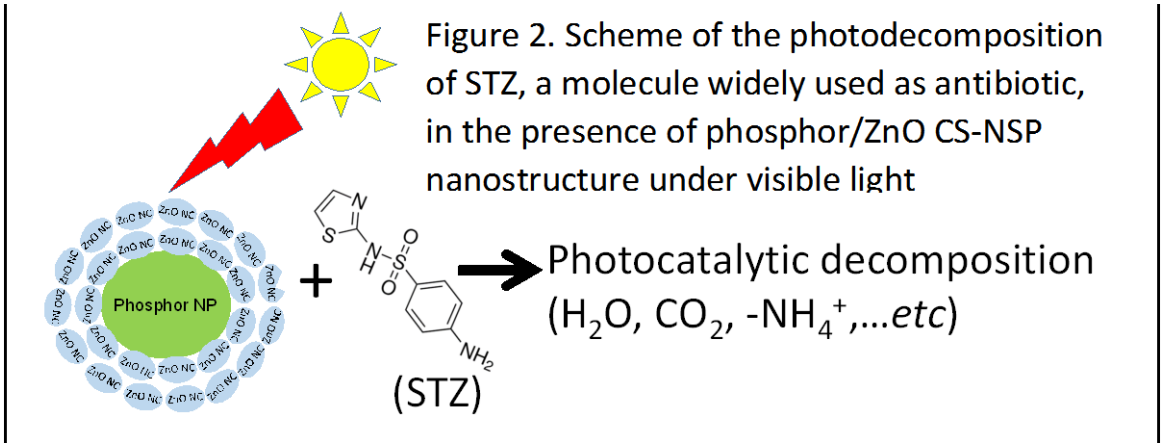

Figure 2. Scheme of the photodecomposition of STZ, a molecule widely used as antibiotic, in the presence of phosphor/ZnO CS-NSP nanostructure under visible light

ELABORATION OF INNOVATIVE CERAMIC MICROFILTRATION MEMBRANE FOR WASTWATER TREATMENT FROM NATUREL MOROCCAN SAND

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Ceramic membranes possess several desirable chemical and mechanical properties such as resistance to corrosive environments, high thermal stability, mechanical strength and relative inertness. The development of membrane technology can lead to new revolution which adds very important economic value to natural minerals. Recently, the elaboration of low cost ceramic membranes based on natural raw materials such as kaolin, clay, zeolite, limestone, dolomite, feldspar, quartz and other appear an efficient solution of purification of water and other liquid media at a low cost.

This work describes manufacturing and characterization of low-cost plan ceramic microfiltration membrane from naturel Moroccan sand. This raw material has been dictated by its beneficial properties and natural abundance. XRD, IR and EDS techniques were used to characterize it.

Firstly, plastic paste was prepared from sand powder (average particle size = 100µm) mixed with organic additives and water. Plasticizer and binder are required to prepare a paste with rheological properties allowing the shaping by extrusion. The major advantage of the organic additives is that they are removed by combustion during the sintering. Ceramic support was prepared by extrusion technique followed by sintering at a temperature of 1050°C/2h. This formulation is conducted to obtain a ceramic support with uniform porous structure and high water permeability. Secondly, the membrane layer was prepared from the same naturel sand powder (average particle size <50µm) by dip coating method using a mixture of powder sand (8%), water (30%) and polyvinyl alcohol solution (PVA 12%). The membrane thus prepared was characterized by SEM scanning electron microscope. The performance of the membrane was judged by filtration of methylene blue.

The major component of sand powder is silica, calcite and aragonite in accordance with other techniques; sintering temperature was observed that at 1050°C a very good product with stability towards chemical corrosion. The support has shown a porosity of 44.04% and an average pore diameter of 11.60 µm.

The layer thickness is about 84,8µm which is a suitable value for microfiltration layer. The pore size of the microfiltration membrane sintered at 1050°C/2h, estimated from SEM images, has been 1µm. Methylene blue (MB) containing water was allowed to flow through the membrane simply by gravity with a flow rate of 1.4 ml min^{-1}. Permeate was analysed using a UV spectrophotometer. The active microfiltration layer obtained has displayed an excellent adhesion with the support, a high surface quality and water permeability of 1770 L/h.m2.bar. This study proved that ceramic membrane can remove up to 85% of methylene bleu after 40 min of filtration.

Keywords: Ceramic support, Membrane, Microfiltration, Sand, water treatment.

ASSESSMENT OF SOME POLLUTANTS IN WATER AND IN SOME MACROALGAE AT ESSAOUIRA COAST- MOROCCO

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Essaouira city is located west of Central Morocco along the Atlantic Coast characterizing by tourism, industrial and recreational activities. A little attention was given to the negative impact resulting from these activities as discharging of solid or liquid wastes to water streams. The aim of this work is to evaluate some pollutants in different water bodies and in some macroalgae at Essaouira city through the analysis of some important physicochemical characteristics (suspended matter (SM), electrical conductivity (EC), Biological Demand of Oxygen (BOD), Chemical Demand of Oxygen (COD), dissolved oxygen (DO), orthophosphates, ammonium, nitrates and total nitrogen and phosphorus) according to AFNOR norms. In addition to some heavy metals (Cd, Cu, Pb and Cr) in different water bodies digested with concentrated nitric acid and analyzed using Atomic Absorption Spectrophotometer. Water samples were collected seasonally (autumn 2017, winter, spring and summer 2018) from three studied area: Moulay Bouzerktoune station (S1) as a reference station, Bab Doukkala station (S2), and the port station (S3) as polluted ones. The analysis showed minimum concentrations of Dissolved Oxygen (DO) and Nitrate (NO_3^-). On the other hand, maximum concentrations of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Matter (SM), Electrical Conductivity (EC), Ammonium ($NH4^+$), Orthophosphates (PO_4^{3-}) and Total Nitrogen (TN) and Phosphorus (TP). The heavy metals Cadmium (Cd), Copper (Cu), Lead (Pb) and Chromium (Cr) concentrations in all water samples fit with the Moroccan standards for direct discharges of heavy metals into environments. However, the analysis of heavy metals in some macroalgae showed high concentrations in the polluted areas. The main species that has recorded high heavy metal concentrations is *Cystoseira tamariscifolia*. These elements decreased in the following order: Cu > Pb > Cr > Cd. The results obtained are discussed on the basis of comparison of these heavy metals levels in seaweed *Cystoseira* sp. from other different locations in the world. The highest concentrations of all heavy metal were recorded in the polluted areas, the port station at Essaouira coast (Cd: 2.60±0.15 µg/g during spring; Pb: 4.43±0.73 µg/g during autumn, Cu: 10.60±1.14 µg/g during summer and Cr: 2.90±0.23 µg/g during autumn). Thus, macroalgae, especially *Cystoseira tamariscifolia*could be used as a tool to monitor the state of coastal areas because of its capacity to withstand the future pollution scenarios mentioned by many authors.

Keywords: Assessment,Water pollutants,Physico-chemical parameters,Heavy metals, Essaouira coast.

DIATOMS COMMUNITIES AS BIOINDICATORS OF SOIL QUALITY IRRIGATED BY DIFFERENT WATER QUALITY IN MARRAKESH AREA (MOROCCO)

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Due to the increase in water demand and wastewater reuse for irrigation in arid area, there is a need to assess the beneficial or detrimental effects (impacts) of recycling wastewater for irrigation on soil quality via soil microorganisms. Soils are a valuable resource that, once degraded, would be extremely difficult and costly to reclaim. Irrigation with treated or untreated wastewater should, therefore, be accompanied by close monitoring of different indicators of soil structure in order to maintain their integrity state for continued productive use. In this study we investigated the changes of soil microalgae (diatoms communities) as bioindicators of suburban soils quality irrigated by groundwater and treated wastewater in Marrakech area. Diatoms, unicellular siliceous microalgae, are one of the most diverse groups of photosynthetic eukaryotes algae, commonly studied in aquatic ecosystems and used as bioindicators for assessing water quality. Conversely, studies on terrestrial diatoms communities as potential bioindicators of soil quality are rather rare. This study aims to assess the effect of irrigation with treated wastewater (discharged downstream of the treatment plant) on soil diatoms composition in comparison with soils irrigated by groundwater (Azzouzia farmland) and rainwater (Zaouiate Ben Sassi as reference site). The sampling of soils and physico-chemical measurements (soil moisture, pH, electrical conductivity, total organic carbon, ammoniacal nitrogen and available phosphorus) were done at three sampling sites during two seasons (February and May 2016). Diatoms were identified by using specialized flora after treatment with hydrogen peroxide. The spatial distribution of soil diatoms and associated environmental factors were investigated using Principal Component Analysis (PCA). The results revealed the existence of a significant diversity of soil diatoms with 17 taxa recorded in all sites divided into 10 genera. The soils sampled are characterized by the abundance of the Pennate diatoms (95%) compared to central ones (5%). The highest species richness was recorded in soils irrigated with treated wastewater (11 taxa), compared to the one irrigated by groundwater (5 taxa). Diatoms communities of soils irrigated with treated wastewater were dominated by *Nitzschia* genus (71.43%) which is an indicator of polluted areas. This genus was weakly present in soils irrigated with groundwater (28.57%), whereas in the reference site no *Nitzschia* species has been inventoried. Statistical analysis showedthat the highest species richness in soils irrigated with treated wastewater was correlated to the highest content of TOC (6.66±1.11%), nutrients P-PO4 (1.28±0.15 mg/g of soil) and N-NH4+ (0.12±0.00 %). The pH of the soil irrigatedwith treated wastewater decreased (7.2 pH unit) compared to the reference site (9.03 pH unit). The results showed that the composition and structure of soil diatoms communities vary according to practice and water irrigation (groundwater, treated wastewater or rainwater irrigation). These practices strongly influenced the soil physico-chemical characteristics. The reuse of treated wastewater, as a marginal quality water, for irrigation in arid area is a justified practice, yet care should be taken to minimize adverse environmental impacts and to prevent soil deterioration and contamination.

Keywords: Diatoms, Suburban soil, Treated wastewater, Irrigation, Human impact, Marrakech area.

EVALUATION DE LA QUALITE DES EAUX DE LA NAPPE PHREATIQUE DU HAOUZ APRES LA MISE EN PLACE DE LA STEP DE MARRAKECH

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Marrakech, une ville à vocation agricole, caractérisée par des conditions climatiques favorisant un stress hydrique avec une pluviométrie moyenne de 250 mm/an, ce qui laisse penser à d'autres solutions alternatives en particulier la réutilisation des eaux usées pour des fins d'irrigation et d'arrosage.Jusqu'au début des années 2000, et avec un réseau d'assainissement presque inexistant, les effluents issus de l'activité domestique et industrielle de la ville de Marrakech sont rejetés dans une zone délimitée par les axes routiers Casablanca, Safi et l'oued Tensift. Cet épandage des eaux usées vu leur richesse en éléments nutritifs a favorisé le développement de certaines agricultures avec, éventuellement, un impact néfaste sur l'environnement et sur l'état de santé de la population avoisinante. Actuellement, et avec la mise en service de la Station d'Epuration de la ville de Marrakech, les eaux résiduaires sont canalisées vers la station pour un traitement biologique, conçu selon le procédé des boues activées. Après plus qu'une dizaine d'années de mise en service, l'impact positif de la STEP a été prouvé par la mobilisation d'une ressource hydrique utilisée essentiellement dans l'irrigation et dans l'arrosage des golfs.Ce qui a permis le développement d'un nouveau mode de tourisme "tourisme golfique" et a contribué à l'amélioration des conditions de vie de la zone ELAZZOUZIA (ex-zone d'épandage), reste à confirmer par une compagne de mesure (étude) son impact sur la qualité de l'eau de la nappe de la ville et de la région.

Le site d'étude est défini comme étant un périmètre délimité par les axes Route de Casablanca, Route de Safi et l'Oued Tensift, ce site et jusqu'au début des années 2000 recevait des eaux usées sans aucun traitement préalable ce qui influence négativement la qualité des eaux de la nappe de ladite région.

Pour évaluer la qualité des eaux souterraines de cette zone, nous avons choisi judicieusement 13 points éparpillés dans les quartiers d'El Azouzia Almassar et lotissement Acharaf.

Les paramètres recherchés au niveau des 13 puits sont la bactériologie (Coliformes Totaux, Coliformes Fécaux, les Germes Totaux à 22°C et à 37°C, les Streptocoques fécaux, les Clostrodiums sulfito-reducteurs, la physicochimie avec les paramètres pH, Turbidité, Conductivité, Chlorures, Sulfates, Titre Alcalimétrique et Alcalimétrique complet en plus des composés azotés : Nitrates ; Nitrites, et Ammonium. Les prélèvements pour analyses sont effectués selon un protocole normatif selon le type d'analyse à effectuer pour les analyses physico-chimique, les flacons utilisés sont des flacons de 1 litre en plastique, les flacons de 500 ml en verre stériles sont utilisés pour les échantillons destinés à l'analyse bactériologique.Les flacons sont ainsi transportés vers le laboratoire dans des glaciaires thermostatées à 4°C. Les analyses sont effectuées juste après l'arrivée des échantillons au laboratoire. Les méthodes d'analyses utilisées sont des méthodes normalisées ou ayant suivi un protocole de validation.Les résultats d'analyses obtenus dans un premier temps et suite à trois compagnes de mesure ont montré une charge bactérienne assez importante dans la majorité des points de contrôle à l'exception de deux puits qui ont subi un traitement à un dérivé de chlore.

Les paramètres physicochimiques étaient marqués par l'enregistrement des valeurs importantes de nitrates et des chlorures pour la turbidité et le pH les valeurs sont très correctes.

Mots clés: Nappe du Haouz, Eau, Qualité, Bactériologique, Physicochimique.

FIELD SURVEY OF CYANOTOXINS IN THE FRAMEWORK OF THE EUROPEAN PROJECT TOXICROP – PRELIMINARY RESULTS

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Fresh water resources in many countries are vulnerable due to their biogeographical and climatic characteristics. Moreover higher water consumption and higher human impacts in the downstream water bodies is leading to a higher eutrophication with increased incidence and intensity of cyanobacteria blooms and their toxins. TOXICROP is a European project funded by the Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE) programme and aims, among other objectives, (1) to evaluate water quality, (2) map agricultural risk areas of cyanotoxin occurrence, and (3) to investigate the bioaccumulation of cyanotoxins in crops exploring the association of food contamination to the use of eutrophic waters in irrigation. Environment-friendly, low-cost technologies of water treatment will also be developed, and methods to detect and assess toxicity of cyanotoxins will be improved. To develop TOXICROP a multidisciplinary consortium was constituted by leading EU, South-Mediterranean and South-American academic organizations and 3 stakeholders. In the framework of workpackage a field research will take place with the aim of assessing cyanotoxins in main irrigation reservoirs, as well as the dispersion of these natural water pollutants in agricultural soils and cultured horticultural products. The field research will be carried out in selected regions of the consortium countries, El Pañe Lake in Peru, Alqueva Lake in Portugal, Takerkoust in Morocco and Surface and groundwaters in Egypt. We will study the occurrence and diversity of toxic cyanobacteria and cyanotoxins, and the toxin levels in water, soil and vegetable products will be used to determine the toxicological and contamination levels of these materials to assess the risk of human exposure and impacts in the environment. Here we present the research plan to be implemented during 2020 and 2021, in the framework of TOXICROP Project.
The preliminary results obtained from the water monitoring of Alqueva reservoirs have shown a general predominance of cyanobacteria potentially producing of microcystins (e.g., Microcystis aeruginosa and Anabaena flos-aquae), however the quantity of cells/mL is considered of low risk (<<20 000 cell/mL). Interestingly, the identification of species belonging to the Aphanizomenon genus and Cylindrospermopsis raciborskii, well recognized as cylindrospermopsin and anatoxin-a producers, was also verified frequently with large number of cells/mL in the summer months (>20 000 cell/mL). These results show the importance in proceeding to the monitoring of microcystins and cylindrospermopsin in these reservoirs, in order to better predict the potencial risks for agricultural plants due to irrigation.

Keywords: Cyanobacteria, Cyanotoxins, Environmental monitoring, Eood safety, Risk assessment

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DATA UPTADE OF TOXIC CYANOBACTERIAL BLOOMS SURVEY IN THE TAKERKOUST LAKE RESERVOIR-MOROCCO

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For the last three decades, the Lalla Takerkoust dam has suffered from seasonal infestations of massive proliferation of toxic cyanobacteria. This uncontrolled development of water bloom-forming cyanobacteria poses serious public health problems, especially since these cyanobacteria release toxins with increasing deleterious effects in the water. The most documented category of cyanotoxins is Microcystins (MCs), which are hepatotoxic heptapeptides. This study is intended to be a precursor to providing an inventory of Microcystin detections in the Lalla Takerkoust dam from a qualitative and quantitative point of view over the last 30 years to date. This information is invaluable in thinking about means of decontamination. The Microcystin analysis techniques reported here are either Enzyme-linked Immunosorbent assay (ELISA), giving the overall amount in microcystin-LR equivalent (µg Equiv. MC-LR/L), or high-performance liquid chromatography coupled with Mass Spectrometer, to determine the variants of MCs present. Thus, the ELISA results of the natural blooms collected from the Lalla Takerkoust dam since 1994 have shown great temporal variability in the concentration of toxins. Indeed, the highest concentrations recorded are at the scale of (3100; 3200; 4147.8; 8800 and 11600) µg Equiv. MC-LR/L, respectively in 1996; 2005; 2018; 1995 and 2008. Similarly, the lowest concentrations recorded coincided at (83; 120.3 and 496) µg Equiv. MC-LR/L, respectively in 2003, 1994 and 1999. Furthermore, during the same period, the HPLC analysis made it possible to highlight the dominance of the variants, namely MC-LR, -RR, -YR, -WR, -FR; -LY; - (H4) YR; DMC-LR, although the MC-LR, and MC -RR variants seem to share the large percentage. Moreover, the Takerkoust dam lake being a eutrophic to Hypereutrophic Lake, the concentration of Microcystins is still largely above the WHO limit (1 µg/L) even in the absence of bloom with an average of 28.85 µg/L.While in summer period, October and November 2019, the HPLC-MS analyses of lake water showed a concentration of 5 µg/L MC-LR, this concentration was of the order of 95.4 µg/L and 60 µg/L respectively between 2005 and 2006. Ultimately, by being aware of this toxinological temporal variability of both qualitative and quantitative, it is possible to take targeted actions aimed at preventing the danger linked to the use of water contaminated by cyanotoxins.

Keywords: Toxic cyanobacteria, Blooms, Microcystins, Microcystin-LR, Heptapeptides, Hepatotoxic

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ROLE OF RHIZOSPHERE BACTERIA IN THE PROTECTION OF *VICIA FABA* AND *TRITICUM AESTIVUM* CULTURES AGAINST MICROCYSTINS-LR EXPOSURE IN BLOOM-CONTAMINATED WATER

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Over the last decades, global warming has increasingly raised the public concern about the expansion of massive cyanobacterial blooms in freshwater ecosystems worldwide, in which toxic cyanobacteria release multiple variants of cyanotoxins, chiefly microcystins (MC) congeners. Thus, MC-contaminated water destined for crop irrigation has diverse phytotoxic effects on growth and development of local agricultural plants, leading eventually to a significant yield loss. In this study, greenhouse experimentation has been carried out, so far, with two different cultures; *Vicia faba* and *Triticum aestivum*. Both plants have been exposed to MC-contaminated water (100 µg equivalent MC-LR/L) during 2 months of treatment. The experiment was designed to investigate the potential microbial protection against MC-LR exposure in the complex rhizosphere-plant, in which plants were cultivated in sterile and non-sterile soils. The results obtained show that chronic exposure to MCs (100 µg equivalent MC-LR/L) in absence of rhizosphere microorganisms reduces the plant growth, photosynthesis and induce antioxidant defenses.Whereas, the presence of these microorganisms enhances significantly all the aforementioned parameters.

Keywords: Microcystins-contaminated water, Irrigation water, Toxic cyanobacteria, Microbial protection, Plant growth, Photosynthesis, Antioxidant defense.

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EFFECT OF CONTAMINATED IRRIGATION WATER BY CYANOTOXINS(MICROCYSTINS) ON GROWTH AND DEVELOPMENT OF STRAWBERRY *FRAGARIA VULGARIS* L.

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In recent years, the use of artificial lakes (dams and water storage basins) for the irrigation of agricultural products has become more intensive, following the national program for the expansion of the "Green Morocco Plan". However, this operation must be accompanied by a water quality control especially used for irrigation. The health risks incurred are mainly linked to the proliferation of toxic cyanobacteria and the production of cyanotoxins, which are likely to degrade water quality. In general, the use of water contaminated by cyanotoxins (microcystins: MCs) could have a negative impact on plant development and agricultural production. The aim of our work is to study the effects MCs contained in irrigation water on strawberry, *Fragaria vulgaris* L. physiology and metabolism.
Strawberry (*F. vulgaris*L.) cultivation was conducted, in pot containing perlite, with Leaf-stage seedlings under controlled condition. The plants were treated (3 times/week) with MCs crude extract at different concentrations: 1, 5, 10, 20 µg /L respectively for two months. Several physiological parameters of *F. vulgaris*, in response to MCs exposure, were analyzed.
In fact, the exposure of *F. vulgaris* to MCs caused a net decrease on plant growth in a dose-dependent manner. High tested concentration (10 and 20 µg/L) induced pronounced negative effects on strawberry plants parameters such as a net decrease in root and plant length, leaf number, shoot and root dry weight.
Besides, chlorophyll-a and the antioxidant enzyme activity showed significant modifications based on exposure to higher MCs concentrations (10 and 20 µg/L). The increased activities of Catalase, Peroxydase and Superoxide dismutase indicated an induction of oxidative stress related to MCs contamination of irrigation water.
The obtained results indicated the negative impact of MCs on off-ground crops. The findings state the risk related to MCs contaminated water used for yield crops in addition to the need of monitoring and survey of toxic cyanobacteria blooms occurrence in irrigation water reservoirs.

Keywords: Microcystins, Irrigation, Agricultural production, Horticultural,*Fragaria vulgaris* L.

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PERFORMANCE OF MULTI-SOIL-LAYERING (MSL) TECHNOLOGY FOR THE REMOVAL OF MICROCYSTIN-LR FROM SURFACE WATER: PRELIMINARY RESULTS

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The anthropization of aquatic environments results in harmful algal blooms occurrence known as cyanobacteria blooms. These blooms occur frequently in freshwaters around the world and occupy spaces sustainably. Some cyanobacteria can produce and release toxic compounds called cyanotoxins which represent a danger both for the environment and for human health. Microcystin-LR (MC-LR) has been the most toxic variant reported all over the world. Ecological and economic factors are determinant in the choice of the technology for the treatment of this water contaminant. Conventional water treatment methods are expensive and require specialized personnel and equipment. Wherefore, many rural areas and developing countries may not be able to afford it. Recently multi-soil-layering (MSL), a natural and low-cost technology has been introduced as an attractive cost-effective technology, environmentally friendly, alternative to conventional water treatment methods. This study aims to evaluate MSL ability to remove MC-LR on a laboratory scale using local materials. For that MSL system pilot was constructed to treat distilled water contaminated with MC-LR. The pilot was constituted of an alternation of permeable layers (pozzolana) and soil mixture layers (local sandy soil, sawdust, charcoal and metallic iron on a dry weight ratio of 70, 10, 10 and 10% respectively) arranged in a brick-like pattern. Operation days of the MSL pilot experiments were five weeks with 200 L m^{-2} day^{-1} hydraulic loading rate. The synthetic water was obtained by contaminating the distilled water with a microcystin crude extract from freeze dried natural bloom. The concentrations used were 0.18; 0.91; 2.5; 5 and 10 µg/L successively each week. Samples were collected from MSL pilot influent and effluent twice a week at the same time (first sampling in the first day, and second sampling in the last day of each contamination week). Results showed a total removal of MC-LR (removal percentage around 46% to 100%) at the MSL effluent. The increase in dissolved oxygen at the outlet of the MSL system (4.81 mg/L) is proof of aeration and therefore of the proper functioning of the system regardless the presence of the toxin. Based on these preliminary results, MSL ecotechnology could efficiently remove cyanotoxins from contaminated water. As low cost technology, MSL system could be considered an effective solution to be adopted for purifying eutrophic water containing cyanotoxins.

Keywords: Cyanobacteria, Cyanotoxins, Bloom, Multi-Soil-Layering system, MC-LR removal,Water treatment

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BACTERIAL ROLES IN THE PROTECTION OF CROPS AGAINST THE HARMFUL EFFECTS OF CYANOTOXINS IN IRRIGATION WATER

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Water used to irrigate crops is involved in enhancing the performance of rhizospheric bacteria in terms of strengthening the various mutually beneficial associations between these bacteria and the plants involved. Bacteria with plant growth-promoting properties are essentially telluric. Nevertheless, they could also be delivered to the plant roots via irrigation water. In this study, a specific emphasis was placed on bacteria from waters contaminated with cyanobacteria and cyanotoxins, which waters are nevertheless used in crop irrigation. The purpose of the research was to investigate whether bacteria capable of degrading cyanotoxins -Microcystin (MC)- present in eutrophic waters used in agriculture can also degrade the toxin in cultivated soil, and thereby allow the plant to escape the harmful effects of the toxin on its health and promote the plant growth. In this regard, bacteria from three biotopes, namely massive colonies of a toxic cyanobacterium, *Microcystis aeruginosa*, water sampled at the Lalla Takerkoust dam in full bloom, and a rhizospheric soil permanently irrigated by water contaminated by Microcystins, were isolated on Mineral salt media (MSM) agar with a concentration of 1000 µg/L where Microcystin acted as the only source of carbon and nitrogen for bacteria. The bacteria were used to inoculate, individually or in consortia, pea seedlings *Pisum sativum* subsp. transplanted after germination in pots containing two Kg of soil previously sterilized in the oven. Four concentrations of the MC extract were applied, namely: 0; 25; 50 and 100 µg/L. The bacterial inoculations were divided into eight groups, namely, NI, the non-inoculated control, then A, B, and C as the bacterial isolates were inoculated individually and then their respective consortia, i.e. AB, AC, BC, and ABC. Each treatment was repeated 6 times and in each pot, 3 germinated seeds were transplanted. Thus with 18 plants per treatment *8 cases of bacterial inoculation*four increasing MC concentrations, 575 plants were bred in semi greenhouse conditions. Irrigation was carried out using well water free of any Microcystin contamination and was proportioned with the different toxin concentrations. A watering schedule of twice a week at 30% of the field capacity of the soil was observed for three months from December 6, 2020 to March 12, 2021. The experiment was stopped at the fruiting stage and morphometric and physiological parameters were recorded. The results showed a highly significant inhibitory effect of the gradual concentrations of MC on all the growth parameters studied compared to the non-inoculated control, thus substantiating the importance of inoculation. On the other hand, the comparison of bacterial inoculations against different concentrations showed that almost all growth parameters improved with the degree of bacterial consortization. The more individuals in the inoculation consortium and the higher the concentration of Microcystins, the higher the plant vigor was. This marked

improvement of the plant health was noted in particular by the in situ measurement of the leaf quantum yield, the chlorophyll fluorescence, and the chlorophyll a which were respectfully of 77.28 ±5.2mmole/m^2.S, and 0.81±0.06 Fv/Fm and 76.4±7.3 SPAD in plants inoculated with ABC compared to non-inoculated (NI) plants, respectfully 17.4±2.2mmole/m^2.S, and 0.65±0.011 Fv/Fm and 36.6±0.21SPAD and at 100 µg/L in MCs. Finally, given our results, a bacterial consortium could be an alternative means to grow cultures in case of suspected cyanobacterial toxin contamination.

Keywords: Irrigation water, Eutrophic water, Microcystins, Bacteria, Inoculation, Bacteria consortia, Plant growth-promoting properties.

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CYANOTOXINS IN IRRIGATION WATER: POTENTIAL FACTOR OF DEGRADATION OF WATER QUALITY AND CROPS PRODUCTIVITY

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In the last years, water resources have become increasingly scarce. This situation is mainly due to climate change and the eutrophication of water bodies. They are among the main factors generating massive proliferation of cyanobacteria. The latter, toxic, constitute a potential source of irrigation water contamination by cyanotoxins.
In fact, our studies were based on the evaluation of the phytotoxic impact of cyanotoxins contained in irrigation water on plants with significant economic interest.
Thus, exposure of *Medicago sativa* to cyanotoxins has identified both biological and physiological negative effects. A reduction in seed germination and plant growth, in addition to induction of oxidative stress, were the major disturbances generated by cyanotoxins contained in irrigation water. In addition, cyanotoxins have also shown negative impact on the main bacterial communities of agricultural soils. PCR-based 454 pyrosequencing analysis of rhizospheric bacterial communities associated to *Medicago sativa* in response to cyanotoxins revealed a net decrease of bacterial species diversity, from unplanted soil to root tissues. The bulk soil was essentially inhabited by *Gemmatimonas, Actinobacteria* and *Deltaproteobacteria*, while, the root-adhering soil and the root tissues were inhabited by *Gammaproteobacteria* and *Alphaproteobacteria*. The main bacterial populations showed several variations under cyanobacterial toxins exposure.
The results showed negative impact of cyanotoxins on plant growth and development. In addition to several changes on soil bacterial communities which may alter the rhizosphere functioning. The contamination of irrigation water with cyanotoxins conceals several allelopathic effects related to crop quality and production. This emphasizes the need to set standards to control waters intended for crops irrigation like the adopted ones for drinking and recreational waters.

Keywords: Blooms, Cyanotoxins, Biological and physiological impacts, Rhizospheric bacterial communities, Agricultural production, Water quality.

IMPACT OF IRRIGATION WITH TREATED WASTEWATER ON SOIL CYANOBACTERIA IN SUBURBAN AREA OF MARRAKESH

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Freshwater is vital for drinking water, agriculture, industry and other human activities. In Morocco there is widespread water scarcity, along with gradual destruction and increased pollution of fresh water resources, which means that new alternatives have to be considered for supplying water. The treated wastewater reuse for irrigation is a practical solution and an important strategy to cope with fresh water scarcity, especially in arid and semiarid area. However, there are several potential environmental and health risks associated with these practices.The concern of our study is to assess the effect of agricultural land irrigation by treated wastewater on soil cyanobacteria, compared to soils irrigated with groundwater and rainwater. This study aims to explore, for the first time, the diversity of soil cyanobacteria communities in suburban soils in Marrakesh area and to evaluate the impact of wastewater irrigation on their composition and structure in correlation with changes in the physico-chemical soil properties.

The sampling of biological soil crust and measurement of soil physicochemical characteristics (soil moisture, pH, electrical conductivity, total organic carbon, ammoniacal nitrogen and available phosphorus) were done at three farmlands sites during two seasons (February and May 2016): site 1 located at Zaouiate Bensassi agricultural land irrigated by rainwater as reference site, site 2 located at Azzouzia farmland irrigated by groundwater and site 3 located in agricultural fields irrigated by treated wastewater discharged in Tensift river (downstream of the treatment plant of Marrakesh). Two methods of cyanobacteria study were used, morphological characterization by light microscopic observations of soil samples and culturing of soil inoculums in nutrient media under laboratory controlled conditions. The spatial distribution of soil cyanobacteria communities and associated environmental factors were investigated via statistical analysis using Principal Component Analysis (PCA).

The results showed significant cyanobacterial diversity with 16 taxa belonging to two orders, 4 families and 6 genera. Oscillatoriales constitute the most diversified order (93.75%), followed by Chroococcales (6.25%). 16 species belonging to six cyanobacteria genera were identified from surface soils samples. The highest species richness of cyanobacteria was recorded in soils irrigated with treated wastewater (10 taxa), compared to the one irrigated by rainwater (3 taxa). This diversity could be explained by the high content of organic carbon and nutrients. The soil irrigated with treated wastewater has high content of TOC (6.66±1.11%) and nutrients P-PO4 **(**1.28±0,15mg/g of soil) and $N\text{-}NH_4^+$**(**0,14±0.00 %) compared to soil irrigated with rainwater (0.02 %). Therefore, this research exhibited that, with caution, treated wastewater can effectively be used as fertility source for soil and a resource for agricultural irrigation. The composition and diversity of cyanobacteria communities vary according to the physicochemical soil properties and the irrigation water quality. Moisture, total organic carbon and nutrient inputs, appear to be the environmental factors determining spatial distribution of soil-cyanobacteria.

Keywords: Agricultural soil, Cyanobacteria; Irrigation, Treated wastewater, Impact, Marrakesh area.

POTENTIAL OF *VICIA FABA* AND *OPUNTIA FICUSINDICA* EXTRACTS AS NATURAL COAGULANTS TO TREAT MICROCYSTIS AERUGINOSA WATERBLOOM

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In the last few years, Harmful cyanobacterial Algal Blooms (CyanoHABs) have increased in water supply globally which pose a worrying problem on several levels, namely in drinking water treatment plants. Further, the frequency and the apparition of CyanoHABs is still increasing and mainly due to eutrophication and climate change. Since CyanoHABs in water supplies increase in frequency, nowadays, the protection of water supplies becomes more important and challenging. For this reason, several treatment methods are used in drinking water treatment plants to treat water contaminated with cyanobacterial blooms, such as chlorination, coagulation-flocculation, adsorption, filtration, and ozonation. Coagulation-flocculation is one of the most promising and adopted method to treat turbid water, due to its simplicity and effectiveness. This process consists on addition of chemical coagulants and flocculants to destabilize colloidal particles which promotes the formation of flocs and subsequently their elimination. However, the chemical coagulants and flocculants used present adverse effects on public health and the environment, despite their performance and effectiveness to sanitize turbid water. Recently, green process methods based on natural coagulants have been studied widely because of their benefits, such as reducing costs, providing biodegradability, without risk to public health and environment and maintain sustainable development of water purification process. In view of this, the aim of this study is to investigate the potential of *Vicia faba* seeds and *Opuntia ficus indica* cladodes extractsas natural coagulants to sanitize water polluted with *Microcystis aeruginosa*. The coagulation-flocculation assays were conducted using standard jar test method under various experimentally conditions. The results of coagulation-flocculation assays showed that the extracts of these two plants were capable to reduce turbidity, chlorophyll a and carotenoids by up to 85% of *Microcystis aeruginosa*. In this regard, chemical analysis of faba bean seeds and cactus cladodes extracts were conducted in order to determine components that are known to have the potential of coagulation-flocculation activity. On the other hand, a characterization using FTIR spectral analysis was also conducted for purposes to differentiate the material and provide information on the nature of functional groups on the surface of the natural coagulants tested. The results of FTIR spectral analysis showed the presence of alcohols, phenols groups and aromatic group such as C=C. However, chemical assays have indicated the presence of sugar and phenols groups, which were present in higher concentrations than all other constituents dosed. Nevertheless, extract of cactus cladodes have shown a high amount of phenols, flavonoids, and sugar, in the contrast, extract of faba bean contains more amounts of proteins and flavonoids. At the same time, the analyses have also shown the presence of other constituents that are proven according to the literature to possess having the potential of coagulation-flocculation, such as phytic acid and tannins. Therefore, the FTIR and chemical analysis results have demonstrated that

Vicia faba seeds and *Opuntia ficus indica* cladodes extracts contain components that are responsible for the potential of coagulation-flocculation activity. In brief, these findings indicate that the extracts of *Vicia faba* seeds and *Opuntia ficus indica* cladodes could be used, as ecofriendly coagulants and as alternative to chemical coagulants and flocculants in drinking water treatment plants, to sanitize water contaminated with the cyanobacterium *Microcystis aeruginosa*.

Key words: Green coagulants, Vicia faba seeds, Opuntia ficus indica cladodes, FTIR analysis, Chemical assays, *Microcystis aeruginosa*.

GROWTH MITIGATION OF THE BLOOM-FORMING CYANOBACTERIUM *MICROCYSTIS AERUGINOSA* BY MOROCCAN HERBS

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Worldwide, Harmful Algal Blooms (HABs) in freshwater ecosystems, especially *Microcystis aeruginosa* blooms, are one of the greatest aquatic environmental concerns. It has resulted in the reduction of aquatic biodiversity, disruption of ecosystem functions and deterioration of water quality. For this reason, the control of algal blooms has become a great challenge in recent years and several researches of new methods and processes to fight against blooms are being developed. Algal management in swimming pools, fish ponds and large water bodies is usually carried out using physical, and chemical processes that are usually very expensive or potentially harmful to the environment. Restrictions on the use of herbicides in potable water of freshwater supplies and some environmentally sensitive areas have encouraged the use of alternative algal control strategies.
Extracting biomolecules and Essential Oils from plants and applying them into water bodies is a new ecofriendly and safer botanical alternative algicidal agent for controlling toxic cyanobacterial blooms. Recently, green biocontrol methods based on natural algaecides have been studied widely because of their benefits, such as reducing costs, biodegradability and no toxicity without risk to public health and environment. This study aims to investigate the potential of three Moroccan herbs organic extracts as natural cyanobactericide to mitigate *Microcystis aeruginosa* blooms.

In this study, the toxic cyanobacteria strain of *Microcystis aeruginosa* was exposed to different concentrations of *Thymus maroccanus, Origanum compactum* and *Artemisia herba alba*ethyl acetate extracts. Organic extracts were screened in liquid and solid medium (disc diffusion method) against the growth of *M. aeruginosa.* The results showed that with increased concentration and time exposure, the cell density of *Microcystis aeruginosa*was significantly reduced in a concentration-dependent way. After 7 days of exposure, the highest inhibition rate reached 97.41%, 97.16% and 93.13% for *Thymus maroccanus, Origanum compactum* and *Artemisia herba* respectively. *Thymus maroccanus* ethyl-acetate extract present the most inhibition zone of *Microcystis aeruginosa* compared to the control with 36.7 ± 0.99 mm, followed by *Origanum compactum and Artemisia herba alba* with 35 ± 0.49 mm and 29.5± 0.2 mm respectively.

The results of this study would be useful to further studies to validate the feasibility of plant extract treatments to inhibit overall cyanobacterial growth in water bodies, before this can be put into practice. A marginal reduction in the use of chemical algaecides over time will be a significant economic advantage and also reduce harmful effects on the environment.

The challenge for the research community is to increase our understanding of harmful algal blooms and provide the tools to develop environmentally acceptable strategies for direct intervention in ongoing HAB events for the purpose of eliminating toxic or harmful cells or inhibiting their growth.

Keywords*:* Harmful algae bloom, Control, Microcystis aeruginosa, Terrestrial plants, Ecofriendly, Plant organic extract**.**

Session 3

Non-conventional water resources reclamation, recycling and reuse

TREATMENT OF OLIVE MILL WASTEWATER BY INFILTRATION-PERCOLATION THROUGH FILTER BED

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The Mediterranean countries together are responsible for 96% of the entire worldwide olive oil production, and this industry is growing year after year due the modern way used for the extraction of this valuable matter, which make the extraction process so much faster, easier and gives the best yield. However this activity produces huge quantities of solid and liquid wastes during this process. The liquid effluent called olive mill wastewater (OMW) is often discharged into waterways, or spread on the ground without any pretreatment, which could cause serious environmental issues such as affecting the superficial and groundwater quality and affect the fertility of soil or even sterilize it. The reason of those problems is the high polluting activity that the Olive Mill Wastewater has which is linked to their high concentration of organic matter and especially the polyphenols. This compound confers to the olive mill wastewater an anti-microbial effect and making the self-purification of water so much harder, besides the organic acid that increased the acidity of that effluent. OMW contain other organic molecules such as sugars and nitrogen compounds that increased their organic load (chemical oxygen demand (COD) =80-200g/l))

The infiltration percolation is an ecological and economical method that is used by too many authors using different types of filter such as sand filter but a few one have used natural and biological materiel as adsorbent to treat that effluent in such method like the infiltration percolation. The mean goal of our project is treating the OMW using this method with low coast natural adsorbent that could improve the capacity of the system to enhance the yield of elimination of pollutant from the OMW.

We started our project by characterizing the OMW who came from a modern unity of extraction of olive oil. Then based on preliminary tests we decided the adsorbents that we can mix with sand in order to enhance their capacity of elimination of pollutants from the OMW by the different mechanisms that are used by the system to treat liquid effluents. The aeration of the filter can provide a better treatment of the effluent than using a non-aerated filter bed, by providing good conditions for bacteria to survive and degrade the organic matter properly. For that the experimental pilot consisted of a column of opaque PVC of 10cm as diameter and a height of 1m, then we decided to oxygenize the filter by inserting lateral aeration columns that could provide a better aeration for the substrate.

On the other hand in order to visualize the effect of pretreatment on the efficiency of treatment of liquid effluent by infiltration percolation, we used three different type of OMW. The first one is raw OMW, then we diluted it with urban wastewater, and for more experimental result we used also OMW pretreated by lime which has already eliminated 40% organic compound (chemical oxygen demand) and 62% of the phenolic compounds. After proceeding to the treatment, for each filtrate we determined the total and dissolved COD, the concentration of the phenolic compounds, orthophosphate, total phosphate, nitrate and ammoniac. Beside the pH and the electrical conductivity and dissolved oxygen.

Keywords: Olive Mill wastewater, Infiltration-percolation, Low cost natural adsorbents.

FEASABILITY OF A PILOT SCALE VERTICAL FLOW CONSTRUCTED WETLAND FOR THE TREATMENT OF OLIVE MILL WASTEWATER

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Constructed wetland (CW) is an ecological wastewater treatment system which is based on the combination of physical, chemical and biological phenomenon for the elimination of pollutants. CW was engineered for the treatment of urban wastewater (UW). However, recent studies show it capacity to treat more complex effluent such as tannery, textile and agro-food effluent such as Olive mill wastewater (OMW). OMW is an olive oil extraction byproduct characterized by acidic pH, high conductivity, high organic load and the presence of antibacterial and phytotoxic compound which is polyphenol. The aim of the present study is to examine the feasibility of a pilot scale constructed wetland (PS-VFCW) in which pozzolan is adopted as new filling media to enhance the treatment efficiency of a mixture of olive mill wastewater (OMWW) and municipal wastewater (MWW). Special attention was devoted to the removal of specific toxic phenolic compounds. The PS-VFCW consisted on a PVC tank (height: 0.60 m, diameter: 0.56 m and surface area: 0.24 m^2). The pilot plant was planted with *Phragmites australis* and filled from the bottom with 10 cm of gravel, 10 cm of pozzolan and 30 cm of sand. The applied hydraulic loading rate (HLR) was 25 L/m^2/day with a mean influent concentration of 6100 mg/L, 131 mg/L, 9.45 mg/L, 10.19 mg/L, 232 mg/L, 2.04 mg/L, 12.40 mg/L for chemical oxygen demand (COD), polyphenols, orthophosphates (PO_4^-), total phosphorus (P), sulfate (SO_4^{2-}), nitrite (NO_2^-) and ammonium (NH_4^+) respectively. The PS-VFCW was monitored for a period of one year. Obtained results show that the PS-VFCW achieved high removal rates: 91%, 89%, 95%, 94%, 58%, 92% and 96% respectively for COD, polyphenols, PO_4^-, P, SO_4^{2-}, NO_2^- and NH_4^+. High pressure liquid chromatography (HPLC) analysis of phenolic fractions in studied effluents highlight the removal of a variety of these compounds, especially toxic one's such as tyrosol and hydroxytyrosol after treatment by the PS-VFCW. Moreover, analysis on the CW filling medium demonstrates the absence of phenolic compounds which is probably due to their biodegradation by microorganisms or adsorption by pozzolan. Final results confirm that PS-VFCW effluent complies with the Moroccan regulations regarding the reuse of treated wastewater in agriculture and therefore could be used for irrigation of cereal, industrial and fodder crops, pastures and plantations trees.

Keywords: Vertical Flow Constructed wetland, Pozzolan, Olive mill wastewater, Organic load, Polyphenol, Hydroxytyrosol.

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COMPARISON OF TWO AEROBIC PROCESSES FOR OLIVE MILL WASTEWATER TREATMENT: ACTIVATED SLUDGE AND MEMBRANE BIOREACTOR

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The aerobic treatment biotechnologies are recognized as economic alternative to physicochemical methods for the treatment of a wide range of wastewater effluents. In most cases, conventional activated sludge (AS) is used and preferred for large-scale application. Recently, the MBR has appeared as a novel process that has successfully performed for OMW treatment.
However, as the MBR is reported more expensive to implement or to handle than AS. The study aims at comparing the performances of two pilots MBR and AS operating simultaneously for the treatment of OMW. The COD and phenolic compounds removal efficiencies and the quality of the treated water were principally assessed and compared to Morrocan water standards. In addition, the study aims at showing which one of the reactors is effective in OMW wastewater treatment considering the Moroccan context.
A specific acclimation protocol was performed in both reactors for biomass pre-adaptation to OMW biodegradation. The gradual dilution of OMW to a specific concentration was necessary to avoid substrate inhibition. The system stabilization was obtained for the MBR at Sludge Retention Time (SRT) of 25 days and Food to microrganisms ratio (F/M) of 0.2 $kg_{COD}/kg_{MLVSS}/d$. For AS pilot it was obtained at SRT of 25 days and F/M of 0.3 $kg_{COD}/kg_{MLVSS}/d$. In addition, daily purges were performed for both systems in order to keep respectively a constant value of MLVSS concentration of 8 g/L for MBR and 4-5 g_{MLVSS}/L for AS. The monitoring of the MBR performances and AS was done at their stable states.
According to the obtained results, the MBR showed a better global efficiency than CAS. Removal of COD was successfully reached (95%) by MBR than by CAS (86%). In addition, the treated water obtained by the MBR was free from suspended solids (MLSS) and characterized by less turbidity whichcomplylargely the water reject standard. However, for CAS Eventhough the elimination of COD (152mg/L) and MLSS (30-40mg/L) were slightly lower than the MBR they remain acceptable and meet the water reject standards. Apart from, the elimination of phenolic compounds was similar for both systems (80%).The fouling was easily managed for the MBR and the water clarification was effective in the case of AS. Considering the Moroccan situation, the performance of AS could not be neglected and in this case the AS could be more adapted and economically viable for OMW treatment.

Keywords: Aerobic treatment, Conventional activated sludge process, External ceramic membrane bioreactor, Olive mill wastewater, Treatment efficiency, Wastewater treatment

RECOVERY AND VALORIZATION STRATEGIES OF POLYPHENOLS FROM OLIVE MILL WASTEWATER

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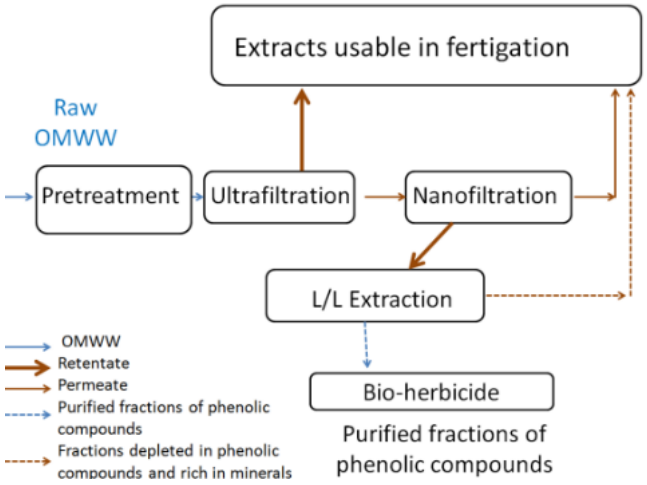
Olive mill wastewaters (OMWW) are considered as a toxic industrial effluent because of theirhigh content of organic matter (COD between 50 to 100 gO2.L-1) and total phenolic content TPh (TPh between 0.5-24 g.L-1). Globally, no economically viable technology for processing OMWW has yet been implemented. As a result, this effluent recognized as the main environmental problem of olive industry and their treatment and/or valorisation constitute a real challenge not only at local or national level but for the entire Mediterranean region. Membrane technology has been widely developed in recent years. Membrane processes are already used at the industrial level, because they have the advantage of not modifying the structure of the compounds to be concentrated, they are compact and adaptable.Many studies have investigated the feasibility of treating OMW by membrane processes; from the laboratory scale to the industrial scale, by studying the pre-treatment, optimal filtration conditions, etc. Unfortunately, no work has been performed for the characterization and control aspect of fouling. Understanding this phenomenon in the case of OMWW will be essential to ensure the sustainability of treatment with membrane processes. Therefore, the main objectives of this study are i) the development of an appropriate membrane chain with focus on fouling study and ii) the establishment of different patterns of valorization for generated flux (fig.1). The pretreatment and the filtration operating conditions (circulation speed, trans-membrane pressure, pH and temperature) have been optimized for all membranes, in order to limit fouling phenomena which could reduce filtration performance. The membrane chain envisaged has a satisfactory TPh retention rate of 80%. Tests on the bioherbicide potential of enriched TPh fractions generated are currently performed in order to find an innovative way of valorization of these compounds.



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TRANSFORMATION OF THE LEACHATE FROM THE LANDFILL TO COMPOST USING PHOSPHATE WASHING SLUDGE AND GREEN WASTE

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The burial of household waste rich in water without upstream sorting is at the origin of the overabundance of leachate in the landfills, which may causes soil and groundwater pollution. Several techniques can be used to ovoid pollution by leachate. However, the cost of these processes is high and difficult for operators to bear. This is why we have tested the composting as a new technique using phosphate sludge and green waste.
We used five combinations using five substrates (leachate, green waste, sugar lime sludge, phosphate sludge and olive mill wastewater) with different proportions to build five windrows. 24 hours contact between the phosphate sludge and the leachate took place before the addition of green waste.
A significant reduction of microbia was observed after 24 hours of contact between the phosphate sludge and the leachate, which is probably due to the effect of the lime contained in this waste. The monitoring of the physicochemical parameters had shown that the temperature of the different windrows followed the theoretical evolution of the temperature; the percentage of humidity was close to 40%, the pH was slightly alkaline (8.6-8.9) and an interesting degradation of the organic matter was observed (34.1%). The C/N ratio of the final composts was between 11.8 and 13.7. Microbiological analyses revealed the significant effect of the combination of composting and phosphate sludge addition on the hygienization of the leachate, with a total (100%) reduction of faecal streptococci. The humidification indices and heavy metals dosage suggest that composts with phosphate sludge are the most mature and that the composts produced do not present any risk of contamination.
All the results showed that the quality of the final composts complies with NFU 44-05; they can be therefore be used as an organic amendment for Moroccan soils as well as a substrate to rehabilitate former phosphate extraction sites.

Keywords: Landfill, Leachate, Phosphate sludge, Olive mill wastewater, Composting.

STUDY ON THE EFFECTIVENESS OF A GREEN COAGULANT IN DYES AND TURBIDITY REMOVAL FROM SYNTHETIC WASTEWATER

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The textile industry is one of the sectors posing a pollution threat to the world, considering the wastewater content and high volume of discharge into the environment. Textile effluents containing dyes are mostly discharged in aquatic environments, leading to water pollution and causing toxic effects on aquatic life and also on human health. Thus, to address this problem and in order to maintain the water quality, a broad range of techniques have been developed and employed in water treatment. Amongst this wide range of methods, coagulation is one of the most efficient methods widely used for color removal and turbidity removal from wastewater. Indeed, coagulation-flocculation is an efficient, cost-effective, simple and widely practiced water treatment method.
However, chemical coagulation involves the use of chemical coagulants. It poses detrimental consequences on living organisms and human health as well as producing a large amount of toxic sludge. The alternative solution to these problems is the replacement of chemical coagulants with natural coagulants, which are more environmental friendly, lower cost, biodegradable and restrain variations in the pH of treated water.
In this work, the treatment of a synthetic solution containing the red-congo dye as a model pollutant and kaolinite as colloidal particles, using physicochemical technique (coagulation process), was investigated employing a biocoagulant from a tropical plant. The proximate compositions, structure, and surface morphologies of the biocoagulant were investigated using standard methods, Fourier-Transform infrared (FTIR) spectroscopy, and scanning electron microscopy (SEM). The parameters investigated to study the performance of this plant in terms of dye removal and turbidity abatement were dose and granulometry of bio-coagulant, pH of aqueous dispersion, initial dye concentration and temperature. The effectiveness of the natural coagulant was evaluated based on the reduction of color and turbidity during the treatment process. The data indicate that performances in terms of turbidity abatement and red-congo removal were 98% and 90% respectively after only one hour of sedimentation time. However, the significant performance reaches for particle size less than 315µm of bio-coagulant. The removal efficiency increases with increasing of pH value from 4 to 7.

Keywords: Bio-coagulant, Color removal, Turbidity removal, Coagulation/flocculation.

ADSORPTION OF CHROMIUM FROM HIGHLY CONCENTRATED TANNERY WASTEWATER WITH NOVEL POROUS COMPOSITE BEADS: CENTRAL COMPOSITE DESIGN OPTIMIZATION STUDY

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The environmental impact of industrial effluents has been very worrying in recent decades. Large proportions of industrial effluents are organic and contain toxic substances in appreciable quantities. Efforts have been made in various research fields to preserve our environment. However, they are still insufficient from the considerable amount of micropollutants in the wastewater released into the receiving environment by various industries without pre-treatment. The objective of this study was to develop a bioadsorbent for the treatment of tannery wastewater. A new kind of porous beads was prepared based on powdered marble, solid waste produced in high quantities, and valorized as an effective, low-cost carbonaceous material. Besides, the batch and column adsorption experiments were applied. The beads neutralize the acidic pH value from 2 to 7. The adsorption mechanism showed high removal of organic matters (from 6058.95 mg/L to 1042.4 mg/L), sulfates (from 10264.8 mg/L to 2900 mg/L), and total phosphorus (from 8.052 mg/L to 0 mg/L). The adsorption kinetics and isotherm models were established, and the maximum adsorption capacity of Cr total deduced from the model is about 67.74 mg/g (C0=7100mg). After 90 minutes, the removal efficiency of Cr total can reach above 90%.
Furthermore, the results of column experiments indicate that the removal efficiency could maintain above 90% after 120 min. Consequently, the beads exhibited high performances in neutralizing the pH of tannery effluents and removing the main pollutants: COD, sulfates, total phosphorus and Chromium (Cr). The effects of two adsorption variables (Temperature and time) were investigated using central composite design (CCD), which is a subset of response surface methodology (Cr, COD, sulfate, and total phosphorus percentage removal).

Keywords: Beads, Biosorption, Powdered marble, Tannery wastewater, Chromium, Central composite design.

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MULTIPLE LINEAR REGRESSION AND CUBIST ALGORITHM FOR PREDICTING NITROGEN REMOVAL FROM DOMESTIC WASTEWATER USING MULTI-SOIL-LAYERING SYSTEM

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Domestic wastewater is likely polluting the environment into which it discharged. The multi-soil-layering (MSL) system has been considered in the latest research as an innovative technology for reducing the level of nitrogen pollution. The efficiency of the system towards nitrogen pollution is due to the reactivity of the ammonium with soil and gravel by adsorption. The ability to predict nitrogen reduction is very beneficial for understanding the operation of the MSL system, optimizing the treatment process and securing human health. Based on hydraulic loading rate (HLR), electrical conductivity (EC), chemical oxygen demand (COD), total nitrogen (TN) and total coliforms (TC) as independent inputs, a Cubist models are developed and compared with linear models to better predict the concentration of NH_4^+ and TKN, respectively. This work attempted to use the data of one year monitoring of an MSL pilot plant system located at Tlat Marghen village (Tensift-Al-Haouz Province), Marrakech (Morocco). The prediction process was conducted in a way to select the parsimonious models that are able to shown good performance on the training and validation sets. The Cubist models showed excellent results compared to linear models. The gaps between predicted and actual values are calculated by many criteria (RMSE, MAE and R^2). The R^2 for Cubist model seem to be about 91.2% for $NH4^+$, and 90.6% for TKN. Furthermore, the sensitive examination on the trained set of the Cubist model indicated that the HLR had the maximum of influence on predicting $NH4^+$ and TKN compared to other input variables.

Keywords: Cubist model, Multi-Soil-Layering,Linear model, Nitrogen, Importance analysis.

PERFORMANCE EVALUATION OF WASTEWATER STABILIZATION PONDS UNDER ARID CLIMATE

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The purpose of this work is to evaluate the efficiency of a stabilization pond to treat domestic wastewater in peri-urban area under arid climatic conditions. The experiment was set up in the commune of Saada located 18 km in the west of Marrakech (31°39'16''N; 8°06'59''W), Morocco. The wastewater treatment plant is composed of one anaerobic pond (primary treatment), two facultative ponds (secondary treatment) and two maturation ponds (tertiary treatment) which are laid in series. The system treats inflow averaging 525m^3/day. The performance efficiency was evaluated through periodic sampling and analysis of physicochemical and bacteriological parameters at inflow and outflow of each step of treatment and of the system as a whole. Phytoplankton monitoring was conducted in the three lagoons (anaerobic, facultative and maturation).Water sampling was conducted from May 2019 to March 2020. During the study, the maximum pollutant removal was found in the warmer months of the year, mainly May, June and July and a minimum during winter period. The maximum removal percentages of TSS, COD, BOD5 and NH_4^+ were respectively 80, 70, 60 and 70%; while the minimum removal rate were respectively 45, 50, 40 and 30% for TSS, COD, BOD5 and NH_4^+. Total phosphorus removal rate didn't exceed 30% and 56% for its assimilable form (PO_4^{3-}). However, the reduction of fecal Coliforms was very low (40%) as an average during all studied period due probably to wastewater treatment plant malfunction. The study of the phytoplanktonic parameters based on the qualitative and quantitative aspects of microalgae showed a dominance of Cyanobacteria (Anabaena, lyngbya): 43.33%, and Chlorophyceae (Chlorella, Coelastrum): 30.01% respectively in the anaerobic, facultative and maturation ponds; while diatoms were moderately present (13.33%) in all ponds which might confirm the unsatisfied purification performance of the investigated stabilization pond.

Keywords: Stabilization ponds, Domestic wastewater, Organic matter, Nutrients, Microalgae, Arid climate.

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ETUDE DES PERFORMANCES EPURATOIRES DE LA STATION DE TRAITEMENT DES EAUX USEES DOMESTIQUES PAR FILTRE IMBRIQUE HYBRIDE SOUS CLIMAT ARIDE

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Au Maroc, comme tous les pays en développement, l'assainissement et le traitement des eaux usées constituent l'un des plus grands problèmes environnementaux. L'absence de réseau public, le manque de stations d'épuration, l'absence de contrôle et de sensibilisation à l'environnement contribuent à la propagation des maladies, à la dégradation du paysage et à la contamination des eaux superficielles et souterraines. Les eaux usées sont considérées comme les principales sources de pollution pour les eaux souterraines et de surface. Le traitement des eaux usées domestiques par des systèmes dits 'extensifs' tels que la technique des filtres imbriqués caractérisée par de faibles contraintes d'exploitation, aussi bien en termes économique que technologique, se présente comme une solution prometteuse pour les petites et moyennes communautés. Cependant, la plupart des tests réalisés sur les filtres imbriqués verticaux, montrent leur limite quant à l'élimination du risque sanitaire. L'objectif de ce travail est d'évaluer l'efficacité d'une station d'épuration par filtre imbriqué hybride à traiter des eaux usées domestiques sous climat aride. La station est composée d'une fosse septique (traitement primaire), d'un filtre imbriqué à écoulement vertical (traitement secondaire) et d'un filtre imbriqué à écoulement horizontal (traitement tertiaire). La combinaison d'un filtre imbriqué vertical et un filtre imbriqué horizontal (filtre hydride) est testée pour la première fois et constitue l'originalité de notre travail. La filière de traitement a été conçue pour traiter un débit de 16m^3/jour des eaux usées domestiques provenant d'un établissement relevant de l'université Cadi Ayyad (Marrakech, Maroc).

L'échantillonnage a été effectué d'une façon bimensuelle pendant 2 ans (Avril 2018-Mars 2020) à l'entrée et à la sortie de chaque compartiment de la filière de traitement. Les paramètres suivis sont le pH, la conductivité électrique, l'oxygène dissous, la température, la matière organiques (DBO_5, DCO), les matières en suspension (MES), les composés Azotés (NH_4-N, NO_2-N, NO_3-N, TKN, TN), les composés phosphorés (PO_4-P, PT) ainsi que les paramètres microbiologiques (coliformes totaux, coliformes fécaux, et streptocoques fécaux). Les résultats de suivi des performances épuratoires de la station d'épuration par filtre imbriqué hybride montrent un important abattement de MES (99 %), DBO5 (98 %), DCO (92 %), NH_4^+ (91 %) et du PT (90 %) ainsi qu'une grande capacité d'élimination des coliformes totaux, des coliformes fécaux, et des streptocoques fécaux (respectivement 3.41, 3.12 et 3.23 unités log). Ceci démontre une amélioration considérable de l'efficacité du filtre imbriqué hybride par rapport à un filtre imbriqué vertical seul du point de vue performances épuratoires en particulier l'élimination des bactéries indicatrices de contamination fécale. En conclusion, la station de traitement des eaux usées domestiques par filtre imbriqué hybride sous climat aride a permis d'obtenir une bonne qualité d'eau traitée répondant aux normes d'irrigation Marocaine.

Mots Clés *:* Filtres imbriqué hybride, Eaux usées domestiques, Performances épuratoires, Charge organique, Aspect sanitaire, Climat aride.

EFFECTS OF SHORT TERM IRRIGATION WITH SECONDARY TREATED WASTEWATER ON SOIL PROPERTIES AND KORONEIKI OLIVE TREES (*OLEA EUROPAEA*L.)

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The aim of this study is to evaluate the effect of secondary treated wastewater (STW) from Marrakech activated sludge plant on soil and plants in comparison to well water (WW). Each experiment has been done in pots with five replications per treatment. In total, ten young olive trees koroneiki, were irrigated with two different qualities of irrigation water (STW, WW) over a period of two years. Physicochemical parameters were analyzed in water and soil. Likewise, agro physiological and leaf mineral composition in the crops were also assessed.Soil, water and olive leaves were analyzed according to standard methods. Results show that the secondary treated wastewater (STW) is characterized by relatively high contents of electrical conductivity NH4, Cl, K, Na and Mg in comparison to WW. Irrigation with STW significantly increases fruit production during the first and second year (165.74-203.97 kg fruit per tree versus 82.4-26.69 kg per tree under WW irrigation). While no significant differences in morphological parameters (regarding plant height and trunk diameter) and physiological parameters (stomatal conductance, chlorophyll fluorescence and total chlorophyll content) were noticed between the two sources of irrigation water. *Olea europaea L* leaf tissue irrigated with secondary treated wastewater showed high contents of Na, P, Ca and K. Nevertheless, Fe and Mn concentrations were higher in olive leaves irrigated by well water. Results also showed no trend of increasing heavy metal concentrations in the leaves of olive trees in both treatments. In addition, no significant difference in pH values between the two sources of irrigation water was noticed, while a significant increase in soil electrical conductivity (EC) has been observed, showing important increases after irrigation with TSW compared to WW. On the other hand, soil irrigated by STW showedan increase of N, K, Mg, P, Ca and Na concentrations compared to WW; while irrigation water salinity and Na were slightly higher in STW compared to well water. However, Cl-, Fe and heavy metals (Cu, Zn, Mn and Pb) contents were low in both investigated soils after two years of irrigation. Finally, it can be concluded that besides their benefit use as irrigation water, STW are also a potential sources of plant nutrients and soil fertilizer.

Keywords: Secondary treated wastewater, Soil, Koroneiki olive trees, Macro-elements, Micro-elements, heavy metals

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TENDENCIES ON RECLAIMED WATER USE FOR POTABLE PURPOSES

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The increasing demand on water resources due to the increase of population and standards of life as well as climate change and all related circumstances is leading the societies to a shift in the water management schemes. New resources are being searched and the necessary equilibrium between demand and offer is becoming more difficult to reach.
Following an historic approach of the problem in arid and semiarid areas, used- and waste-water reclamation and reuse have been used for millennia, and nowadays are becoming more common all around the world. Although the classical uses of reclaimed water are mainly agriculture, leisure and other uses not demanding high water qualities, in the last decades reuse for potable purposes is becoming more and more common for several causes and circumstances.
The traditional indirect potable reuse of wastewater is common elsewhere, through the disposal of used water (wastewater, treated or untreated) from several activities to the water bodies. Then water can then be extracted from those bodies, and (not always) further treated for potable/drinking water purposes. This so-called indirect (potable) reuse has been common all over the world and until the moment has not raised so much concerns, at least publicly.
Less accepted is the direct reuse for potable purposes of urban wastewater. In this case, pipe-to-pipe reuse is described, and is denominated direct potable reuse (DPR). DPR presents specific features, which made this reclaimed water reuse unique.
When examining the possibility of DPR a number of questions arise. First of all, the safety of the practice in terms of health-related risk is a matter of concern. This is followed by concerns on the necessary treatments and ways to operate and maintain the facilities. Not only the technical, engineering aspects must be considered but also other sciences take part in the equation, like epidemiology or toxicology when reusing water.
Then, health risk approaches are of paramount importance for managing reclaimed water for any reuse, and a number of regulations are prepared considering the safety of the practice, both in terms of health and amount of water available, which are strongly related. In reclamation and reuse, it is necessary to start the management with the supply of potable water to towns, and control the discharges to the urban sewerage. In a second step, wastewater should be fully treated including reclamation procedures, as well as the application and the final use of the reclaimed water. Distribution and end-use point controls are also compulsory.
Typically, direct reuse for potable purposes has been refused by many rules, regulations and authorities; but in a few places, like Windhoek, the capital town of Namibia, DPR has been employed for decades. Recently the severe and recurrent droughts in California and other places, forced to reconsider the DPR approach and further study the possibilities of the implementation of this practice at a bigger scale.The rules and regulations which exert influence on reuse practices and its possible developments for DPR are examined, as well as the economic, social and risk considerations to be implemented. The authorities' point of view, public acceptance and operation and maintenance aspects must also be fully studied. The conclusion is that potable reuse can be implemented if the necessary conditions are fulfilled, but this conclusion is justified from the scientific point of view.

Keywords: Reclaimed water, Direct Potable reuse, Climate change, Water scarcity, Health risk assessment.

CIRCULAR ECONOMY: HEALTH IMPACTS IN DEVELOPING COUNTRIES

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The circular economy framework for human production and consumption is an alternative to the traditional, linear concept of 'take, make, and dispose'. Circular economy (CE) principles comprise of 'design out waste and pollution', 'retain products and materials in use', and 'regenerate natural systems'. This commentary considers the risks and opportunities of the CE for developing countries (DCs) in the context of the Sustainable Development Goals (SDGs), acknowledging that DCs must identify their own opportunities, while recognizing the potential positive and negative environmental health impacts.

The implementation of the CE in DCs is mostly undertaken informally, driven by poverty and unemployment. Activities being employed towards extracting value from waste in DCs are imposing environmental health risks including exposure to hazardous and toxic working environments, emissions and materials, and infectious diseases. The CE has the potential to aid towards the achievement of the SDGs. However, since SDG 3 (Good Health and Well-Being) is critical in the pursuit of all SDGs, the negative implications of the CE should be well understood and addressed. We call on policy makers, industry, the health sector, and health-determining sectors to address these issues by defining mechanisms to protect vulnerable populations from the negative health impacts that may arise in DCs as these countries domesticate the CE.

Striving towards a better understanding of risks should not undermine support for the CE, which requires the full agency of the public and policy communities to realize the potential to accelerate DCs towards sustainable production and consumption, with positive synergies for several SDGs.

Keywords: Circular economy, Environmental health, Developing countries, Sustain-able production, Sustainable consumption, Sustainable development goals.

THERMAL PERFORMANCE OF A COMBINED SOLAR DRYER OF SEWAGE SLUDGE

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The volume of sewage sludge imminent from wastewater treatment plans is in continuous increase in the whole world. The management and revalorization of this product constitutes a main environmental and economic challenge. Drying process is fundamental for further disposal (incineration, agriculture…).

In the industrial heat process of drying, a high amount of energy is required. Researchers are focused on the use of alternative source of energy. Morocco has a high potential solar energy. The yearly average of global radiation is 5.3 kWh/m^2/day. In literature, the greenhouse solar dryers are the most suitable systems for drying sewage sludge. They are environmentally friendly, because they have low emissions of CO_2. In this context, we have studied a simple and economical solar energy storing rock bed system to heat the air inside the greenhouse. The aim of this study is to investigate the thermal performance of a combined solar greenhouse dryer (CSGD) of sewage sludge. Fig. 1 shows the schematic diagram of the combined solar greenhouse dryer of sewage sludge. It consists of three main parts: a rock bed storage and a flat plat solar air collector coupled with a greenhouse solar dryer. From 8:00 am to 6:00 pm, during the sunshine hours, solar radiations absorbed by the solar collector are used to generate hot air. A part of this hot air is injected directly in the solar greenhouse to enhance the drying process along the day. The other part of this hot air enters the rock bed at the top and transfers sensible heat to the pebbles. At night, from 6:00 pm to 8:00 am, the diurnal storage energy in the rock bed is released to the greenhouse solar dryer by running air from the bottom to the top of the bed. The heated air is collected from the rock bed through a pipe to the greenhouse solar dryer. Consequently, the drying time will be reduced in comparison with a traditional greenhouse solar dryer, where the drying process occurs only at the day during the sunshine hours. A numerical model is developed using TRNSYS software to predict drying kinetics of sewage sludge. The experimental part of this study is focused on testing the drying efficiency of sewage sludge in solar greenhouse. Results show that the drying time is greatly reduced in winter and summer period and the drying process continues even overnight, which led to operate the greenhouse solar dryer efficiently.

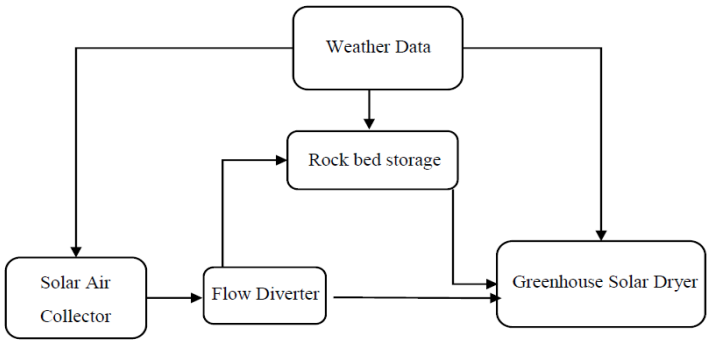

Fig. 1. Schematic diagram of the CSGD

Keywords: Greenhouse solar dryer, Thermal performance, Numerical model, Drying kinetics.

STUDY OF CONVECTIVE DRYING AND DETERMINATION OF THERMAL DIFFUSION COEFFICIENTS OF SEWAGE SLUDGE FROM THE WWTP OF OUJDA CITY

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The treatment of wastewater in treatment plants WWTP is accompanied by a significant production of waste sludge. This represents a real problem from an environmental point of view, hence the importance of treating this sludge and proposing recovery methods. Drying of Sewage sludge has become a best solution used to respond to the needs of communities in regulatory compliance. At the moment the study of drying still complicated due to the combination of mass transfer and heat involved in the drying process added thermo-physical properties which are strongly related to the temperature and the moisture content X of the sludge.

This work aims to contribute to study the drying kinetics of sewage sludge collected from WWTP of Oujda city in an indirect forced convection solar dryer for three different temperatures (50, 70, and 90°C). The experimental apparatus used to study the drying kinetics of sewage sludge is a convective solar dryer with polyvalent shelves and enable total or partial recycling of drying air. This dryer produces a hot air with controlled aerothermal conditions (temperature, air flow).

The drying rate was empirically determined and the influence of drying air speed, temperature and humidity on the drying kinetics of the sludge was studied in order to define the most suitable model for describing the drying curves, with a correlation coefficient close to unity and in aerothermal conditions controlled. It was noted that the drying rate was increasing continuously with increase of the temperature and moisture content at the same flow rate of drying air, as for the majority of porous hygroscopic products.The present work aims also to determine experimentally the diffusion coefficients and activation energy of sewage sludge generated at the WTP of Oujda city by an experimental macroscopic approach during its drying. The value of the sludge diffusion coefficient was measured by applying the Fick's diffusion model. The Arrhenius equation gives an activation energy value of 16.8 kJ/ mol expressed the effect of temperature on the effective diffusivity.

The results of drying experiments of sewage sludge in convective dryer illustrate the influence of temperature and show that the drying of the sludge is accelerated significantly with increasing the drying air temperature. The exploitation of the drying results allows us to determine the values of the diffusion coefficient; the values of the diffusion coefficient calculated thus the effect of temperature on thermal diffusivity was studied. The activation energy was calculated using the drying results and the Arrhenius equation, and was 16.8 kJ / mol.

Keywords: Sewage Sludge, Convective Solar Drying, Drying Kinetics, Thermal Diffusivity, Activation Energy.

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EVALUATION OF THE LONG-TERM CND POTENTIAL OF WASTE ROCK PILES AT THE ABANDONED ZN - PB ERDOUZ MINE (OCCIDENTAL HIGH ATLAS, MOROCCO)

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Pollution of soils, surface and groundwater can be of natural or anthropogenic origin. Mine drainage is one of the sources of metal emissions into the environment, affecting the ecological systems and human population. In this respect, the abandoned Erdouz mine (Occidental High Atlas, Morocco) was used as an example. However, the objective of this study is the environmental characterization and evaluation of the long-term contaminated neutral drainage (CND) potential of waste rock piles at the abandoned Erdouz mine (Pb and Zn).

Metallographic analysis of waste rock samples showed the presence of two main metal assemblages primary paragenesis composed of galena, chalcopyrite, pyrite and arsenopyrite and secondary paragenesis outcome following partial oxidation of the primary sulphide assemblage composed primarily of hematite and marcasite.

The modified Sobek static tests have shown that the Erdouz waste rock is generally not a generator of acid mine drainage (AMD). The leachates obtained by the column test showed a neutral pH (7.07 to 7.92) but significant contains on SO4 (233,1 to 2902 mg/L), Ca (234 to 697 mg/L), Mg (6,55 to 202 mg/L) and Zn (1,65 to 21,83 mg/L). Erdouz waste rock produces contaminated neutral drainage, mainly with sulphates whose concentrations exceed Moroccan standards for direct discharges.

This waste remains relatively stable chemically and its recovery as a substitute for construction materials is possible after a pretreatment to eliminate the harmful fraction.

Keywords: Contaminated neutral drainage, Static tests, Kinetic tests, Erdouz mine, Morocco.

MICROALGAE CULTIVATION IN TREATED WASTEWATER BY MULTI-SOIL-LAYERING SYSTEM UNDER EXTREME CONDITIONS

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Wastewaters are widely studied and demonstrated to be good medium to cultivate microalgae and have an economic efficiency to produce high-value biomass used in many fields, meanwhile proving sanitation alternatives by removing nutrients and heavy metals from these wastewaters. This study aims to adapt the microalgae to flat photobioreactor conditions to enhance phycoremediation and biomass production. Samples of multi-specific algae mixture were collected from a stabilization pond located in peri-urban area of Marrakech (Morocco) and have been grown in culture media prepared using treated wastewater by hybrid Multi-Soil-Layering (MSL) system. Different quality media were used for algae cultivation namely domestic raw wastewater, treated wastewater by MSL, and synthetic media both sterilized and non-sterilized. The cultivation was done under batch system in order to select the most tolerant species to extreme conditions of light (1000 µmol/m^2.Sec) with active photosynthetic radiation (460-700 nm) and temperature (35°C) while enhancing the medium quality against the environmental issues related to nitrogen and phosphorus compounds pollution by removing them. Preliminary results showed that almost a complete removal of $PO_4^{3-}$was achieved within three days of the cultivation. However, the nitrate showed a fluctuation during all the period of the experiment. Moreover, results showed that during last days of the experiment no species could grow under the extreme conditions used exception made to *Micractinum* sp which could slowly divide. The only strain that could still grow exponentially even under these hard conditions of light and temperature was *Chlorella* sp. This finding was deepened and optimized with the treated and raw wastewaters as being a good culture medium for biomass production. Besides, assays of pigment concentrations mainly chlorophyll a, chlorophyll b and carotenoids confirmed that the treated wastewater by MSL could be considered as a good culture medium for *Chlorella* sp.

Keywords: Microalgae, Cultivation, Treated wastewater, Extreme conditions, *Chlorella* sp.

Acknowledgment : This work was financed by the FRAME Project, ERANET-MED/3-075, big thanks to the National Center for Research and Studies on Water and Energy (Cadi Ayyad University) and the Pole of competences on Water and Environment (PC2E) for their technical and scientific support for this work.

POSTERS PRESENTATIONS

SPATIAL MODELING OF WATER MANAGEMENT IN TADLA IRRIGATED AGRICULTURE, MOROCCO

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Water scarcity is among the main problems to be faced by many Mediterranean countries. In Morocco, studies on this phenomenon show a clear downward trend in water availability. In addition to the recurrent droughts that the country has experienced in recent periods, the aquifers are becoming increasingly vulnerable. This vulnerability is generated naturally by the impact of climate change, and under the anthropogenic influence, by the harmful effects of human activities (withdrawals, pollutant discharges, etc.). As a result, there is overexploitation of water to meet an ever-increasing demand for drinking, industrial and irrigation water. This use has increased due to demographic pressure, accelerated urbanization, and socio-economic development. Besides, competition for access to water resources is intensifying between different sectors. In this context, agriculture is considered to be a highly water-consuming activity, hence the need for thrifty behavior concerning the use of irrigation water. Modeling frames have been developed to improve the interactions between the various hydrological, agronomic and economic components without integrating the spatial aspect. This requires a rethinking of new solutions to have continuity and an improvement in these studies. Spatial modeling of water management will be an effective tool for controlling and organizing the distribution of water resources to assure their protection and conservation and to improve their equitable sharing among users. The objective of our study is to use geographic information systems (GIS) to develop a spatial model of irrigation water management. The use of a geographic information system will offer great flexibility for water management modeling, facilitating the collection and integration of spatial data in a coherent form, as well as their visualization in thematic maps. This study concerns the Tadla sub-basin in Morocco characterized essentially by an important agricultural activity based on different modes of irrigation, hence, the need for a spatial model of water resource management in this region. In such a way, the results will be of interest to water managers, local stakeholders and farmers to achieve sustainable management of this resource. Overall, this research will offer an innovative approach to protect water resources and limit their overexploitation.

Keywords: Spatial Modeling, Water Resources, Sustainable Management, Agriculture, Irrigation Water,Tadla, Morocco.

LA GESTION INTEGREE DES EAUX URBAINES DU GRAND MARRAKECH: NOUVELLE APPROCHE D'ADAPTATION AU CHANGEMENT CLIMATIQUE

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Les ressources hydriques dont dispose le Maroc sont limitées et soumises à l'augmentation continue de la demande, due à l'évolution rapide de la population, à l'amélioration du niveau de vie, au développement industriel et à l'extension de l'agriculture irriguée. Cette situation serait exacerbée par les effets du changement climatique qui sont déjà ressentis pour le Maroc. Ces effets auraient des impacts néfastes directs et indirects sur le potentiel des ressources en eau, tant du point de vue quantité que qualité. Cet article aborde la problématique de la sécurisation de l'eau urbaine dans un contexte climatique menaçant pour les ressources conventionnelles. Il présente une étude de cas du grand Marrakech, constitué de la ville de Marrakech et des centres qui lui sont liés. Marrakech est parmi les villes les plus importantes du Maroc. La situation hydrique critique de cette ville ainsi que le développement touristique croissant qu'elle connaît, interpelle tous les acteurs à réfléchir sur la préservation de ses ressources en eau. La méthodologie suivie dans ce travail consiste en l'adoption d'outils d'aide à la décision pour étudier le bilan des ressources en eau du grand Marrakech et l'analyse des options d'aménagement futures. Une analyse de la simulation du bilan Ressources-Besoins en eau de la ville de Marrakech avec son système actuel d'alimentation est établie. La confrontation Ressources-Besoins a abouti à l'apparition de déficit dans des horizons futurs proches. Un aménagement projeté est proposé et étudié. Une synthèse de l'étude des performances hydrauliques de cet aménagement et son influence sur le renforcement de la sécurisation en eau urbaine de la ville est présentée. L'analyse des résultats du bilan hydrique et de la simulation hydraulique conduit à soulever les limites du système actuel d'alimentation en eau urbaine de Marrakech et met en évidence la nécessité d'adopter une nouvelle approche de gestion intégrée adaptée au changement climatique et au développement socio-économique des zones urbaines. Une approche de gestion intégrée des eaux urbaines (GIEU) récente proposée par la FAO est présentée pour une planification intégrée des ressources en eau de la ville basée sur la diversification des ressources de l'offre et la gestion de la demande. L'objectif étant de faire face au stress hydrique des grandes villes, exacerbé par des milieux urbains en expansion. La simulation du système hydraulique est effectuée en adoptant l'approche GIEU et en intégrant des options de diversification des ressources en eau. Les résultats confirment la nécessité de se tourner vers la diversification des ressources pour pouvoir sécuriser l'alimentation de la ville de Marrakech pour les horizons futurs.

Keywords:Estion intégrée des eaux urbaines, Bilan ressources-besoins, Performances hydrauliques, Grand Marrakech, RIBASIM, Changement climatique.

POSTHARVEST CONTROL OF TOMATO USING AQUEOUS AND ORGANIC EXTRACTS OF THE GREEN SEAWEED *ULVA LACTUCA*

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Tomato cultivation is one of the most widespread in the Mediterranean countries. However, this Solanum fruit is exposed to many post-harvest diseases, usually caused by various pathogens fungal or bacterial microorganisms. Several chemical fungicides used for decades have proven to be harmful to health and the environment. Therefore, the need to find other alternatives more safer like to develop a biopesticide using natural molecules from a green alga for the protection of citrus fruits.
The *Ulva lactuca* green algae selected for this study are collected from Sidi Bouzid coast (El Jadida, Morocco). Different extracts of this alga were tested for their antifungal powers. We determined the antifungal activity of the methanol and aqueous extracts on the growth of phytopathogenic fungi *Fusarium oxysporum* and *Botrytis cinerea*.
The results showed that the methanolic extract has a very important inhibitory potency against these two fungi, while the aqueous extract has a low effect on them. The antifungal effect against *Botrytis cinerea*is obtained only with the high amount of the methanolic extract (4.73 cm ± 0.08), while *Fusarium oxysporum* is more sensitive in the presence of the low and high amounts tested. The study of the temperature effect (60°C) on the biological activity of *Ulva lactuca* showed her sensitivity to high temperatures, which resulted in a net decrease in antifungal activity against the tested fungi. Treatment of Tomato inoculated by the two phytopatogenic species and whether the seed stage or fruit by the aqueous extract of *Ulva lactuca*, ensure their protection against the attack of these two fungi. We also analyzed heavy metals (cadmium and copper, zinc) accumulated by the green seaweed. The results showed that the metal concentrations do not seem high enough to lead to a risk of toxicity of the extracts prepared from the studied alga.
The practical use of the seaweed in agricultural field opens a new way in the biological control. Their aqueous and organic extracts could be an alternative for the protection of crops against pathogens.

Keywords: Antifungal Activity, *Ulva lactuca*, *Fusarium oxysporum*, *Botrytis cinerea*, Methanolic extract, Aqueous extract.

SEASONAL MONITORING OF THE APPEARANCE OF TOXIC CYANOBACTERIAL BLOOMS IN A FRESHWATER DAM: A CASE OF THE LALLA TAKERKOUST DAM

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The occurrence of toxic cyanobacteria in the lake of the Lalla Takerkoust Dam seems irregular and initially influenced by certain exogenous environmental parameters. Certainly, global warming contributes to the fluctuations of the periods of the year at which the bloom appears in the lake, but it would seem that temperature alone does not justify the phenomenon. In this study, monthly monitoring over two successive years showed that the bloom in Takerkoust does not form in the summer at the hottest times of the year (up to 40 °C). The blooms seem to form preferentially at average ambient temperatures around 30 °C and when the water temperature does not exceed 25 °C and not lower than 16 °C. For the emergence of bloom, the water temperature must specifically correlate with the nutrient supply in the water. Physicochemical analyzes, regarding nitrogen and phosphorus inputs showed that the onset of bloom seems to follow the precipitation pattern by only a few days (about a week), justifying the high peaks in phosphorus and nitrate. Unlike previous years where bloom in Takerkoust appeared from June, July, or August, in this study, during the year 2019 and 2020, the cell count of cyanobacteria using the ohmmeter permitted positioning the onset of bloom in the middle of September in 2019 with the buoyant colonies of Microcystis visible. Rainfall and water temperature were 30°C and 56 mm, respectively. The quantity of phosphorus and nitrates was 0.323±0.011 mg/liter 1.29±0.023 mg/liter, respectively. In 2020, despite the high summer temperatures, blooming did not occur until mid-November. The precipitation and water temperature were 36 mm and 21°C respectively. Phosphorous and nitrate levels were 0.183±0.028 mg/liter and 0.914±0.090 mg/liter, respectively. In the light of these results, the present approach provides useful indications that could be used to monitor the occurrence of bloom to take action against this phenomenon of freshwater eutrophication.

Keywords: Toxic cyanobacterial blooms, Global warming, Cyanobacteria, Freshwater eutrophication

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EVALUATION OF WATER QUALITY IN SHALLOW LAKES USING MULTIVARIATE STATISTICAL TECHNIQUES: CASE STUDY ON BOUDAROUA LAKE (OUAZZANE, MOROCCO)

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Lake Boudaroua is one of the most important shallow lakes in Morocco. It is located 5 km west of Ouazzane city and it is very important in terms of biodiversity and tourism, but knowledge of its water quality is somewhat limited. The aims of this study are to assess water quality in Lake Boudaroua and to provide information for future management decisions.This case study reports different multivariate statistical techniques such as Pearson's Correlation, Principal Component Analysis (PCA), and Cluster Analysis (CA) generated during June 2019, October 2019 and January 2019 with monitoring at five different sites depending on 20 parameters.The parameters were Temperature (T), pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Turbidity, Total Hardness (TH), Anion (F^-, Cl^-, SO_4^{2-}, NO_2^-, NO_3^-,NH_4^+, Kjeldahl Nitrogen), Cation (Na^+, K^+, Ca^{2+}, Mg^{2+}), B, COD and DBO5.
The PCA supported in extracting and recognizing the factors that are responsible for surface water quality variance. Two factors that are responsible for 77.2% of the total variance in water quality of the lake are identified. Two significant sampling locations: (sites 1, 2 and 4) and (sites 3 and 5) were detected based on the similarity of their water quality using cluster analysis.
According to qualitative and quantitative observations, the effects of human impact and the status of the lake were determined. The physical and chemical characteristics of the lake water have changed according to human activities and nutrient loadings. We, therefore, suggest wise management of anthropogenic activities in the lake Boudaroua.

Keywords: Lake Boudaroua, Water quality, Multivariate Statistical Techniques, Ouazzane, Morocco.

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POLLUTION ASPECTS OF SPRINGS WATER IN NATUF CATCHMENT-RAMALLAH AREA / PALESTINE

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Natuf catchment is considered as one of the most important recharge areas for the Western Aquifer Basin. Twelve samples of spring water were collected for hydrochemical qualitative analyses of major and trace elements as well as microbiological analyses in the summer of 2017. This study aims at determining the types of pollutants and their sources for the springs in the study area in addition to evaluating the socio-economic environmental impact on water utilization from residential people. Fifty questionnaires were distributed to the farmers and springs owners in order to study the impact of socio-economic and environmental conditions for the spring water utilization. The study shows that 90% of local people using the springs for agricultural purposes. The chemical analysis of water samples are free from industrial pollutants, this refers to the fact that 84% of them are located away from the dumping sites. The existence of water network as well as the absence of the roll of the official authority contributes to the reduction of people's dependence on spring water.

Keywords: Pollution aspects, Hydrochemistry, Socio-economy, Natuf catchment.

EFFECTS OF ANTHROPOGENIC FACTORS ON GROUNDWATER ECOSYSTEM IN ZAGOURA REGION

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The depletion of aquifer systems in arid and semiarid regions worldwide is causing acute water scarcity and quality degradation, and leading to extensive ecosystem damages. Groundwater is exposed to a variety of anthropic water pollution as raw wastewater disposal in the Draa wadi and the use of septic tanks. In this respect the study performed in some wells of Zagoura (South-east Morocco), aimed at both the discovering of the main components of the aquatic subterranean fauna unknown up to now in this area, and the potential relationships between this fauna and the well water quality. For this purpose more than 50 groundwater wells were first surveyed occasionally. Then the principal physico-chemical characteristics of water from wells were measured regularly at 16 selected wells. From the physico-chemical side, the Fazouata groundwater is distinguished by its high salinity. In many stations, water was hard and saline with an increasing gradient from upstream to downstream. The aquatic fauna present in these 16 stations was also monthly sampled during seven-month. These wells were selected considering their fauna and their position with respect to the pollution sources known in surface. The results of this survey showed a rich and diverse aquatic fauna including 8 species and one genus new to Science. In the protected wells which are situated far from the pollution sources. The fauna population was dominated by the Amphipodes métacrangonctydae, Stenasellidae, Cirolanides, Thermosbaenacea and ground gasteropodes. On the other hand, in the less protected well, close to the pollution sources, the fauna population is made of species such as insect larva Culicidae and chironomideae. The analysis of both water quality and biodiversity shows that the latter decreases with increasing groundwater pollution. It is the stygocenose species that diminish and vanish in case of acute pollution.

Keywords: Groundwater pollution, Stygoby funa, Biodiversity, Water physicochemistry.

MODELISATION DE L'IMPACT DES REJETS DES STATIONS D'EPURATION SUR LE MILIEU RECEPTEUR

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La qualité des ressources en eau au Maroc est sujet à une pression sans cesse croissante, due à l'accroissement démographique, l'urbanisation, l'essor industriel et le développement de l'agriculture intensive. Pour la plupart des centres urbains et ruraux et des unités industrielles, les eaux usées sont rejetées dans le milieu récepteur (eaux de surface, sol, Océan) soit avec ou sans traitement préalable, Cet état exacerbe les processus d'eutrophisation, et prédispose à la toxicité du milieu par les métaux lourds et les agents pathogènes, en raison des apports de pollution ponctuelle et diffuse. Ces processus combinés entraînent une dégradation considérable de la qualité physico-chimique des ressources en eau et plus particulièrement au niveau des eaux de surface. Dans cette étude, nous évaluons la qualité physicochimique des cours d'eau du bassin versant de l'Oued Tensift dans la région Marrakech, par une surveillance expérimentale et une modélisation de la qualité des eaux de surface. La suite logicielle PegOpera (incluant le modèle mathématique Pégase) a été utilisée pour appliquer pour les rivières amont du bassin versant de l'Oued Tensift. Dans le cadre d'une thèse de doctorat en cotutelle (ULiège – Université de Marrakech) une première application du modèle pour un BV marocain a permis de calculer les différentes concentrations des paramètres physicochimiques de la qualité des eaux. Les premiers mois de cette étude ont été consacrés à la construction des Bases de Données de l'application (construction du domaine de simulation) tout en gérant les contraintes locales associées au manque des données et les ruptures dans les fréquences des analyses de la qualité de l'eau (gracieusement rendues disponibles auprès de l'administration locale). Cette période de travail a déjà rendu possible les premières simulations numériques du modèle PEGASE grâce à l'exploitation de la suite logicielle PEGOpera. L'outil de la modélisation PEGOPERA a été développé afin d'être conforme aux exigences européennes pour le contrôle de la qualité de l'eau de surface. PEGASE est un modèle physico-chimique décrivant le comportement de systèmes fluviaux entiers, à différentes échelles, de plusieurs dizaines à plusieurs centaines de milliers de km². La spécificité du modèle est sa capacité à travailler à une résolution spatiale élevée autant pour les petits bassins versants que pour les grands bassins versants. Le modèle est utilisé et exploité par plusieurs Administrations/Agences de l'Eau et Ministères en Europe et, par ailleurs, de nombreuses applications scientifiques sont en cours au niveau international (Europe, Afrique, Amérique,…). L'outil de modélisation PEGOPERA s'avère être un outil opérationnel efficace pour planifier et gérer les eaux de surface Marocain et dans les Pays du pourtour méditerranéen. Grâce à ce travail on simule les effets de la gestion anthropique, tant à court qu'à long terme, exploitant au maximum les données géo référencées, en particulier en simulant l'impact de la réalisation des stations d'épuration sur la qualité des rivières réceptrices dans différentes communes du bassin de Tensift.

Mots Clés *:* Pegase, Modélisation, Qualité, Rivière, Pollution.

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FIRST STUDY OF THE ECOLOGICAL STATUS OF SAFI ATLANTIC COAST USING THE MACROALGAE AS BIOINDICATORS

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This work is intended to evaluate the quality of Safi city coastline waters (Moroccan Atlantic coast), by using the macroalgae as bioindicators. The correlation between physico-chemical parameters (nitrogen and phosphorus compounds, dissolved oxygen, temperature, conductivity, pH) and the content of algal chlorophyllian pigments were carried out during four seasons between January and October 2018.

The obtained results show, that the physico-chemical changes of sea water, induced by urban and industrial waste waters coming from the anthropogenic activities of Safi city, are influencing on the salubrity of this coastal marine ecosystem. Indeed, the specific algal richness decreases in the polluted stations (S2) and (S3), the industrial area and the phosphate area respectively, receiving urban and industrial water discharges, compared to the reference station Beddouza (S1). The level of the chlorophyllian pigments in four dominant algales species (*Osmundea pinnatifida, Fucus spiralis, Ulva lactuca and Codium elongatum*), indicate an important level of stress in these species, especially in the polluted stations S2 and S3.

The use of the spatial distribution of the specific richness and the algae recovery, along with the biodiversity measurments seem as an effective tool for the ecological assessment of Safi coastline in the Atlantic coast of Morocco.

Key words: Macroalgal Biodiversity, Bioindicators, Polluted stations, Safi coastline waters.

DETERMINATION OF METHYLENE BLUE DECOLORIZATION RATE FOR THE ASSESSMENT OF BACTERIAL VIABILITY IN TRETAED WATER

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After water disinfection, the detection of bacterial viability is considered a primordial step to control and to improve the efficiency of the water treatment process. Indeed, the dysfunction of the tertiary water treatment phase can contribute to the spread of water-borne diseases and consequently, may have harmful effects on the public health and on the environment.

Generally, the conventional method was used for water assessment. This type of method is based essentially on the count of viable and culturable bacteria on usual media. Despite its importance, this assessment technique requires several days and the results can underestimate the real bacterial quality of treated water. Indeed, after water disinfection, many species of bacteria can enter in viable but non-culturable (VBNC) state as an adaptation strategy to survive and to persist in a hostile environment. Accordingly, the monitoring of bacterial water quality based only on the classic methods is not sufficient for the assessment and for the diagnostic of trouble in the water disinfection process in a short period of time. To overcome this problem, it's important to develop rapid, sensitive non-culture, reliable and low-cost methods.

The main focus of this study was to develop a protocol for the assessment of microbial water quality using cationic dye; Methylene Blue (MB). The developed protocol was extended to demonstrate sensitivity to assess water after photocatalytic treatment.

The study of the interaction MB dye and bacteria (determination of MB decolorization rate, the MB decolorization percentage and MB biodegradation rate) shows a correlation and spectral sensitivity between MB and added bacterial biomass. Indeed, MB absorbance spectra were progressively decreased when the bacterial suspension was added to the MB solutions (hypochromic effect). This decrease was correlated with bacterial density. Thus the methylene blue adsorption assay could be applied to monitor treated water and to detect the presence of potential active bacterial in the treated water sample.After water treatment, the progressive decrease of DDR was correlated with a decrease in potential active bacteria caused by the injured effects of photocatalytic treatment. This continuous decrease could indicate the presence of active bacteria in the treated sample. Based on this result, an extending on proceeding time was recommended to avoid the bacterial resuscitation and the potential public risk after water treatment.

The correlation between bacterial density and MB spectra profiles allow as to use the dye adsorption assay as an alternative to monitor treated water and to establish an action plan to react in real-time and to correct the malfunction of the disinfection step.

Keywords: Methylene Blue, Bacteria, Decolorization rate, Viability, Assessment.

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THE EFFECT OF SUPPLEMENTARY PHOSPHORUS FERTILIZATION ON TOMATO PRODUCTION UNDER SALINE CONDITIONS

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The main objective of the study is to evaluate the effect of two factors: the salinity of the irrigation water and phosphorus fertilization on the production of tomato in the Souss-Massa region. This trial was carried out as part of a project led by the OCP Group. For the first factor, three levels of salinity were used [S1 (3 dS/m), S2 (6 dS/m) and S3 (8 dS/m)]. For the second factor, three doses of phosphorus [P1 (100% of the crop needs in P), P2 (120%) and P3 (140%)], were used in a greenhouse on a sandy soil.

The results have shown a negative correlation between the salinity and the majority of the measured parameters. Vegetative growth, yield, physiological activity and leaf mineral content are reduced by the salinity of the water irrigation. The electrical conductivity of the soil and the levels of physiological disorders were significantly higher in the plants treated by saline water compared to the control. The additional supply of phosphorus has effect the majority of the parameters. In fact, the proportion of necrotic fruits, the acidity of the fruits and the amount of proline in the leaves in the salinity of 3 dS/m and 6 dS/m decreased in the presence of higher quantities of phosphorus. However, on the third salinity level (S3: 8 dS/m), additional supply of phosphorus had a negative effect on the studied parameters.

Keywords: Saline conditions, Phosphorus fertilization, Tomato production.

EVOLUTION DE LA CHARGE POLLUANTE AU NIVEAU D'UN TRAITEMENT BIOLOGIQUE AVEC FILTRATION MEMBRANAIRE - CAS DE LA STEP DE MEDIOUNA AU MAROC

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Le développement urbain est une composante majeure du développement territorial. Dans ce sens, le Schéma Directeur d'Aménagement Urbain de la ville de Casablanca au Maroc homologué en 2014 (SDAU-2014) a défini les grandes orientations de développement du périmètre de la ville de Casablanca en ouvrant à l'urbanisation une superficie de 25 000 hectares supplémentaires.

C'est dans ce cadre que le centre de la commune de Médiouna d'une superficie d'environ 450 hectares, situé en périphérie de la ville de Casablanca, a été ouvert à l'urbanisation. Selon le SDAU-2014, cette commune connaitra une densité de population forte à intermédiaire et s'y localisera un parc d'activités économiques « non nuisantes ». Afin d'assurer le suivi des stratégies de développement territorial au niveau des zones péri-urbaines tout en assurant une gestion durable des ressources en eau, Lydec en tant que gestionnaire délégué privé des services de distribution d'eau, d'électricité, d'assainissement liquide et d'éclairage public a doté la commune de Médiouna, dont la population est de 22 500 habitants, d'une Station d'Epuration des eaux usées (STEP). L'objectif de cet ouvrage est le traitement des eaux usées brutes de l'agglomération et la protection contre la pollution des eaux de l'Oued Hassar, unique cours d'eau de la région, tout en offrant une possibilité de réutilisation des eaux traitées pour l'irrigation agricole. En effet, cette station de type RBM (Réacteur Biologique Membranaire), est dotée d'un traitement tertiaire de type biologique intensif couplé à une filtration membranaire. La STEP de Médiouna a été conçue pour recevoir un débit de 3 800 m^3 par jour pour une capacité de traitement de 40 000 Equivalent-habitant.

Ce travail propose un diagnostic de l'état de saturation de la STEP en se basant sur l'évaluation de la charge hydraulique et de la charge polluante reçues par la STEP depuis sa mise en service en 2013, jusqu'à l'année 2019. L'objectif étant de montrer l'impact du raccordement des eaux usées rejetées par les petites industries locales de Médiouna sur les performances épuratoires de la station. Les résultats obtenus montrent qu'à partir de la première année de mise en service, la STEP a atteint 95% de sa capacité de traitement en DCO, DBO5 et MES, contre une charge hydraulique ne dépassant pas 50% du débit de conception. De plus, à partir de l'année 2015, le dépassement de la capacité de traitement de conception a été enregistré de façon régulière plusieurs fois dans l'année. Dans les faits, la STEP reçoit régulièrement des effluents issus de petites industries locales (délavage de tissus et imprimeries) aux rejets extrêmement variables en débits mais surtout en flux polluants. Les conditions générales d'admission des eaux résiduaires industrielles sont définies par le cahier des charges d'assainissement du contrat de gestion déléguée. Cependant, les mesures et les analyses réalisées sur ces rejets montrent généralement la non-conformité des effluents. Cette situation très contraignante, pourrait impacter la qualité des eaux traitées à la sortie de la STEP, augmenter les coûts d'exploitation mais surtout obliger le gestionnaire de la STEP à débloquer des investissements plus rapidement pour le renforcement ou l'extension du traitement.

Mots clés : Médiouna, Traitement, Eaux usées industrielles, Evaluation, Filtration membranaire.

ROLE OF RHIZOSPHERE MICROBIOME IN THE PROTECTION OF *VICIA FABA* AND *TRITICUM AESTIVUM* CULTURES AGAINST MICROCYSTINS EXPOSURE IN BLOOM-CONTAMINATED WATER AND HEALTH RISK ASSESSMENT

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Over the last decades, global warming has increasingly raised the public concern upon the expansion of harmful cyanobacterial blooms (HCBs) in freshwater reservoirs worldwide. In eutrophic conditions, toxic cyanobacteria of HCBs thrive and release multiple variants of hepatotoxic and tumor-promoting cyanotoxins into the waterbody, chiefly microcystins (MCs). Thus, MCs-contaminated water used for crop irrigation pose a threat to human and animal health via bioaccumulation and food chain contamination. Furthermore, MCs has diverse phytotoxic effects on growth and development of local agricultural plants, leading eventually to a significant yield loss. In this study, a greenhouse experimentation has been carried out, so far, with two different cultures: *Vicia faba* and *Triticum aestivum*. Both plants have been exposed to MCs-contaminated water (100 µg equivalent MC-LR/L) during 2 months of exposure. The experiment was designed to investigate the potential microbial protection against MCs exposure in the soil-plant system, in which plants were cultivated in sterile (microorganisms-free) and non-sterile (microorganisms-rich) soils. We found evidence that growth parameters of plants grown in sterile soil were more decreased under MCs exposure compared to plants cultivated in non-sterile soil. Moreover, MCs were more taken up and accumulated in plants grown in sterile soil, in a rate exceeding the reference dose recommended by the World Health Organization and set at 0.04 µg/kg of body weight per day. It is, thus, suggested that MCs are mitigated in the soil compartment through a microbially-mediated degradation. That is to say, microorganisms are implied in MCs removal from soil which attenuated their uptake by agricultural plants and resulted in less bioaccumulation and phytotoxic effects in consequence.

Keywords: Harmful cyanobacterial blooms, Microcystins-contaminated water, Crop irrigation, Vicia faba, Triticum aestivum, Plant growth, Microcystins accumulation, Risk assessment, Microbial protection.

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SYNTHESIS AND TOXICITY OF GRAPHENE OXIDE IN MICE

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Nanomaterials have been widely used in many fields in the last decades, including electronics, biomedicine, cosmetics, food processing, buildings, aeronautics, etc. The application of these nanomaterials in the medical field could improve diagnosis, treatment and prevention techniques. Carbon-based nanomaterials exist in nature with many forms and are used in science and technology for drug delivery, cell imaging and cancer therapy. Graphene oxide (GO), an oxidized derivative of graphene, has very interesting properties, such as nanometric size, specific surface area and electrical charge. Through those physicochemical properties, GO is used in biotechnology and medicine for cancer treatment and drug delivery. However, several studies show that certain nanomaterials used in biomedicine have a health impact, something that has not yet been studied for GO. So, this study aims to assess the GO toxicity on male mice. After synthesized these nanoparticles, the size analysis was performed using a Mastersizer 3000 laser diffraction device. The toxicity effects of this nanomaterial were studied after intraperitoneal injection of GO to mice at different doses (2 mg/kg and 5 mg/kg) for 5 days. Subsequently, histological sections were performed to evaluate pathological and morphological changes in the liver. The particle size analysis results showed that our nanomaterial has a uniform distribution, withan average grain size around 50 nm, which means our sample has a nanoscale size. Besides, the histopathological analysis indicated that the GO caused inflammation of the liver. Moreover, the oxidative stress test exhibited that there is an increase in peroxidase enzyme activity. To sum up, those results show that GO caused toxic effects in mice, but the mechanism by which this occurs requires further study.

Keywords: Graphene oxide nanoparticles, Toxicity effect, Oxidative stress, Effect on liver tissue.

INFLUENCE OF TREATED URBAN WASTEWATER BY STABILIZATION PONDS REUSE ON CROP RESPONSE AND SOIL PROPERTIES

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Quality fresh water for agriculture is becoming an increasingly scarce resource due to climate change effects and increased demand from the agricultural sector. Hence, wastewater reuse for irrigation represents a sustainable option and an advantageous alternative for the mitigation of the ever-increasing irrigation water scarcity and demand in arid and semiarid regions around the world, especially in Mediterranean areas, such as Morocco. The aim of this work is to study the effect of treated urban wastewater by stabilization ponds on soil, growth, physiological and chemical constituents of young olive trees (*Olea europaea* L.) cultivars (Koroneiki). The experiment was carried out from March 2017 to March 2019 in pots located in the faculty garden at Cadi Ayyad University (Marrakech-Morocco (31◦37' N; 08◦02' W)). Ten olive trees were irrigated with two different qualities of irrigation water: treated urban wastewater by stabilization ponds (TUWS), and well water (WW) as control. TUWS is characterized by relatively high contents of electrical conductivity (3497,66 µs/cm), NH4 (1,53 mg/l), Cl (1476 mg/l), K(66,93 mg/l) and Na (146 mg/l) in comparison to WW. Results showed a positive effect of TUWS on plant height and no significant differences in trunk diameter irrigated with treated urban wastewater compared to well water; no significantly, differences between treatments on physiological parameters (stomatal conductance, chlorophyll fluorescence and total chlorophyll content) were observed. After two years, results showed that the leave contents of N, P, K, Ca, and Cl were decreasing in plants irrigated both with treated wastewater and well water; while there was a significant difference between treatments in Na content. Whereas heavy metals (Zn, Pb, Cd and Mn) showed a nonsignificant difference between treatments. No significant difference in pH values between the two sources of irrigation water was noticed; while a significant increase in soil electrical conductivity has been observed. In general, irrigation with TUWS significantly increases fruit production during the first and second year, despite that productivity in first year was higher compared to second years. These results suggest that irrigation with the (TUWS) could be seen as strategic solution to recycle this water resource in agriculture.

Keywords: Koroneiki olive trees, Macro-elements, Micro-elements, Heavy metals, Treated urban wastewater.

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CONTINUOUSLY OPERATED POMACE OLIVE PACKED BED FOR OLIVE MILL WASTEWATER TREATMENT AND PHENOL RECOVERY

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Morocco is among the most olive oil-producing countries in the Mediterranean. This industry, so beneficial for the national economy, generates liquid discharges called "Olive Oil Mill Wastewater (OMWW)" and solid discharges "the pomace", which are by-products of the olive oil extraction process. The OMWW are very polluting wastewater, highly loaded with organic matter. Besides, they are saturated by phenolic compounds that are toxic and extremely difficult to biodegrade. However, those compounds enter in several cosmetic and pharmaceutical products, which make their extraction very promotive. The objective of this work was the preparation of bio-adsorbent from olive pomace of the Moroccan picholine variety and their physicochemical characterization to treat OMWW and extract their phenolic compounds targeting a circular economy. A chemical activation way elaborated the activated carbon.

The prepared bio-adsorbent were characterized by scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), Fourier transform infrared spectroscopy (FTIR) and Brunauer, Emmett and Teller (BET) analysis. The adsorption performance of this material was evaluated in batch and fixed-bed reactors operated in a concurrent flow system.

The obtained results would allow the valorization of olive mill wastes and their use to safeguard the environment. The adsorption capacity of phenolic compounds was 585.71 mg g^{-1}. The adsorption followed by desorption for the recovery of total polyphenols showed high percentage desorption (55%) and was efficient after several OMWW treatment and phenol recovery cycles.

Keywords: Olive pomace, Olive mill wastewater, Phenolic compounds, Activated carbon, Adsorption, Regeneration.

Acknowledgment: This work was supported by the Morocco-Tunisian bilateral scientific cooperation project R&D

UTILISATION DE L'INTELLIGENCE ARTIFICIELLE POUR L'ESTIMATION DE LA TEMPERATURE DE LA RIVIERE SEBOU

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La température joue un rôle majeur sur les écosystèmes aquatiques. Elle est considérée comme l'une des variables physiques les plus déterminantes de la qualité de l'eau car elle intervient dans plusieurs processus chimiques, physiques et biologiques. Au niveau de l'estuaire de la rivière Sebou, les mesures de température ne sont pas assez suffisantes pour décrire convenablement le régime thermique. L'objectif de cette étude est d'utiliser l'intelligence artificielle et spécialement la technologie de Machine Learning pour avoir une estimation rapide de la température au niveau d'un site donné. Le « training »du modèle Machine Learning à été réalisé en utilisant les sorties (séries de températures calculées) par le modèle de transport HEC-RAS.

La première étape du travail consiste à modéliser le régime hydraulique à l'aide de HEC-RAS. Le module hydraulique a été calibré et validé en utilisant une importante base de données hydraulique et morphologique. Le régime thermique de la rivière est simulé aussi sous HEC-RAS en se basant sur l'équation de transport de l'énergie. Plusieurs données sontnécessaires: condition initiale de température, coefficient de dispersion, vitesse de l'écoulement, pression atmosphérique, température de l'air, humidité relative, nébulosité, vitesse du vent et rayonnement solaire. La vitesse de l'écoulement utilisée dans le moule de transport est celle obtenue par le module hydraulique (couplage). Les sorties du module de transport est l'évolution spatiotemporelle de la température dans la rivière. Le modèle HEC-RAS est un modèle déterministe qui tient compte de plusieurs facteurs météorologiques et géophysiques, dont la disponibilité est parfois problématique. Il est alors préférable d'élaborer des modèles de température plus simples en utilisant un nombre minimum de variables d'entrée. Ainsi, la deuxième étape du travail consiste à appliquer la technologie de Machine Learning appliquée à la régression linéaire multiple pour prévoir les valeurs de la température de l'eau de la rivière à partir de seulement deux variables explicatives : la température de l'air et la vitesse du vent.L'algorithme de régression linéaire est un algorithme d'apprentissage supervisé, c'est-à-dire qu'à partir de la variable cible ou de la variable à expliquer (Y : température de la rivière), le modèle donne une prédiction de Y grâce à des variables dites explicatives ou prédictives (X : température de l'air, la vitesse du vent).

À partir d'un échantillon de population qui représente nos données, on répartit les données en deux groupes, les données d'entraînement et les données de test. La première catégorie de données servira pendant la phase d'apprentissage du modèle alors que la seconde sera utilisée pour évaluer la qualité de prédiction du modèle. Les indicateurs statistiques utilisés pour évaluer la performance du modèle Machine Learning sont : l'erreur quadratique moyenne (RMES), la fonction objective normalisée (NOF) et le coefficient de Nash-Sutcliffe (NSC). Nous avons obtenu un coefficient (RMSE) faible, une valeur de la fonction (NOF) inférieure à 1 et une valeur du coefficient (NSC) très proche de 1. Ceci confirme bien la performance du modèle utilisé.

Cette étude à permis d'estimer la température de l'eau de la rivière Sebou à partir de deux paramètres météorologiques seuls, la vitesse du vent et la température de l'air, en utilisant la technologie de Machine Learning appliquée à la régression linéaire multiple.

Mots clés : Machine Learning, Régression linéaire multiple, Température, Rivière.

CIRCULAR ECONOMY: OPPORTUNITIES AND CHALLENGES IN DEVELOPING COUNTRIES

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It is now well understood that a radical global shift to more sustainable growth and consumption patterns is required. Demands for raw materials and natural resources are increasing as the global population gets larger and richer. At the same time climate change means we need to use fewer resources and find cleaner means of production. In this context, interest in the idea of the circular economy (CE) is growing fast, most notably in the EU and China. But the model's potential for developing countries has so far been overlooked by policymakers and businesses.

An Inclusive Circular Economy: Priorities for Developing Countries, highlights how developing countries are already global centres of production and are also set to become the global drivers of consumption. Success now in embedding circular principles in industrial growth and infrastructural development strategies can help to ensure that the needs of growing and urbanising populations are met without risking rises in resource use, emissions and environmental pollution. For example, in adopting modular, adaptive and resilient design principles, the circular economy can help to deliver quality housing and infrastructure at low economic and environmental cost. The circular economy continues to be understood primarily as a waste management and recycling strategy by many, but the economic opportunities are far broader and more diverse. With the right enabling conditions, the circular economy could provide new opportunities for economic diversification, value-creation and skills development.

As CE policies in developing countries are rolled out, it will be crucial for policymakers and development actors to understand and address challenges specific to these economies. The challenges include varying degrees of institutional capacity to implement CE strategies, an often undeveloped and fragmented private sector, and an active informal economy beyond the reach of market interventions. Across most developing countries, a growing and urbanizing population will require significant investments in critical infrastructure, including housing stock, for which primary materials – including concrete – will be needed. Unlike in developed countries, there will not be an existing stock of materials available for reuse, and circular approaches to construction are unlikely to be viable in the near term. In developing economies that rely heavily on extractive industries, growth models predicated on circular value chains and secondary material use are likely to meet resistance from vested interests among public and private actors.

Developed-country governments have an important role to play in facilitating a meaningful dialogue on how the international dynamics of circular economy policies may best be managed. Support from international agencies such as the UN Industrial Development Organization (Unido) and the UN Environment Programme (UNEP) will be critical to facilitating the piloting of circular economy solutions among small and medium-sized enterprises (SMEs) in developing countries and along international value chains to demonstrate the viability of cross-border circular value chains at scale.

Keywords: Circular economy in developing countries, Benefits, challenges, Polices in developing countries, Role of developed countries.

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Wednesday 26 May 2021 (Morning session) https://us02web.zoom.us/webinar/register/WN_OZID9BjKT6uEw-W_x_S4ww	
10h00 – 10h30	**Official Opening Ceremony** **Welcome** by Prof. Laila MANDI, General Chair of WATMED9 Virtual International Conference Prof. My Lhassan Hbid, President of Cadi Ayyad University, Marrakech Prof. Moha Taourirte, Dean of Faculty of Sciences and Techniques, Marrakech Prof. Mohamed Elalaoui Talibi, Dean of Faculty of Sciences Semlalia, Marrakech Prof. Ahmed Chehbouni, President of Development Center of Tensift Region (CDRT)
10h30 – 12h30	**Opening Keynote 1** Pr. Andreas N. ANGELAKIS, Member of European Academy of Sciences & Art; Honorary Prof. of Hubei Univ., Wuhan, China and Distinguished Fellow of IWA (Greece) **Evolution of Water Reuse**
	Opening Keynote 2 Pr. Ahmed KETTAB, Founding Member of WATMED; Associate Professor at the University of Bouira; Research Director of the National Polytechnic School (Algiers) **Water for all in quality and quantity to guarantee sustainable development**
12h30 – 13h30	Lunch break and E-Poster session
Wednesday 26 May 2021 (Afternoon session)	
ORAL SESSION 1: Management of water resources ***Chairs:*** *Pr. Mohamed LOUDIKI & Pr. Faissal AZIZ*	
14h00– 14h30	**Keynote speaker** Dr.Ing. Jean-Louis OLIVER, Secretary General, Water Academy of France (France) **Eau et santé : défis d'aujourd'hui et de demain**
14h30– 14h45	ID 199: Standardized Precipitation Evapotranspiration Index based spatiotemporal analysis for drought monitoring in Morocco from 1979 to 2019 *S. Moutia, M. Sinan, F. Driouech, A. Sebbar, R. Ilmen*
14h45 – 15h00	ID 186: Apport de la modélisation des réseaux d'assainissement pour la gestion des crises d'inondations en milieu urbain. *A. Moutahir, E. Bartali, K. Sebari , D. Loudyi*
15h00 – 15h15	ID 175: Salinity impacts on water quality and benthic diatoms communities in the arid Draa river basin (South of Morocco) *K. Lazrak, E. Berger, K. Mouhri, M. Loudiki*
15h15– 15h30	ID 167: Water reallocation in the input–output framework: empirical application to Moroccan water uses *I. Samih, and D. Loudyi*
15h30– 15h45	ID 326: Tools for the economic evaluation of wastewater reclamation and reuse *A. Díaz, M. Salgot*
15h45 – 16h00	ID 327 : Contestabilité sociale basée sur le « coût-vérité de l'eau » : le cas d'étude des Associations d'Usagers de Réseaux d'Eau Potable (ASUREP) à Kinshasa, République Démocratique du Congo *H. D. Tsumbu, D. Cammaerts, I. Adant, F. L. Nzuzi, J-F. Deliège*
16h00 – 16h15	ID 321: The use of seaweeds and abiotic parameters for the biomonitoring of Moroccan coastal areas: case study of Safi city *M. Hasni, Y. Boundir, M. Cheggour, O. Cherifi, B. Yacoubi*
16h15 – 16h30	ID 316: Potential pharmacological and biological applications of two brown algae organic extracts: *Carpodesmia tamarisifolia* and *Bifurcaria bifurcata* *I. El Bouzidi, N. Bahammou, L. Mandi, O. Cherifi*

Thursday 27 May 2021 (Morning session) **https://us02web.zoom.us/webinar/register/WN_OYpOooNlRbubbU4bERoYWQ**	
ORAL SESSION 2: Water quality and pollution ***Chairs:*** *Pr. Naaila OUAZZANI & Dr. Abdessamed HEJJAJ*	
09h00 – 09h30	**Keynote speaker** Pr. Marie-Noëlle PONS, CNRS Research Professor, Lorraine University, Nancy (France) **Optical methods for water pollution characterization**
09h30 – 09h45	ID 156: Assessment of human exposure to dissolved uranium and radon in groundwater in coastal ABDA region of Morocco *B. Samyh, A. Nachab, A. Nourreddine*
09h45 – 10h00	ID 322: Effects of anthropogenic factors on groundwater ecosystem in Zagora region *A. Boudellah, R. EL Moustaine, A. El Gharmali, M. Boulanouar, Y. El Hachimi*
10h00 – 10h15	ID 320 : Etude Comparative de la Qualité des Eaux de Surface et des Eaux de Mer dans la Région de Safi *B. Mandri, H. Achtaq, F. Rafiq, H. El Khalil*
10h15 – 10h30	ID 337 : Modélisation du devenir des rejets de la STEP de Kenitra au niveau l'estuaire de la rivière Sebou *A. Touazit, Y. Nizar, M. Igouzal*
10h30 – 10h45	ID 191: Flood hazard assessment of mountainous watershed using the SWAT model: Case study of N'fis catchment Morocco *N. Joumar, D. Loudyi*
10h45 – 11h00	ID263: Ecotoxicological diagnosis and marine pollution of Essaouira Coast (Morocco): *Ellisolandia elongata* as bioindicator species of water quality *H. Sabri, A. Maarouf, H. Boularhbar, A. Hejjaj, Y. Boundir, N. Bahammou, L. Mandi, O. Cherifi*
11h00 – 11h15	Coffee break and E-Poster session
11h15 – 11h30	ID 230: Study of the fate of Microplastics in different wastewater treatment plants *Y. Belhaddad, M. Sadani, N. Ouazzani*
11h30 – 11h45	ID 298: Sustainable management of abandoned mining sites *L. T. Coulibaly, L. Midhat, A. Hejjaj, L. Mandi, and N. Ouazzani*
11h45 – 12h00	ID 245 : Elaboration de nouveaux photocatalyseurs Y3Al5O12:Ce3+@ZnO cœur/coquille actifs sous lumière du jour pour l'élimination des antibiotiques des eaux usées *L. Zammouri, R. Mahiou, M. Sarakha, M. Stitou*
12h00 – 12h15	ID 319: Elaboration of innovative ceramic microfiltration membrane for wastwater treatment from naturel Moroccan sand *M. Addich, N. El Baraka, N. Saffaj, A. Laknifli, A. Karim, K. Sbihi, A. El Hammadi*
12h15 – 12h30	ID 265: Assessment of some pollutants in water and in some macroalgae at Essaouira coast- Morocco *H. Sabri, A. Maarouf, A. Hejjaj, Y. Boundir, L. Mandi, O. Cherifi*
12h30 – 12h45	ID 165: Diatoms communities as bioindicators of soil quality irrigated by different water quality in Marrakesh area (Morocco) *F. Minaoui, Z. Hakkoum, M. Douma, K. Mouhri, M. Loudiki*
12h45 – 13h00	ID334 : Evaluation de la qualité des eaux de la nappe phréatique du Haouz après la mise en place de la STEP de Marrakech *M. Khimani, F. E. Titchou, R. Ait Akbour, M. Hamdani*
13h00 – 14h00	Lunch break and E-Poster session
Thursday 27 May 2021 (Afternoon session)	
ORAL SESSION 3: Water quality and pollution ***Chairs:*** *Pr. Ouafa CHERIFI & Pr. Brahim OUDRA*	
14h00– 14h15	ID216: Field survey of cyanotoxins in the framework of the European Project TOXICROP – preliminary results *A. Campos, M. Freitas, F. Oliveira, I. Silva, Z. Mohamed, B. Oudra, L. Mandi, C. A. Ranilla, V. H. V. Uro*
14h15– 14h30	ID 213: Data uptade of toxic cyanobacterial blooms survey in the Takerkoust lake reservoir-Morocco *R. Mugani, E.M. Redouane, R. P. Aba, M. Haida, N. B. De Fraissinette, F. El Khalloufi, A. Hejjaj, L. Mandi, A. Campos, V. Vasconcelos, B. Oudra*
14h30– 14h45	ID 205: Role of rhizosphere bacteria in the protection of Vicia faba and Triticum aestivum cultures against microcystins-LR exposure in bloom-contaminated water *E.M. Redouane, R. Mugani, M. Lahrouni, J. Carlos Martins, S. El Amrani Zerrifi, F. El Khalloufi, K. Oufdou, A. Campos, V. Vasconcelos, B. Oudra*
14h45– 15h00	ID 208: Effect of contaminated irrigation water by cyanotoxins (Microcystins) on growth and development of strawberry *Fragaria vulgaris* L

	M. Haida, F.El Khalloufi, R. Mugani, B. Oudra
15h00 – 15h15	ID234: Performance of multi-soil-layering (MSL) technology for the removal of microcystin-LR from surface water: preliminary results *R. P. Aba, R. Mugani, N. B. De Fraissinette, A. Hejjaj, A. Campos, V. Vasconcelos, B. Oudra, N. Ouazzani, L. Mandi*
15h15 – 15h30	ID329: Bacterial roles in the protection of crops against the harmful effects of cyanotoxins in irrigation water *R. Mugani, E.M. Redouane, R. P. Aba, S. E. Zerrifi, M. Haida, F. El Khalloufi, M. Lahrouni, A. Hejjaj, A. Faissal, L. Mandi, A. Campos, V. Vasconcelos, B. Oudra*
15h30 – 15h45	ID 177: Cyanotoxins in irrigation water: Potential factor of degradation of water quality and crops productivity *F. El Khalloufi, K. Oufdou, W. Achouak, B. Oudra*
15h45 – 16h00	ID 166: Impact of irrigation with treated wastewater on soil cyanobacteria in suburban area of Marrakesh *Z. Hakkoum, F. Minaoui, M. Douma, K. Mouhri, M. Loudiki*
16h00 – 16h15	ID 178: Potential of *Vicia faba* and *Opuntia ficus indica* extracts as natural coagulants to treat Microcystis aeruginosa waterblooms *W. El Bouaidi, S. Essalhi, Z. Tazart, M. Douma, A. Ounas, A. Yaacoubi, M. Loudiki*
16h15 – 16h30	ID209: Growth mitigation of the Bloom-Forming Cyanobacterium *Microcystis aeruginosa* by Moroccan herbs *L. Tebaa, M. Douma, Z. Tazart, K. Mouhri, M. Loudiki*
Friday 28 May 2021 (Morning session) **https://us02web.zoom.us/webinar/register/WN_tfW0YciT7eSMB09eaZLSw**	
ORAL SESSION 4: Non-conventional water resources reclamation, recycling and reuse ***Chairs:*** *Pr. Azzeddine SEDKI & Pr. Lhoucine GEBRATI*	
09h00 – 09h30	**Keynote speaker** Prof. Helmy T. El-Zanfaly, Professor Emeritus of Water and Wastes Microbiology, Water Pollution Research Dept.,National Research Center, Cairo (Egypt) **Maximization the Benefits of Wastewater Reuse for Agriculture as a solution to water and Food Security**
09h30 – 09h45	ID 314: Treatment of olive mill wastewater by infiltration-percolation through filter bed *S. Bakri Alaoui, E. Lamy, M. Achak*
09h45 – 10h00	ID 202: Feasibility of a pilot scale vertical flow constructed wetland for the treatment of olive mill wastewater *A. El Ghadraoui, A. Ahmali, T. E. El Mansour, F. Aziz, A. Hejjaj, M. Del Bubba, N. Ouazzani, L. Mandi*
10h00 – 10h15	ID 232: Comparison of two aerobic processes for Olive Mill Wastewater treatment: Activated sludge and Membrane bioreactor *Y. Jaouad, M. Villain-Gambier, L. Mandi, B. Marrot, N. Ouazzani*
10h15 – 10h30	ID 229: Recovery and valorization strategies of polyphenols from olive mill wastewater *C. Saf, M. Villain-Gambier, M. Belaqziz, L. Gondet, L. Mandi, D. Trebouet, N. Ouazzani*
10h30 – 10h45	ID301: Transformation of the leachate from the landfill to compost using phosphate washing sludge and green waste *M. Mobaligh, O. S. Hassani, S. Rida, A. Meddich, B. Imziln, K. Fares*
10h45 – 11h00	ID315: Study on the effectiveness of a green coagulant in dyes and turbidity removal from synthetic Wastewater *J. El Gaayda, R. Ait Akbour, F-E Titchou, H. Afanga, H. Zazou, M. Hamdani*
11h00 – 11h15	Coffee break and E-Poster session
11h15 – 11h30	ID343 :Adsorption of chromium from highly concentrated tannery wastewater with novel porous composite beads: Central composite design optimization study *A. Lissaneddine, F. Aziz, M. El Achaby, N. Ouazzani, L. Mandi*
11h30– 11h45	ID 222: Multiple linear regression and cubist algorithm for predicting nitrogen removal from domestic wastewater using Multi-Soil-Layering system *S. Sbahi, A. Hejjaj, N. Ouazzani, L. Mandi*
11h45 – 12h00	ID 268: Performance evaluation of wastewater stabilization ponds under arid climate *A. Krimech, O. Cherifi, A. Hejjaj, N. Ouazzani, B. Oudra, M. Kerner, L. Mandi*
12h00 – 12h15	ID 270 : Etude des performances épuratoires de la station de traitement des eaux usées domestiques par filtre imbriqué hybride sous climat aride *K. Zidan, A. Hejjaj, Y. Ait Ichou, N. Ouazzani, L. Mandi*

12h15 – 12h30	ID 237: Effects of short-term irrigation with secondary treated wastewater on soil properties and Koroneiki olive trees (*Olea europaea* L.) *A. Ahmali, A. El Ghadraoui, T. E. El Mansour, T. El Moussaoui, F. Aziz, A. Hejjaj, K. Loutfi, L. Mandi, N. Ouazzani*
12h30 – 15h00	Lunch break and E-Poster session
Friday 28 May 2021 (Afternoon session)	
ORAL SESSION 5: Non-conventional water resources reclamation, recycling and reuse ***Chairs:****Pr. Brahim Benhamou & Pr. Lahcen BOUKHATEM*	
15h00– 15h15	ID 325: Tendencies on reclaimed water use for potable purposes *P. Sepúlveda-Ruiz, M. Folch, M. Salgot*
15h15– 15h30	ID155: Circular Economy: Health Impacts in Developing Countries *H. T. El-Zanfaly*
15h30– 15h45	ID 242: Thermal Performance of a Combined Solar Dryer of Sewage Sludge *F. Berroug, E.K. Lakhal, N. Ouazzani, L. Mandi*
15h45– 16h00	ID235: Study of convective drying and determination of thermal diffusion coefficients of sewage sludge from the WWTP of Oujda city *E. Bougayr, E. Lakhal, A. Idlimam, A.FANTASSE, A. Lamharrar, M. Kouhila, N. Abdenouri, F. Berroug*
16h00– 16h15	ID 345: Evaluation of the long-term CND potential of Waste Rock piles at the Abandoned Zn - Pb Erdouz mine (Occidental High Atlas, Morocco) *A. Goumih, M. El Adnani, R. Hakkou, M. Benzaazoua, S. Ouhamdouch, A. Boumehdi, N. Youbi*
16h15 – 16h30	ID272: Microalgae cultivation in treated wastewater by Multi-Soil-Layering system under extreme conditions *A. Krimech, L. Mandi, A. Hejjaj, B. Oudra, N. Ouazzani, M. Kerner, O. Cherifi*
16h30 – 17h00	Coffee break and E-Poster session
17h00 – 18h00	**AWARDS AND CONFERENCE CLOSING CEREMONIES**

Posters

ID 200: Spatial modeling of water management in Tadla irrigated agriculture, Morocco.
M. Idrissi, H. Lionboui, A. Hasib, T. Benabdelouahab, A. Boulli

ID 201 : La gestion intégrée des eaux urbaines du grand Marrakech : nouvelle approche d'adaptation au changement climatique.
F. Hajoui, K. Sebari, M. El Khaoua, Z. Filali

ID 317: Postharvest control of Tomato using aqueous and organic extracts of the green seaweed *Ulva lactuca*.
I. El Bouzidi, N. Bahammou, L. Mandi, O. Cherifi

ID 330: Seasonal monitoring of the appearance of toxic cyanobacterial blooms in a freshwater dam: a case of the Lalla Takerkoust dam.
R. Mugani, E.M. Redouane, R. Prisca aba, S. El Amrani Zerrifi, M. Haida, F. El khalloufi, M. Lahrouni, A. Hejjaj, A. Faissal, L. Mandi, A. Campos, V. Vasconcelos, B. Oudra

ID 158: Evaluation of water quality in shallow lakes using multivariate statistical techniques: Case study on Boudaroua lake (Ouazzane, Morocco).
H. En-nkhili, M. Igouzal, I. Etebaai, D. Belghyti

ID 144: Pollution Aspects of Springs Water in Natuf Catchment -Ramallah area.
A. Atta, M. Ghanem

ID 224: Effects of anthropogenic factors on groundwater ecosystem in Zagoura region.
A. Boudellah, Y. El Hachimi, A. El Gharmali, M.Boulanouar

ID 243: Modélisation de l'Impact des Rejets des Stations d'Epuration sur le milieu Récepteur.
A. Bouriqi, E. Everbecq, P. Magermans, R. Benaddi, N. Ouazzani, J.F. Deliege

ID 252: First study of the ecological status of Safi Atlantic coast using the macroalgae as bioindicators.
M. Hasni, Y. Boundir, M. Cheggour, O. Cherifi, B. Yacoubi

ID 260: Determination of methylene blue decolorization rate for the assessment of bacterial viability in tretaed water.
M. Ben said, M. Ben saad, L. Bousselmi, A. Ghrabi

ID 267: The effect of supplementary phosphorus fertilization on Melon yeild and fruit quality under saline conditions
S. Attaoui, K. Azim, M. Fallah, R. Choukr-allah

ID 180 : Evolution de la charge polluante au niveau d'un traitement biologique avec filtration membranaire - Cas de la STEP de Médiouna au MAROC.
M. Boutadghart, J. Alibou, L. Asmlal

ID 313: Role of rhizosphere microbiome in the protection of *Vicia faba* and *Triticum aestivum* cultures against microcystins exposure in bloom-contaminated water and health risk assessment.
E.M. Redouane, R. Mugani, M. Lahrouni , J. C. Martins, S. El Amrani Zerrifi , F. El Khalloufi , K. Oufdou , A.Campos, V. Vasconcelos, B. Oudra

ID 341: Synthesis and toxicity of graphene oxide in mice
A. Rhazouani,H. Gamrani, L. Gebrati, Md.S. Uddin, F. Aziz

ID 271: Influence of treated urban wastewater by stabilization ponds reuse on crop response and soil properties.
A. Ahmali, A. El Ghadraoui, T. Elhakim El Mansour, T. El Moussaoui, F. Aziz, A. Hejjaj, K. Loutfi, L. Mandi,N. Ouazzani

ID 344 : Continuously operated pomace olive packed bed for olive mill wastewater treatment and phenol recovery
I. Haydari, L. Mandi, A. Lissaneddine, N. Ouazzani, F. Aziz

ID 342 : Utilisation de l'intelligence artificielle pour l'estimation de la température de la rivière Sebou
Y. Nizar, M. Igouzal

ID 154: Circular Economy: Opportunities and Challenges in Developing Countries.
H. T.El Zanfaly

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