

Water Perspectives in Emerging Countries

Water in Agricultural Practices: Training the Trainers

Jose Araruna Jr., Aluisio Granato, Julia Stuchi, Rodolfo Silva (Eds.)

September 15-21, 2019 - Rio de Janeiro, Brazil



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Water use in agriculture plays a critical role in any discussion of water and food security, since farming activities account for around 70% of water used in the world today. Inefficient agriculture contributes to a great pollution of surface water and also to groundwater depletion with its associated consequences. Also excessive use of nutrients and pesticides are key sources of water pollution in many regions. On the one hand, sustainable management of water in agriculture is critical not only to increase agricultural production, but also to support continued economic growth in other sectors. On the other hand, agriculture faces increasing water challenges, ranging from climate change, increasing water competition from other sectors, and gradual water quality deteriorations.

The objective of this book is to serve as a forum to discuss advance solutions to improve the management of agricultural water risks in developing countries.

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Issue Editors

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CONTENT

Preface	1
Erosion control in agricultural production systems in Brazil <i>(A.G. de Andrade, J.F. Stuchi)</i>	2
Water erosion in Morocco <i>(A. Dahchour, S. El Hajjaji)</i>	17
Hydrogeochemical nitrogenous behaviour in an Andean agricultural basin <i>(A. Berbesí-Jaimes, M. Casamitjana-Causa, J.C. Loaiza-Usuga, S. Cardona-Gallo, G.A. Correa-Londoño)</i>	27
Monthly and seasonally crop water stresses distributions over the Nile Delta using remote sensing techniques <i>(A. Elnmer)</i>	41
DPSIR Framework assessment of land degradation by water erosion in Kenya: A review <i>(E. Kipkirui)</i>	54
Morphodynamical changes in Magdalena River delta (Colombia) and its influence on riverine populations <i>(F.J. Gomez, R.R. Gutierrez, J. Biswell, R. Doria, G. Rivillas-Ospina)</i>	63
The use of humic substances to reduce soil erodibility <i>(G. Portillo, J. Araruna, E. Brocchi)</i>	78
Potentiality of radical terracing, a prevalent water erosion control strategy in Rwanda <i>(I.J.P. Bavumiragira)</i>	88
Soil and water losses in an Acrisol under natural rainfall in different management systems at South of Brazil <i>(L.d.S.C. Lima, C.A.P. de Barros, E.A. Cassol, L. Dambros)</i>	101
Identifying surface runoff using NRCS-CN model at the arid region Nile Delta - Egypt <i>(M. Abu-hashim, E. Mohamed, A. Belal)</i>	115
Fish feed composition and animal manure application as factors in the impairment of aquaculture pond water quality - a pilot study <i>(A.O. Adekanmbi)</i>	127
Hydroponic as one of water conservation techniques in Jordan context <i>(A. Alulayyan)</i>	133
Removal study of a contaminant of emerging concern, hydroquinone from wastewater by adsorption process on activated carbon <i>(D. Houndedjhou, E. Vunain, T. Kodom)</i>	141

A study on farmers' perception of impacts of farm wastes on soil and water quality: A case study of Oyo State, Nigeria (<i>I.O. Kunlere, P.A. Ogar, A.S. Kunlere, A.A. Mumuni</i>)	158
Effects of Paracetamol on seed germination and root elongation of <i>Lycopersicon esculentum</i> and <i>Lactuca sativa</i> (<i>J.W.F. Ferreira, J.C.M. Nascimento, J.L. Costa, D.C. Napoleão, K.K. Barros</i>)	176
Assessment of a wastewater treatment plant performance and suitability of treated water for irrigation purpose in Adjouba area: Case of the brewery BB Lome (<i>L. Tampo, A.R. Bouari, G. Boguido, N. Gnofam, M. Ayah, L.M. Bawa, G. Djaneye-Boundjou</i>)	188
Production of forage cactus fertilized and irrigated with reuse water in the Sertão of Crateús, Brazil (<i>M.R.G.F. Costa, J.B.d.O. Neto, J.L.V. Neto, G.D. Freitas</i>)	205
Evaluation of fly ash pellets for phosphorus removal in a laboratory scale denitrifying bioreactor (<i>S. Li, X. Huang, J. Liu, L. Lu, K. Peng, R. Bhattarai</i>)	212
Wastewater reuse in irrigated agriculture (<i>S. El Hajjaji, J. Mabrouki, C. Bakkouche, A. Dahchour</i>)	223
Characterization of effluents from fecal sludge treatment plant in Cameroon and assessment of their potential use for agricultural irrigation (<i>L.S.T. Tchianzeu, W.A.L. Nzouebet, C. Wanda, V.G.D. Wafo, E.S. Kengne, G. Liégui, J.P. Noutadié, A.P. Agendia, W.K. Arnold, I.M.K. Noumsi</i>)	236
Implementation of treated wastewater and bio-solids generated from WWTP on the plantation of fodder at marginal areas at Al-Karak, South Jordan (<i>T. El-Hasan, H. Hamaidah, S. Al-Jbour, N.B. Hani, F. Ismail, Y. Shakhathreh, D. Al Majali</i>)	244
Engaging, enabling and empowering Bangladeshi youth on climate change projects through facebook usage to ensure sustainable development (<i>Md.A. Razzak, Md.S. Islam, J. Jiang</i>)	255
Impacts of water crises on agriculture sector and governance challenges in Pakistan (<i>M. Mumtaz, J.A. Puppim de Oliveira</i>)	268
Ecosystem services of a seasonally dry tropical forest in semi-arid region of Brazil (<i>R. Souza, B.R. Reverter, J.R.d.S. Lima, A. Coutinho, A.C.D. Antonino, E.S. de Souza</i>)	280

PREFACE

The International Workshop on “Water on Agricultural Practice”, held in Rio de Janeiro, Brazil on September 16-20, 2019 involved 30 participants from 14 different countries that made the event very broad in participation and expertise. Their findings on water-related issues dealing with sustainable agricultural practices covering erosion control and monitoring, use of reclaimed wastewater for irrigation, and environmental services and education are set in chapters grouped around these 3 themes.

This proceedings document is an outcome of the EXCEED SWINDON Project termed “International Network on Sustainable Water Management in Developing Countries”. This initiative is a venture for capacity building through higher education and joint research based on a network of 35 partners from Latin America, Middle East, South East Asia, and Sub-Saharan Africa, coordinated by the Technical University of Braunschweig. This project is carried out within the framework of the DAAD Program “Excellence Centers for Exchange and Development”.

Professor Dr. Ali Müfit Bahadır reviewed all papers submitted to the workshop in terms of their scientific content and also made the final publishing review. As the issue co-editor of this proceedings book, I cordially acknowledge his invaluable contribution while publishing this book.

I believe that the wide range of global interests on sustainable agricultural practices combining with the issue of this proceedings book should contribute to attaining the Millennium Goals set by the United Nations.

Dr. José Araruna, co-editor
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EROSION CONTROL IN AGRICULTURAL PRODUCTION SYSTEMS IN BRAZIL

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Keywords: Public policies, Soil restoration, Sustainable practices, Water conservation

Abstract

With the increase in demand for agricultural and forestry products, the pressure on soil and water resources intensifies, leading to extreme food, nutritional and socioeconomic insecurity in the world. This paper aims to present the political and technological strategies to control erosion in agricultural production systems in Brazil presented during the Workshop - *Water on Agriculture: Training the Trainers*. Erosion has been causing economic damage and degradation in different regions of the country, mainly over sandy soils and areas used since the first agricultural cycles in the 16th century. The largest land use is occupied by pasture with different levels of degradation. Radical changes in soil management and throughout the production system are required to control erosion and to prevent soil and water degradation. The continental expression of Brazil, housing six biomes with different types of vegetation, relief, soils and climate, in addition to the contrasting socio-economic and cultural aspects, requires that the construction of a national policy for sustainable soil and water development should include adaptations considering territoriality and regional specificities. It is necessary as well to develop information on the potentialities and limitations of soil for agricultural production. A strategy to start solving these problems is being initiated through the National Soil Mapping Program (PRONASOLOS) with detailed information on the country's soils over the next three decades at the most appropriate scales in order to plan agricultural production in a sustainable manner and to prevent water and soil degradation. Zero tillage systems and agroecological production systems can also be considered as examples for erosion control. To further reduce soil and water losses due to erosion in Brazil, it is necessary to expand the use of more sustainable agricultural production systems considering the different limitations and potentialities of the soil and the socioeconomic and cultural conditions of the country.

WATER EROSION IN MOROCCO

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Keywords: water, aeolian, erosion, soil, Rif Mountains, Morocco

Abstract

Erosion phenomena could be due to natural phenomena such as heavy rainfall, wind, climate change, or results of human activities. Erosion by water is the dominant process in 55% of the affected area estimated to be between 11.4 and 32.5 million km² worldwide. They are non-renewable on a short time scale and very expensive to reclaim. The specific environmental conditions prevailing in Mediterranean Region are in favor of erosion because of low annual precipitation, high evapotranspiration, intense rainstorms, drought occurrence and steep slopes. Wind erosion is a common cause of land degradation in the arid and semi-arid grazing lands. Soil erosion could also be subsequent to chemical and physical processes occurring in the soil. In Morocco, soil erosion leads to a decline in reservoir capacity of dams by 0.5% per year. The impact of erosion varies according to climate zone and it impacts mainly mountains of Rif, where the degradation exceeds 2000 t/km².yr. Various studies have been conducted to assess the current and future soil erosion risk in vulnerable zones using different models integrating environmental parameters and soil properties. Others have focused on human activities and their role in the erosion of soil. Little has been dedicated to erosion by wind and coastal erosion, which was the main goal of this study.

HYDROGEOCHEMICAL NITROGENOUS BEHAVIOUR IN AN ANDEAN AGRICULTURAL BASIN

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Keywords: Agricultural basin, andisol, hydrological nitrogenous balance, water dynamics

Abstract

Water dynamics in watersheds are related to the interaction and variability of soil moisture, vegetation, temperature, and precipitation, among other factors. Changes of those elements can be used as control tools to simulate hydrological process and proposals intended for ecosystems conservation. Soil is the key component of these systems especially in reference to mountain wetlands behavior, where most processes associated with water levels are regulated. Anthropogenic activities can alter the constant interaction of these elements and generate physical, chemical and biological imbalances. Agricultural and livestock activities have the greatest influence on the ecosystem alteration. The most important factor associated with these activities is nitrate, polluting ground water and surface water reserves. In Colombia, the use of ammonium nitrogen has been increasing during last years but is not as abundant as in European or North American countries. This research had as results that water regimes mostly constrains soil moisture in forest soil use due to factors such as interception; crop and grazing soil uses have high water retention. Environments and polluting nitrate loads do not become significant to the risk to human health at concentrations less than 50 mg/L NO₃⁻. High levels of soil moisture, high rainfall, infiltration ranging from 70 to 90% of total precipitation and low runoff (less than 1%), acidity and high redox potential (typical properties of soils derived from volcanic ashes such as andisols) condition the environments of mobility systems of these pollutants give high resilience to these ecosystems.

MONTHLY AND SEASONALLY CROP WATER STRESSES DISTRIBUTIONS OVER THE NILE DELTA USING REMOTE SENSING TECHNIQUES

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Keywords: Crop water stress, Nile delta, remote sensing, water deficit index, water stress index

Abstract

Determination of water stress and oversupply locations at a regional scale could significantly influence the water management. Recently, remote sensing techniques become an efficient tool to provide water and land surface data at a regional scale. This research aims to evaluate the monthly and seasonally water stress index (WSI) for the center portion of the Nile Delta, Egypt using remote sensing techniques. These techniques were the Simplified Surface Energy Balance algorithm (SSEB algorithm) with Landsat 8 images to estimate the actual evapotranspiration. Additionally, the Split Windows algorithm with Landsat 8 images was used to estimate the spatial distribution of the land surface temperature (Ts). The WSI algorithm was applied to the center of the Nile Delta during the summer season 2016 to assess the crop water stress and the oversupply locations using the Ts spatial distribution. Moreover, it was validated using ground data about the actual crop water stress based on the actual and wet evapotranspiration. The monthly WSI during the crops growing season was poor, where about 40% of the total irrigated area suffered from crop water stresses. However, during the beginning and harvesting seasons 2016, about 18% of the total irrigated area suffered from extreme crop water stresses. The seasonal WSI for the center of the Nile Delta was poor, about half of the total cultivated area suffered from extreme crop water stresses in summer 2016. The crop water stress at a temporal scale indicates the urgent need to efficiently distribute the water supplies in order to ensure the water security for the center of the Nile Delta.

DPSIR FRAMEWORK ASSESSMENT OF LAND DEGRADATION BY WATER EROSION IN KENYA: A REVIEW

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Keywords: Land degradation, water erosion, DPSIR, sustainable land management

Abstract

Water erosion is a leading environmental threat to the sustainability and productive capacity of agriculture in many tropical and sub-tropical regions of the world. Soil erosion by water is by greater margin the most common type of soil degradation, affects approximately 1,100 million ha worldwide. The aim of this paper is to highlight the causes and state as well as effects of land degradation in Kenya through the DPSIR model framework for land degradation analysis. The general pressure and driving factors attributed to the land degradation are varied depending on the climate, human activities and vulnerability of the soil to these effects. Rainfall erosion potential and soil erodibility in most regions in Kenya present an environment, which is very susceptible to soil erosion. The dynamic change towards intensive agriculture has removed much of the protective land cover vegetation cover and led to the need for the introduction of soil and water conservation measures in order to reduce soil erosion to acceptable rates.

MORPHODYNAMICAL CHANGES IN MAGDALENA RIVER DELTA (COLOMBIA) AND ITS INFLUENCE IN RIVERINE POPULATIONS

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Keywords: River dynamics, Affection, Erosion, Sedimentation, Social Fabric

Abstract

The Magdalena River is the largest river in Colombia. It plays an important role in the circulation of goods and services for most of the country. And in the region, where its mouth is located (department of Atlántico and Magdalena), it is vital for sustaining agricultural activities for formal landowners and precarious ones, namely those, who settle on riparian strips and represent the most vulnerable socio-economic portion of the population. Thus, fluvial erosion and sedimentation processes induced by both natural and anthropogenic controls severely impact on the latter group. This research focuses on describing the interrelationship between the river dynamics and the precarious landowners for the lowest 34 km stretch of the Magdalena River. To this end, the river migration was quantified, based on freely accessible satellite observations between 1986 and 2019 and field hydrological, economic and social information provided by Colombian public agencies. The results show that in the study stretch, the river exhibits sedimentation rates ranging 12-20 m/yr and erosion rates up to 65 m/yr with total losses of 630 ha land dedicated to agricultural activities. The fluvial dynamics directly affect the inhabitants that live on the banks, reducing the areas of cultivation and the economic income. This generates an irruption in the social fabric and migration of farmers, who must look for other economic activities for their subsistence. It is an institutional need on the part of the government to improve regional policies for the protection of farmers in the area and to ensure economic productivity, taking into account the risk generated by the river's dynamic processes.

THE USE OF HUMIC SUBSTANCES TO REDUCE SOIL ERODIBILITY

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Keywords: Humic substances, erosion, erodibility, restoration, soil conditioners

Abstract

The research evaluates the efficiency of incorporating HS (Humic Substances) into a material to reduce the material's erodibility. Erodibility (i.e., the susceptibility to erosion) depends on a series of parameters, including particle-size distribution, mineralogical composition, presence of organic matter, and moisture content. The HS was synthesized from the waste of mineral coal from the company "Copelmi Mineracao" in the state of Santa Catarina, and is expected to minimize erosion caused by agricultural practices. The characteristics of the soil in Santo Antônio de Padua and the HS used for erosion control were evaluated by performing laboratory tests to determine the erodibility of soil samples with added HS to reach a content of 3% HS by weight, and comparing these to soil samples with no HS added. The soil mineralogy and the cation exchange capacity (CEC) of the samples were analyzed to interpret the results. To analyze the effect of contact time of the HS with the soil, samples were stored for 2 months or 1 year to preserve the moisture content and specific weight of the samples throughout the storage time. HS addition was shown to increase cation exchange capacity and to interact with clay minerals presented in the soil. Therefore, these characteristics contribute to the stability of aggregates and reduce soil erodibility.

POTENTIALITY OF RADICAL TERRACING, A PREVALENT WATER EROSION CONTROL STRATEGY IN RWANDA

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Keywords: Erosion control, land degradation, radical terrace, Rwanda, steep slope

Abstract

Water use in agriculture is at the core of any discussion of water and food security. It accounts for 70% of water withdrawal globally. Agriculture is the main economic activity for the people of Rwanda, providing employment to about 86% of the total population. The country's topography has been the main cause of land degradation due to severe soil erosion, which recently reflected to poverty and food insecurity. The objective of this study was to highlight the main reason of the potential applicability of radical terracing as the best soil water conservation method in Rwanda's highly steep slopes, population perception in adopting the technology and recommending a way of improvement. Recent nationwide researches conducted about radical terracing implementation and its effectiveness revealed that radical terracing is an environmentally friendly, economical, profitable and effective method, which often increases farm's productivity. Farmers perceive that it is undoubtable solution, although it is labor intensive and hard to adopt, it increases yields when properly planned, maintained and combined with other erosion control methods such as the application of manure, compost or mineral fertilizers. This would be improved, when governmental and NGOs incentives continue and strengthen community-based mobilization to work together in associations or cooperatives to fully adopt the technology, because no farmer working alone can afford its cost.

SOIL AND WATER LOSSES IN AN ACRISOL UNDER NATURAL RAINFALL IN DIFFERENT MANAGEMENT SYSTEMS AT SOUTH OF BRAZIL

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Keywords: Soil loss, water loss, soil and water conservation, bounded plots, field measurements

Abstract

Among the distinctive types of soil degradation processes, water erosion is the most worrisome one, especially in humid climate regions, as it causes the soil to detach and to be transported more easily. Field studies in erosion are scarce in Brazil, mainly due to the costs and time of experimentation involved to gain representative data. About 50% of the experimental studies have 2 years or less of monitored data. It is important to prolong the monitoring period of the experimental sites in Brazil in order to reduce the variability of the observed data, to allow the development of models and to support the decision makers. Data from 1978 to 1983 from Santa Maria, at southern Brazil, were analyzed, thus, a 5 years series. This study aims to evaluate soil and water losses in an Acrisol under natural rainfall in different management systems at south of Brazil. Soil and water losses were higher in conventional tillage than in non-tillage management systems for this 5 years series. Also, for the non-tillage treatments, lupine and corn were more efficient in controlling soil and water losses than oat and soybean crop succession. Water losses are better explained than soil losses, when correlated with EI_{30} and rainfall during summer and winter periods.

IDENTIFYING SURFACE RUNOFF USING NRCS-CN MODEL AT THE ARID REGION NILE DELTA - EGYPT

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Keywords: Soil Types, Surface Runoff, Curve Number, Hydrological Hazard, Forecasting

Abstract

Evaluation of surface runoff is an essential factor in the precision water and soil conservation management through their main extreme impacts on soil properties. Twenty eight soil profiles are prepared in Nile Delta, Egypt to cover different geomorphic units and hydrological soil groups in the study area. The Natural Resource Conservation Service - Curve Number model (NRCS-CN) is used to estimate the magnitude of runoff. Collected topographic data are used to explain the effects of slope variation on water retention and surface runoff. The results revealed that the highest values of surface runoff were distinguished close to the urban area and ranged between 40-50 mm. In urban areas, the surfaces are paved, and there is no infiltration of water. Consequently, the runoff water directly flow to the storm channels. Runoff values ranging between 30-40 mm occurred at north of the study area. The sloping surface and the nature of the clay soil contributed to generate more runoff than do the lowland areas. The study presented and tested the hydric runoff estimation based-model on the integration of hydric balance parameters. The GIS tools analyze and compose these parameters to perform an indirect method for the quantity of water that results from direct surface runoff flow. This method helps to gain a clear imaging of the surface runoff risks on the study area.

FISH FEED COMPOSITION AND ANIMAL MANURE APPLICATION AS FACTORS IN THE IMPAIRMENT OF AQUACULTURE POND WATER QUALITY - A PILOT STUDY

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Keywords: Aquaculture ponds, fish feed composition, animal manure application, physicochemical parameters, metal composition

Abstract

The role of aquaculture in food security, especially the provision of a cheap and affordable source of protein, cannot be completely overlooked. However, in an attempt to boost fish production and to enhance output, so many unwholesome practices such as the use of animal manure as fertilizers are being practiced. This exposes the environment especially water bodies to potential pollutants and pathogens upon discharge of this nutrient and bacterial laden water from fishing operations. This study aimed at determining the physicochemical and bacteriological qualities of water from selected aquaculture ponds in comparison with the water sources used for their operations. Water samples from selected aquaculture ponds were collected in pre-cleaned sample containers, labeled appropriately and transported from the site of collection to the microbiology laboratory on ice chest. Physicochemical and metal analyses of the samples were conducted using standard methods and atomic absorption spectrophotometry (AAS) respectively, while bacteriological analyses were carried out using the pour plate technique on MacConkey agar. The metal analyses showed that the concentrations of copper, zinc, lead, nickel and chromium were highest in the ponds with manure application and lowest in the reservoir ponds. Of the total coliforms obtained, 62.6% were isolated from the manure-applied ponds, while 28.3% and 9.1%, respectively, were isolated from the ponds without manure application and the reservoir ponds. The physicochemical parameters showed that all the parameters including pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Electrical Conductivity (EC), Salinity, Nitrate, Phosphate were higher in the ponds with animal manure application than in the ponds without manure application and the reservoir ponds. The only exception was the Hardness, which was highest the ponds without manure application (59.4 mg/L), with the ponds with manure application having 41.0 mg/L and the reservoir ponds with 56.4 mg/L. The study confirmed the negative impacts the application of animal manure in aquaculture ponds on the physicochemical and bacteriological qualities of water used in aquaculture ponds. Though further studies are going on in this area of research, there is a need for regulations regarding the use of animal wastes in production process in the interest of the environment and the final consumers. There is a need to put an effective treatment option in place for water generated from aquaculture to prevent the introduction of potentially pathogenic bacteria into receiving water bodies.

HYDROPONIC AS ONE OF WATER CONSERVATION TECHNIQUES JORDAN CONTEXT

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Keywords: Agriculture, Hydroponic, Water efficiency

Abstract

Jordan is a Mediterranean country that depends mostly on rain as its main water resource. Recent years have witnessed shortage in the rainfall in different parts of the country. As a result, numerous streams have dried out, underground water level has fallen to critical levels, and most water aquifers are experiencing high salinity as a result of over abstraction, which makes them unsuitable for domestic or irrigation uses. In addition, extreme weather conditions such as flash floods during winter and heat waves during summer are becoming more frequent in the region. These conditions are direct consequences of global climate change that has recently been affecting several locations around the world, which are dramatically impacting wide ranges of ecosystems. The climate change reflected on people's lives in Jordan, especially of people, who live in the rural areas that depend on rain-fed agriculture to make their livings. In addition, Jordan suffers from lack of rain fed cultivatable soil, where more than 80% of the country's land is desert (less than 200 mm rainfall) with a very harsh environment. The soil in these areas suffers from lack of plant nutrients, and cultivation in such environment requires a huge investment in fertilization and soil amending. Lack of sustainable water resources and deterioration of soil affect the agricultural production adversely. The quality of products is highly affected by water shortage, lack of nutrients and soil-borne diseases; consequently, the profitability of the agricultural sector has decreased significantly. Soilless culture and especially the hydroponic emerge as a technical solution to mitigate the consequences of water crisis and the unsuitability of soil for cultivation. Many projects are being implemented in Jordan to provide an evidence-based solution on the effectiveness of hydroponic as one of the adaptation technology to climate change impacts on water availability. The results of these projects are very promising in terms of water conservation, product quality and the environmental impacts and will be presented in this paper.

REMOVAL STUDY OF A CONTAMINANT OF EMERGING CONCERN, HYDROQUINONE FROM WASTEWATER BY ADSORPTION PROCESS ON ACTIVATED CARBON

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Keywords: Activated carbon, Hydroquinone, Sunflower seed hull, Synthetic wastewater

Abstract

The removal of a contaminant of emerging concern (CEC), hydroquinone in aqueous solution has been studied using activated carbon prepared from agricultural waste. Activated carbon from sunflower seed hull has been used in this study. This activated carbon has a high volume of wide micropores and presence of small mesopores, high carbon yield, high surface area, and a large pore volume. Physicochemical activation at two ratios (1:1.5 and 1:2) has been performed using zinc chloride ($ZnCl_2$) as activating agent. FTIR, SEM-EDS, XRD and BET analyses have been performed for the characterization of the synthesized adsorbent. Batch experiments were performed to study the removal of target pollutant by adsorption process. Hydroquinone concentrations in synthetic wastewater were monitored by a High-Performance Liquid Chromatography (HPLC) system equipped with a phenyl Xbridge column and Photodiode Array (PDA) detector. The results show a maximum adsorption rate of 250 mg/g hydroquinone on activated charcoal. The equilibrium has been reached at 120 min. Langmuir isotherm and second order kinetic fit well the removal of hydroquinone by adsorption on this adsorbent, while the thermodynamic calculation show that the adsorption is endothermic. Some parameters such as initial hydroquinone concentration, contact time, solution temperature and adsorbent amount that influence the adsorption of hydroquinone in aqueous media have been studied in order to find the best conditions for an optimal removal.

A STUDY ON FARMERS' PERCEPTION OF IMPACTS OF FARM WASTES ON SOIL AND WATER QUALITY: A CASE STUDY OF OYO STATE, NIGERIA

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Keywords: Farm wastes, environmental impacts, perception, soil quality, water quality

Abstract

For many years before the discovery of oil in commercial quantity in Nigeria, agriculture was the mainstay of Nigeria's economy. Although agriculture was displaced as Nigeria's major income earner following years of concentration on the oil industry, it continues to provide food, jobs and livelihoods for millions of Nigerians. However, every year, farms in Nigeria produce millions of tons of wastes. Every point along the food supplies chain (pre-planting, planting, harvesting, and post-harvest operations, and acquisition by the final consumer) produces one form of waste or the other. Meanwhile, sustainable waste management remains a challenge in many developing countries, including Nigeria. In Nigeria, over 50% of wastes end up indiscriminately in the environment, resulting in water, air and soil pollution. As Nigeria continues to experience increase in population growth and agricultural activities, the accompanying increase in volume of farm wastes, which are large caches of untapped biomass resources, has been linked to incessant cases of pollution that threat food security, environmental sustainability and national development. Despite the threats that farm wastes pose, little is known about how aware of these critical issues, Nigerian farmers whose farms produce these enormous wastes, are. A qualitative approach was employed for the study, which saw fifteen farmers engaged in a semi-structured interview format. Data obtained from the interviews were interpreted using thematic analysis. The study showed low knowledge and poor perception of respondents on farm wastes and their impacts. One of the three farms in the study exclusively either burned its wastes or allowed them decay over time on the field and has had no contacts with municipal waste management authorities since its inception. The study concludes by recommending intense and sustained public awareness, targeted capacity building training on sustainable waste management and environmental reporting for farm owners, employers, and residents of host communities.

EFFECTS OF PARACETAMOL ON SEED GERMINATION AND ROOT ELONGATION OF *LYCOPERSICON ESCULENTUM* AND *LACTUCA SATIVA*

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Keywords: Paracetamol, phytotoxicity, hormesis, seed germination

Abstract

Many Pharmaceutically Active Compounds (PhACs) enter agroecosystems during reuse of treated wastewater, biosolids and manure, presenting a potential impact on plant development. Paracetamol (PCM), one of the most frequently used pharmaceuticals was tested to explore its role on initial growing effects in crop plants. This study aimed to test effects upon germination and development of two crop species, namely tomato (*Lycopersicon esculentum*) and lettuce (*Lactuca sativa*) after exposure to different PCM concentrations (1, 10, 100, 1000 mg/L). Various growth parameters such as germination percentage, root and shoot length, germination rate index (GRI), seedling vigor index (SVI) and Phytotoxicity Index (PI) were evaluated. The results showed that no significant effects were found on germination frequency. However, significant response for shoot and root elongation was found. It was observed that 1 mg/L PCM induced stimulus on tomato growth, and the same response was verified for lettuce, when its concentration was 100 mg/L, whereas doses above stimulating values caused phytotoxic effects. Remarkable hormetic effect for both crops was found. It was concluded that the different concentrations of PCM showed different responses in the species, and PCM can be classified as shoot and root elongation stressor at high concentrations (ranging from 100 to 1000 mg/L), but at concentrations that are environmentally realistic (up to 1 mg/L) it can induce stimulation or non-significant response to tomato (*L. esculentum*) and lettuce (*L. sativa*).

ASSESSMENT OF A WASTEWATER TREATMENT PLANT PERFORMANCE AND SUITABILITY OF TREATED WATER FOR IRRIGATION PURPOSE IN ADJOUGBA AREA: CASE OF THE BREWERY BB LOMÉ

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Keywords: Brewery, Irrigation, Nutrients, Wastewater Treatment Plant

Abstract

One of the options for coping with water scarcity problems is not only the improvement of wastewater treatment technologies, but also opportunities for reuse of treated wastewater. This study was conducted to evaluate the performance of the wastewater treatment plant (WWTP) of a brewery located at Lomé and to present the opportunities of water reuse taking this brewery as an example. The results showed that the COD removal efficiencies ranged from 74% to 96%. Microbiological parameters showed high values for total coliforms (120,000/100 mL), but compatible with agricultural use because of the absence of *Escherichia coli* in the final effluent. Regarding the potential in irrigated agriculture, it was found that the final effluent is more suitable for irrigated agriculture with a Sodium Absorption Ratio (SAR) under 10 in comparison with groundwater. The final effluent provided a supply of nutrients (13.2 mg N/L and 7.9 mg P/L) and a potential of fertilizing elements in irrigated agriculture for crops growth. This paper includes effluent and freshwater characterization, treatment scheme and performance of a brewery effluent treatment plant. In addition to it, the problems associated with this water's suitability for irrigation purpose was discussed and suitable recommendations were made.

PRODUCTION OF FORAGE CACTUS FERTILIZED AND IRRIGATED WITH REUSE WATER IN THE SERTÃO OF CRATEÚS, BRAZIL

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Keywords: *Opuntia ficus indica*, semiarid region, wastewater

Abstract

The objective of this research was to evaluate the number of sprouts, to measure the area of the cladodes, to determine the dry matter (DM), organic matter (OM) and mineral matter (MM), and to evaluate the morphometric measurements of fertilized forage palm and those irrigated with reuse water. Forage palm seedlings were planted at the Água Branca-Junco Experimental Didactic Unit of the IFCE, Crateús campus. Five treatments were used, three combinations of chemical fertilization, one organic fertilization and one control that did not receive fertilization. The chemical fertilizations were carried out in three combinations of nitrogen, phosphate and potassium fertilization: 130/70/30 (T1); 130/130/50 (T2); (N), P₂O₅ and K₂O, respectively, an organic fertilizer (T 4) and a control treatment (T 5). The irrigation method adopted was of the localized type consisting of motor pump assembly; control head, consisting of disc filter, pressure and record; pipes, main line, tapping line, in this one contained an easel with hydrometer; self-compensating type drippers, katif model, with a flow rate of 3.75 L/h at a service pressure of 100 kPa. Statistical analyses were performed using the ASSISTAT Version 7.7 Beta computational package. The results show that the application of chemical fertilizers together with the irrigation of reuse water provide higher cladodes production, greater development and higher morphometric measurements in forage palm plants, since in the dry matter (DM) contents it did not provide change, but it can change

EVALUATION OF FLY ASH PELLETS FOR PHOSPHORUS REMOVAL IN A LABORATORY SCALE DENITRIFYING BIOREACTOR

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Keywords: Denitrification bioreactor, non-point pollution, subsurface drainage

Abstract

Nitrate and orthophosphate from agricultural activities contribute to the main nutrient loading in surface water bodies. The objective of this study was to evaluate the efficacy of using woodchips and fly ash pellets (FAP) in flow-through tests for their abilities to remove NO₃-N and soluble P from the agricultural runoff. A lab scale bi-column system with two sections was designed to target the nitrate and orthophosphate removal, respectively. The front section was a 3 m long, 0.152 m diameter PVC pipe, filled with woodchips. The subsequent section was 1 m long, filled with fly ash pellets facilitated by an adjustable height outlet pipe. The influent nutrient concentrations were 12 mg/L and 5 mg/L for nitrate and orthophosphate, respectively. Three tests were conducted with different flow rates in this study. The results showed, the woodchip bioreactor section demonstrated average nitrate removal efficiencies of 49.2–85% and hydraulic retention times (HRTs) of 0.67–4.04 h. The fly ash pellet showed a very stable removal efficiency of 68.4–74.8% and HRTs of 0.67–4.04 h. The woodchips had a nitrate removal rate of 40.2–49.2 mg N/m³.d. The fly ash pellets effectively removed phosphate in the bioreactor effluent, and the total phosphate adsorption was 0.059–0.114 mg P/g, which is far less than the saturated capacity (1.69 mg/g). The effluent phosphate concentrations increased with decreasing HRTs. The fly ash pellet section reduced a certain level of nitrate in the bioreactor effluent, but was not significant. Overall, the results of this study suggest that woodchip denitrification followed by fly ash pellet filtration can be an effective treatment technology for nitrate and phosphate removal in subsurface drainages.

WASTEWATER REUSE IN IRRIGATED AGRICULTURE

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Keywords: Irrigation, Wastewater Reuse, Agriculture, Morocco

Abstract

Morocco's interest in the reuse of wastewater for irrigation purposes comes from its water resources, which are limited and unequally distributed over space and time, particularly in some cities located in regions characterized by an arid or semi-arid climate with a large water deficit and high agricultural activities. The agricultural reuse of wastewater has had variable applications and has become an unavoidable practice for the majority of farmers already weakened by lack of water. Direct irrigation of crops from raw sewage is practiced despite its prohibition. This practice is not without dangerous consequences causing damage to human health and the environment. As a result, Morocco has been called upon to develop its regulatory and legal aspects of wastewater development through integrated approaches to water resources management, while taking into account technical, socio-economic and environmental factors, to preserve the quality of its bodies of water and to obtain safe alternative supplies.

CHARACTERIZATION OF EFFLUENTS FROM FECAL SLUDGE TREATMENT PLANT IN CAMEROON AND ASSESSMENT OF THEIR POTENTIAL USE FOR AGRICULTURAL IRRIGATION

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Keywords: Agriculture, fecal sludge, purification plant, tropical urban area

Abstract

The present research work is a contribution to the characterization of wastewater treatment plants' discharges in the city of Bafoussam with a view of their use for agricultural irrigation. From July 2017 to February 2018, fecal sludge treated effluents from the treatment plant of Kuekong, Bafoussam were analyzed in order to determine their physicochemical and bacteriological characteristics following standard protocols. Physicochemical parameters recorded at the outlet of the treatment plant are at the order of 25.6 mg/L for TSS, 791 $\mu\text{S}/\text{cm}$ for EC, 2.93 mg/L for NO_3^- , 5.46 mg/L for NH_4^+ , and 3.31 mg/L for PO_4^{3-} . The average values recorded were at the order of 227 mg/L for COD and 70 mg/L for BOD_5 , respectively. As for the values recorded at the exit of the station for bacteriological parameters, they were at the order of 130 CFU/100 mL for fecal coliforms and 64 CFU/100 mL for fecal streptococci. In general, the system allows a reduction of fecal sludge pollutants with discharge values in accordance with the discharge standards for treatment plants as prescribed by MINEP DED and WHO, except for COD, BOD_5 and TSS that are above the standards. In view of the parameters analyzed and their comparison with standards, this shows that the latter being in conformity with national and international standards and can be used in agriculture without having considerable health and environmental impacts. However, fecal sludge also contains trace metals that can have an impact on health and the environment. So, these waters from sludge treatment must be analyzed before reuse.

THE RESULTS OF IMPLEMENTATION OF TREATED WASTEWATER AND BIO-SOLIDS GENERATED FROM WWTP ON THE PLANTATION OF FODDER AT MARGINAL AREAS AT AL-KARAK, SOUTH JORDAN

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Keywords: Bio-Solids, Land application, Sorghum, Marginal areas, WWTP, Co-digestion

Abstract

Decentralized integrated management of sludge is considered a viable solution for solving the problem of sludge accumulated in wastewater treatment plants in Jordan. This research is part of a project that aims at reducing the carbon footprint of sludge handling and thus considers primarily the use of sludge as a source of energy and soil conditioner. The objective of this study is to assess the application of bio-solids (solid sludge and treated organic matter (TOM) that results from the co-digestion process) as soil amendments and its effect on plant and soil production, and water use efficiency (WUE). This assessment also includes analysis of the organic matter before application. The field application on sorghum plantation at marginal areas in south Jordan shows that bio-solids increases the dry and fresh yield of sorghum crops up to 40%. The effect on soil shows that heavy metals concentrations were slightly noticed by bio-solid addition, but is it still under the permissible limit and should be continuously monitored. Correlation analysis shows positive correlation between Zn, Mo and Co concentration in the soil and the added bio-solids. Moreover, it shows an increase of P but depletion of K and N as they are macronutrients for sorghum. Obviously, the use of bio-solids positively affected the water use efficiency by 2.4 and 3.2 times those of normal fertilizers. Therefore, sludge could be used as soil amendment in rangelands with < 200 mm/yr of rainfall. Nevertheless, bio-solid quality needs to be monitored before application. More research on land application measures, effect on food chain and effect on pollutants accumulation is needed.

ENGAGING, ENABLING AND EMPOWERING BANGLADESHI YOUTH ON CLIMATE CHANGE PROJECTS THROUGH FACEBOOK USAGE TO ENSURE SUSTAINABLE DEVELOPMENT

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Keywords: Bangladesh, Youth, Facebook, Climate Change, Sustainable Development

Abstract

The purpose of this study is to identify the involvement of Bangladeshi youth on climate change projects through Facebook usage to ensure sustainable development. The study seeks to investigate the combined roles of Facebook usage for engaging, enabling and empowering the youth force of Bangladesh accelerating sustainable development. The study used a sample of youth (N=250) and a closed ended survey questionnaire to probe the real youth Facebook users' contributing spirit on Bangladeshi climate change projects. The study found that youths are extremely vocal on Bangladeshi climate change issues, projects and sustainable development agenda in Facebook. Surprisingly, two special groups as youth Facebook users were found. The Facebook users were active to disseminate information promptly, had tendency to comment or to clear their opinions on viral issues. Finally, it was found that Facebook accelerates youth's contributing spirit on climate change issues that are really needed for the developing countries like Bangladesh.

IMPACTS OF WATER CRISES ON AGRICULTURE SECTOR AND GOVERNANCE CHALLENGES IN PAKISTAN

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Keywords: Adaptation, governance, Pakistan, subnational level, water scarcity

Abstract

The study develops a framework to understand the water governance challenges for agriculture sector at subnational level in Pakistan. The country is facing severe water crises and it may run dry by 2025. According to the International Monetary Fund, Pakistan is the third most water-stressed and has the world's fourth highest rate of water use. Agriculture is the major source of economy in the country. Pakistan uses 93% of its freshwater resources in agriculture. Agriculture sector contributes 24% of Gross Domestic Product, accounts for almost half of employed labor force and is the largest source of foreign exchange earnings. However, agriculture sector is under stress due to population growth, increased demands for food, ever-growing competition for water and land, climate change, and less-participatory water resources governance. It is imperative to introduce improved water management in agriculture and adaptation of agricultural systems to enhance water use performance and water productivity, particularly to face water scarcity. This study is conducted to understand the water governance for agriculture sector at subnational level by looking the case of Punjab province in Pakistan. It also identifies the key challenges in the way of effective water governance towards agriculture sector. The Punjab government has launched massive level awareness campaigns to understand the linkage between agriculture sector and water scarcity. One of the notable initiatives is the newly established national water policy of Pakistan. Some advances in irrigation system are also being incorporated. Water crises are escalating due to poor governance of water resources, lack of communication and education on water crises, and lack of investment and infrastructure development. The study proposes a framework for managing the risk of water scarcity based on preparedness rather than a crisis approach. The importance of diverse strategies to handle the forthcoming challenges associated with water resources management are emphasized, but the potential benefits depend on the appropriate multi-institutional and multi-stakeholder coordination to water resources management in a changing climate.

ECOSYSTEM SERVICES OF A SEASONALLY DRY TROPICAL FOREST IN SEMI-ARID REGION OF BRAZIL

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Keywords: Caatinga; Carbon balance; Degradation; Ecosystem management; Grassland

Abstract

Ecosystems can provide many essential services for the society, although sometimes their valuation is ignored. The seasonally dry tropical forest in the semi-arid region of Brazil, named Caatinga, is characterized by a fine-tuned adaptation to extreme rainfall seasonality. Caatinga, like many other ecosystems, is under pressure for food production, whereas grassland is a typical replacement of native areas. The main goal of this paper is to study the carbon uptake, biomass production in Caatinga and grassland in order to quantify the level and potential revenue of environmental services in the semi-arid region of Brazil. Measurements of carbon flux, meteorological variables, and biomass in the preserved native vegetation Caatinga (CA) and in a degraded grassland (GR) in the semi-arid region of Brazil were carried out. The carbon flux was measured using the eddy covariance technique for one hydrological year. Owners chose all decisions of management areas (preserve or explore) without interference or advise. These areas have conditions that affect the price of the same product, such as carbon credit due to other not priced variables. Total rainfall during the studied period was lower than average for the region. However, carbon uptake was 2.74 t/ha in CA and 3.00 t/ha in GR. Based on current carbon credit trade value, local market and current management, CA is potentially 56% more profitable than GR. The total potential revenues in CA are 78.97 USD/ha. yr and in GR 50.74 USD/ha.yr. The lower revenue in GR is due to necessary expenses with nutrient reposition and reseeding to avoid a collapse in this area in few years. The analysis made here may be useful for policy-makers in order to preserve natural ecosystems and to reduce deforestation and land degradation.