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SWDCC
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**"Soil & Water Resources Management
for Combating Desertification in Drylands under
Climate Change"**



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DAY 1: 14 June 2022

Special Session: FAO

Yields, water productivity gaps and farmers' perception of vulnerability factors, in irrigated areas with contrasting climates,

A. Lasram, F. Yakoubi, R. Nabli, H. Maaroufi, A. Maki, M. M. Masmoudi, N. Ben Mechlia

Farmers' perceptions of vulnerability factors were investigated in two contrasting climatic zones sub-humid and arid located in northern and central Tunisia.

The availability of water and fertilizers were the main concerns of farmers who were not well aware in general about environmental threats such as climate change and loss of soil fertility. Efficient farmers are more likely to be aware about risks associated with climate change such as water scarcity and plant disease threats and willing to receive technical assistance.

The main adaptation intentions and requests expressed by farmers were the improvement of water and inputs management in the sub-humid area and the improvement of the reliability of water and fertilisers supply in the arid zone.

Less efficient farmers' intentions and requests for adaptation moved towards more subsidies and access to credit and the use of adapted varieties.

Keywords: farmer perception, vulnerability factors, technical efficiency, aridity.

Combining Remote Sensing data and AquaCrop model for assessment of water productivity of Durum Wheat in semi-arid conditions in Tunisia.

B. Latrach, A. Lasram, S. Mnasri, R. Nciri, W. Gharbi, M. M. Masmoudi, N. Ben Mechlia

The suitability of AquaCrop model using weather and remote sensing (RS) data for simulating yield and water productivity of durum wheat has been assessed under semi-arid conditions and results compared to FAO WaPOR output and in-situ observations.

Canopy cover (CC) of durum wheat derived from RS-NDVI have been used as input to AquaCrop model Performance of AquaCrop model fed by RS CC, in estimating yield and water productivity was better than WaPOR. WaPOR tends to overestimate actual evapotranspiration and underestimate actual biomass and water productivity.

A validation and adjustment of its outputs is required before its use for decision making.

Keywords: NDVI, AquaCrop, WaPOR, Yield, Water productivity, Durum Wheat, Semi-arid conditions.

Literature Review on Water Productivity of date palm trees in Tunisian agro systems L. Dhaouadi, S. Ben Maachia, F. Aboudhief, A. Namsi, K. Nagaz, M. Masmoudi

The study aims to assess the water productivity for date palm cultivation in Tunisia.

A literature review of the previously published scientific papers and documents related to works carried out in these regions for the evaluation of the different aspects of water productivity.

The outcome of this review indicates that (i) the date palm plantations surfaces are expanding, they cover 58.000ha with a total production of 355.000t in 2021(ii) the distribution of irrigation water is variable and irregular. iii) The reported water supply for date palm is from 20,000 to 30,000 m³/ha while a number of scientific-based calculations estimate the crop water requirement for regular date palm production between 10,000 and

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18,000 m³/ha (iv) The common irrigation systems are the traditional surface methods (v) Soil salinization, alkalization and loss of soil permeability is growing and may impact productivity of date palms and sustainability of the production system (vi) There is an important overexploitation of conventional water resources reaching 250 % in Nefzaoua Oases for example (v) Biophysical water productivity is not mentioned in most documents, estimations based on reported data revealed that it is not exceeding 0.66kg/m³.
Keywords: date palm, oasis, Tunisia, water productivity, bibliographic review.

Water productivity of date palm trees under two irrigation systems : Case study in a Tunisian oasis,

S. Ben Maachia, L. Dhaouadi, M. Jemni, A. Namsi, M. Masmoudi

The objective of this study is the estimation of water productivity of date palm Deglet Nour Variety via field survey and experimental work on two irrigation systems implemented in a private farm in southern Tunisian oasis. The considered systems are submersion irrigation system (SIS) and Bubbler Irrigation System (BIS).

The obtained results from field investigation indicate that the biophysical water productivity (WP) of date palms was, in average, 0.30 Kg/m³ under traditional submersion irrigation and around 0.94 Kg/m³ for the bubbler system. During the experimental years for the selected farmers and additional field observations during 2018-2020 reveals that (i) After 4 years of the BIS implementation. The use of BIS with appropriate scheduling reduced water supply to 40% and improved yield to 125% in comparison to SIS system (ii) the fruit quality in terms of size, Water activity, pH, sugar content (TSS) and antioxidant activity was not affected. In fact, the BIS have decreased fruit firmness (55%) and increased phenolic compounds content by 24%.

The BIS system showed a high capacity to improve water use and sustainability of date production in Tunisian oasis.

Keywords: palm trees, production, irrigation, bubbler, water productivity, quality sustainability, tunisia, oasis

Yield and water productivity of olive trees and significance of farmers' behaviour on water productivity of irrigated olive farms in arid regions (Kairouan-Tunisia)

S. Elfkah, A. Elkadri, K. Gargouri, M. M. Masmoudi

A survey seeking the analysis of water productivity of olive is conducted in central Tunisia covering 40 farmers. Only 25% of the surveyed farmers grow olive as monoculture and provided required information for WP estimation Biophysical and economic water productivities were within the range 0.45-1.28 kg/m³ and 0.31-1.05 TND/m³ respectively Water availability and reliability seems to be the most significant source of yield and water productivity losses. Farmer field schools initiated by the WEPS project may be an operational solution to improve the situations and reduce yield gaps

Keywords: olive trees, yield, water productivity, farmer, behaviour, central Tunisia

Validity of shirps rainfall data and its use for rapid water accounting in an irrigated perimeter in northern Tunisia,



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A. Jlassi et al.

With its highly spatial and temporal variability, rainfall measurement in Tunisia is a crucial operation that requires financial as well as human efforts to cover the whole country in a representative and continuous way. Satellite rainfall data can be a freely accessible solution that came as an alternative information source. Climate Hazard Groups Infrared Precipitation with Stations (CHIRPS) is a global set of rainfall data calibrated with in situ rain gauge stations from national and regional authorities starting from 1981 until today. The study aims to compare and validate this database with 294 ground stations in Tunisia for the period from 1981 up to 2015 with the monthly time step in a station to pixel basis. Both statistical analysis and goodness of fit statistics are used for the comparison including the Coefficient of correlation (r), the coefficient of determination (R^2), Probability of BIAS (PBIAS), RMSE- observations standard deviation ratio (RSR) and Nash-Sutcliffe efficiency (NSE). Results show a good fit of CHIRPS data for the coastal zones as well as the subhumid and humid bioclimatic stages located in the Northern and North- western part of the country with $RSR < 0.7$, $r > 0.75$, $NSE > 0.7$ and $|PBIAS| > 0.2$. For the semi-arid, arid and Saharan bioclimatic stages located in the central and Southern part of Tunisia, CHIRPS tends to overestimate the amount of rainfall with a lower estimation accuracy. This study concluded that CHIRPS dataset can be used in the coastal and the rainy parts of Tunisia located in the North, North-West and the Est without further calibration but for the Centre-West and the South parts there is a need for an adjustment before the use.

Keywords: CHIRPS, Rainfall, comparison, validation, Tunisia, Statistics

Estimation of wheat evapotranspiration using in-situ CORDOVA-ET system, FAO 56 method and WaPOR platform.

I. Alaya, R. Zitouna Chebbi, J. A. J. Berni

CORDOVA-ET is a station developed by the University of Cordob-Spain for measurement of evapotranspiration. It makes use of low cost electronics, sensors and wifi and internet technology for measurement, transmission, and sharing of collected data.

A station installed in the INGC platform of Kodia, northwest of Tunisia, was used to estimate the actual evapotranspiration (ET_a) of durum wheat.

The collected data, covering a period of three months corresponding to development-mid season, shows that daily ET_a was in the the range 0.8-4.8 mm/day while reference evapotranspiration (ET_o) varied between 1.0 and 5.8 mm/ day during the same period.

In ordrer to compare in-situ measurement with remotely sensed estimation of ET, the Wapor platforms output corresponding to the experimental plot was extracted and used.

A good correlation between CORDOVA-ET and Wapor was observed during the considered period for both ET_o and ET_a.

Keywords: evapotranspiration, durum wheat, CORDOVA-ET

Water Productivity and Yield of barley and vegetable crops, irrigated with low quality waters in arid Tunisia,

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K. Nagaz, F. ElMokh, M. M. Masmoudi

Water productivity of barley and some vegetable crops (carrot, pepper, faba bean and potato) was determined under arid conditions of southern Tunisia.

Experimental work was carried out over the period 2012-2016 within farmer fields and under different water supplies using deficit irrigation and low quality water.

Irrigation scheduling based on soil water balance and deficit irrigation improved WP with values ranging from 5 to 9 kg.m⁻³ Economic WP was between 3.0 and 5.8 TND.m⁻³ with an advantage for short cycle crops that profit from rainfall period.

Keywords: barley, vegetable, carrots, potato, fababeans, pepper, irrigation, deficit, economic, water productivity, arid.

Production gaps in Tunisian arid and sub-humid irrigated perimeters: Diagnosis and causal factors

A. Lasram, R. Nciri, F. Yakoubi, R. Nabli, H. Maaroufi, A. Maki, M. M. Masmoudi, N. Ben Mechlia

Production gaps are estimated in two contrasting climatic zones : arid and sub-humid in north and central Tunisia. Average values of technical efficiency and resource efficiency for all grown crops were about 60% and 78%, respectively.

The difference in climatic risk between the two regions resulted in differences in crop and irrigation management behavior and efficiency.

The technical efficiency of water seems to decrease when the aridity increases.

Keywords: Yield gap, water productivity, technical efficiency, aridity.

Session 1: Water Resources Mobilization and Management

***The assessment of climate change impact on Water resources in the Arab region
Iheb Jnad***

The available fresh water resources in the Arab countries are under enormous, pressures and are facing many significant challenges such as high demographic growth (2.6 per cent) , the expansion of irrigated agricultural lands, overexploitation, pollution, and climate change. The annual available water resources in the Arab countries are estimated to be 260 billion cubic meters annually, of which irrigation sector consumes about 87%.

Considering that, In 2020, the total population of the Arab world amounted to approximately 436.08 million inhabitants, per capita share of water has become only 596 cubic meters per year, which is less than the water scarcity limit (1,000 cubic meters per person per year). In fact, 12 of the world's most water scarce countries are : Algeria, Bahrain, Kuwait, Jordan, Libya, Oman, Palestinian, Qatar, Saudi Arabia, Tunisia, the United Arab Emirates, and Yemen. It estimated that about 40% of the Arab population is living in the regions of absolute water scarcity (less than 500 cubic meters per person per year).

Climate change will intensify water scarcity problem in the region through its impact on the quantity and quality of available water resources.

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In recent years, the Arab Center for studies of arid zones and dry lands (ACSAD) has given a high priority to the issue of climate change and implemented several projects and studies in this field. ACSAD and the United Nations Economic and Social Commission for Western Asia (ESCWA) implemented in cooperation among other organization, the Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR). Outputs from RICCAR shows that projected climate changes in the Arab region will include increases in temperatures, changes in precipitation patterns, changes in extreme weather events, and reductions in water availability. These projected changes may result reducing in agricultural productivity and can reduce access to food.

In a study implemented in cooperation among ACSAD, FAO, and ESCWA, to assess the impact of climate change on crops yield, the yield of rainfed wheat in Morocco was projected to decrease by 27 % and the yield of rainfed sorghum in Sudan was projected to decrease by 15 %. Less impact was projected on irrigated crop such as tomato and potato. In order to cope with the projected impact of climate change on water resources and crop yield, ACSAD, implemented several adaptation measures in the Arab region. In the field of cereal crops, ACSAD developed 77 different varieties of wheat and barley. These varieties are drought-tolerant, disease-resistant, and have high yield. Moreover, ACSAD promoted conservation agriculture (CA) in several Arab countries to mitigate the impact of climate change. Results show that CT cropping systems increased wheat and barely yield about 30% and saved on energy costs due to less tillage. ACSAD also applied rainwater harvesting techniques as an adaptation measures to climate changes in Yemen, Saudi Arabia, Iraq, Syria, Lebanon, Libya and Egypt. These techniques provided needed water for supplementary irrigation and watering of livestock during dry season. Which is in turn resulted in increasing agricultural productivity.

Given that agriculture is the largest consumer of water in the Arab region, ACSAD since 2015 have been implementing a project on raising the efficiency of irrigation water in the Arab region. One of the results of this project was preparation of a comprehensive study on efficiency of irrigation in the Arab countries. In this study, principal causes of poor efficiency were determined. Accordingly, ACSAD presented number of practical proposals to improve efficiency of irrigation water use, especially on the field level and adaptation to the effects of climate change.

Contribution of Geospatial Tools to Rainwater Management and Flooding Risk Reduction in the Southeast of Tunisia.

Abdelli F.

In Tunisia, the extent of damages, related to recurrent floods of recent years revealed management deficiencies in the flooding risk areas. Throughout history, many specific rainfall events happened and affected target regions around the hydrographic network. The catastrophic floods (huge infrastructures damages and some human losses) of 11th and 12 November 2017 in Matmata and Mareth regions, Gabès governorate, southeast Tunisia, will remain certainly for a long among the most unforgettable events.

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In this context, the main aim of this work is to conduct an in-depth study of that event. Field works were carried out to localize the most damaged areas. In parallel, a hydrological modeling operation, using the adjusted Soil Water Assessment Tool (SWAT_WH) model, was performed to establish the water balance of the Ségui catchment (177 km²) in order to test watershed management scenarios for flood prevention particularly in the downstream city of Mareth. Following meetings with local stakeholders, solutions have been adopted and part of them are being under implementation.

KEYWORDS: Flooding, GIS & RS, geospatial tools, Management scenarios, Hydrology, Modeling, Arid, Tunisia, SWAT-WH.

Current State of Pomegranate (*Punica Granatum L.*) Fertilization in the Tunisian Coastal Region.

Ouni A., S. Abboud, S. Dbara, and M. Mars.

Pomegranate (*Punica granatum L.*) culture in Tunisia is ancient and traditional. It is well adapted to Mediterranean zones and arid climate. Having long been considered as secondary, this culture has known during the last decades a great extension even in coastal areas. However, researches on this fruit crop remained limited. One of the major cultivation problems is fruit cracking, related to irrigation and fertilization in terms of timing and doses. In this context, a research on fertilization optimization was undertaken. For this purpose, a survey was made in nine delegations of Sousse governorate. In total, 31 farms were prospected. Results showed that the main cultivated varieties were Kaali and Gabsi. Out of 31 farmers, 21 do not apply any mineral fertilization; they are limited to an arbitrary spreading of animal manure. The rest are applying random quantities without taking into consideration the antagonisms between elements. Fruit cracking is affecting almost all pomegranate plantations. Only one orchard is not facing this problem. Farmers confirmed that their orchards suffer from non-availability of irrigation water, they have to irrigate infrequently. Thus, only four farmers are watering their trees daily, and one is irrigating three times per week. Apart from the field survey, a set of fruit samples were taken for the study of pomegranate arils and juice quality. The analyses showed that the quality of the fruits in terms of size, flavor, color and quantity of juice is moderate. Also, leaf samples were taken for mineral analyses. It was concluded that pomegranate fertilization in our conditions is a challenge for pomegranate growers who try to master the use of ferti-irrigation. These results are useful to develop appropriate strategies related to the fertilization and irrigation to combat the phenomenon of fruit cracking and offer high quality fruits.

KEY WORDS: Pomegranate, fertilization, fruit cracking, Tunisia.

Vegetable Crops Production Under Irrigation with Magnetic Treated Low-Quality Water in Arid Tunisia.

Elmokh F., I. Jamil, M. Chammakhi, and K. Nagaz.

The evaluation of two magnetic devices effect on improving crop growth and production, water productivity and soil salinity was studied in a farm field in the arid part of Tunisia. The crops studied were potato, pepper and lettuce cultivated on a sandy soil and irrigated with

water having an Eci of 7.3 dS/m. Three treatments were considered in a randomized complete design with three replicates, two consisted in treating water with magnetic field (Delta water, D.W and Magiko) and the third one is considered as control. Field monitoring concerned crop growth parameters, soil moisture and salinity, yield and its components. Irrigation water supplies for each crop were determined by Aquacrop model using soil, crop data and real time climate conditions. Results showed that soil salinity values for all treatments decreased at the end of the three crop seasons compared to the initial ECe values due mainly to natural leaching by rain events. Magnetically treated water improved the canopy cover, the leaf water potential, the yield and its components compared to untreated one. For pepper crop, dry matter increased by 19.7 and 27.7% for the D.W and Magiko techniques, respectively, compared to the control. For potato, the average canopy cover was higher by 14% for both treated waters compared to control. The increase in growth was due to a significant improvement in the relative moisture content for pepper crop and leaf water potential for potato and lettuce crops. These techniques result also in an increase in yields by 8 to 18%, which is attributed mainly to the improvement in fruits size, and consequently in an increase in WP by 11.7%. The use of magnetic water treatment in agriculture could be a promising technique in the recovery of saline water which remains to be confirmed by long-term experiments.

Managing Salinity for Sustainable Agricultural Production in Salt-Affected Soil of Irrigated Drylands.

Devkota M. and K. Devkota.

Declining water quantity and quality and poor land, water, and crop management practices are leading to increasing soil salinity, land degradation, desertification, and threatening the overall sustainability of crop production in irrigated drylands. Assessments of salinity dynamics and sustainability indicators under alternative agricultural practices are needed to identify the right combination of practices that improve sustainability while minimizing land and environmental degradation. The objective of this study was to assess the potential of conservation agriculture (CA)-based practices, water-saving irrigation, water quality, and nitrogen rates for improving sustainability of rice-wheat (RWS) and cotton-wheat (CWS) systems in salt-affected irrigated drylands.

The study included mixed-method approaches of two years of field experiments, simulation using Hydrus-1D model, and multi-criteria analysis for holistic assessment of alternative innovations. The treatments were composed of combination of CA-based practices, water-saving irrigation and N rates. Fourteen sustainability indicators were computed and compared to evaluate sustainability of those cropping systems. Compared to the initial conditions, soil salinity decreased in both cropping systems, while the reduction rate was higher in RWS than CWS (by 28%). In RWS, the conventional treatment had lowest salinity, while in CWS, CA had the lowest. RWS raised the groundwater-table by 25% compared to CWS. With increased irrigation water salinity and soil evaporation rates, soil salinity increases by 78% in RWS and 66% in CWS. RWS had a higher net profit (+81%) and soil organic carbon (SOC) (+29%), but lower water productivity (WP) (-147%), nitrogen, and energy use efficiency (EUE) (-46%) than CWS. The CA-based practices in CWS improved sustainability indicators with

higher yield and profit (+20%), WP (+26%), SOC (+456%), and EUE (36%) with decreased soil salinity than in conventional system. The findings from this study strongly demonstrated the role of CA in sustainable agricultural production particularly under CWS in salt-affected irrigated dryland.

Efficient Adsorption of Dibutyl Phthalate from Aqueous Solution by Chitosan Extracted from Local Crab Shells

Mkaddem H. and H. Ben Amor

The contamination of the aquatic environment by chemical substances, garbage, and pathogens causes water pollution. Among the most significant harmful organic pollutants found in the world's water supplies are phthalate esters (PAEs), particularly dibutyl phthalate, which has the potential to alter human DNA. The major purpose of this study is to eliminate dibutyl phthalate by a manually extracted Chitosan (from local marine resources) via adsorption. Because it is technically straightforward, the adsorption process has sparked a lot of interest recently. The Langmuir isotherm model describes the experimental results. This bio-material had an adsorption capacity of roughly 23 mg/g. The results demonstrated that this adsorbent is more effective at removing dibutyl phthalate than other biomaterials such as corncob biochar and shell sand.

Keys Words: Chitosan, Dibutyl Phthalate, Adsorption, Isotherms.

Quantification and Analyses of Wheat Evapotranspiration for Improving Water Productivity in Arid Regions

Gamal R., V. Nangia, and S. Irmak

Evapotranspiration is a vital variable for water resources supply-demand-projection-allocation-management-use analyses; effective agricultural water management and improving crop water productivity (CWP). Implementing 2030 agenda for sustainable development requires evidently a transformational change in managing strategic resources such as water, land and energy. Egypt is one of the arid MENA countries that needs to strategically analyze its water resources management and allocation, implement effective conservation practices to ensure alignment with setting the suitable limits of water consumption, making the best utilization of each drop of water to enhance CWP.

Mechanized raised-bed is an effective means of increasing productivity and saving scarce water, but the technology still needs substantial adaptation to local conditions and primary water management variables.

One of the objectives of this research is to quantify and analyze the absolute water saving which represented by water consumptive use under raised-bed technology and traditional practice (flatbed) for wheat and investigate the feasibility of both production systems to be adopted in Egypt. Two energy balance flux towers were installed in two locations in raised-bed wheat production fields in middle Egypt (Sids) and traditional practice in Egypt Delta (Sakha) for comparative analyses.

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Climatic zone had significant impact on ETo and ET. Cumulative grass-reference evapotranspiration (ETo) was 434 mm and 557 mm at Sakha (flatbed) and Sids (raisedbed) sites, respectively. Cumulative ET was 321 mm and 375 mm at Sakha and Sids sites, respectively. The ratio of ET to ETo changed substantially between the locations with ET/ETo ratio of 0.74 at Sakha and 0.67 at Sids site. In terms of yield response to water use, the CWP was 12% higher with the raised bed production system (1.99 kg/m³) as compared with the traditional flatbed practice (1.77 kg/m³), Results indicate enhance CWP with raised bed system with reduced ET for wheat production in the region.

Water for Food, Water for Life: The Drylands Challenge ***Vinay Nangia***

Water scarcity is increasing, especially in dry environments with climate change and degradation of natural resources. About 41% of the Earth's land area is classified as dryland; wherein the farming system is characterized by low annual rainfall with much of it falling in the winter and spring. Agriculture, especially in Africa, is required to produce more food and welfare for rapidly increasing populations but with less freshwater resources. Conventional responses to this situation focus on increasing yields, improving irrigation efficiency and managing demand. We argue that those strategies are either not working under current conditions or not anymore sufficient to cope with the daunting demand for more food in water scarce dryland regions. A paradigm shift in how we manage water is needed going into the future. The debate on how better to handle agricultural water allocation and use with increasing scarcity is being intensified over the last decade and is producing new transformative solutions.

Climate-smart agricultural practices that require less water, can sustain climatic stresses, produce food with high nutritive value but require less water and energy to produce are the need of the hour.

ICARDA success stories in these regards will be presented.

Papers

Water Scarcity Conditions Improve Peach Fruit Quality Traits in Warm and Arid Areas ***Toumi I., O. Zarrouk, and K. Nagaz***

Peach fruit is a high economic value crop in arid regions of Tunisia, produced during dry season, and required irrigation to ensure high yields. The application of deficit irrigation strategies may contribute water saving and improve some quality traits of peach tree. Deficit irrigation (DI) and Partial root zone drying (PRD) were evaluated for their impact on fruit quality in Flordastar peach fruit grown in warm area over two growing seasons (2014 and 2015). Irrigation treatments consisted of full irrigated (FI) at 100% of crop evapotranspiration (ETc), continuous deficit irrigation (DI) and partial root zone drying (PRD) where trees were irrigated at 50% of the ETc. FI trees was irrigated with 861 mm (2014) and 880 mm (2015). Results showed that DI and PRD improved dry matter content and firmness similarly.

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Glucose, fructose, citric and quinic acid were accumulated with water stress conditions. Total phenolic content increased significantly in DI and PRD fruits. In warm and dry areas, DI and PRD irrigation strategies will be a tool of irrigation management in peach orchards. It contributes in water saving (50%) and improve water productivity (30%) and internal fruit quality.

KEY WORDS: Prunus persica L.; deficit irrigation; partial root zone drying; fruit quality.

Optimization of the Purification Efficiency of Shredded Dry Palms in the Treatment of Urban Wastewater by Infiltration-Percolation

Eturki S., M. Ben Saed, F. Souid, F. Hajjaji, and M. Ouessar

The aim of this study is to enhance the palm leaves waste in the tertiary treatment of urban wastewater. The palm leaves waste can serve as a filtering medium that can be used, after treatment by infiltration-percolation, as a composting product for organic amendment in arid oasis. Laboratory column trials were carried out to treat wastewater from El Hamma treatment plant (urban and geothermal wastewater) which is reused by farmers in the Bechima area in the irrigation of fodder crops and arboriculture. Three PVC columns, 20 cm in diameter and 130 cm in length, were installed on a mobile open-air support filled with different thicknesses of raw palm leaves waste and mixed with different doses of smectic clay from Jbel Aidoudi. The thickness of the filtration mixture is 60 cm for the first column (C1), 90 cm for the second column (C2) and 120 cm for the third column (C3). The analyses results of the filtered wastewater through the columns showed that the purifying performance of the raw palm leaves waste is weak. The optimization of the purifying efficiency of our treatment system requires the addition of an adsorbent material (swelling clay) facilitating the retention of the pollutant load and increasing the residence time of the water in the columns. Significant quality improvement of the filtrates was observed by the addition of the smectic clay with yields up to 87 % for SS, 95 % in NTK, 99 % in NH₄⁺ and 71 % in COD for the C3 column containing 20 % clay. While the purifying power of the raw crushed dry palm was in the order of 77 % in SS, 41% in NH₄-N and 38 % in COD. And even the addition of 10 % clay did not result in satisfactory yields for the three columns.

Isotopic Signature ($\delta^{18}O$, δ^2H) and Self-Organizing Maps for Identifying Contamination Processes in Arid Aquifer: Jerba Island Case Study (South-eastern of Tunisia)

Souid F., M. Hamdi, F. Khalfalli, A. Kharroubi, and M. Moussa

The purpose of this study is to identify the relationship between the mineralization of groundwater and anthropogenic activities and to assess the physical processes controlling groundwater geochemistry. An approach combining the use of water dissolved chemical species, isotopic fingerprint (2H and ^{18}O), and the unsupervised machine learning techniques, such as the self-organizing maps, has been used to understand the behavior of an unconfined aquifer system and to determine the origin of its different contamination sources. In the present work, geochemical characterization of the coastal aquifer from the unconfined Jerba aquifer, Southeast Tunisia, was carried out in 2015. In fact, 68 wells were sampled and analyzed. Geochemical modeling and isotopic data demonstrated that seawater intrusion,

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exchange reactions occurring within the aquifer matrix, and anthropogenic activities were the major processes controlling the groundwater contamination in the island (>75%). The isotopic tracers indicate that the increasing salinity in the shallow coastal aquifer is caused by seawater intrusion. The Self-organizing Maps (SOM) indicated that Cl^- , Br^- , Na^+ are mainly originated from seawater intrusion and Mg^{2+} , Ca^{2+} , and Li^+ mostly derived from rock-water interactions. The methodology appears as a valid tool applicable in other coastal areas to determine the main factors governing groundwater mineralization.

KEYWORDS: Jerba Island, coastal aquifer, groundwater salinization, SOM, isotopic behavior.

Challenges of olive growing in the Tunisian arid environment under climate change ***Ben Rouina Y., F. Ben Rejeb, and B. Ben Rouina***

Since the 1980s, the arid climate of southern Tunisia has showed notable changes and has continued to deteriorate. These changes were experienced by high temperatures and less rainfall which risk inducing disastrous consequences on the olive growing and yields. In this hard environment the high summer temperatures induce a less oil accumulation of the main olive tree varieties and deplete their fatty acid composition making it non-compliant with international standards for the trade of olive oils. Hence, this study was initiated a decade ago and concerns two olive groves, one located in the coastal area (experimental farm of the Olive Tree, Taous - Sfax) and the other in the Sahara from Kebili (Rjim Mâtoug) and, interested 3 olive tree varieties: Chemlli Sfax and Dhokkar (from the South) and Chetoui (from the North). Trials concerned the study (1) of the climate characteristics, expressed by the temperatures, atmospheric humidity, wind speed and hours of sunshine (2) olive stress indicators (MDA and H_2O_2), (3) biochemical responses of the olive tree to stress (starch, soluble sugars, proline) and (4) olive yields, oil biosynthesis and characterization.

SWDCC

2022

DAY 2: 15 June 2022

Session 2: Climate Change: Vulnerability and Adaptation in Drylands

The Olive Tree in Arid Zones and Global Warming Impact **Abichou M., H. Rajhi, and S. Boubtane**

Land degradation due to loss of topsoil was a serious problem in skeletal lands when unsuitable agricultural practices were applied. In fact, an extension on reserved lands for grazing was observed; this extension was amplified by an excessive use of tillage technique namely the conventional plowing: this technique was based on frequent passages throughout the year. The effects of winter warming will be the most decisive for rainfed crops, in particular for the olive tree. Indeed, a year of strong harvest followed by a mild winter during which the minimum temperatures remain around 10 ° C represents doubly unfavorable conditions for the setting in flower and consequently, the expected production can only be derisory. In addition different factors such as the salinity, the hydromorphic, the presence of gypsum and limestone crusts, the mobility of sands can constitute a limiting factor for the development of rain-fed agriculture. In arid zones, the striking feature of soils was the reduction in plant cover and the low rate of organic matter over the entire soil profile. The soils were therefore sensitive to various types of erosion, particularly wind-generated. The serious severe effects of wind regime were observed especially in the area that characterized by prolonged droughts season and a texture soil of sandy to sandy loam. In fact, all these factors mean that wind erosion was particularly severe in the sandy steppes. Furthermore, changes in precipitation regimes will result in a decrease in the volumes of surface water mobilized. Such reductions will result in a greater demand on groundwater. These effects were amplified by the poor soil organic matter.

Quantifying Climate Variability for Actual and Projected Conditions in a Large South Mediterranean Catchment

Gara A., K. Gader, S. Khelifi, M. Vanclooster, and C. Bouvier

Climate changes (CC) proved to have major impacts on the sustainable life on earth, especially for regions already suffering from water resources deficiency. In this context, most of the south Mediterranean countries are classified as hotspots for CC and the pressures induced by CC challenge reaching in this region the Sustainable Developments Goals. To provide exhaustive CC information at the regional scale, we quantify in this research the current and the projected alterations on the Precipitation (P) and Potential Evapotranspiration (PE) for the Medjerda catchment situated in Tunisia.

We used the observed daily data provided from 20 rain gauges and 3 climate stations collected from the governmental institutions. First, we used these data to calculate climate indicators from the Climdex package available in R, which permits mapping the spatial and quantitative variability for the current conditions. Subsequently, we collected CC prediction data from the CMIP5 Coupled Model

Intercomparison Project - Phase 5.

We adopted the Multi-Model Mean (MME) methodology for CC predictions and we corrected these data for bias for two emission scenarios (RCP 4.5 and RCP 8.5), by means of a linear scaling method using the observed historical data.

The metrics obtained for the current conditions showed the existence of seasonal and annual changes in average and extreme for P and PE, which is conform with the Mediterranean context. Benchmarked with the historical observed data, the projected maps for two prediction horizons 2040-2070 and 2070-2100, showed an increased frequency of dry spells and heat waves with a severe drought and climate indices when using various statistical tools. The potential projected decrease in rainfalls was more significant for the catchments situated in the semi-arid regions in the eastern part of the catchment, especially for the RCP 8.5, where we strongly suggest appropriate risk management actions to face CC impacts.

Production Gaps in Tunisian Semi-Arid Irrigated Perimeters: Diagnosis and Causal Factors ***Lasram A., R. Nciri, F. Yakoubi, R. Nabli, H. Maaroufi, and A. Maki***

Exposed to many environmental constraints, such as climate change (CC) and soil fertility loss (SFL), farms are still under optimal technical efficiency values in irrigated Tunisian areas. Nevertheless, adopting some adaptive options can improve farmer resilience and enhance their productivity.

Supposing that farmers' perceptions about vulnerability factors and adaptation intentions depend on both climate risk and technical efficiency (TE) levels, a survey was carried out in two climates contrasting irrigated areas, semi-arid and sub-humid, located in Kairouan and Jendouba governorate, respectively, to explore this hypothesis. For this purpose, analysis of relative risks and odds ratios were used.

The results showed production factors' availability was mainly the concern of farmers. Perceptions of CC, SFL, and lack of technical assistance (LTA) are independent of climate risk. However, efficient farmers were 4 and 8 as likely to think that CC and LTA, respectively, have a limiting effect on productions, compared to low efficient farmers. Positive perceptions of CC and SFL limiting effects doubled the probability of farmers' intention to change crops. Dominated options of adaptation intention are the improvement of water and inputs management for the sub-humid area and their reliability for semi-arid zones. Low technical efficient farmers have moved more towards subsidies and access to credits alternatives in addition to the use of more adapted varieties. Further efforts on raising awareness of the tangible effects of climate change are needed to boost the adoption of approved technologies improving technical efficiencies and water productivities in irrigated Tunisian areas.

Assessment of Climate Changes Impacts on Olive Production South of Tunisia ***Wassar F., H. Mairech, M. Pasqui, V. Tarchiani, and K. Naguez***

Olive groves occupy Mediterranean areas characterized as an important climate change hotspot (Cos et al, 2022) which may become particularly challenging for olive growers in this

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area (Orlandi et al, 2020). To assess Climate change impact on olive production south of Tunisia, we used precipitation and temperature data collected from Medenine station for the period between 2002 and 2012. We started with the analysis of olives phenology so we can understand the progress of olive stages during the year and build hypothesis for the possible impacts of climate. We analyzed interaction between precipitations of September-March season with olive production of the following year. We noted a clear coherence between the amount of precipitation of the season of interest and the production of olives with a coefficient of correlation of 0.86. We analyzed also the same interaction with precipitations of November-March. We noticed a strong consistency with 0.95 as coefficient of correlation. Interaction between olive production and mean maximum temperature of March-April season were also analyzed. We found a good consistency with a coefficient of correlation of -0.65. Seasons with low mean maximum temperature result in an increase of olive production quantity due to a better condition for bloom and bud development. We analyzed also relation between olive production and mean maximum temperature of September-October season. We observed a good correlation with a positive coefficient of correlation of 0.61. This is in opposition to the hypothesis that high temperature for the same period damages foliage and can cause fruit fall. We evaluated the impact of temperature of June-August season on olive production in terms of number of days with temperature above 40°C. We noticed a moderate interaction with a correlation coefficient of -0.52. June-August season correspond to fruit development stage. Temperature above 40°C may cause fruit drop decreasing therefore oliveproduction.

Keywords: olive production, climate change, temperature, precipitation, Medenine

Projected Drought under Climate Change Using Deep Learning in a Semiarid Mediterranean Region (Medjerda, Northern Tunisia)

Gader K., A. Gara, S. Khlifi, and M. Vanclooster

Water resource management is a huge challenge in climate change hotspots regions such as in the south Mediterranean region. Predicted climate change in these regions indicates precipitation decrease, temperature increase, and increase in recurrence, magnitude, and duration of extreme events. Climate hazards and natural disasters are therefore expected to increase, especially droughts. Monitoring, prediction, and risk management of drought are therefore of paramount importance for achieving the Sustainable Development Goals for Climate Change (SDG 13) in this region.

In this study, standardized climate indices such as SPI, SRI and SPEI are used to predict climate change impacts on the hydrometeorological regime of semi-arid Mediterranean Medjerda catchment in Tunisia.

Climate modeling using the statistical downscaling method was performed to obtain precipitation and temperature projections under RCP 4.5 and RCP 8.5 with the MIROC5 global climate model by 2100. Then, the conceptual hydrological model GR2m, developed under the AirGR package available for R language, was implemented for four subcatchments of the Medjerda to simulate projected hydrological behavior and the SCI package available for R language is used to calculate the standardized climate indices.

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Results show a consecutive decrease of predicted runoff and, indicating that high increase of extreme drought will be expected. This will impact available water resources of the Medjerda catchment. The results also confirm the need to implement urgently climate resilient water management strategies.

Adjustment of Crop Coefficient (Kc) of Wheat (Triticum durum) Using Remote Sensing Based Vegetation Index and effects of Climate Change Projection on irrigation in Bousalem, Jendouba Region (North-western Tunisia)

Ben Bahri I., S. Khelifi, A. Bousselmi, and A. Skhiri

The crop coefficient (Kc) is the main characteristic for determining crop water requirements in irrigated farming. In the context of climate change, the North African area faces serious challenges with continuously decreasing water resources. The aim of this work is to contribute to the development of the climate change adaptation strategy for cropped wheat in the Medjerda watershed, as a strategic sector for the country. The study was conducted in the experimental station El Kodja of The National Institute of Field Crops (INGC) located in Bousalem-Jendouba region north-western Tunisia. The monitoring of wheat growth during 5 successive cropping seasons led to adjust the Kc according to Normalized Difference Vegetation Index (NDVI), derived from sentinel 2 images, for wheat and considering the accumulation of its heat requirement. A model, estimating Kc by NDVI, is developed which allows the assessment of this coefficient from derived satellite data. Results indicate that the water requirement of wheat is 456 mm under current climatic conditions. Climate projections, under worst case scenario the RCP8.5, indicate that the decrease in precipitation would be 30% and the temperature would increase by nearly 2.9°C by 2070. Five crop management adaptation scenarios were compared: two early scenarios, the standard scenario, and 2 late scenarios. The very early scenario, corresponding to the last ten days of October, i.e. the start of useful rainfall, appears as an adaptive way for irrigated wheat. This scenario seems to be suitable in terms of water consumption considering the projected rainfall with water benefits of nearly 85 mm/year. These results could be useful to adjust irrigation scheduling and management. However, more trials in other Bioclimatic zones may be necessary for evaluation.

Special Session: DGACTA/GIZ

La stratégie d'Aménagement et de Conservation des Terres Agricoles ACTA 2050
Mustapha Louhichi

Innovation et mesures d'accompagnement de la stratégie ACTA 2050
Faouzi Harrouchi

Promotion des bonnes pratiques pour la protection et réhabilitation des sols face au changement climatique : Approches et perspectives.

Rafika Jmal

Session 3: Soil Degradation and Conservation

Monitoring of the Potential Ecological Risk of Heavy Metals Pollution in Agricultural Soil around a Phosphate Fertilizer Factory (Gabes, Tunisia)

Ben Amor A., L. Ben Miled, K. Ben Atia Zrouga, L. Ben Yahia, N. Chaira, and K. Nagaz

This study aimed to investigate the heavy metals (HMs) contamination in agricultural soils around the phosphate factory in Gabes region, Tunisia. Soil samples were collected randomly from 6 sampling oasis located in various distance from the factory. Four heavy metals; Lead (Pb), Copper (Cu) Manganese (Mn) and Zinc (Zn) were analyzed.

Various pollution indices including Contamination factor (Cf), Degree of contamination (Cdeg), Index of geo-accumulation (Igeo) and ecological risk index (ERI) were calculated to estimate the heavy metals pollution. Results showed that heavy metals were classified in increasing order of abundance as : Mn (72.22 mg / kg) > Zn (32.71 mg /kg) > Cu (28.47 mg / kg) > Pb (23.26 mg / kg).

The heavy metals were concentrated in soils near to the industrial area and causes a high contamination (Cdeg > 32) of oasis located at 4 km from the industrial area and considerable contamination of Kattena oases (Cdeg > 21.7) located at 20 km. However, the soils far 20 km from the industrial area were uncontaminated (Cdeg < 8).

These heavy metals contamination causes an ecological risk ($114.7 < IR < 234.4$) of all studied soils which decrease the soil pH and reduce the Extracellular Enzymes Activities (EEA).

KEY WORDS: agricultural soil, contamination, ecological risk, heavy metals, oasis, phosphate factory

Effect of the Cereal-Legume Intercropping on Nutrients Levels Availability and Ph Variation in Arid Region Soil

Souid A., W. Hemdi, A. Atallah, F. Telahigue, N. Hamdi, M. Moussa, I.-R. Zoghlami, and A. Bouajila

Intercropping legume-cereal is an important crop practice for improving the availability of nutrients in the soil, especially for intercropped cereal. The aim of this work was to evaluate the effect of intercropping systems cereals (durum wheat)-legume (chickpea) on pH soil variation, plants growth, nitrogen (N) and phosphorus (P) acquisition through root-induced processes in arid soil of South Tunisia. A split plot experiments with triplicate repetitions were carried in the experimental station of the Arid Regions Institute (IRD) of Medenine. At the full vegetation stage of durum wheat and chickpea, three soils samples were

carried in layer surface for each experimental plot. After dried and sieving of 2mm, the following soils analyses were carried: PTotal, POlsen, Ntotal and pH soil. The results showed that the levels of PTotal, POlsen and N in the durum wheat intercrops rhizosphere increased around 28, 5 and 15% and around 94, 36 and 72% than durum wheat monoculture and bulk soil respectively. Besides, for the rhizosphere of chickpea in intercropping, it can be revealed that the rates of PTotal, POlsen and N were increasing about 3, 16 and 1% and about 94, 49 and 68% than chickpea monoculture and bulk soil. Furthermore, it can be seen that pH decrease (5%) in the rhizosphere of chickpea in intercropping than soil bulk.

KEY WORDS: intercropping, durum wheat, chickpea, Nitrogen, phosphorus, pH.

Assessment of Water Erosion Processes and Control Using RUSLE

Hadj Taieb A., Louis Evence Zougrana, M. Mimouni, F. Joumade Mansouri

The North Africa region is suffering from a long drought episode, erosion and climate change, where predicted impacts are of significance on natural resources, agriculture productivity, socio-economic implications and processes of desertification.

Therefore, reliable information on water erosion will support the north Africa region to mitigate damage and impacts of water erosion.

Water erosion is a very sensitive to both climate and land use in the North Africa region, where the situation is aggravated in recent decades under anthropogenic practices and of climate change effects.

The North Africa region is particularly prone to erosion because it is subject to long dry periods followed by heavy bursts of erosive rain, falling on steep slopes with fragile soils.

Water erosion is one of the most critical factors responsible for land degradation. This leads to deterioration and a loss of soil capital especially in agricultural areas which are characterized by a high vulnerability to erosion.

The aim of this study is the assessment of the vulnerability to water erosion using RUSLE model which was used to spatially quantify the rate of erosion in a watershed unit after the introduction of several scenarios in order to protect soil. The model outputs help to identify the most vulnerable farmlands and hence develop an action plan to their protection against erosion and the installation of the appropriate tools to reduce the soil erosion.

The study showcases the operational use geospatial technologies in deriving individual RUSLE factors, placing an emphasis on related successes and challenges. The quantification of erosion has shown the efficiency of the vegetation cover in the fight against erosion control compared to physical developments. Despite the challenges raised by data availability, the study targeted the improvement of understanding of the role played by such technologies in deriving RUSLE.

What Drives Wind Erosion in Barley Cropped Areas? The Example of Southern Tunisia

Bouet C., M. T. Labiadh, S. Sekrafi, M. Ltifi, B. Marticorena, and J.-L. Rajot

Wind erosion is the entrainment of soil particles by wind. It is a natural phenomenon occurring mainly in arid and semi-arid areas of the planet. It is modulated by climate (wind, precipitation) and soil surface properties (soil texture, vegetation cover...). In areas where anthropogenic activities develop, wind erosion is a serious environmental problem that

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threatens sustainable development and population wellness. Accurately evaluating wind erosion processes is then important for reducing the risk of impoverishment of soils and dust emission. This requires to document at the same time the dynamics of wind erosion, meteorology, and surface properties.

In the Maghreb, wheat and barley are the major cultivated cereals. The aim of this study is to document wind erosion occurring in a traditionally cultivated barley field and its drivers. To do so, an experimental field campaign was conducted in southern Tunisia during agricultural year 2015-2016, and meteorological parameters, surface characteristics, and wind erosion fluxes were simultaneously measured.

The major result is that wind erosion in the barley field mainly occurs after harvest: 97% of wind erosion fluxes were measured between mid-May and November 2016. This was explained by the cycle of barley crop and the practices. Barley is sown in fall after a rainfall and the soil is immediately ploughed creating clods, which increases the aerodynamic roughness length. Next vegetation grows, and reaches its maximum of development in spring. So does the aerodynamic roughness length, which is then the highest when wind speed is the highest, preventing wind erosion in the barley field. Late April-beginning of May, during harvest, the entire plant (ears and stems) is torn off, leaving the soil almost bare and trampled, thus very prone to wind erosion.

Impact of Organic Amendments from Date Palm Residues on Water Retention Properties of Two Coarse Texture Soils

Le Guyader E., X. Morvan, M. Gommeaux, V. Miconnet, B. Marin, M. Moussa, N. Karbout, I.-R. Zoghalmi, D.-S. Intrigliolo, and M.-J. Iniesta Delgado

The dryland soils of North African region present low fertility and productivity due to low organic matter content. Date palm residues are an abundant resource in these regions and only a minor part is recovered in oasian agroecosystems. ISFERALDA project – Improving Soil FERTility in Arid and semi-arid regions using Local organic Date palm residues – aims at developing the use of organic amendments based on traditional production (composting and pyrolysis) as a key tool to improve soil fertility and soil properties.

The objective of this study is to quantify the effects of compost and biochar based on date palm residues on the water retention of two soils sampled in a semi-arid Mediterranean area of southeast Spain.

These 2 soils have properties similar to soils present in the oasis of North Africa. The different types of organic amendments were tested: compost alone, biochar alone and mixture of compost and biochar

(50/50). They were tested at different application rates: 30 and 60t/ha. Water content has been measured for different matric potential from the saturation to the permanent wilting point using pressure membrane apparatus.

The data is currently being acquired and will be analyzed and presented during this presentation.

Use of Mycorrhization and Biochar Amendment as a Strategy for Improving the Drought and Salinity Tolerance in Date Palm (*Phoenix dactylifera* L.)

Jaiti F., I. Benaceur, Abdelhi Dihazi, K., and R. Meziani

Intensive agricultural use of soils along with changing climatic conditions threatens global food security, which calls for new environmental approaches that build up soil health and resilience. Biochar, a product of thermochemical biomass decomposition under poor oxygen conditions has been proven by scientists as a potential mitigator of soil degradation and climate change impacts. Our study focuses on the evaluation of the impact of amending a substrate with biochar derived from Moroccan biomass crops including date palm, argan and olive trees on the growth and development of date palm seedlings grown under salinity conditions. The findings shew a promising response of Majhoul variety which is known to be sensitive to abiotic stresses since the studied parameters in both of the studied varieties (Boufeggouss, tolerant and Majhoul, sensitive) showed almost the same reaction at the end of the trials in lots supplemented with biochar, which is reflected not only by physiological and biochemical parameters but also visually. On the other hand, the sensitivity is easily noticeable in the Majhoul control lot.

In addition, the area of cultivation of date palm is increasing more worldwide and is done in areas where the conditions of culture are unfavorable (poor soils, lack of water). Therefore, the introduction of the technique of mycorrhization of vitroplants to be planted in these new farms increases their survival and recovery rates and also protects them against drought given their fragility. The three-year follow-up of a field trial in the TATA region (southern Morocco) showed that under water-limited conditions, the recovery rates of mycorrhizal vitroplants were significantly higher than those of control plants with an improvement in their growth and development. The combination of these two biofertilization techniques will be of great interest for the improvement of the soil quality and thus the production of the date palm.

Nutrient Management: A Way for Dealing with Low Soil Fertility in Semi-Arid Cropping Systems in Morocco

Boulal H., M. El Mourid, and M. El Gharous

Dryland agriculture covers main parts of Moroccan areas. It is largely subsistence farming with lower rainfed production. The present review is an overview of the most findings on soil fertility and nutrient management in dryland areas of Morocco. In semiarid regions, the depletion of soil nutrient decrease soil fertility, limit crop production and reduce water productivity. The present review on soil fertility and nutrient management showed that most of research were developed in the 80's and 90's followed by some initiatives in the previous 10 years. Past research on nutrient management in dryland areas of Morocco has produced few data. In consequence it has not been possible to establish any rational basis on fertilizer use based on the 4Rs nutrient stewardship. Lack of information on nutrient dynamic in the soil, on crop nutrient uptake and how these are related to soil nutrient status, shows that it is a need on further research on nutrient management for specific sites and crop related to water

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limiting factors. As fertilizer sources based on N and P are now common in dryland areas of Morocco, more attention is needed for K.

The common conception is that soils are rich in K and it is no need to apply K in semiarid areas. However, soil analysis results and on-farm trial on omission K plots of wheat undertaken in the last 10 years have proved recently that omission K has significant effect on grain yield of wheat. The evidence concluded through this review showed that the domain of soil fertility and plant nutrition in Moroccan dryland areas need further research. There is a need to develop interpretation norms and new or adapted fertilizer formulations in order to provide farmers with tools and alternatives to improve nutrient use efficiency.

KEYWORDS: Dryland, Morocco, soil fertility, nutrients

Impact of Biochar Derived from Green Waste on Physical-Chemical Soil Properties in Arid Land Soil of Medenine

Lamourou H., N. Karbout, Z. Zriba, I.-R. Zoghlami, A. Bennour, M. Ouessar, and M. Moussa

A third of the planet's land is severely degraded, and the soil lost her fertility at a speed that threatens the health of the planet and the civilizations that depend on it. In recent years, organic fertilizers have been attracted attention due to the increasing quantity of waste and the important role of organic amendment in improving physicals, chemicals and biologicals properties of soil.

Biochar as an organic environmentally friendly amendment has received extensive attention for its capability to improve soil fertility.

The main goal of this work is to investigate the effect of green waste biochar on chemical soil properties in arid land. The biochar production and its characteristics, including feedstocks used and different process-parameters (pyrolysis temperature, residence time ...) are thoroughly examined. In this work, two different doses were applied: 20 t ha⁻¹ and 40 t ha⁻¹. The study concluded that the use of biochar as organic amendment increases the soil organic carbon concentration and through their role in influencing soil physical properties. Then, biochar as an organic multi nutrient fertilizer caused an increase at the amount of available N, P and K in soil.

Also, the application of biochar as an organic amendment decreased the bulk density of the soil.

Keywords: biochar, organic amendment, organic matter, environmentally friendly.

Short-Term Effects of Olive Mill Wastewater Land Spreading on Soil Humic Acids in Arid Regions

Ben Mbarek H., R. Chaker, C. Mbadra, H. Rigane, I. Ben Mahmoud, P. Charzynski, and K. Gargouri

Few studies have assessed the changes in soil quality based on humic acids (HA) in relation to the application of fresh olive mill wastewater (OMW) obtained from a new generation three-phase oil extraction on HAs in real conditions. The purpose of this study is to evaluate if OMW is suitable for the sustainable increase of soil quality with increasing soil humic



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structures. To make a contribution in this context, an experimental field was established in south-east Tunisia. According to the World Reference Base for Soil Resources (WRB 2015), the studied site soils were classified as Regosols with sandy loam texture. The experimental field included: a control soil, a soil treated with 10 l·m⁻² OMW, and another amended with 10 kg·m⁻² manure. Soil samples were collected from soil depths of 0–20 cm, 20–40 cm and 40–60 cm at the beginning of the experiment (day 0) and after four months (120 days). Results found that soil treated with OMW had the highest soil organic matter (SOM) content (1.42±0.13%), CEC (3.03 ±0.51 meq·100g⁻¹) and soil pH value. OMW mineralisation supplied soluble ions which enhanced the electrical conductivity (1.44 ±0.34dS m⁻¹). Infrared spectroscopy showed higher aliphatic, aromatic and phenolic groups in OMW amended soil than the manured soil for initial and final dates. Short-term OMW application improved the quality of SOM in sub-surface soil layers, especially in soil surface (0–20 cm). Spreading OMW on soils provides a favourable environment for the improving HAs via the recycling of organic matter and enhancing properties by transferring aromatic and aliphatic structures into deeper horizons, which in turn increases sequestration of SOC. This study showed the usefulness of controlled spreading of OMW on the agricultural land of arid area which indicated by improved soil fertility and HAs.

Effects of Municipal Solid Waste Compost as Soil Amendment on the Distribution of Heavy Metals in a Sandy Soil

Oueriemmi H., P.-S. Kidd, P.-F. Angeles, and M. Moussa

The application of municipal solid waste compost (MSW compost) may serve to enhance soil physical and chemical properties and soil fertility by increasing organic materials. However, these wastes may also have some potential risks to human health and to the agricultural environment due to their metal content. The aim of this study was to evaluate the effects of MSW compost on soil fertility and the distribution of heavy metals in soil. MSW compost was applied in Sandy soil, at doses equivalent to 0, 20, 40 and 60 t ha⁻¹. The compost was produced under aerobic conditions by mixing a separated organic fraction of household rubbish with green garden waste.

A field study, had been conducted at the experimental field station of the Arid Regions Institute, located in southeastern Tunisia, northeast of the city of Medenine.

The fractionation of heavy metals in the soil was evaluated after one year using a sequential extraction procedure.

Results showed that studied parameters changed significantly with MSW compost dose. Indeed, the incorporation of MSW compost was found to increase soil total organic carbon, DOC, nitrogen, phosphorus and potassium concentrations. Total concentrations of heavy metals in the soil were slightly higher in treated soils. They remained within the normal thresholds.

The distribution of heavy metals between the different fractions in control and amended soils showed the residual fraction to be dominant. The most important changes in fractionation of the elements were observed in the MSW-treated soil. This organic amendment induced increased labile fractions (acid-extractable and reducible) of Co and Ni. The effect on the



reducible fraction (F2) was observed with the medium and high dose of the amendment. MSW compost increased the absolute amount and proportion of acid-extractable Cu. Overall, the MSW compost as organic amendment can be used to improve soil fertility in sandy soils.

Exploring the Potential of Super-Absorbent Polymer and Biochar as Water-Absorbent Amendments for Drought Resilient Sandy Soils

Ibrahimi K., R. Aloui, W. Saadaoui, and N. Tarchoun

Water-absorbent soil amendments are advocated especially for low water retentive sandy soils and drought prone environments. These amendments are considered as a promising adaptive soil management under climate change. Here we investigated the efficacy of super-absorbent polymer (SAP) and biochar (BC) in enhancing soil water retention and alleviate water stress. Two levels of SAP (SAP1: 0.1%, SAP2: 0.2%) and BC (BC1:2%, BC2: 4%) were applied on a sandy soil in a pot trial. Germinated seeds of faba bean (*Vicia faba*) were sown in these pots and water-deficit stress was applied one week later. Soil water evaporation was monitored at daily basis during the first 10 days of experiment. Additionally, performance of selected physiological and morphological traits of faba bean was evaluated during and at the end of the experiment. Results showed that cumulative water evaporation decreased from soils amended with SAP1, SAP2 and BC2 compared to control suggesting that these amendments can be used to increase the amount of water available to plants. No difference in cumulative evaporation was found between BC1-amended and control soils. The application of SAP and BC significantly and positively affected most of the studied faba bean traits. Compared to control, higher number of leaves and flowers per plant and larger stem diameter were observed under SAP and BC treatments regardless of the applied dose. Belowground biomass weight significantly increased by 222 and 200% under SAP1 and SAP2, respectively, while BC application did not induce a significant change in this trait compared to control. Moreover, it was found that flavonoids and phenolic content in faba bean shoots were in the decreasing order: Control > BC1 > BC2 > SAP1 > SAP2. These findings suggest that SAP and BC application improved the self-defense system of faba bean against water-deficit stress.

Application of Biochar Derived from Sewage Sludge Pyrolysis at Different Temperatures on a Sandy-Loam Alkali Soil: Effect on Carbon Sequestration, Barley Growth, and Other Selected Properties

Zoghلامي R.-I., R. Weghlani, S. Hechmi, Y. Suidi, H. Oueriemmi, H. Lamourou, Y. Zarrouki, and M. Moussa

Biochar derived from biomass pyrolysis has been widely used as a soil amendment to increase soil carbon sink (C) and enhance crop production. However, the effects of biochar produced at different pyrolysis temperature on soil C sequestration, soil chemical properties, and crops yield was seldom highlighted. Therefore, a microcosm study was assessed using sewage sludge wastes as the raw feedstock and biochar derived from sewage sludge (SS) pyrolysis at a different temperature: 260° C (PSS1), 420° C (PSS2), and 610° C (PSS3) at equivalent field rate of 20 t-ha⁻¹. The aim was to monitor the effects of different pyrolyzed sewage sludge on

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a sandy-loam alkaline soil in terms of CO₂ emissions, soil carbon sequestration (SCS), barley growth. The microcosm study demonstrated that pyrolysis temperature significantly affected biochar characteristics compared to the raw feedstock (SS). The pH of SS increased from 6,74 up to 7.8 in PSS2 and 9.11 in PSS3. On the other hand, as the pyrolysis temperature raised OM and N levels decreased remarkably in the following order: SS < PSS1 < PSS2 < PSS3. The soil amended with PSS2 (S+PSS2) and PSS3(S+PSS3) had the lowest carbon dioxide (CO₂) emissions and so higher C sequestration (SCS). The highest CO₂ levels were recorded in S+SS which was related to the intense activity of carbon microbial biomass (CMB). Trace elements (TE) namely, Zn, Pb, Cd, Cu, and Cr increased in all amended soils with respect to soil control (C). As such, S+SS and S+PSS1 showed higher TE contents regarding S+PSS2 and S+PSS3. The highest fresh weight and dry weight of barley were also observed in PSS2 reaching 2500 Kg·ha⁻¹. Overall, biochar derived from sewage sludge pyrolysis at 420°C (PSS2) showed the greatest potential to mitigate greenhouse gas emissions, increase C sequestration and enhance barley production in alkaline arid soil.

Joint Effect of Non-Tillage and Crop Rotation on Dynamic, Kinetic and Phosphorus Mineralization Potential, under Semi-Arid Tunisia Climate

Boudabbous K., R.-I. Zoghlami, M. Barbouchi, K. Abida, and N. Ben Aissa

In regions with weathered soils, the adaptation of non-tillage with crop rotation subject to phosphorus deficient merits more consideration to explain the P availability (P). To fill in such a gap in knowledge, this study was carried out to evaluate changes in dynamic (Pd), kinetic (Pk) and phosphorus mineralization potential (Pm) by seven (NT7) years of applying non-tillage (NT) as compared to conventional tillage (CT). Two crops rotations were adopted, wheat/faba bean (W/F) and faba bean wheat (F/W). The field experiment was established under rain-fed conditions on a clay loam soil in a dry subhumid zone of North Tunisia. Soils cores were collected each month at 0-10, 10-20 and 20-40 cm depths during the growing season.

Overall, our investigation revealed that all studied parameters depended significantly ($P < 0.05$) on tillage, crop rotation and their interactions, in particular at the top 10 cm soil layer. For the dynamic of available phosphorus, we registered the highest phosphorus amount at the beginning of crop season under non-tillage plots with more than 18 ppm. More interestingly, the obtained cumulative levels of mineral phosphorus occurred the maximum concentrations at 0-10 cm compared to the two others soil layers under NT system (66.51 ppm).

Nonetheless, the Pk reached the highest content for CT for the two crop rotations. The results suggest that both non-tillage system combined with W/F rotation offers some improvements in P availability in weathered soils of northern Tunisia, particularly at 0-10 cm.

KEYWORDS: Non-tillage, crop rotations, phosphorus dynamics, kinetic, potential mineralization

The Use of Olive Mill Wastewater as Biofertilizer to Reduce Land degradation

Dbara S., A. Ouni, S. Abboud, A. Sebai, and K. Lahmar

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In Tunisia like Mediterranean countries which produce olive oil large volumes of liquid effluent are generated from agro-food industries.

These olive byproducts should be appropriately managed. In last years the olive mill waste water (OMWW) are used in the agriculture and it employed as biofertilizers. It is widely used by spreading on orchards to reduce land degradation and rehabilitation. The present research evaluates the impact of the stored OMWW on soil and plant growth.

Results show that the storage of OMWW leads to modify its chemical properties particularly the decrease of phenols. The olive plant amendment improves growth and soil properties. An increase in organic matter and minerals are noted.

Key words: Olive mill waste water, biofertilizer, plants, soil.

Impact of Drought and Saline Water Applied for Olive Trees (*Olea Europaea. L*) on Soil Fertility under an Arid Climate

Trabelsi L., K. Gargouri, H. Ben Mbarek, C. Mbadra, M. Ghrab, A. Ben Hassena, and R. Gargouri-Bouzid

Water scarcity and the increasing water demand for irrigation in olive orchards are leading to adopt deficit irrigation approaches and the use of saline water. Field experiment was conducted on twenty six years old olive trees (*Olea europaea* L. cv. Chemlali) grown on sandy-silty deep soil and drip irrigated with saline water (EC 7.5 mScm⁻¹) under arid Mediterranean climate in southern Tunisia. Five irrigation treatments (i) Rain-fed, (ii) FI: full irrigated with saline water, (iii) PRD: partial root-zone drying were applied and supplied 50% of the FI with an alternate irrigation switched every 30 days, (iv) RDI: regulated deficit irrigation, that supplied 50% of the irrigation water applied in FI and (v) TW : full irrigated with tap water (EC 2.46 mS cm⁻¹). The main objective of this study was to investigate the effects of saline water irrigation on soil fertility.

The results showed that soil organic matter (OM) increased from 1.21% observed for the upper soil horizon (0-20 cm) to 0.69 and 0.91% for mid (20-80 cm) and deep layers (80-220 cm), respectively. The potassium, phosphorus and nitrogen increased gradually with the application of irrigation. Similar evolution of Ca profile was observed in all treatments at the end of experimentation. Irrigation and deficit irrigation with saline water maintained the soils permeability, induced the distribution of salts outside the root zone.

Then, maintaining an adequate hydration of the rhizosphere through continuous and efficient leaching of salts to deep horizons. This practice is an alternative solution to improve soil fertility.

KEY WORDS: *Olea europaea*. L, arid climate, drought, saline water, deficit irrigation, soil fertility.

Windblown Loss of Topsoil from Agricultural Lands under Different Tillage Systems During Aeolian Erosion

Labiadh M.-T., G. Bergametti, J.-L. Rajot, C. Bouet, M. Ltifi, S. Sekrafi, T. Henry des Tureaux, and H. Khatteli

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In the last years, several studies have demonstrated that wind erosion intensity varies with the surface land cover. In northern China, Zhang and Dong (2014) showed that sediment transport by wind differed among surfaces, with the greatest transport being observed above mobile dunes, followed by cultivated land, semi-fixed dunes, fixed dunes and a shrub community. In the Sahel (eastern Niger), Abdourhamane Touré et al. (2019) drew the same conclusions: saltation fluxes produced on a mobile dune is 2 to 40 times higher than on a cultivated field and a rangeland, respectively.

The south of Tunisia is a region very prone to wind erosion because the soils are sandy and shallow, the vegetation sparse, and precipitation scarce. The region also presents a variety of landscapes and land uses on a relatively small area: 5 types of cultivation and 6 types of rangelands in the 4 southernmost Governorates (Tataouine, Medenine, Kébili, and Gabès; ~77 676 km²) (Labiadh et al., 2011).

This region thus represents a unique opportunity to study wind erosion intensity on different types of land surface, but also on different types of land use. This is why, from November 2012 to June 2016, six sites were instrumented to monitor wind erosion in the most extended land uses existing in southern Tunisia.

The main results are that wind erosion: (i) is nil in oasis, (ii) is weak in olive grove even if the surface may be ploughed up to 8 times a year, (iii) is moderate in barley field even though the surface is tilled using a disc plough and left almost bare following harvest, (iv) may be important in the Chott except when it is flooded, (v) is intense in rangelands, with higher wind erosion fluxes being measured on rangeland on sand than on rangeland on flat bed.

Short-Term Effects of Organic Amendment Source on Total Carbon and Total Nitrogen in Loam Soils (SE Tunisia)

Chniguir N., A. Bouajila, Z. Omar, and S. Mahmoudi

Arid and semi-arid ecosystems are vulnerable to soil degradation, which decreases quality and productivity. One strategy for restoring degraded soils in semi-arid regions is the application of organic amendments. Therefore, the aim of this work was to study the short-term effects of organic amendments on the physico-chemical properties of loamy soil (South-East of Tunisia). For this, three organic treatments were applied consisting of Poultry droppings and citric acid fertilizer (C1), date palm waste compost (C2), and a mixture of date palm waste with cow manure (C3). After different periods (three, six, twelve, and twenty-four months) soil properties, especially the electrical conductivity, pH, the total organic carbon, and the total nitrogen, were evaluated at the depths of 0-10 cm and 10-30 cm. Results indicated that organic amendments improved significantly all soil properties compared with control soils. SOC and TN contents in the twice soil layers increased considerably with organic amendment compared with unamended soils. The effects of different studied amendments on the dynamics of SOC and TN contents, at the experimental site, after one and two years were broadly similar. SOC content increased from 0.13 % in the control soil to 0.97 % ,0.5 % and 0.22% after three months of C2, C1 and C3 treatment, respectively.

Furthermore, the SOC and TN contents decreased slightly with time in the upper layer, which can be due to the important mineralization rate. However, in the lower depth, SOC and TN

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contents increased significantly after two years in which the most important contents were obtained. This effect can be explained by the migration of carbon and nitrogen in the lower horizon, with time. These results together suggest that all treatments had an important effect on the soil quality. (C1) and (C3) were the best treatments for short-term restoration of degraded soils in a semi-arid environment.

Investigation of Mechanisms of an Upflow-Downflow Siliceous Sand Filtration System for Surfactants Bathroom Grey Water Treatment

Chaabane S., Khalifa Riahi, Béchir Ben Thayer, S. Anibi

Sustainable Decentralized Wastewater Treatment Systems (DEWATS) at the local level are considered as a smart alternative for small communities. Among these DEWATS, sand filters appear to be efficient and contributing to community well-being particularly in arid areas. The present study examines the mechanisms of an upflow-downflow siliceous sand filtration system involved in surfactants bathroom grey water treatment. Once grey water pre-treatment system has been conducted, optimization of an upflow-downflow and vertical sand filtration system were operated to ascertain the average surfactant removal efficiencies. In order to get a better understanding of the mechanisms involved in surfactant removal, particle size distribution and IRTF spectroscopy analysis were performed on the surface of these solid matrixes. Results indicate that resulting silicate materials react with surfactant cations in a cooperative assembly process involving the interaction of silicates with surfactant aggregates. BET surface area, pore volume and pore size were found to be significantly reduced post-filtration with respectively 3.39%, 24.31% and 21.86% reduction. From IRTF spectroscopy analysis of the thiones, sulfonates, sulfures, silanol functional groups, CH₃ head group and CH₂ in-chain IR vibrations, the surfactant appears to be complexed or micellised. Such siliceous geo-materials could be green and sustainable for various applications in environmental engineering.

Estimation of CO₂ Emission from an Amended Soil under Arid Condition

Chaker R., H. Ben Mbarek, S. Maktouf, J. Bouzid, and K. Gargouri

Organic amendment application is an efficient technique that could contribute to stock organic C in soil reducing CO₂ and enhancing soil fertility. However, some types of amendments increase CO₂ emission from soil as soil respiration. Modeling soil respiration after addition of exogenous organic matter will help to provide carbon fates and then to choose the most efficient amendment.

Empirical method was used to develop a pseudo-empirical model based on soil wealth and composition of organic matter. These data were obtained during an incubation experiment. The obtained model simulated immediate CO₂ emission from the soil in controlled and natural conditions following carbon input basing on the chemical and biochemical compositions of the organic matter applied in the soil.

The simulated values showed an excellent correspondence with the amounts of CO₂ emitted from an arid soil after organic matter application. This model allowed a good prediction of the exogenous organic matter mineralization. Moreover, it can be used to predict CO₂ emission,

as a greenhouse gas, from the soil following exogenous organic matter input. Nevertheless, this empirical model can only be applied in areas with the same climatic characteristics.

Improvement of Degraded Agricultural Soils after Short and Long Period of Municipally Treated Wastewater Irrigation, Tunisia (Gabes) in Humid Season

Werheni R., Y. Hidri, F. Soud, F. Hajjaji, H. Abdennaceur, M. Moussa, and S. Eturki

This study pointed to training the short, medium, and long-term impacts of the municipally treated wastewater, named as secondary treated wastewater (STWW), application on physical, chemical, biochemical and microbiological soil properties. Three tentative fields were irrigated with (STWW) for 1, 7 and 15 years, respectively. A pluvial irrigated field was used as control. The study was conducted in El Hamma of Gabes, an arid area facing a secondary wastewater (East-south of Tunisia), at the end of the humid season. Three soil profiles at 0–20, 20–40 and 40–60 cm were sampled. Physical and chemical analysis including pH, electrical conductivity, total organic carbon, were evaluated. Soil microbial biomass C and N were performed according to fumigation-extraction method. Soil microbial contamination was controlled by determination of total and Fecal Coliforms, *E. coli*, and Fecal Streptococci with the most probable number (MPN) method and plate medium count. Bacterial and fungal enumeration was done by the plate count agar method. In addition, the DGGE molecular analysis was also assessed on the different soil samples.

Potential Use of Olive Mill Wastewater Spreading in Olive Orchards for Improving Soil Fertility, Yield and Olive Oil Quality under Semi-Arid Environment

Abboud S., A. Ouni, and S. Dbara

Land and water are the most fundamental resources for food production systems. However undeniable climate change and frequent periods of drought in the Mediterranean region will exacerbate water scarcity, threatening the sustainability of agricultural production. In Tunisia, olive growing and olive oil production represent a key element of the agricultural and economic sectors. Furthermore, olive producing areas are mostly located in semi-arid and arid regions with low water availability. On the other hand, olive oil industry generates high liquid effluent volumes (olive mill wastewater (OMW)) that represent a major environmental concern, and therefore must be appropriately managed. Accordingly, spreading OMW on agricultural lands in water scare areas may help to sustain drylands productivity. In this study, we investigated the long-term effects of OMW spreading to an olive orchard in a semi-arid region. Physicochemical and biological properties of soil as well as yield and olive oil quality were monitored. OMW was applied, after the end of the olive milling season, at annual doses in the range of 50–70 m³ ha⁻¹ y⁻¹ every two years. The findings revealed that the OMW application increased soil water content. Moreover, OMW positively affected soil fertility, increased, soil organic matter, nutrient contents and biological activity. The overall results of this study indicate that OMW spreading at doses of 50–70 m³ ha⁻¹ y⁻¹ in a semi-arid region improves soil physicochemical properties and does not have a negative impact on yield and olive oil quality. Additionally, direct spreading of

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OMW, if applied every 2 years, could be a sustainable practice in olive orchards under semi-arid environments.

KEYWORDS: Olive mill wastewater, spreading, soil, olive oil quality.

Assessment and Monitoring of Soil Degradation and Yields in the Agricultural Areas of Skhira-Golf Gabes using a Statistical Approach: Spatial Interpolation and Principal Component Analysis

Souidi Y., M. Bagues, H. Ben Mbarek, I. Ben Mahmoud, H. Oueriemmi, H. Rigane, and M. Moussa

Crop rotation takes more than seven years after a tunnel cultivation of watermelon in order to recover soil properties. This phenomenon is known in Tunisian arid environments. In the Skhira region, the cultivation of sub-tunnel cucurbit crops relies excessively on chemical fertilizers. Therefore, lands cultivated for this agriculture have decreased every year. The main aim of this investigation is to determine the effects of excessive fertilizers (Chemical or/and organic) and irrigation water quality on soil with using a spatial survey of the watermelon culture, through a survey with 50 farmers in Skhira-region, which were planted in 2017. An analytical study of soils, as well as their effects on watermelon yield accompanied these surveys. During this study, we concluded that, the most responsible factor for the variation of watermelon yields is the soil salinity such that the electrical conductivity reaches 8.630 (mS/cm) in some soils. Additionally, the water used for irrigation in this region is already very salty, such that the electrical conductivity reaches 9.040 (mS/cm). This increased salinity can affect directly the watermelon yield, by sodium and chloride ions, and indirectly, by affecting the soil microbial activity. Fortunately, the soil texture is almost sandy over most of the surface of this zone, which favors the infiltration of salt towards the depth by precipitation. However, it takes a lot of time (after many years) because arid environments are known to have low annual rainfall. That explains our problem concerning "The rotation of cultures which takes at least seven years, after a sub-tunnel culture of watermelon". Therefore, it is necessary to find a solution or type of effective treatment for this high salinity in arid environments and especially that the phenomenon of global warming and droughts increases from one year to the next.

KEYWORD: Soil quality, fertilizers, Irrigation, Salinity, Watermelon yield.

Effects of Long-Term Tillage on Soil Organic Matter Humification in Soil Profiles Under Arid Climate

Ben Mahmoud I., H. Ben Mbarek, A. Sanchez, M. Medhioub, H. Rigane, and K. Gargouri

This study aims to assess the effect of intensive tillage on the humification degree, variations in molecular structures of HAs and physic-chemical properties along soil profile of an arid soil in south-eastern Tunisia.

Soil profiles from fields tilled for 100 years were compared with profiles from zero-tillage soils. Soil samples were taken from layers between 0-180 cm depth under tilled profile (TP) and no-tilled profile (NTP) to determine pH, Electrical Conductivity (EC), Cation Exchange Capacity (CEC) and SOM content. Humic acids (HAs) were isolated from two layers for TP

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and NTP. UV-visible ratios (E465/665, E280/664 and E472/664) and fluorescence spectroscopy were used to study soil HAS.

Results showed that pH and EC were higher in TP but SOM and CEC were higher in NTP. Tillage reduced SOM amount, molecular size, aromatic condensation and humification degree confirmed by UV-visible and fluorescence spectroscopic analyses. The SOM amount and the humification degree were higher in the surface layer of NTP compared to TP, improving a high degree of condensed aromatic structures.

However, higher aliphatic structures, mainly polysaccharides, are dominant in TP. Inversely, in deep layers, results showed a greatly humified organic matter and aromatic structure condensation in TP.

Farm Manure Combined with Sandy Amendments Improve Soil Fertility and Barley Production in Different Oasis Topography in Arid Regions

Zriba Z., N. Karbout, H. Lamourou, F.-E. Ben Azaiez, H. Bousnina, and M. Moussa

The oases of Nefzaoua located in the south of Tunisia, like all continental oases, are never in balance with their environment, they suffer from soil degradation. To survive, they must constantly defend themselves against silting up, lack of water and poor soil. Their protection can be done by several methods of bonusing.

Thus, to cope with soil degradation and restore crop productivity, oasis farmers resort to amendments using sand and manure treatments.

To study the effect of different amendments on soil fertility, irrigation parameters and barley yield, three treatments (control (C), sand amendment (T1) and combined amendments composed of sand and manure (T3)) were applied in two oases having a different topography (oasis of Negga at an altitude of 20 meters and the oasis of Menchia at an altitude of 40 meters). The results showed that T2 improved the yield parameter compared to the control treatment in the two oases, thanks to the improvement in the concentration of total nitrogen, soil organic carbon and therefore the C/N ratio for the T2 treatment at the level of the layer 0-20 cm. The results showed that the application of the T2 treatment improved the irrigation dose to be applied for the barley crop compared to the control treatment and the T1 treatment. Our results obtained confirmed the effectiveness of the combined amendment composed of sand and manure in improving the fertility and productivity of the amended oasis soil.

Effect of Urbanization on the Evolution of Soil Salinization in the El Fejja- Mornaguia Region Application of the Hölder Multi-Fractal Approach

Hmidi O., N. Brahim, and Z. Ben Dhiarf

The urbanization at the level of the delegation of Mornaguia is essentially of a residential nature, which triggers the installation of a housing center and a continuous commercial activity, currently forming going from upstream to downstream of the catchment area of Chafrou, large urbanized areas which were previously agricultural soils occupied by market gardening and arboriculture. Our study site is an agricultural plot of cereals affected by salinity located in El Fejja-Mornaguia, it is a mini watershed of Oued Chafrou. We studied the spatio temporal degradation of soil type according to aerial mapping based on the Holder multi-fractal approach,

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contrast adjustment, K-means segmentation and unsupervised classification of aerial photos dating from 30 years. By following a toposequence consisting of three soil profiles P1, P2 and P3 500 meters apart and in an East-West direction, in the heart of the plain and parallel to the A3 Tunis-Medjez el Bebb motorway. Our soils evolve whose classes change from the class "alluvial contribution soil" to the class of "saline soils" or commonly have transformed over time into a salsodic soil. The salinity measurement of the three profiles is respectively 17; 125 and 20 mS/cm. These values prove that the winter hydromorphy, the non-maintenance of the drains and the evolution of the geomorphology of the plain are the cause of this degradation.

KEYWORDS: Urbanization, Agricultural plot, Soil salinity, Hydromorphy, Chafrou watershed, Holder multi-fractal tool, Mornaguia

DAY 3: 16 June 2022

Session 4: Environmental Monitoring and Assessment in Drylands

Sentinel-2 Data for Land Use Mapping: Comparing Different Supervised Classifications in Semi-Arid Climate, Nord-Est Area Case of Zaghouan, Tunisia

Abida K., M. Barbouchi, K. Boudabbous, K. Saad, Z. Ben Rabeh, and H. Bousnina

Accurate land use maps using satellite imagery can be effective tools for managing the soils potential throughout the year and monitoring its fertility. Optical remote sensing image are used to be useful for mapping land use and land cover. The principal objective of this study was to classify land use using supervised classification methods and to compare the efficiency of the different machine learning methods.

In this paper, the optical satellite image sentinel-2 was taken at four singles dates (January April, June and August). The study area in this research is located in the Nord-Est area of Tunisia, governorate of Zaghouan (Smenja). For land use mapping, we tasted four algorithms of machines learning models: Random Forest (RF), K-Decision Trees K-nearest neighbors (KDTree-KNN) and Minimum Distance classification. This research showed that the RF classification provided better results with the mean square error (RMSE) =0.4 compared to others classification models. According to season, we obtained the best outcomes at the beginning of autumn with an overall accuracy = 96.8% for the RF classification, while the minimum of the overall accuracy (=53.1 %) was observed at winter for Minimum Distance classification model with RMSE = 1.233. The investigation highlights that Random forest classification is more efficient using sentinel-2 image with an optimum accuracy at the beginning of autumn.

KEYS WORDS: Sentinel-2, land use, Soil Mapping, supervised classification, machine learning

Using Sentinel-2 Satellites for the Change Detection of Shallow Bathymetry: The Case Study of Ousja Ghar El Meleh Coastal Area, North-East Tunisia

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Khaled A., S. Bel Hadj Ali, and F. Trabelsi

Bathymetric remote sensing offers capabilities to solve land use problems for coastal or near shore areas. These data can provide detailed water depth information that can be used as the basis for building 3D models for modeling saltwater intrusions.

This research will provide a general overview of the main benefits of integrating remote sensing for the management of the Ousja Ghar El Meleh (OGM) coastal zone. Satellite-derived bathymetry (SDB) has been widely regarded as an advanced and inexpensive method for depth estimation.

This study relates to the cartography of the bathymetry of the coastal zone of OGM, of the catchment basin of Basse Medjerda.

In this study, the satellite-derived bathymetry method was applied using USGS Sentinel 2 satellite imagery which provides image acquisition at 10 m spatial resolution.

The result of the work by the SDB technique makes it possible to obtain a bathymetric map which identifies the depth of the seabed at any point in the region of Ghar el Meleh, whose interval is relatively regular between 4.52 meters and -14.95 meters of bathymetry with sufficient accuracy for tracking changes in depth over large areas.

The lower areas were obtained between 4.52 m and -0.5.m but some of the negative values appeared near the shore which can be recorded in the lowest high tide and the lower shallow areas reached the -14 .95m deep.

Remote sensing has enormous potential for monitoring sea depth in coastal areas. Earth observation data are and will be increasingly integrated into intelligent coastal zone management systems.

Potential of ALOS-2 and Sentinel-1 Data to Estimate Soil Moisture Over Cereal Fields Ayari E., Z. Kassouk, Z. Lili-Chabaane, N. Baghdadi, S. Bousbih, and M. Zribi

The south Mediterranean regions are suffering from water scarcity under the pressure of the arid climate, the high demographic growth, and the expansion of irrigated areas. This critical situation requires the optimization of irrigation needs where soil moisture is a key parameter. Over the last decades, operational approaches were developed using remote sensing products to estimate soil water content. In the present work, we compare the potential of C-band Sentinel-1 (S-1) and L-band Advanced Land Observing Satellite-2 (ALOS-2) radar data to estimate soil moisture. Simultaneously to Synthetic Aperture Radar (SAR) acquisitions, in-situ measurements were acquired over cereal fields in the Kairouan plain in Tunisia. To link the gathered data to radar signals, we used the Water Cloud Model (WCM). The total backscattering is the sum of bare soil backscattering contribution attenuated by vegetation, vegetation contribution term, and soil-vegetation interactions term. We consider two options of WCM without and with the proposed interaction term. WCM is coupled with the best accurate tested models over bare soils: the modified Integral Equation Model (IEM-B) for co-polarized data and empirical model for the entire dataset. After the calibration and the validation of WCM, we invert the two options to estimate the soil moisture. The inversion of WCM coupled to IEM-B presents the best performance where the root mean square error values (RMSE) are under 5 vol.% using S-1 and ALOS-2 data in Vertical-Vertical (C-VV)

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and Horizontal-Horizontal (L-HH) polarizations, respectively. By considering the interaction term, we notice a better improvement where RMSE values decreased from 13 vol.% to 7 vol.% using L-band data in Horizontal-Vertical polarization (L-HV). The integration of the soil-vegetation interaction component into the WCM model leads to a limited improvement in the estimation of soil moisture using C-band data in VH polarization (C-VH).

Using Combined Approach Sentinel-1- RUSLE to Spatialize Soil Erosion in the North of Tunisia

Barbouchi M., H. Cheikh M'hamed, A. Souissi, M. Annabi, and H. Bahri

In Tunisia, soil erosion is one of the main processes reducing the soil productivity by removing fertile topsoil layers, thus decreasing levels of organic matter and nutrients. To evaluate the impact of soil erosion, different approaches were used. In the recent decade, satellite remote sensing applications in soil erosion mapping and modeling have gained a large interest around the world. Most importantly, recent advancements in remote sensing technology and the availability of this data in various resolutions, as well as the immediate demand for up-to-date information on levels of soil loss, soil erosion mapping and modeling, have rekindled interest, especially to ensure that productive agricultural land is still there to ensure food security.

In this paper we present a combined approach for mapping soil erosion in the region of Siliana in the north of Tunisia using Sentinel 1 data and GIS tools. The Parallel computing version of the Small BASeline Subset (P-SBAS) approach and RUSLE was used for mapping soil erosion in cm per year and tone per hectare respectively. For validation, the loss of soil is measured in the field.

Two map of soil erosion was obtained from this work: The velocity maps of the soil displacements due to soil erosion which represents the loss of soil (cm per year), and the RUSLE map which represents the loss of soil (tone per hectare). Our results suggest that this approach holds some potential for operational applications, including monitoring of erosion processes at large scale.

A National Land Reference System for Tunisia

Essifi B., A. Di Gregorio, M. Henry, K. Selmi, S. Belhaj Salah, A. Salis, K. Aloui, I. Cherif, K. Saad, R. Dannunzio, F. Khemakhem, and B. Karray

Land Cover/Land Use (LCLU) is an essential component in addressing natural resources monitoring and assessment, land and water management, agricultural development, etc. Change detection in land cover allows a better understanding of the status, dynamics, and use of natural resources. However, the legends used to describe LCLU often have many inconsistencies, which limits their use and the sustainability of land cover monitoring efforts. The implementation of a common land cover classification system is one of the solutions identified to ensure consistency between the maps prepared by different organizations. With the establishment of an international standard (ISO 19144-2) for the development of land cover classification systems, it is possible to use a national representation system and derive legends from it, which enables the use of the same map for different purposes.

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In Tunisia, various land cover maps have been developed, but, as in most countries, the legends have been derived for very specific purposes. Consequently, they are not interoperable and their use for evaluating temporal changes is greatly limited. In the framework of the national inventory of forests, rangelands and olive trees (IFPON), the Tunisian Government had the opportunity to establish a national system of classification of land cover and land use, ensuring the required interoperability and integration whether for local or national mapping applications. The objective of this paper is to introduce the land cover reference system of Tunisia, based on the concept of “object-based” representation and according to the Land Cover Meta-Language (LCML) ISO 19144-2 standard. The land representation system of Tunisia can be used to derive land cover legends for different purposes, with a diagram and a detailed description of each LCLU class.

Detecting the Effects of Fires Using Sentinel-2 Data Satellite Images and Case Monitoring Their Deterioration of Abu Aisha Agricultural Project/Libya **Alfurjani Abdullah F.**

Abu Aisha Agricultural Project situated which is located 60 km to the south of Tripoli is one of the state-run investment projects. Contains different types of agricultural crops under the irrigation system. The study area was exposed to many force majeure conditions such as fires and drought as a result of the lack of water supply, which caused the deterioration of its condition and the death of thousands of fruit trees. To detect the degradation, several Sentinel-2 satellite images were acquired. The study relied on (field visit) and visual interpretation in the analysis and processing using the SNAP program and using remote sensing techniques through the use of spectral indicators) Normalized Difference Vegetation Index NDVI), (Normalized Burn Ratio Index NBR), by calculating the spectral reflectivity values at different wavelengths and finding the difference between years by calculating (difference Normalized Burn Ratio dNBR) to extract the burned areas and estimate the level of fire intensity. The action steps were to assess the deterioration status of the entire project area and assess the deterioration status of the separately produced farms. The results showed a correlation between the NDVI values and the density of vegetation cover and the deterioration status of agricultural crops. Where the value of the plant index for the captured visuals in the year (2016-2021) ranged between (-0.65-0.02) and (-0.48-0.01), respectively, for the entire study area and for the farms. It ranged between (0.48-0.07) and (0.39-0.05), respectively. The burned areas were calculated for the year (2018-2019-2020), The results of dNBR index show that a total of 483,000 hectares, and the loss of about 463,900 fruitful trees in the productive farms. The study concluded that there is a significant decline of vegetation cover, due to fires and water cuts, which amounted to 88% of the deterioration.

Land Use Classification of a Semi-Arid Watershed Using Sentinel 2 **Gharnouki I., Z. Kassouk, J. Aouissi, and S. Benabdallah**

It is recognized that major land cover changes affects the key hydrological components at the watershed scale. It can be caused by the loss of forest cover, agriculture activities or other factors. Thus, monitoring land use is crucial for water management to achieve sustainable

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development. In Tunisia, land use has changed dramatically over the past few decades due to climatic change, population growth and agricultural intensification and expansion. These phenomena are significantly inherent in Merguellil basin, located in central Tunisia, where climate and anthropogenic activities are the main drivers of soil erosion and landcover degradation.

The objective of this study is to investigate the current spatial dynamics of seasonal land cover on the upstream part of Merguellil basin, using high temporal and spatial resolution Sentinel 2 data for the period between March and August 2021. The potentialities for both supervised and non-supervised classification are also evaluated. The adopted approach for the supervised classification is based on combining field data observations and spectral indexes such as the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI) and the Brightness index (IB) for processing Sentinel 2 images within the random forest classifier.

Based on the K-means classifier, the non-supervised classification allows identifying the density of vegetation but not the cluster itself. while the supervised classification has allowed the identification of the appropriate classes since it is based on training field data.

KEY WORDS: Landuse map, Merguellil, Sentinel-2, unsupervised and supervised classification.

Mapping and Monitoring of Salt-Affected Soils from Landsat 8, Sentinel-2 and PRISMA Satellite Data **Saad K.**

This study focuses in the development of salt-affected lands in arid and semi-arid region which is major cause of land degradation and desertification. The combination of satellite image analysis and field measurements makes it possible to study salinity changes at local scales.

The purpose of this study is to assess and detect the changes of soil salinity for a part of Zaghouan Governorate. This includes the examination of soil salinity effect over the period from 2017 to 2021.

The purpose of this study is to estimate the level of soil salinity in the study area located in Zaghouan using spectral indices and field measurements. For soil salinity analysis and mapping, data must be collected using soil sampling and laboratory analysis methods, as well as RS techniques.

For multi-temporal analysis, both Radar and Optical images were classified with the different processes. The evaluation of the classified images showed relatively variations over 5 years. The result of this study revealed the possibility of detecting important soil salinity changes by using Multispectral satellite data.

KEYWORDS: Remote sensing, Soil salinity, Mapping, Zaghouan

Sentinel-1 and 2 Time-Series for Crop Landcover Mapping in Irrigated Arid Region: Cases of Siliana, Kef and Kairouan in Tunisia **Kassouk Z., G. Ramat, I. Dayeg, and Z. Lili Chabaane**

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Tunisian agricultural sector has played key role in the economic in Tunisia is one of the important. It is also important for its contribution for food security. In a context of natural resource management, the characterization and monitoring of land use in rural areas is crucial. The monitoring of land use helps to better understand the causes and the consequences of mitigations in different geographic areas. As such, land use and land change maps are real planning and decision support tools, especially in terms of management and preservation of natural resources. This study aimed to investigate and assess the capability of Sentinel-2 optical, and Sentinel-1 radar data for landcover mapping in three different pilots sites (in Kef and Siliana and Kairouan gouvernorates). A time series of Sentinel-2 optical and Sentinel-1 radar images acquired from September 2017 to August 2021 and 505 field observations, collected in the Merguellil plain, 200 for the kef and 283 for Siliana, were used. We compare three classification algorithms based on pixel approaches (Random Forest (RF), maximum likelihood (ML) and nearest neighbor (K-NN)) with spectral indices (NDVI (Normalized difference index), EVI (enhanced vegetation index), NDRE (Normalized difference red edge index) et the difference of S1 polarisation (VV-VH)). A hierarchical approach was used to evaluate different combinations of bands and algorithms for land cover mapping on the three study sites. Obtained results demonstrate the efficacy of using combined indices NDRE, NDVI, EVI and S1(VV-VH) for crop land use mapping in both three sites. The results highlighted that the RF classifier and NDVI et EVI (optical indices) and VV-VH (Radar indice) have a slightly higher overall accuracy (OA) and Kappa statistics with the 92 % and 0.86 for Kef Region and 93 % and 0.87 for Siliana region. Achieved results underlined the potential of radar and optical data for landcover mapping.

Drought Analysis and Return Periods in North and West Africa, with its Connection to the El Nino–Southern Oscillation (ENSO)

Henchiri M., J. Zhang, and B. Essifi

Droughts are one of the most destructive natural disasters on the planet. Droughts can have severe environmental and economic consequences across large parts of Africa. Understanding and forecasting the mechanism that causes drought is critical for improving early warning and disaster risk management. Using multi-source data and statistical analysis approaches such as the Joint Probability Density Function (JPDF), this study examined the meteorological drought and its return years in North and West Africa between 1982 and 2018. At 1–12-month timescales, the Standardized Precipitation Index (SPI) was used to assess large-scale spatio-temporal drought characteristics. SPI-12 was used to determine drought intensity, severity, and duration in the research area. The results showed that the drought magnitude (DM) was maximum in 2008–2010, 2000–2003, and 1984–1987, with 5.361, 2.792, and 2.187, respectively. The lowest DM values were found in 1997–1998, 1993–1994, and 1991–1992, with DM values of 0.113, 0.658, and 0.727, respectively. It was assured that the probability of drought return years was higher when the drought duration was shorter, with short droughts occurring more regularly, but not all severe droughts hit after longer time intervals. We also found a direct link between drought and the North Atlantic Oscillation Index (NAOI) over Algeria, Morocco and the sub-Saharan countries, as well as some hints that drought is linked

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to the Southern Oscillation Index (SOI) over Ghana, Guinea, Mali, Sierra Leone, Burkina Faso, Cote d'Ivoire, Nigeria, and Niger.

Estimation of Crops' Water Consumption by Remote Sensing: SEBAL Model Calculations Versus Ground Observation in the Irrigated Area of Lakhmass (Siliana, Northern Tunisia)
Belhaj Kilani A., S. Khlifi, M. Vanclooster

ESTIMATION OF CROPS' WATER CONSUMPTION BY REMOTE SENSING: SEBAL MODEL CALCULATIONS VERSUS GROUND OBSERVATION IN THE IRRIGATED AREA OF LAKHMASS (SILIANA, NORTHERN TUNISIA)

Agriculture remains a crucial sector in the Tunisian economy and is facing considerable hydric constraints due to climate change that needs to be addressed by appropriate irrigation water management.

Assessing irrigation water requirements for the public irrigated areas (PIA) is therefore one of the priorities in supporting irrigation water management. In the present study, water consumption and requirements for the PIA of Lakhmass in Tunisia are assessed using remote sensing technology. PIA scale ET is estimated through the implementation of the Surface Energy Balance Algorithm for Land (SEBAL), within the Google Earth Engine (GEE) platform, by combining ERA5-land meteorological reanalysis data with visible, near-infrared, and thermal imagery satellites from high-resolution (10 m) Sentinel 2 images. The remote sensing data were combined with the seasonal supplied water to the PIA Lakhmass, collected at plot level. This study was conducted over five agricultural campaigns from 2016-2017 to 2020-2021. The results indicate that ET decreases in winter to be lower than 20 mm/month and increases in spring, 20 and 50 mm/month.

During summer, it exceeds more than 70 mm/month. Furthermore, the results of the method were satisfactory, relevant, and encouraging, which could allow the monitoring of overconsumption with the identification of areas where there have been water losses. The seasonal ET was compared with water allocations which will allow calibrating the estimation of derived estimated from the SEBAL model.

KEYWORDS: Evapotranspiration, Irrigation, Water use, Remote sensing, GEE, SEBAL.

Assessment of The Impacts of Long-Term Wind Erosion Control Measures on Land Degradation in the Arid Southeastern Tunisia using Remote Sensing and Field Observations
Khatteli A., A. Tlili, M. Chaieb, and M. Ouessar

During the last decades, substantial human disturbance combined to climate change have led to significant transformation of landscapes, particularly in the drylands. The South-eastern Tunisian regions (known as Djefara plains), characterized mainly by an arid Mediterranean bioclimate and sandy soils very prone to wind erosion, are typical. The government has been engaged since the middle of the last century in huge programs for combating wind erosion and desertification. This study aims to assess the impact of various control measures (i.e. windbreaks, reforestation, controlled grazing, etc.) on remediation of land cover dynamics in six managed areas in the Djefara plain. Ecological indicators (i.e. vegetation cover, floristic richness, plant density, diversity and productivity, soil texture) combined with derived

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vegetation index (SAVI, PVI and NDVI) derived from Landsat 5 (TM), Landsat 8 (OLI) and Sentinel-2 imagery during the period 1960-2021 have been analysed to monitor the dynamics of the wind erosion and map the land degradation inside and outside (control) the protected areas. Results show that management affects the vegetation structure by increasing vegetation cover. Meanwhile, wind erosion control measures have contributed significantly in the improvement of the ecosystem health status as well as the fixation of soils. Nevertheless, the reopening of those sites to grazing needs to be carried out very carefully to avoid any risks of new degradation wave. The outputs could be used to support decision makers in targeting land degradation neutrality objectives.

Keywords: Dryland, management, plant communities, GIS, vegetation index.

Identification of high-value date palm pollinators (*Phoenix dactylifera* L.) by Geographic Information System in the Djerid region (South west Tunisia)

Kadri K., Safwan Chida

In Tunisia, male palm trees represent an important link in the date production chain. Therefore, it is essential to evaluate the genetic diversity and to select a certain number of male palm trees with superior genotypes. The choice of such high-quality pollinators is essentially based on morphological and physiological criteria, in particular the size of the spathe, its pollen productivity, the rate of pollen viability and pollen germinability. In order to enhance the use of geographic information systems in the agronomic field and to facilitate access to these high added value pollinators, we tried to design a digital database based on the GPS coordinates of these selected pollinators. A total of 50 male feet distributed over the delegations of the governorate of Tozeur were characterized on the morphological and physiological level according to the protocol described by IPGRI in 2005, the data relating to these pollinators are placed in the form of a table with the images relating to each pollinator and its GPS location. These data were processed using Google Earth Pro software to create the landmarks and then hosted on a free server with their respective images as kmz data (google drive).

Finally, to facilitate free access to this data, they have been placed on the google maps application. This database is a model pilot design that will serve as a digital resource for farmers in the region seeking good quality pollen. This work represents a test before the creation of a pollinator database in the Djerid region grouping all the cultivars with important agronomic qualities.

Key Words: date palm, pollinators, GPS, database, Google maps.

Special Session: ACSAD

ACSAD role to combat desertification and rehabilitation of degraded lands in the arab region ***Abdul Rahim Loulou***

The Arab Center for the Studies of Arid Zones and Drylands (ACSAD) is an Arab organization working within the framework of the League of Arab States . One of the main tasks of ACSAD is to address the adverse effects of desertification, drought and land degradation through the

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development of scientific research, project implementation and capacity building to promote the sustainable management of natural resources and improve the living conditions of people in affected areas.

In this domain ACSAD Conducting studies and Implementing projects to combat desertification and rehabilitation of degraded lands in cooperation with the concerned national institutions in the Arab countries, in line with their national plans to combat desertification, Conducting economic and Social studies in the affected areas, and promoting the participatory approach and raise awareness among the population of the affected areas. The most important of these studies and projects include:

- ✓ Monitor and combat desertification in Al-Bishri area, Syrian steppe , 1994-1999
- ✓ Combat desertification in Sabha and Al-Sira - area, Jordan steppe, 2000-2005
- ✓ Land Degradation Study in Yemen 2000-2002
- ✓ Rehabilitation of a degraded area in North Kordofan State - Sudan - 2006-2009
- ✓ Fixing creeping sand in Haribsha and Kabageb area - Syrian steppe - 2009-2011
- ✓ Rehabilitation of degraded pastoral lands in Amaria area - Saudi Arabia 2009 - 20012
- ✓ Study of Land Degradation in the Al-Layth Valley Region, Saudi Arabia, 2000-2012
- ✓ Rehabilitation of degraded pastoral lands in the Algerian steppe 2012-2016
- ✓ Fixing sand dunes and creeping sand in Siwa Oasis - Egypt - 2014 - 2019
- ✓ Protection of the infrastructure from creeping sand in Sinai area - Egypt - 2017 – 2019
- ✓ Monitoring and assessing land degradation in Kuwait 2018 – 2022

In general, all the projects have had positive reflections on the environment and man such as :

- Fixing soil surface and stopping wind and water erosion
- Increasing moisture due to evaporation and transpiration decreasing.
- Rebalancing ecosystem and positive development of vegetation cover
- Improve physical and chemical properties of soil and reduce dust and sand storms
- Preserve the genetic diversity of plant and animal groups within the new ecosystem.
- Provide an environment free of contaminants, especially fresh air.
- Improve income generating due to Increase fodder production and grazing capacity.
- Reduce immigration and create a new jobs facilities for local people.
- Increase financial income from animal and plant products which enhance food security and support poverty alleviation

The status of land degradation in arid and semiarid regions

Ihab Jnad

Land degradation is one of the world's most important environmental problems currently challenging sustainable development in many parts of the world. About 25 percent of the total land area has been degraded. Scientists recently warned that 24 billion tons of fertile soil was being lost per year, largely due to unsustainable agriculture practices, and about 95 percent of the Earth's land areas could become degraded by 2050. Globally, 3.2 billion people are affected by land degradation. The world population is projected to increase by about 35 percent to 9.7 billion in 2050, with rising demands for agricultural products including food,

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feed, fiber, and fuel. However, pressure on the global land resource is increasing due to other factors.

The Arab region is highly susceptible to land degradation, which is exacerbated by the growing scarcity of water resources and high levels of aridity. The region is extremely dry, with 92 per cent of hyperarid land, and 73 per cent of arable land affected by land degradation. Average vegetation cover as a percentage of land area in the Arab region decreased from 3.7 per cent in 1990 to 2.8 per cent in 2013. Most soils of Arab region suffering for low content of organic matter stock(less then 0.80 Mt/m²), high level of salinity , low fertility level, and poor physical characteristics.

Land degradation are associated with climate variability and human influences. The most common soil degradation processes are: 1) water erosion; 2) wind erosion; 3) excess of ions: salinization (ECs) and alkalinization (ESP); 4) chemical degradation: acidification and toxicity ; 5) physical degradation; 6) biological degradation .and urbanization.

The Arab Center adopted a scientific strategy in the field of monitoring, combating and rehabilitating degraded lands, and implemented many relevant research projects at the Arab level, through the development of programs for monitoring and diagnosing cases of deterioration and the development of special programs for rehabilitation, which includes increasing the soil content of organic matter and organic carbon, covering bare soil, and keeping it covered, with living or dead plant material (litter) to restoring soil health and the biggest hope for immediate salvation from degradation.

Water Harvesting Techniques in the North West Coast of Egypt ***Ibrahim Daoud***

The North West Coast Zone of Egypt (NWCZ) is located in the northwest corner of Egypt, between Alexandria Governorate borders in the east and the Libyan borders in the west, and extending for depth of about fifty kilometers from the Mediterranean coast to the south, with total area of 1.25 million hectares. It is a rainy region that depends entirely on rain as a main source for drinking water for humans and animals and for irrigation of rain-fed crops represented in barley, figs, olives and almonds, with average annual rainfall amount of 140 mm, to maximize the benefit of this low rainfall value; several water harvesting techniques are used in the area, especially in the wadis bed which spread in the region, which numbered 218 wadis.

Water harvesting technologies in the NWCZ are used for many purposes, such as human and animal drinking, which is represented in cisterns, reservoirs, or Gawaby as well as to establishment of dikes which represented in cemented stone dikes, dry stone dikes, earthen dikes and recently Gabions to irrigate the rainfed cultivations in the wadis bed.

The use of any of the previous technologies depends on the characteristics of the soil surface of the wadis in terms of tendencies and width.

Session 5: Geology, Geo-Resources and Environment

Web-based Deployment of a Hydrogeological Database using the Observations Data Model 2 (ODM2)

Hammami M.A., S. Brahem, H. Chihi, I. Mezni, M. Ould Baba Sy, and P. Cau

The inadequacy of using separate and specific datasets leads to data heterogeneity in the sense that information is stored, described, and encoded in a manner that makes it difficult to exploit and interpret.

In fact, attempts to store hydrogeological data such as time-series data of water levels, depth-series data for geological data, and aquifer systems revealed the limitations of using separate databases for each type of hydrogeological information: the inability to properly record sample hierarchies, inability to properly store time-series data, inability to accommodate classification schemes, deficiencies of identifying and documenting datasets that are not part of publications. Access to data for cross-domain studies can therefore be challenging because common characteristics of observational data such as time, location, methods, and units are often described differently within information models, including physical implementations and data exchange schema.

In this work, we will report on the design and implementation of a case study model using the ODM2 information model (ODM=Observation Data Model) aimed at properly storing hydrogeological information. The O&M model, adopted as an international standard by the Open Geospatial Consortium, and later by ISO, is the foundation of several domain mark-up languages such as OGC WaterML 2, used for exchanging hydrologic time series. We also built a web-based application where we deployed the case study database. The web application is designed to provide user-friendly tools for browsing, visualizing, and extracting data at ease by non-programmers who wouldn't otherwise be able to exploit a complex relational database.

The main goal of this work is to create a unified relational representation for different types of spatially discrete hydrogeological observational data, ensuring that the data can be efficiently stored, shared, cataloged, and queried thus, improving the interoperability across scientific disciplines and domain infrastructures.

Contribution of Geophysics in The Characterization of Aquifers in the Region of Gabes (Southeast Tunisia)

Aydi H. and M. Gasmî

The south of Tunisia is an arid area where socio-economic activities are dependent on groundwater resources. This region is characterized by the superposition of three main aquifer systems. These are, from bottom to top, the Continental Intercalary (CI), the Terminal Complex (CT) and that of the Jeffara. The populations groundwater needs in southern Tunisia, have led to several operations of drilling implementation based on geophysical studies.

The presented study aims to evaluate the South Gabes region (South East Tunisia) water potentialities based on geological, hydrogeological and geophysical data in order to develop a rational exploitation program.

The geophysical data consisted of the reinterpretation of four hundred and fourteen Schlumberger Vertical Electrical Soundings (414 VES). The VES were carried out with AB

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line lengths ranging from 600 m to 2000 m and covering the entire study area. They are characterized by a great importance to complete and refine the information on the characteristics of the noted aquifers. The interpretation of the electrical data was carried out, first, in a qualitative way (establishing of apparent iso-resistivities maps and pseudosections) and, then, in a quantitative way (calibration of the VES on water boreholes, realization of geoelectric and electrostratigraphic sections, the roofs isobath and isopach maps of aquifer levels).

All the results have allowed to delimit the areas considered favorable to the exploitation of the different potential units at varying depths. Finally, recommendations were suggested in order to rationalize the management of water resources extracted from these different aquifers in the region of South Gabes.

KEY WORDS: Electrical prospecting, aquifers, South Gabes, South of Tunisia.

Study of the Geochemistry Composition of Aquifers in the Zouarine Region (Northwest Tunisia)

Ben Alaya M., G. Ben Zid, M.-H. Msaddek, and F. Melki

The Zouarine basin contains a multi-layered aquifer with three principal levels: Limestone of Abiod (Maestrichian), limestone of Garia (Yprisian) and alluvial Quaternary formations. The study of this aquifer system in Northwestern Tunisia, based on the interpretation of geochemical (major and traces element), has aided the understanding of the hydrodynamics of this multi-layer aquifer system, which is greatly influenced by tectonics. This basin is an important unconfined groundwater resource for freshwater supply and agriculture. The use of geochemical tools made it possible to understand the groundwater flow system and the origin of groundwater salinization of this patrimonial resource. Two types of groundwater were identified. The first, of low salinity that the majority of the samples belongs to HCO₃-Ca hydrochemical facies characterizes springs drains Yprisian limestone. The second, of higher mineralization that the majority of samples belongs to SO₄-Cl-Na and Cl- SO₄-Na hydrochemical facies is represented by the Quaternary aquifer in Zouarine basin. The groundwater salinization of the Quaternary aquifer results essentially from the dissolution of evaporites (halite and gypsum), from the infiltration of runoff water and from the return to the aquifer of irrigation water that is loaded with salts that were initially concentrated in the soil or in the unsaturated zone. The high concentrations of nitrates (NO₃- > 50 mg/l) and chlorides (377.93 mg/l) are indicators of anthropogenic pollution, of urban or rural origin, which affects the whole Zouarine plain to various extents.

Salinization Processes in the Coastal Aquifer of Grombalia (NE Tunisia): A Hydrogeochemical Study

Ben Saad E., M. Ben Alaya, J.-D. Taupin, A. Abdelkrim, G. Ben Zid, N. Chaabene, and N. Patris

Over the last decades, the migratory flow of the population towards coastal cities and the development of industrial and agricultural activities, increase the risk of salinization and contamination of groundwater resources and quantity degradation through excessive

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groundwater pumping rates higher than the present recharge. The determination of the origin of salinity for the aquifer of Grombalia (North-east Tunisia), and the understanding of its hydrogeological and geochemical characteristics related to severe natural and anthropic constraints, were approached by hydrochemical study (majors and traces element). The classification of groundwater into homogeneous groups is performed by graphical techniques, including a several binary diagrams, an expanded Durov diagram, HFE-D diagram and the study of ionic ratios. Based on these approaches, it has been established that the high groundwater salinity is due to water/rock interaction; the irrigation water return flow; the industrial discharges influence; as well as saltwater intrusion by lixiviation process during wet season from the Sebkhate El Maleh. Furthermore, the elevated salinity observed along the coastline (5814mg/l) is explained by an intense agricultural irrigation activities, sea spray, aerosols and diffusion from salt of sea water towards fresh water presenting a low depth. This hypothesis is justified by the high chloride concentrations, to the presence of reverse ionic exchange reactions and a sodium chloride facies. The freshwater-saltwater mixture is highly modified by geochemical interactions: precipitation/dissolution phenomena and cation exchange.

KEYWORDS: Coastal aquifer; hydrochemistry; salinization; seawater contamination; Tunisia

Groundwater Recharge and Groundwater Flow in the Plio-Quaternary Unconfined Aquifer of Jerba Island (Southeastern Tunisia), using Hydrogeochemistry, Isotopic Techniques and ^{222}Rn Concentrations

Telahigue F., W. Hamdi, and A. Kharroubi

The present work was conducted in Jerba Island (Southeastern Tunisia) to identify the recharge and flow characteristics of the Plio-Quaternary unconfined aquifer; and to provide information for the aquifer's rational assessment. Hydrogeochemical, isotopic compositions and ^{222}Rn concentrations combined with the geological and hydrogeological settings were used for this purpose. An enrichment in isotopic content (Oxygen-18 and Deuterium) and low d-excess values exist in the studied groundwater, reflecting the contribution of modern recharge from precipitation and the evaporation. The sampled points are gathered under the two meteoric lines, the global meteoric waterline (GMWL : $\delta 2\text{H} = 8 \delta 18\text{O} + 10$, Craig, 1961) and Regional meteoric water line (SMWL: $\delta 2\text{H} = 8 \delta 18\text{O} + 13$, Zouari et al., 2005), in the $\delta 18\text{O}-\delta \text{D}$ diagram. The isotopic signatures permit to classify the studied groundwaters into two different groups. Evaporated groundwaters with enriched $\text{d}18\text{O}$ and $\text{d}2\text{H}$, are especially encountered in the central areas of the island. Saline water, from coastal areas, results from mixing of groundwater with seawater. The ^{222}Rn concentrations in groundwaters from the Plio-Quaternary aquifer show a clear decreasing from the coastal to the central areas of the island. The combination of isotopic composition in terms of ^{18}O , radiologic composition in terms of ^{222}Rn concentrations and chemical composition in terms of Electrical Conductivity (EC) and Cl^- contents is the basis for separating the studied groundwater into groups that reflect the recharge sources and isotopic, radiologic and chemical modifications during groundwater flow.

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KEY-WORDS : Plio-Quaternary unconfined aquifer ; Hydrogeochemistry ; Stable isotopes ; Radon 222 ; Groundwater recharge ; Seawater intrusion ; Groundwater flow.

Electrical Resistivity Contribution to the Hydrogeological Study of the Triassic Sandstone Aquifer in Arid Regions, Southeastern Area of Tunisia
Frifita N., M. Ben Zaied, M. Ouessar, and K. Mickus

Water shortage and overexploitation of the ground water resources in arid regions may lead to a situation that decreases the economic development of Southeast Tunisia if appropriate measures and more studies are not taken. The aquifer system under the Jeffara plain, has not been studied in detail using geophysical methods. Therefore, the purpose of this study is to characterize the Triassic sandstone aquifer (Jeffara plain, Southeast Tunisia) using electrical resistivity imaging. To map the ground water distribution more precisely and understand the aquifer rock more accurately, geo-electrical approach was conducted. The vertical electrical sounding (VES) and the electrical resistivity tomography (ERT) were applied in order to detect the underground layer and its resistivity and thicknesses and also to understand the characteristics and depth of the Triassic sandstone aquifer. The electrical survey was carried out using the Syscal Junior R1+ instrument which was provided by the Arid Regions Institute of Medenine. The data acquisition was designed with five lines of Schlumberger - Wenner array with about 345 meters length each. The resistivity measurements were closely interpreted using least square inversion by the RES2DINV program. Findings indicate that the layer which is mainly presented by fine sand and claystones sediments may associate to the Triassic sandstone aquifer. This layer was detected at approximately 40 m depth and its thickness is about 47 m, while toward the West, the Triassic sandstone aquifer becomes deeper. The geo-electrical analyses prove the thinning of sedimentary cover toward the coastal of Jeffara, and define two different levels of the Triassic sandstone aquifer: it was detected at about 40 m depth in the eastern site, while it reached the 75 m depth in the western site of the study area.

Reconstruction of Paleoclimate and Paleoenvironments of the Sidi Ali El Mekki Lagoon (Gulf of Tunis)

Gaceur E., N. Kallel, and S. Desprat

In the Mediterranean region, several palaeoecological records reveal the climate dynamics for the late Holocene (e.g. Roberts et al., 2011; Azuara et al., 2015, Di Rita et al., 2018).

Palynological studies represent an important tool to reconstruct the continental environments history. The aim of this study is to reconstruct the Holocene landscape and palaeoclimates from the sediment of Sidi Ali el Mekki lagoon. This lagoon situated in the northeastern of Tunisia represents a key area for studying past climate change system in the Mediterranean region.

In order to provide high-resolution analyses of past vegetation changes, this work presents and interprets the pollen analyses in a lagoon pollen sequences (GEM5 and GEMP1) recorded in the Sidi Ali el Mekki to document the regional vegetation and climatic changes in the northeastern of Tunisia during the last two millennia.

The pollen record of these cores shows drastic changes in vegetation and an alternation between the expansion of Mediterranean trees and the development of dry grasslands. Five intervals of change in vegetation cover have been highlighted and probably coincide with Mediterranean historical periods known during the Late Holocene. In fact, three wet episodes are recorded by the increase in the olive tree. The two arid episodes recorded in our study area are correlated with North Atlantic cooling events of Bond around 1.3 and 0.4 Ka B.P. (Bond et al., 2001). The dynamic of plant associations is modified by both climatic variability and human activity. The local human impact on regional ecosystems is recorded in the form of episodes of intensification of pastoral and/or agricultural activities. The development of olive production associated with agriculture attest of increasing human populations during classical antiquity. The significant increase in *Artemisia* (wormwood) is linked to intensive pastoral activity, associated with heightened interannual and/or seasonal climatic instability.

Conceptualization of the Hydrogeological System of Menzel Bourguiba Aquifers (Northeastern Tunisia)

Ayari I., M. Ben Alaya, and M. Zammouri

The Menzel Bourguiba basin, located in the northeastern of Tunisia, hosts shallow and deep aquifers that have been intensively exploited during the last years and require serious intervention. The following study aims to develop a conceptual hydrogeological model of this aquifer system, ensuring the visualization of the groundwater framework. Based on the collecting data, a geographic information system (GIS) is used to integrate data and to create a two-dimensional model of the specific region. Cross-sections were drawn to characterize the geology and hydrogeology of the studied basin. The construction of the conceptual hydrogeological model presents one layer formed by the two permeable shallow and deep aquifers with a thickness of 300 m. The estimated values of the transmissivity range from 1.62×10^{-4} m²/s to 17.54×10^{-4} m²/s. The water balance studies show that the principal source of the recharge of the Menzel Bourguiba aquifers is the infiltration of rainwater when the discharge is ensured by the pumped wells and the drain of the wadis. The developed model serves as support to construct a numerical model and simulate the hydraulic head of the aquifer system in the steady-state and the transient-state.

Characterization of the Nefza Dunes Aquifers (Northern Tunisia) using Electrical Sounding and Gravity Data

Kraiem J., H. Balti, F. Hachani, and M. Gasmi

The Nefza dunes (northern Tunisia) are considered as a very important area known for water resources management. The water table is lodged in the Quaternary sands which overcome the clayey sand of the Miocene and those of the Oligocene. The present study aims to improve the knowledge of the structure of the Nefza dunes based on the analysis of electrical sounding and gravity data.

The vertical electrical soundings (VES) consisted of over 30 Schlumberger VES performed in the Nefza dunes. The lengths of the current lines are equal to 400 m. Results were interpreted qualitatively (iso-resistivities maps and pseudo-sections) and quantitatively (geoelectrical

sections, and isobaths and isopachs maps). The main findings of VES calibrated on water wells are: 1) In the Nefza dunes, the Quaternary is characterized by a heterogenic resistivity, a thickness exceeding 50 m to the NW and SE of the study area. 2) The Miocene is characterized by a resistant sand ($> 30 \Omega\text{m}$), conductive clays ($< 20 \Omega\text{m}$), and thickening ($> 60 \text{ m}$) to the SE of the dunes. The Oligocene is characterized by resistant sand ($> 30 \Omega\text{m}$) which deepens towards the SE (more than 110m).

The gravity method was used to correlate gravity anomalies and understand the geological structures of Nefza dunes. The interpretation of the gravity data consisted in the establishment of the Bouguer anomaly maps, the horizontal and vertical gradient maps as well as the estimation of the structure's depths by the Euler deconvolution. The Bouguer anomaly map ($d = 2.4\text{g}\cdot\text{cm}^{-3}$) provided information on the density variation of the basement and showed very contrasting anomalous areas. The processing applied to this map allowed us to detect new deep structures and have provided details on their depths, some of which exceed 1218 m in a number of places. The establishment of a structural map shows that the study area is affected by faults of major directions: NW-SE and NE-SW and which have remained unseen on the surface.

The synthesis of all geophysical results in the present study allowed us to locate areas considered favorable for the exploitation of the various potential units.

Evaluation of Cd Adsorption of Phosphogypsum Aqueous Solution on Haidoudi Clays: Equilibrium and Kinetics

Ben Moussa K., S. Eturki, A. Ghorbal, F. Khalfeli, F. Souid, F. Hajjeji, and M. Ouessar

In South-eastern Tunisia, Clay materials are known for their abundance. These clays are known by their great surface area, interchange capacity and their adsorbent character. However, the importance of studies dealing with the treatment of heavy metals in industrial waste becomes interesting especially in territories exploited by industrial activities. In Gabes, untreated phosphogypsum, produced by the Tunisian Chemical Group (GCT) as a result of phosphate industry, contains metals (Cd, Zn, and As...) threatens the environment. The phosphogypsum waste is of serious environmental concern as it is discharged directly on the Mediterranean coast of Gabes city. Therefore, used natural clay as adsorbent is one of the important solutions due to their low cost. The main goal of this research is to assess the capacity of local natural clay (Haidoudi) in sorbing Cd from phosphogypsum waste aqueous solutions. Haidoudi clay (Aleg formation) was characterized by different techniques, including X-ray fluorescence (XRF) and X-ray diffraction (XRD). Haidoudi clays consist mainly of smectic and kaolinit. Chemical analysis of phosphogypsum waste (ICP) indicated a high concentration of metals (Cd, Zn, and As...). Adsorption batch experiments were carried out.

The results indicated that adsorption took place during the first 60 min. The isotherm studies showed that the best linear fit was obtained with the Langmuir isotherm. Haidoudi clay proved to be an effective natural adsorbent for capturing metals from phosphogypsum waste, making it potentially operational in contaminated wastewaters treatment.

KEY-WORDS: Gabes; phosphogypsum waste; Cadmium; Haidoudi clays; adsorption; kinetic

Electrical Resistivity Tomography Contribution to the Characterization of Soil Sediments Physical Properties behind Gabion Check Dams in Arid Regions, Southeastern Area of Tunisia

Ben Zaied M., N. Frifita, F. Abdelli, and M. Ouessar

Soil erosion is one of the principal environmental problems producing soil degradation in arid regions. The gabion check dam is a very important structure for torrent control areas. Determining the soil hydrological properties behind gabions check dams is assumed to be an effective method of estimating the sediment yield and evaluating the efficiency of the hydraulic infrastructure at different levels in small and medium catchments. This study aims to define the physical properties of deposited sediments beneath six gabions check dams distributed in the upstream and downstream area of the Koutine catchment, located in Southeast of Tunisia, which is characterized by an arid climate with an annual mean precipitation of less than 200mm.

The detection of sediment characteristics was based on_ _Electrical Resistivity Tomography (ERT) supported by laboratory analysis and associated with topographic measurements. The ERT measurements were conducted using Syscal Junior/R1+. The electrical survey involved about ten lines consisting of a Schlumberger-Wenner array with different configurations using 72 electrodes that were planted and arranged in a straight pattern along with the measurements profile.

The resistivity data were inverted using the RES2DINV program. Samples are taken for laboratory analysis and used to calibrate the calculated values. The ERT findings and the classical soil science measurements prove that the density increases with the sediments deposit depth and the corrected hydraulic conductivity of retention basins where the average value was about 69mm/hr. The interpretation of the conductivity values indicates a spatial and temporal variability of soil physical properties. Topographic methods were used to estimate the surface and the relief of deposited sediments in the area monitored by the gabions check dams. These results will be beneficial for decision-makers to evaluate the existing installed water harvesting structure, which can be furthered, duplicated using appropriate management options for soil resources based on scientific evidence.

Morpho-sedimentary Study of the Downstream of Wadi El Alem: Catchment by Discharge of Wadi El Fakka and Appearance of a Fossil Valley

Lahmar K., and A. Sebai

Archives of alluvial deposits are often considered to be an indicator to memorize past morphodynamics and mutation in catchment conditions due to the proximity of the source of sediment compared to accumulated alluvial deposits. Mainly the contributions coming from small watersheds, formed in confluence of two ravines before reaching the main valley, are considered a clear spatial image and a close coupling between erosion and slopes. Moreover alluviums are very sensitive to changes in land use in their upstream watershed. In the vicinity of Sabkat El Kalbia in eastern Tunisia, such favorable conditions for studying the phenomenon of over-sedimentation observed at the level of the downstream of the El Alem

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wadi before reaching the Elkalbia sebkhat, are observed. Mutations in hydromorphological units in small streams are also noted.

The downstream part of Wadi El Alem corresponds to the current zone of confluence between Wadi Bogal and Wadi El Fakka. The latter extends to reach Sebkhat El Kalbia. The area contains a dense hydrographic network, often made up of endorheic rivers, which gradually filled the bottoms of watercourses with alluvial sediments. This phenomenon was noticed during the 1969 floods. This area also constitutes vast terraces, the soils of which are arable with little watering and favorable to agricultural development. This region of eastern Tunisia was thus the cradle of many geomorphological forms of different ages.

These forms reflect a very variable dynamic affecting the study area: it sometimes violent, capable of modifying the forms and sometimes symbolizing the vulnerability of the soil in the face of the erosive action of meteoric factors. Braiding of the downstream side of Wadi El Alam caused by the rapid deformation of the floodplain - Overview of the current dynamics between Wadi Bogal and Ataf.

KEY WORDS: Wadi El Alem, Sedimentary, catchment and fossil wadi

Offshore Extension of Confined Aquifers in the Gulf of Gabes Continental Shelf, Tunisia Bachtouli S., M. Abidi, J.-C. Comte, and M. Zairi

The recent discovery of worldwide occurrence of offshore fresh groundwater reserves along continental shelves, is one of the primary sources of inspiration for the present research in hydrogeology and water resources, which focuses on the Mediterranean region. The Gulf of Gabes in Tunisia is examined as a first attempt to provide clues of offshore freshened groundwater bodies beneath the Tunisian continental shelf. Existing geological, lithological, geophysical and hydrological data acquired in both the marine and terrestrial sides of the Gulf of Gabes are being synthesised and analysed in order to map the extension and assess the hydraulic behavior of the terrestrial Serravallian-Tortonian water-bearing horizons. The spatial distribution of the Serravallian-Tortonian units does not show physical separation between the offshore and onshore sides in the Gulf of Gabes region. The Serravallian-Tortonian units, as identified across the Gulf of Gabes, forms a 200 m confined sandy aquifer layer intercalated between impermeable clay and marl layers. The groundwater salinity values of the offshore part of the Serravallian-Tortonian sandy materials, obtained directly from borehole resistivity logs, ranged from about 4,5 to and 7,5 g/L. It reveals a groundwater salinity similar to terrestrial hydrogeologic systems. The analysis and synthesis of existing onshore-offshore data, particularly the geological continuity and the hydrodynamic properties, along with the comparison with wider international literature on offshore freshened groundwater reserves suggests that the Serravallian-Tortonian submarine horizon is a potential non-conventional offshore water resource. However, more in-depth studies using direct prospecting methods are necessary to further confirm the presence of a freshened groundwater reservoir beneath the Gulf of Gabes continental shelf, and elaborate recommendations for its development.



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POSTER PRESENTATIONS

SWDCC

2022



Session 1: Water Resources Mobilization and Management

Germination Responses of *Reaumuria Vermiculata* to Salinity and Temperature ***Abbassi F., T. Tebra, H. Benabdallah, J. Faghim, K. Nagaz, and F. Guesmi***

The aim of study is to determine the effects of temperature and salinity on germination of medicinal plant *Reaumuria vermiculata* which is a xerohalophyte perennial dwarf shrub distributed in many gypsum and saline areas of southern Tunisia. Optimum temperature for seed germination was between 10°C and 30°C Different concentrations of NaCl ranging from 0 to 700 mM were tested. We demonstrated that the highest germination percentages were obtained under non-saline conditions and increases in salinity inhibited seed germination. Salt stress decreased both germination percentage and germination rate (increase in average germination time). An interaction between salinity and temperature yielded no germination at salinity of 300 Mm. The aim of study is to determine the effects of temperature and salinity on germination of medicinal plant *Reaumuria vermiculata* which is a xerohalophyte perennial dwarf shrub distributed in many gypsum and saline areas of southern Tunisia. Optimum temperature for seed germination was between 10°C and 30°C Different concentrations of NaCl ranging from 0 to 700 mM were tested. We demonstrated that the highest germination percentages were obtained under non-saline conditions and increases in salinity inhibited seed germination. Salt stress decreased both germination percentage and germination rate (increase in average germination time). An interaction between salinity and temperature yielded no germination at salinity of 300 Mm.

KEYWORDS: Germination; Salinity; *Reaumuria vermiculata*; Temperature.

Salinity of Phreatic Water Resources: Water–Rock Interaction and Saltwater Intrusion from Sebkhass (Northeast Tunisia)

Abdelkrim A., M. Ben Alaya, J.-D. Taupin, E. Saâd, G. Ben Zid, N. Cahbenne, and N. Patris

The coastal phreatic aquifer of the lower Medjerda Valley basin is located in the Northeast of Tunisia in Plio-Quaternary sediments. It housed in the alluvial deposits of Plio-Quaternary. Due to its location close to the coast and the presence of sebkhass on the study area, this aquifer is subject to significant quantitative, and above all qualitative geochemical variations under natural and anthropogenic pressure. While much of the Plio-Quaternary groundwaters are saline (from 1,39 to 10,05 g/L), this study try to discriminate the salinization processes in this aquifer in relation with water–rock, surface-water interactions, and seawater intrusion. Two approaches have been jointly carried out: (1) a hydrodynamic study to understand the seasonal hydrogeological behaviour of the aquifer and (2) a hydrochemical study of naturel tracers (majors elements, traces elements and Tritium) to determine the age of water and the origin of the salinity. According to these methods, based on ionic ratios study, it is demonstrated that the strong salinity of the groundwater is due to interactions between water and geological aquifer formation, and interactions between water and the lagoon-marine deposit layers of Missinian that constitutes locally the substratum of this aquifer as well as salinity due to ancient saltwater intrusion from the sebkhass lixiviated during wet season towards the aquifer. No present marine intrusion seems affected this aquifer despite of a high

aquifer exploitation .The freshwater/salt water mixing is characterized by geochemical interactions: cationic exchange and the precipitation/dissolution process of minerals in the aquifer formation. The tritium concentrations show the main contribution from recently recharged water coming from direct rain infiltration through plain and boundary of basin. Key words: Hydrogeology, hydrochemistry, salinity, sebkhas, water–aquifer interaction, Northeast Tunisia.

Water Resources Valorization in Arid Regions by Small Ruminants Herds and their Impacts on the Degradation of Rangelands and the Sustainability of Livestock Farming
Atoui A., A. Laaroussi, M. Abdennebi, and S. Najari

In arid regions, the pastoral animal breeding mode depends largely on the availability of water in quantity and quality, for the survival of humans, flora and herds. Traditional herd management is adjusted to the availability of water resources and irregular rainfall. This relationship was studied by a survey of nearly 118 herds, comprising approximately 22,000 sheep and 12,000 goats. The analyzes showed that, apart from the winter and rainy period, only the rangelands equipped with water sources are exploitable by the animals which graze on a radius not exceeding 7 km. Watering sources are in 52% of cases public or private underground cisterns; while 38% of breeders use public forages. The herd's watering rhythm varies with the season and is once for 87% every two days, and every 3 days for 8% of the herds. 27% of breeders do not water their livestock during the 3 winter months. The majority of studied cases buy regularly water to meet their needs, which represents an increasingly high cost. The operation administrative mode of public forages is not adapted to summer animal gardening mode for 66% of users of these water points. The availability of water, in quantity and quality, seriously affects the degradation of rangelands and the production of herds of small ruminants. Hence it is essential to plan the pastoral area well-reasoned in order to optimize the management of natural resources and ensure sustainable livestock farming in arid regions.

Keys words: Pastoral breeding, water sources, Rangelands, Small ruminants

GIS and Multi-Criteria Analysis to Select Potential Sites of OMWW Storage Tanks
Elkadri A., S. Elfkih, H. Sahnoun, and M. Abichou

The selection of the potential sites to the creation of OMWW storage tanks requires a large amount of spatial information. Geographical information systems are capable of managing this information, providing the ability to integrate multiple layers of information and deriving new ones. This study incorporates environmental, socio-economic and hydro-geological data. A multi-criteria analysis is performed to select the potential sites to the creation of OMWW tanks in Monastir region. The comparison by pair method adopted in this paper, based on a linear combination pondered after having assigned to every factor of decision a coefficient of level-headedness, creates many scenarios among which we selected the sustainable development one. This scenario assigned the same weight to the environmental, socio-economic and hydrogeological factors (0.3 for each factor), which shows the presence of seven suitable sectors for the creation of OMWW storage tanks.

Keywords : Olive mill waste water (OMWW), Storage tank, Multi-criteria analysis, GIS, Monastir-Tunisia

Recovery of Ammonia in a Digested Manure Plant of Arborea (Sardinia – Italy) using a Gas Permeable Membrane Technology

Viridis A. and M.-A. Dessena

This paper aims to verify the potential of the membrane gas extraction technique for the recovery of high-purity concentrated ammonia solution from the centrate of an anaerobic digester for the treatment of manure produced in the plain of Arborea (Italy). The plain is a very extended area devoted to intensive cattle farming and agricultural activities and represents an excellence in the Sardinian agro-livestock system. Due to the intensive agricultural practices the plain of Arborea is a Nitrate Vulnerable Zone. The principle of the technique is to apply a difference in vapour pressure for ammonia over a hydrophobic gas permeable membrane to transfer gaseous ammonia from the feed digestate solution into a stripping solution in order to produce concentrated ammonium sulphate which can be used as a fertilizer. The pilot plant is equipped with a pre-treatment unit that hold back particle size greater than 50 μm followed by six membrane modules with a total flow capacity of about 450 - 750 L/h. The treatment follows a batch type scheme. Each cycle, about 250 liters of digestate, rich in ammonia (about 1'800 mg/L of total ammoniacal nitrogen), is brought into caustic feed that crosses the membrane modules where an acid stripping solution of about 60 liter provides to strip the ammonia and to convert it in ammonium sulphate solution $(\text{NH}_4)_2\text{SO}_4$ that continually enriches in the stripping side as digestate feed rich in ammonia is replaced. The results showed that more than 98% of ammonium content in the digestate solution could be transferred to the acid stripping solution and final ammonium concentrate concentrations of about 2 wt% as nitrogen were achieved. The residual total ammoniacal nitrogen, less than 100 mg/L of total ammoniacal nitrogen, confirms the suitability of the treatment to contribute to the reduction of the anthropogenic nitrogen production in the environment

Assessment of the Physio-Biochemical Performance of Tunisian Barley Landraces under Deficit Saline-Irrigation in Arid Environment

Bagues M.

Salinity is one of the main and important abiotic stresses that adversely affects crop growth, development and production. In this study, two barley (*Hordeum vulgare* L.) landraces were subjected to three treatments of deficit saline-irrigation (12 dS/cm) ($T_0 = 100\%ET_c$, $T_1 = 75\%ET_c$, and $T_2 = 50\%ET_c$) during grain filling stage.

Carbon isotope discrimination ($\Delta^{13}C$) was associated with some physio-biochemical parameters to evaluate barley response to saline conditions. Results of this study showed that deficit saline-irrigation significantly ($p < 0.05$) decreases $\Delta^{13}C$ in both barley landraces. Moreover, photosynthetic rate (A), transpiration (E), stomatal conductance (g_s), and instantaneous water use efficiency (iWUE) were significantly affected by treatments. Relative water content (RWC), chlorophyll a , and chlorophyll (SPAD) value were significantly (p

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< 0.01 and $p < 0.001$) were affected by deficit saline-irrigation. In addition, phenolic compounds were affected by treatments and landraces (except syringic and p-coumaric acids), and their interactions (except syringic acid). Moreover, high correlations were noticed between $\Delta^{13}C$ and physio-biochemical parameters. Results suggested that both barley landraces make a higher iWUE, and a weak variation in phenolic compounds. Moreover, $\Delta^{13}C$ associated with physio-biochemical traits can also be good criteria for screening of salt-tolerance of barley during grain filling stage.

Taken together, our study suggests that the response to deficit saline-irrigation in barley landraces involves an interplay between various physiological and biochemical mechanisms mainly related to $\Delta^{13}C$.

KEYWORDS: barley, $\Delta^{13}C$, phenolic compounds, gas exchange, photosynthetic pigments

Spatio-temporal Treated Wastewater Irrigation Effect: Key Components of Soil Physical Changes in the Case of Light Texture Soil

Bekir S., K. Boudabbous, M. Barbouchi, R.-I. Zoghlami, M. Moussa, and H. Bousnina

In view of water deficiency, the development and use of non-conventional water resources were a global concern. Understanding seasonal distributions and migration of soil physical properties is relevant for agricultural management. A field experiment was carried out in sandy soil in North Tunisia, to investigate the effect of 38 years of treated wastewater (TWW) application on soil salinity (EC), permeability (K) and structural stability (IS). Three sampling seasons have been adopted (winter, summer and autumn) and five soil depths (0-20, 20-40, 40-60, 60-80 and 80-100 cm) were considered.

Overall, results showed that K and IS were depended significantly on the depth, season as well as the double interaction. However; the EC depended only on the depth. The highest EC and K were showed in summer at 0-60 and 0-20 cm, respectively. Nonetheless, the greatest IS was revealed in winter at 40-60 cm depth layer. More interestingly, to encompass both factors interactions, a positive correlation was obtained between K and EC, and IS ($r = 0.56^{***}$, $r = 0.62^{***}$, respectively) and between EC and IS ($r = 0.44^{**}$) in summer. Otherwise, in autumn; we occurred a negative correlation only among K and EC ($r = -0.35^*$), but no relationship was detected between all parameters in winter. In conclusion, our findings provide constructive insights on wastewater utilization during various seasons, especially in marginal soils which have very poor physical properties. Further research is required to investigate the effect of this wastewater on crops responses. **Keywords:** Physico chemical parameters; treated wastewater irrigation; sandy soil; Season; depth;

Performance of Olive Cultivars under Partial Root-Zone Drying (PRD) Irrigation in Semi-Arid Region of Tunisia

Abboud S. and M. Braham

A 2-year field experiment (2015 and 2016) was conducted in a super-high-density olive orchard to investigate the physiological and yield response of three olive cultivars (Arbequina, Arbosana and Chetoui) subjected to different irrigation regimes in a semi-arid environment. The treatments consisted of full irrigation (FI) at 100% of crop potential

evapotranspiration (ETc) and partial root zone drying irrigation at 100 (PRD-100), 75 (PRD-75) and 50% (PRD-50) of the FI. Results showed that relative water content (RWC) and stem water potential (Ψ_{stem}) had been significantly affected by irrigation regime.

On the other hand, PRD treatments decreased net CO₂ assimilation rate (Pn), stomatal conductance (gs), and transpiration rate (E). The highest gs reduction was registered under PRD-50 and was more pronounced in Arbequina cultivar leading to an increase in photosynthetic water use efficiency. Moreover, Arbequina showed the highest values for chlorophyll fluorescence parameters (Fv/Fm and Φ_{PSI}) under PRD irrigation. Significant differences in yield responses among cultivars were found. According to the results obtained during the two experimental seasons, PRD-50 enhanced oil content and water use efficiency (WUE) mainly for Arbequina cultivar. This study underlines that PRD irrigation was recommendable for improving oil yield and WUE under limited water conditions and Arbequina was more suitable for cultivation under this irrigation strategy over Arbosana and Chetoui.

KEYWORDS: PRD irrigation, physiological parameters, water use efficiency, olive yield.

Effective Actions on Water Pollution from Nitrates in Sardinia, Italy

Perelli C., G. Sistu, A. Pireddu, M. Cordeddu, M.-A. Dessena, A. Viridis, and I. Ghiron

The reduction of nitrates excess in water sources is among the priorities of the European Commission. The main concern is nutrient pollution sources from agriculture in the Member States. The EU introduces the EU soil strategy for 2030, aiming to agree to soil the same level of protection as water, marine environment, and air. The EU Soil Strategy originated from the European Green Deal and the EU Biodiversity Strategy for 2030. Acknowledging the relevance of healthy soils for biodiversity conservation, good food production, and carbon sequestration, the Commission decided that legal protection for soils is needed. Legally binding measures are introduced and combined with voluntary tools to augment carbon storage in agricultural land, repair degraded terrains, and struggle with desertification. MEDISS project supports relevant interventions, aiming at reducing soils salinization by adopting effective water and soils management practices. In Arborea (Italy), identified as a Nitrate Vulnerable Zone (NVZ), the MEDISS project supports an experimental facility for the extraction of fertilizers from the sludge of the wastewater treatment plants of the Cooperativa Produttori Arborea. The technology was firstly introduced in Italy by the project and implemented by ENAS, the Sardinian Water Board, and CRENoS, University of Cagliari. Re-using sludges from livestock facilities "clean" fertilizers are produced in a plant equipped with biogas cogeneration, using advanced stripping technology, and reducing direct nitrate pollution. The plant consists of a container furnished with filtration units, membranes, and all the essentials for the system's proper functioning. In the first months of 2021, the prototype plant was delivered and installed.

The poster will describe the results achieved after six months of functioning and a first assessment of the technical and economic results for the hosting farming communities. Furthermore, the impacts of the pilot plant on soil and water dynamics will be described.

Deciphering Strategies for Salinity Stress Tolerance in Tunisian Henna Plant (*Lawsonia Inermis*) in the Context of Climate Change ***Enneb H.***

Tunisia is considered as one of the most vulnerable countries in the world in terms of climate change concerns. The prediction is that the country will encounter extreme climate adversaries, such as, extreme temperature, drought excessive, and soil salinization in the years ahead. Therefore, salinity, are the primary causes of crop loss worldwide. Accordingly, henna (*L. inermis*) is widely grown in arid and semi-arid regions, where the salinization may have developed through irrigation. Thus, a greenhouse experiment was conducted to investigate NaCl stress on growth, photosynthesis, and nutrients of henna cultivars. One group was irrigated twice a week with a nutrient solution. The second and the third groups were watered with the same nutrient solution with 70 and 140 mM NaCl, respectively, for three weeks. Biomass production and relative growth rate decreased as NaCl concentration increased in the nutrient solution. At 70 mM NaCl, *L. inermis* plants responded to salinity by decreasing intrinsic water use efficiency (iWUE), shoot to root ratio, increasing leaf specific mass (LSM) and accumulating high concentrations of Na⁺ and Cl⁻ in leaves and root. At 140 mM NaCl, plants increased iWUE, maintaining water status, leaf and root Na⁺ and Cl⁻ concentrations were lower than expected. At this salinity level, *L. inermis* plants reached the reproductive stage, but their growth was severely reduced. The effective PSII quantum yield and the quantum yield of non-regulated energy dissipation recovered with time exposure to salinity. Overall, henna plants respond to salt stress by avoiding stress. From the time of application of salt stress, leaf conductance decreases to control water loss through transpiration and avoid leaf turgor losses. iWUE appears to be essential for henna plants to adapt to high salinity when morphological adaptation fails.

KEYWORDS: Climate change, *Lawsonia inermis*, salinity, LSM, shoot to root ratio, iWUE, chlorophyll fluorescence.

Role of Natural Clay and Cattails in Improving Purification Performance in an Urban Wastewater Treatment System

Hajjaji F., S. Eturki, F. Khalfelli, F. Souid, K. Ben Moussa, and M. Ouessar

The objective of this study is to assess the purification performance of three filtration mixtures made up of sand, sand mixed by Aidoudi clay, and the same mixture on which we have planted macrophyte. The pilot site is located in arid region of Wadi Echerka Bechima in the North of El Hamma district (South-east Tunisia). The pilot system is composed of three reactors (Silos) with a capacity of 1 m³. The installation of this wastewater treatment system in the region of Bechima aims to improve the irrigation water quality by using an innovative infiltration-percolation system and promote the farmers of the region to use non-conventional water as an alternative for irrigation of agricultural land and protect the environment. The permeability, the granulometry, and the mineralogical properties (CEC, mineralogy, DRX, Infrared, specific surfaces, etc.) of the filter medium have been studied. The wastewater, in the input and the output of the reactors, were analyzed for temperature,

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pH, electrical conductivity, and dissolved oxygen (in situ), while the major tracer of organic pollution BOD₅, COD, and total suspended solids (TSS) were tracked. The obtained results, for the wet season, show the improvement of wastewater quality by using the mixture of sand and Aidoudi clay. Furthermore, the planting of macrophyte on the surface of the third silo has contributed to the enhancement of wastewater physicochemical and bacteriological quality.

KEY-WORDS: Wastewater treatment, Infiltration-percolation, Aidoudi clay, Cattails, Reactors.

Approved Cyclic Treatment System of Grey Water Used for Irrigation ***Filali H. and M. Hachicha***

Treated grey water (TGW) reuse for irrigation has been emerged as an alternative resource to meet in the growing demand for water for agricultural irrigation and reduce the pressure on limited existing fresh water. However, this reuse needs adapted management in order to avoid environmental and health risks. In this work, treatment of grey water (GW) was studied from a cyclic treatment system that we designed and implemented in the greenhouse of INRGREF. This system is composed by three levels for treatment (TGW 1, TGW 2 and TGW 3). Each level includes sandy soil box. The use of grey water was moderated depending on the chemical and microbiological quality obtained. Different samples of soils and treated grey water was performed and analyzed for 14 irrigation cycles. TGW through cyclic treatment showed physicochemical parameters like pH, electrical conductivity (EC), chemical oxygen demand (COD), biological oxygen demand (BOD₅) in the range of 7,35-7,91, 1,69-5,03 dS/m, 102,6-54,2 mgO₂/l, and 31,33-15,74 mgO₂/l, respectively. The cyclic treatment of grey water resulted a reduction in the pollutant load with a significant effect on the three treatment levels, however an increase in salinity was observed during all irrigation cycles. Microbiological results showed good grey water treatment with low health risk on irrigated soil.

Treated water quality was below permissible Tunisian standards (NT106.03) and treated water is suitable for non-potable options.

Keywords: Treated grey water; Irrigation; cyclic treatment, soils; physicochemical parameters, Microbiological parameters

Majhoul as the Most Sensitive Variety under Salinity Conditions Among Five Date Palm (Phoenix Dactylifera L.) Cultivars Propagated In Vitro ***Benaceur I., R. Meziani, J. El Fadil, M. Idbella, and F. Jaiti***

Exploitation of Oasian soils in Morocco, which are heavily contaminated by dissolved salts, requires a screening of the cultivated varieties in these regions as a basic strategic tool in the promotion of phoenicultural production, given that in these areas salinity is typically associated to drought stress. For this reason, some Moroccan superior quality cultivars were tested for their tolerance to salinity stress in order to simultaneously contribute to the improvement of yield per tree and therefore improve the financial situation of the farmers. The experimental design comprised 20 salinity regimes [(4 cultivars + a male clone) x 4 separate salinity levels] with 10 randomized replicates, i.e. 40 plants for each of the tested cultivars.

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Each 15 days, Biometric, physiological and biochemical measurements were carried out in order to be able to estimate the indices of tolerance. Although date palm is known to be tolerant to salinity stress, our results revealed that the behavior of the investigated cultivars under salinity differed significantly over time and according to several criteria. Moreover, results analysis allowed us to differentiate 2 main groups of cultivars regarding their reactions to the applied stress. A resilient/tolerant group (T) that, within 60 days of treatments, began to exhibit improved biometric, physiological and biochemical performances, and a non-tolerant group (NT) that includes Majhoul, showing values within stress ranges, particularly for chlorophyll fluorescence, leaf area, number of neoformed leaves, electrolyte leakage, stomatal conductance which appear to be decisive criteria in the screening of this specie for salinity tolerance.

Groundwater Artificial Recharge with Reclaimed Water for Sustainable Water Resource Gdoura K.

Everything live on this world need water. This vital element generates principally health and socio-economic situations of countries. In fact, agriculture accounts on average more than 70% of all freshwater withdrawals. Industries also need large supplies of water for fabricating, washing, cooling and transporting products.... Daily life needs clean water for drinking, cooking, cleaning...On the other hand, sanitation and good solutions to evacuate the wastewater are very essential to save environment and health. More than the quarter of Glob population doesn't have access to safe drinking water (Ritchie et al. 2021). It is expected that in 5 years, about 50% of the world's population will live in a water stressed regions (World Health Organization, 2018).

In our days, research on water security is recent subjects that aim to find the good method of assess and quantify human and living being water needs (Wutich et al., 2017). Especially that such information can inform about the rejected wastewater which make a great environmental problem. And despite the increase of reclaimed water reusing principally in irrigation, a very important quantity is rejected in the sea that causes an aquatic disaster on fauna and flora.

So that, among the important solution of reusing reclaimed water outside of irrigation, is groundwater recharging with treated waste water. This strategy is increasingly installed where the use of surface water and groundwater resources is considered important. In fact it presents a good solution to reduce pressure on conventional water, because of the quality amelioration of the percolated water and reliability of water supply (Alsano, 2006).

The aim of this study is to develop why re-using reclaimed water in groundwater recharge is essential nowadays and explain how it is a universal solution for sustainable water resource.

Keywords: Groundwater, Artificial recharge, Reclaimed water, Wastewater, Reuse, sustainable water resource, Save environment.

Irrigation Water Between Degradation of Quality and Continued Exploitation for Tunisian Saharan Oasis Agrosystems

Dhaouadi L., H. Besser, and M. Moussa

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The continuous overexploitation of the water resources with inappropriate farm management explains the progressive degradation of land productivity and soil fertility in oasis Tunisian regions. In this context, this study aims to assess water quality resources used for irrigating through reviewing published works and field surveys. The estimated values of ionic indices (SAR; TH: PI: PS) and quality indices (IWQI; CWQI) showed that these resources are unsuitable for irrigation purposes. The field surveys indicated that natural resource exploitation in this region is not sufficiently controlled, as illegal oases were found to be much larger in number and extent than legal oases. These waters are also unusable for agricultural purposes, as they have harmful effects on soil fertility, vegetation development, agricultural profitability (dates), and on the ecosystem in general. The area is suffering from an irreversible loss of natural resources, economic value, and cultural heritage, and the landscape will be lost to desertification and soil infertility unless a scientifically based remediation plan is adopted.

Geostatistical Analyst for the Spatial Modeling of Rainfall in Gafsa Governorate ***Mchich H., F. Karaouili, M. Ouessar, and L. Dhaouadi***

In an arid environment, the precipitation is random, so it is difficult to understand the terms of the hydrological balance. However the geostatistical information and field observation data mix makes it possible to build a data base to presenting graphically the spatial distribution of precipitation.

In this context, Geostatistical analyst tool was applied in Gafsa gouvernorate using the deterministic interpolation methods, such us the Inverse Distance Weighting (IDW) which the map shows us that the rain is from NE to SW and we note that at the level of Garaat « Sidi Aich » and Oued Sened are the wettest areas in the gouvernorate with an average of 208_213 mm/year. While at El Gouifla and El Gharsa are characterised by averages of the order of 88-128 mm/year. In second part, we use the Radial Array method of the Basic Function which keeps the same configuration with an overage of 87-215 mm/year. Then, we try the geostatistical methods such us the Ordinary Kriging which makes it possible to carry out the estimation standard deviation mapping which produce a more realistic map than that obtained by deterministic methods. It is characterised by low values near the measuring points (12 mm) and values of the order of 29 mm at the SE and SO which have no measuring points.

To conclude, this study based on the comparison of the statistics of the estimation error show that the ordinary kriging is more accurate because the mean of the errors is closer to zero and standard deviation of the estimation. Errors is smaller with a decrease in the order of 4% in relation to the IDW method and 1% in relation to RBF method.

Evaluation of Groundwater Quality of Skhira Coastal Phreatic Aquifer in Southeast of Tunisia: Assessment of Potential Risk of Alkalinization and Soil Sodicity ***Melki S. and M. Gueddari***

In Southeast of Tunisia, it has been proven through various previously published studies that agricultural overexploitation, urban and industrial activities increase the risk of groundwater quality deterioration. The present study is a new research to be added to groundwater appraisal

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and comes to assess groundwater quality of the phreatic Skhira aquifer in relation to surrounding anthropic activities and also tries to evaluate potential risk threatenings of the local population. For that, 20 water wells samples, covering the phreatic aquifer were analysed for physical and chemical parameters (pH, CE) major cations (Ca²⁺, Mg²⁺, Na⁺, K⁺) and anions (SO₄²⁻, HCO₃⁻, Cl⁻), nutrients elements (NO₃⁻, NO₂⁻, NH₄⁺). Spatial distribution maps developed by GIS, showed that the area close to the phosphogypsum storage site is the zone which is the most affected by the industrial activity. This area corresponds to the upstream part of the aquifer, where we recorded the highest conductivity values, high orthophosphate and sulfate concentrations and a relatively low hydrogen potential. High nitrate are recorded especially upstream of the aquifer and are thought to be caused by high fertilizers use. Overall, well waters use for irrigation represent a medium to high sodicity and alkanisation risk. The current study sheds light on the increasing deterioration risk of Skhira groundwater resources and is an awakening call for decisions makers to imply means for urgent solutions.

KEY WORDS: nutrients elements, major elements, irrigation, sodicity risk, GIS, Skhira aquifer, Tunisia.

A Study on Rainfall Prediction Using Stochastic ARIMA Model

M'nassri S., B. Latrech Basma, A. El Amri, A. Lasrem, A. Rkik, and R. Majdoub

Predicting rainfall is important for agricultural and watershed planning. However, it is complex and difficult due to the high temporal variability of rainfall. These variations in hydrologic time series can be analyzed mathematically. The auto-regressive integrated moving average (ARIMA) model was used in this study to analyze annual rainfall over the Medjez El Bab region in northwest Tunisia. For the period 1959-2013, rainfall data were subjected to a stationarity test using the augmented Dickey-Fuller (ADF). The Akaike information criterion was used to evaluate and validate the selected models (AIC).

The results showed that the best fitted ARIMA model (p,d,q) for rainfall for the Medjez el Bab region is (1,1,0), with AIC and determination coefficient values of about 0.71 and 0.49, respectively.

Furthermore, the model's efficiency was evaluated using mean absolute error (MAPE), root means square error (RMSE), theil inequality coefficient, bias proportion, variance proportion, covariance proportion, theil U2 coefficient, and symmetric mean error (SMAPE).

The statistical analysis revealed that the ARIMA model was adequate and could aid future water planning projections and decision-making to manage irrigation water resources.

KEYWORDS: Rainfall modelling, ARIMA model, time series, annually forecasting, Medjez El Bab region.

Physiological and Biochemical Impacts of Salt and Osmotic Stress on the Germination of Pea (Pisum Sativum L.)

Mohamed A. and M. Loumerem

The work is part of the problematic dealing the effect of salinity and osmotic stress on Pisum sativum behavior during the germination and the early crop development. For this purpose,



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twelve populations of peas were conducted under nine NaCl-based treatment (0, 1.7, 5.8, 12 and 20.88 g / l) and PEG (10, 20, 30 and 40 g / l). In the first part, we studied the morphological parameters of germination. The results are a reduction rate and germination energy, length of radicle and epicotyl and their fresh biomass. The analysis of germinal parameters shows that P12 seems to be more tolerant to stress. However, the growth parameters showed no intraspecific variability. Regarding the biochemical aspect, the results indicate that osmoregulation is probably provided by the ability to synthesize and accumulate proline and soluble sugars. On the other hand, our results showed that the polyphenols are involved in the antioxidant response. On the contrary, the greater accumulation of the parameters in P12 population is considered as a marker of sensitivity to saline and osmotic stress.

KEYWORDS: germination, *Pisum sativum*, osmotic stress, salinity, adaptation, osmotic adjustment.

Impact of Treated Wastewater Irrigation on Soil, Case of Sfax Region, Tunisia

Abidi M., S. Bachtouli, and M. Zairi

The scarcity of good quality water in arid and semi-arid region has led to the use of unconventional water resources such as irrigation with treated waste water. This practice may induce: the contamination by pathogenic germs, pollution by heavy metals and the salinization of soils as well as the degradation of their physical properties.

The main purpose of this research is to analyze the long-term effect of irrigation by treated wastewater on heavy metals soil contamination. Thus, the HYDRUS 1D model for transport in unsaturated porous media was used to simulate Cr, Cu, Ni, Zn and Fe transport in the irrigated Fluvisoil and Calcisoil. The model calibration was undertaken considering chemical analysis on irrigated soil samples.

For a provisional simulation period of 30 years, the heavy metals were transported deeper in the two soils horizons. The superficial horizons are particularly enriched by Cr, Cu and Ni and concerns all the soil profile for Zn and Fe. However, the concentrations of heavy metals are greater in the Fluvisoil than the Calcisoil. Consequently, when considering the irrigation by treated waste water, the soil type and its Heavy metals potential retention must be considered in addition to the water quality.

Macrophyte and Indigenous Bacterial Coremediation Process for Pentachlorophenol Removal from Wastewater

Werheni R., S. Eturki, and A. Hassen

This study has contributed in the description of bioaugmentation-phytoremediation efficiency process using *Typha angustifolia* concerning PCP tolerance and removal from wastewater. Samples of wastewater were collected from industrial wastewater plants, namely row wastewater effluent "E.WW", primary wastewater "P.WW", secondary wastewater "S.WW", clarified wastewater "AC.WW". These effluents were spiked with PCP at different rate (100, 500, and 1000 mg.L⁻¹), physical, chemical and biological properties were monitored. A second experiment was set up in order to check the efficiency of phytoremediation treatments



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of the different effluents artificially contaminated with 200 mg.L⁻¹ PCP after 20 days lab scale experiment. An important PCP removal by indigenous bacteria was showed in S. WW with values from 1000 to 72.2 mg.L⁻¹ from T₀ (start of the experiment) to T_F (end of the experiment), respectively. Phytoremediation process allowed a decrease of PCP rate from 200 to 6.4 mg.L⁻¹, a decrease of chloride content from 14.0 to 4.0 mg.L⁻¹ in S.WW samples was observed. Furthermore, a significant increase of bacterial number in S.WW and AC.WW to 1.700, and 1.450, 106 CFU.mL⁻¹, respectively was observed. In addition, the DGGE analysis showed that after bioaugmentation-phytoremediation treatments, the highest species richness and relative abundance in wastewater effluent was observed.

Valorization of dam sediment, Case of the Siliana dam NW, Tunisia Anibi S., S. Ellouze, N. Jardak, W. Lassoued, and M. Zairi

Siltation is a determining phenomenon in the life of a dam. It is generally related to (1) the characteristics of the watersheds, which are sometimes vulnerable to erosion or have seasonal or insufficient vegetation cover, (2) the intensity and variability of precipitation as well as (3) the fragility of geological formations and steep slopes.

The Siliana dam proposed as a case study is an embankment dam built of zoned earthfill in 1987 with an original reservoir capacity of 70 million cubic meters. The evaluation of sediment quantity that accumulated in Siliana Dam reservoir have shown that it has increased from 0.63 to 1.05 Mm³/year with a current reservoir capacity loss of 50%.

In order to overcome the dam storage capacity reduction by siltation, several solutions can be considered: dam elevation, dam replacement or dam dredging. The last one can cause enormous environmental problems in case of discharge of dredged materials into watercourses.

The purpose of this study is to examine the possibilities of sediments valorization in case of dredging. For that, a hydrological and geological study of the watershed of the Siliana dam is carried out. The collection of samples from the sediments of the reservoir, their identification and classification using laboratory tests are done. Finally, the possibilities of their valorization are discussed.

Possibility of Agricultural Valorization of Treated Textile Effluents: Effects on the Soil and a Fodder Plant

Mzahma S., D. Souguir, R. Ben Amar, J. Duplay, and M. Hachicha

The arid climatic conditions in the majority of Mediterranean countries, the growing demography and the important needs in water for agriculture and industry, imply an increasing water demand, particularly in Tunisia suffering from water resources scarcity, their poor quality and their unequal distribution within the country. Hence, to overcome this lack of water, adoption of non-conventional water resources in irrigation as alternative resources has given an interest. Treated wastewater released by textile industry is one of these alternative resources. Indeed, these textile discharges are characterized by a high volume and an extreme variability of composition, which can include non-biodegradable dyes and toxic substances for the environment and for humans. As a result, many treatment processes have been developed

to treat textile effluents and to meet, then, standards for irrigation purpose. However, few studies have been interested in the impact of irrigation with treated effluents provided by textile dyeing plants, on soils and plants.

The main objective of this work is to evaluate the effect of a continuous irrigation with the treated textile effluents on the biological and physicochemical quality of a local Tunisian soil and on a forage plant *Sesbania bispinosa*. To conduct this work, secondary effluents from a Tunisian textile factory have been subject to different membrane processes (Ultrafiltration, Nanofiltration and reverse osmosis) in order to reach, in force, the Tunisian standards for irrigation purposes. The impact of irrigation with these non-conventional water qualities on the soil and plant will be assessed through a physicochemical and microbiological characterization of the soil, a monitoring of the *Sesbania* growth parameters and its mineral composition.

Effect of Irrigation Methods using Saline Water on Carrot Yield, Water Productivity and Soil Salinization

Tlig W., F. El Mokh, A. El Mokh, K. Nagaz, and G. Provenzano

Improving irrigation water productivity can be considered as a key factor for crop production in arid areas. The choice of irrigation method is a way to save irrigation water. This study was conducted over two consecutive seasons (2017-2018 & 2018-2019) to evaluate the effect of surface and drip irrigation methods on carrot yield, water productivity and soil salinity. For both methods, irrigation was applied based on crop water requirements using saline water (7.4 dS/m).

Results showed that the highest carrot yield was obtained with drip irrigation for both seasons (32.6 and 32.45t/ha) compared to surface method (30.1 and 30.42 t/ha) due to the soil moisture and salinity levels maintained with this method. However, for both methods, no significant differences were observed between the two years due to the amounts and distribution of rainfall events. The high values of yield obtained in addition of the relative low amount of water used under drip method resulted in higher water productivity values (6.3 and 6.2 kg/m³) compared to surface method (5.7 and 5.4 kg/m³). The relatively low difference in WP can have positive economic impact in terms of farm productivity and sustainability. For both seasons, the decrease in soil salinity at harvest, compared to initial values, was a result of salt leaching by rainfall events. Highest soil salinity values were observed under surface irrigation system over the two years due to higher water losses through soil evaporation. Therefore, farmers under these conditions should re-think about their common choose of irrigation method.

KEY WORDS: Salinity, irrigation method, carrot, yield, water productivity.

Natural Bioadsorbent and Photocatalysis for the Removal of Textile Dye Herbicide in Presence of Heavy Metals: A Combined System for Water Treatment

Elfalleh W., I. Assadi, and A.-A. Assadi

The photocatalytic degradation of acid orange II (AOII), which is a toxic dye effluent for textile applications, has been studied using natural pomegranate as heterogeneous

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bioadsorbent in the presence of TiO₂ activated by an external ultraviolet radiation under various conditions. Powder of pomegranate rind and leaves has been tested for heavy metals adsorption. A special attention has been paid to the treatment efficiency of a real dye effluent in the presence of heavy metal, namely zinc (Zn). The experimental results showed that for low values of Zn²⁺ in the solution (40 mg/L), AOII removal kinetics fastened until reaching an optimum, then slowed down for higher concentrations (100 mg/L). This behavior could be explained by the fact that at low zinc concentrations, Zn²⁺ could be incorporated in the photocatalytic process because of its photonic character. At high concentrations, zinc is more susceptible of consuming radicals due to competition effect. On the other hand, results showed that no photocatalytic activity of Zn²⁺ was recorded. The degradation rate was strongly influenced by the presence of heavy metals, initial concentrations of AOII, and amount of crushed powder of pomegranate rind and leaves. Moreover, different ways of adding natural pomegranate in the photocatalytic reactor have been tested to keep Zn²⁺ concentration in optimal conditions.

Caractérisation physicochimique des huiles et des sols dans les deux cas de conduite : irrigué et pluvial.

Faghim J., Ben Mohamed M., Triki T., Gasmî A., Abbassi F., Nagaz K., Guasmi F.

La nature de sol est influencée par plusieurs facteurs tels que l'érosion et la pluviométrie. Aussi bien que la qualité de l'huile d'olive est influencée par des autres facteurs climatiques, agronomiques et génétiques. Etant donné son rôle dans le processus de développement économique et social, l'irrigation est un facteur important de développement. Dans ce travail nous avons étudié les effets d'irrigation sur la composition physicochimique du sol issu de deux sites différentes irrigué et non irrigué (el Massreb et Douiret du gouvernorat de Tataouine). Nous avons procédé à une analyse granulométrique (texture du sol) à l'aide d'un appareil laser. D'autre part, on a déterminé les paramètres physicochimiques du sol (pH, conductivité électrique, calcaire total, calcaire active et matière organique). Pour l'huile d'olive, nous avons étudié les effets de l'irrigation sur la composition chimique d'huile d'olivier de la principale variété en Tunisie 'Chemlali'. Nous avons procédé, à une analyse quantitative et qualitative des composés majeurs de la fraction saponifiable, des polyphénols et des pigments. D'autre part, on a déterminé quelques indices de qualité (acidité, extinction spécifique). Nos résultats ont montré que les sols étudiés appartiennent au même virage granulométrique et que l'irrigation a un effet sur les paramètres physicochimiques des sols et des huiles.

Session 2: Climate Change: Vulnerability and Adaptation in Drylands

Vulnerability of the Tunisian Oases Agriculture under the Change of Production's Factors: Impact of Climate Change and water Resources Deficiency

Aljane F., M. Bekkay, M.-H. Neily, and H. Hamza

The steady changes of oases's production factors such as irrigation frequency, fertilization and phytosanitary treatments have influenced the cropping system. Moreover, such situation is further aggravated by significant climate changes caused by the rise of temperatures and the decrease in rainfall. The survey covered 11 oases (Gabès), 14 oases (Kébili) and 5 oases (Gafsa) patches and a total of 345, 124 and 86 framers were respectively questioned. In orchards, farmers' resources were investigated (farm size, irrigation water sources, irrigation tower, fertilization in-put, phytosanitary treatments, amendment soil's frequency). In this work, a survey was performed to describe and compare different oases's characteristics. The distribution of oases showed that the patches size of a farm's average varied within regions and were 0.19 ha in Gabès, 0.5 ha in Kébili and 1.63 ha in Gafsa, which have led to an excessive farm's size fragmentation. The long frequency of irrigation showed a scarcity of water resources particularly in the oases of Gafsa and also in some parts of Kébili's oases. Such finding showed that the oases studied are characterized by a deficit of water irrigation resources. The average of the period between two successive additions of organic amendments in the ancient oases was significantly higher and the tendency towards the use of chemical fertilizers. The ancient oases farms had an average of sand input once every 5 years. The limited use of phytosanitary treatment in ancient oases can be attributed to the use of varieties with less sensitivity to various pathogens. The change of oases production's factors and their effects on agriculture, especially the intensification of date palm ("Deglet Nour" variety) have led to the marginalization of local varieties. Which are known by their interesting potential to adapt to the rise of temperatures, to drought, to salinity and to the resistance of pathogens.

Spatio-temporal Analysis of Drought in the Merguellil Watershed, Central Tunisia Hamrouni F., H. Omar, and H. Abida

Chronological series of monthly and annual precipitation data recorded in Merguellil Watershed, Central Tunisia, were analyzed. The study is based on the standardized precipitation index (SPI) values, computed for 13 rainfall stations over the period 1982–2018, which corresponds to an observatory period of 36 hydrologic years (from September to August) which allows the characterization of drought intensity and spatial variability. Moreover, the chronological graphic method of information processing (MGCTI) of the "Bertin Matrix" was also applied to detect the trend of climate regime. The results obtained show a great variability in SPI values. The historical evolution of the SPI made it possible to define the periods of excess and deficit, corresponding to wet and dry periods respectively. To highlight this interannual variation in precipitation, the BERTIN matrix was used for all stations. We thus find four phases that mark the rainfall of the study area; The first phase, from 1983 to 1989, is considered to have a dry trend. The second phase begins in 1989 and ends in 1993 with an increase in wet or very wet years. The period from 1994 to 2002 is characterised by a dry trend. The last phase, from 2002 to 2018, is characterized by an increase in wet or very wet years and normal years. The MCGTI matrix method confirms that there is agreement with the SPI index during the cycles considered dry, wet, dry and wet.

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Adaptation of Schinus Molle and Schinus Terebinthifolius in Two Different Locations in Tunisia (North and South): A Study Based on a Phytochemical Analysis

Tir M., A. Mufti, A. Feriani, and N. Tlili

The goal of the present study was to evaluate the effect of location (North and South of Tunisia) on the oil, protein, and phenolic compounds of *Schinus molle* L. and *Schinus terebinthifolius* Raddi fruits. Significant variability in the content of protein was detected between the two regions for *S. terebinthifolius* (17.5% and 26.5%, for Tunis and Gafsa, respectively), while no differences were observed for *S. molle* (ca. 9%). No significant variability was noticed among location for oil content (ca. 8% and 14% for *S. molle* and *S. terebinthifolius*, respectively), whereas significant differences were detected between fatty acid compositions especially for monounsaturated and polyunsaturated fatty acids. Results clearly showed that total phenolic compounds and antioxidant capacity vary significantly among regions. Moreover, HPLC-ESI-QTOF-MS analysis revealed noticeable differences between regions. Significant differences were detected between *S. molle* and *S. terebinthifolius* for carbohydrates (ca. 37% and 31%, respectively) and ash (ca. 17% and 14%, respectively) contents. Results of this work reported information on the influence of locality on the phytochemical content of *S.*

molle and *S. terebinthifolius* fruits and highlight the importance of these plants as an attractive source of bioantioxidants and might be appropriate for the development of reliable index to estimate the adaptation characteristics of these species to different climate.

KEYWORDS: *Schinus* species; Protein; Fatty acids; Phenolic compounds; Carbohydrates.

New Water and Soil Management Strategy and Implementation of Green Technologies for Climate-Resilient Agriculture EauSIRIS Project

Rhouma O., H. Laabidi, M. Louhichi, R.-E. Musumeci, F. Ferlito, V. Campailla, G. Pasciuta, and F. Abdelli

A pillar of both Tunisian and Sicilian economies, agriculture faces today new challenges that need to be urgently addressed to ensure the sustainable development for this vital sector. In fact, water scarcity and soil degradation, intensified by the adverse effects of climate change are increasing vulnerability of agriculture production and putting at high risk water and food security in both regions. Moreover, the agriculture sector's current heavy dependence on fossil fuels increases its economic vulnerability and carbon footprint.

The EauSIRIS project proposes the elaboration and promotion of a new multidimensional science-based strategy to ensure a sustainable, climate resilient and energy efficient agriculture.

Following the completion of various studies and the establishment of mechanisms to stimulate cross-border collaborative work, a strategic alliance between key Tunisian and Italian actors will be created to develop innovative scientific solutions and propose a new legal framework for the Implementation and promotion of the EauSIRIS strategy that will focus on: (i) securing and diversifying water resources at small and medium scales, (ii) soil conservation and adaptation measures to extreme weather conditions, (iii) Use of smart agriculture

techniques and " renewable energies for the rationalization of water and energy consumption, and (iv) Use of monitoring and evaluation systems.

The project pilot actions will first target selected hill lakes that will be upgraded. Local authorities and communities will benefit from a capacity building program for the optimal management and use of hill lakes resources and environment protection.

The project will also target farmers directly through the delivery of a training program and training the implementation of Demonstration Farms that will help promote the implementation of the EauSIRIS strategy.

Session 3: Soil Degradation and Conservation

Valorization Mode of Pastoral Lands in Arid Regions by Small Ruminants Herds and the Impacts on the Rangelands Preservation and the Pastoral Breeding Sustainability Towards Aridity and Climate Changes

Laroussi A., A. Atoui, M. Abdennebi, and S. Najari

The rangelands of the arid zones are mainly exploited by the pastoral breeding of camels and small ruminants, which transform the scarce and irregular vegetal resources into animal products. The herds' traditional management is adjusted to the pastoral resources available. A survey of nearly 118 herds, comprising approximately 22,000 sheep and 12,000 goats, was carried out to establish the patterns of use of pastoral land. Lands status oriented the exploitation of pastures, of which 66% was collective in the studied sample. The animal charge is rarely adjusted to the highly variable pastoral resources from one season to another; which can accentuate land degradation process. The pasture exploitation seems conditioned by its equipment in water points and roads; indeed, apart from the winter and rainy period, only the courses equipped with water points are exploitable by the animals which graze on a radius not exceeding 7 km. About 88% of the herds use the pastures all year and the rest never graze (3%), or for a limited period (10%). The practice of transhumance is observed, for 3 to 7 months and depending on the annual conditions, in 72% of the cases surveyed. Pastoral vegetation only covers part of the needs of herds. All breeders, 100% of cases, use food supplementation to cover their needs; among them, 70% supplement the livestock ration during all the year. The rational development of pastoral land contributes to the sustainability of livestock farming and the preservation of natural resources threatened by desertification.

The Potential of Legume (Chickpea) to Advance Nitrogen, Phosphorus and Microbial Biomass in Rhizospheric Alkaline Soil of Arid Climate

Atallah A., W. Hemdi, A. Souid, F. Telahigue, N. Hamdi, R.-I. Zoghlami, A. Bouajila, and M. Moussa

The soils of the arid and semi regions of Tunisia are characterized by their alkalinity and their low availability of nitrogen (N) and phosphorus (P) which will certainly limit agricultural production. In order to evaluate the effect of a legume (chickpea) on soil richness in microbial

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biomass and on the acquisition of nitrogen and phosphorus by the plant through exchange mechanisms, an experiment was carried out in an alkaline soil deficient in nitrogen (N) and phosphorus (P) in the experimental station of the Institute of Arid Regions, Medenine. During this research we were able to demonstrate that the legume plant (chickpeas) allows to substantially increasing the bioavailability and the biodynamic in P and N especially in the rhizospheric zone following an acidification of the rhizospheric under the action of the symbiotic reactions with the microbial mass of the soil. It was found that the microbial activity was particularly intense for chickpeas with a microbial biomass of nitrogen of 0.083 mgN/g in the rhizospheric part of the soil and 0.052 mg N/g in the non-rhizospheric part. In addition, experimental site soil characteristics with a pH above 8 and average salinity (1.74 ms.m⁻¹) were key in determining the rhizospheric processes involved.

KEYWORDS: legumes, symbiotic fixation, nitrogen, phosphorus, pH, bacterial biomass, rhizospheric part.

Amendment of the Sandy Soil by Clays of the Region (Effect on the Physicochemical Characteristics)

Bennour A., N. Karbout, E. Farhat, H. Lamourou, and M. Mohamed

The present work consists of an experimental study of the improvement of certain physical and chemical properties of the sandy soil of the arid zones of southern Tunisia by adding clays from the region.

The aim is to improve the water retention capacity and the fertility of the sandy soil by adding two types of illito-kaolin clays (the Chouamekh region) and smectic clays (the Aleg formation of Djebel Hidoudi-El Hama). Sand-clay mixtures at different percentages (5%, 10%, 15%, 20%) were prepared in greenhouse pots, and tested under chilli cultivation.

The results obtained show that the addition of clay has a remarkable effect on the quality of the soil studied, by improving its water retention capacity.

The best characteristics were recorded by adding 15% smectite clay and 10% illito-kaolin clay.

Key words: smectite, illito-kaolin, Soil+Clay mixture, water retention, useful reserve, southern Tunisia, arid regions.

Effect of Organic and Inorganic Amendment on the Carbon Mineralization in the Soil of Arid Region

Mekki F., N. Karbout, Ali Bennour, I. Lassoued, and M. Moussa

This work is part of the current issues of agriculture in arid regions, which suffer from various soil degradation processes resulting in the reduction of their fertility and their production potential.

Three amendments were applied which are farm manure (FM), chemical fertilizers NPK, and the combined amendment (organic and mineral) in plots in the institute of arid regions of Medenine. The main objective of this work is to study the effect of these amendments on the chemical and microbiological properties of the soil as well as on the development of the barley plant.

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The results obtained showed that the organic matter content changes significantly in the amended plots compared to those of the initial soil, essentially with manure treatment and more precisely in larger aggregates. Likewise, the treatment with manure has the highest value for the total nitrogen with content a percentage of 31% and for all the other major elements. An increase in biomass was observed in the amended plots. The greatest increase in biomass was obtained in the plots amended by combined amendment where the quantity of DNA increased from 0,63 ng/μl in the control soil to 1,66 ng/μl in the amended soil. The effects of the amendments practiced were clearly manifested in the growth of culture practiced. The best development was obtained in the amended crop with organic amendment with a maximum plant length of 60 cm compared to 30 cm for a control soil.

KEY WORDS: amendment, farm manure, NPK, chemical properties, microbiological properties, carbon.

Estimation of Soil Losses and Mapping of Multifactorial Vulnerability to Water Erosion in Combination with the Sidi Aich Dam Releases ***Karaouli F., Chihawi Rim, and Khlif Nadia***

Water erosion is an important agronomic, economic and environmental concern in semi-arid area. The method of estimation depends on the available data and the conditions of the study area. In this context, this study focuses on quantifying soil losses at the level of dam before and after its implementation (1999) in the Sidi Aich watershed. Three methods were used to assess the impact of the well controlled releases for both recharge and spreading: tele-detection, empirical equations and USLE model.

The results showed that the impact is visible by satellite images. The rate of losses which was evaluated by the two other methods reveals between 360 and 677 T/Km²/year without release, and between 470 and 740 T/Km²/year with releases, using the USLE model, it reaches 1955 T/Km²/year without release and 3957 within. The impact of releases is far from negligible, in fact, a proportion of releases generate between four and six times more losses in soil than rain effects alone.

Despite its imperfections, the model adopted remains a management and planning tool for decision support, it makes it possible to quantify soil losses and to map the area of intervention in terms of erosion control, in other hand, frequency statistical study could be an important support for predictive estimations and future development plans.

Key words: Erosion, soil losses, dam, releases

Innovative Methods to Enhance Composting Process in an Oasis Ecosystem ***Hidri Y., Znaïdi Ibrahim El-Akram, Werheni Rim, Abid Ghassen, Cheikh Mhammed Hatem, Riahi Jouhaina, Somenahally Anil, and Sassi Khaled***

In Tunisia, declining quality of soil resources is one of the central components for unsustainability and vulnerability of smallholder farms.

This situation has worsened by the climate changes. The organic dates production system in the oasis requires large quantities of organic matter. This latter can be produced by the recovery of organic oasis wastes through the composting process. Our research carried out in

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the oasis of Chenini (Southeastern Tunisia) aims to develop new methods in order to accelerate the composting process and guarantee a better quality finished product. All oasis wastes were soaked in water for five days. Three Composting windrows were carried (about 6 000 kg) in pyramidal form. In every windrows, we have used crushed date palm fronds (30%) and sheep manure (70%). The windrows I (Test), with alternative layers of crushed date palm fronds and sheep manure, method used by farmers in Oasis. windrows II, oasis wastes soaked in water with cow dung (innovation 1) and windrows III, just two layers, crushed date palm fronds down and sheep manure in top (innovation 2).

The physico-chemical parameters of composting process revealed that the highest temperature of windrows in thermophilic phase has reached 67°C (windrows I). The pH has fluctuated between 7.6 and 7.9. The electrical conductivity ranged from 1.3 to 1.6 dS/cm and the highest total organic carbon content was about 28%. Microbiological analysis revealed the absence of Salmonella, Pseudomonas.aeruginosa and Staphylococcus in the finished product. For the innovation 1 and 2, the results show that the composting process is faster than the traditional methods adopted by farmers.

Characteristics of Aeolian Sediment Transport over Different Land Surfaces in Southern Tunisia

Labiadh M.-T., C. Bouet, G. Bergametti, J.-L. Rajot, S. Sekrafi, M. Ltifi, B. Attoui, A. Tlili, and M. Hlel

In southern Tunisia, where conventional tillage continues to be used in cultivated areas, tillage ridges and soil cloddiness are the only soil roughness elements that help to reduce soil erosion by wind when vegetation cover is limited. If tillage ridges on soils are effective at trapping saltation aggregates, few studies have mentioned that they may not reduce emission rates as much as estimated for suspension-size aggregates when wind speed is high.

To evaluate the impact of ploughing techniques on windblown loss of top soil, airborne sediment fluxes were measured in southern Tunisia on two neighbouring experimental plots tilled with a mouldboard and a tiller plough, respectively, during five wind erosion events of different intensities. The sediment fluxes were sampled on both plots using a mast equipped with 7 sand traps positioned between ~10 and 120 cm height.

The major results are that the windblown sediment fluxes in the 0-100 cm layer were about 8 times higher on the tiller plot compared to the mouldboard plot due to different efficiencies in the trapping of the saltating particles in the furrows depending on the ridges characteristics. On both plots, sediment fluxes of larger (smaller) particles were depleted (enriched), in the sediment samplers compared to the parent soil. When examining the sediment flux in the 30-100 cm layer, we observed that the efficiency of the vertical transfer was about twice higher on the mouldboard plot than on the tiller one. This implies that a higher fraction of the sediment mobilized by wind can be transported over long distances in the case of a surface ploughed with a mouldboard. This result could decrease in part the benefit of using the mouldboard instead of the tiller plough regarding soil loss by wind erosion.

Effect of Organic Amendment in the Fertility of Sandy Soil in South Tunisia



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Karbout N., H. Lamourou, A. Arjoun, A. Bennour, and M. Moussa

Exposure of arid soils to severe climatic conditions (drought, salinity....) and poor practices by farmers make these soils more vulnerable and lose their fertility.

The aim of this study is to improve the fertility of sandy soil of arid regions which have been subjected to the application of three types of organic amendments (gFarm manure (FM), compost-based on-date palm waste(C), and a combined amendment between compost and manure (C/FM).

The experimental device installed on a plot at the institute of Arid Region in Mednine region in South Tunisia consists of 12 plots of the surface of 1 m² with three repetitions for each treatment. The aim of this work is to highlight the effect of the application of these organic amendments on the Physico-chemical propriety of sandy soil.

The results obtained show a significant improvement mainly in the chemical properties of the soil and a slight improvement in its physical properties, these effects are most noticeable in soil amended with compost and essentially the combined amendment in comparison with the unamended soil and that treated with manure.

Effectiveness of Irrigation in Degraded Agricultural Soils by Treated Wastewater at Short and Long Period in Arid Zones Werheni R.

This work should study the short, medium, and long-term impacts of the treated wastewater application on microbial agricultural soil properties. Three experimental fields were irrigated with treated wastewater for 1, 7 and 15 years, respectively. A pluvial irrigated field was selected as a control. The study was conducted in El Hamma of Gabes, an arid area facing a water crisis (East-south of Tunisia), at the end of the dry season for soil profile 0–20, 20–40 and 40–60 cm. Some physicochemical parameters analysis was conducted including pH, conductivity, total organic carbon, etc. Soil microbial biomass C and N was performed according to extraction-fumigation method. Soil microbial contamination was assessed by enumerating Total and Fecal Coliforms, E. coli, and Fecal Streptococci with the most probable number (MPN) method and plate medium count. Bacterial and fungal enumeration was done by the plate count agar method. The obtained results prove a significant increase in soil microbial biomass (heterotrophic bacteria and filamentous fungi). The pathogen bacterial soil show's a significant increase in treated wastewater irrigated plots compared to the control. The irrigation with treated wastewater showed positive effects on soil fertility. However, this practice has led to a deterioration of the soil sanitary quality. The quality of wastewater treated in Gabes Sud plant must be improved to ensure the reduction of emerging bacterial pathogens to non-detectable levels or to level not associated with human significant health risks.

Effect of Long-Term Grazing Exlosure on Soil Properties and Carbon Mineralization in Sidi Toui National Park, Southern Tunisia

Chibani R., H. Bahri, M. Mohamed, M. Annabi, F. Ben Salem, and M. Neffati

The assessment of soil properties in degraded soils in arid steppe and rangelands is crucial for the adoption of adequate management strategies that respond to sustainable development. The

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aim of this study was to evaluate the impact of long-term grazing enclosure (more than 25 years) on the soil properties and soil carbon mineralization by comparing between inside (grazing enclosure) and outside (continuous grazing) sidi Toui national parc for two defined plant groups: (i) G1 dominated by *Anthyllis henoniana* and *Gymnocarpos decander* and (ii) G2 dominated by *Rantherium suaveolens* and *Stipa lagascae*. At each site, soil samples were taken from the top 30 cm and analyzed for their chemical and microbial properties. The main results indicated that under long-term grazing enclosure the soil organic carbon (SOC) significantly increased with 68% for G1 but not affected for G2. However the total nitrogen decreased by 10% and 32% for G1 and G2, respectively. The pH and the electronic conductivity (EC) were not affected by the grazing regime. A net increase was observed in the carbon mineralization amount by 73% for G1. This effect were not significate for G2. The analysis of soil texture confirm that all soils are sandy with more than 87% of sand. Soil chemical and biological indices as ecological indicators can reflect grazing enclosure effects on soil restoration in arid rangelands.

Potential Risk of The Long-Term Reuse of Reclaimed Wastewater under Semi-Arid Conditions: Application of Soil Adsorption Ratio (SAR), Exchangeable Sodium Percentage (ESP), Geoaccumulation Index (Igeo) and Pollution Load Index (PLI)

Hechmi S., S. Melki, R. Ghrib, N. Jedidi, and M.-N.- Khelil

Reclaimed wastewater (RWW) represents an unconventional renewable water that could be an attractive and inexpensive source to use for cropland irrigating. However, most of the studies predict that soil properties can be endangered over the long-term reuse of these resources due to their high salts and Na contents. On the other hand, the contribution of RWW on the accumulation of trace elements is seldom highlighted. The aim of this study is to evaluate the potential risk of 10 years of RWW irrigation on a sandy loam soil under semi-arid conditions using some pollution indices. In addition to sodium adsorption ratio ($_SAR_$) and exchangeable sodium percentage (ESP), geoaccumulation index ($_Igeo_$) and pollution load index ($_PLI_$) are also investigated to assess the intensity of metal contamination caused by the RWW treatment. Results have been compared to a nearby field irrigated with groundwater (GW) as control. Despite the increase of soil salinity (Na, EC), $_SAR_$ and $_ESP_$ results have revealed no risk of soil sodicity ($_SAR_ < 13$; $_ESP_ < 15\%$) in both fields. On the other hand, $_PLI_$ results have shown that the field irrigated with the RWW is moderately polluted ($2 < 2.33 \pm 0.26 < 3$). $_Igeo_$ results have indicated an extreme contamination with Cu ($6.65 \pm 0.39 > 5$), a heavy to extreme contamination with Ni ($4 < 4.57 \pm 0.75 < 5$), a moderate contamination with Pb ($1 < 1.45 \pm 0.8 < 2$) and no contamination with Cd ($-0.54 \pm 0.19 < 0$). $_PLI_$ results of the field irrigated with the GW have shown no to a moderate pollution ($1 < 1.41 \pm 0.17 < 2$). The same trend was observed for $_Igeo_$, highlighting the geogenic origin of Pb and Cd and the anthropogenic origin of Cu and Ni.

The Potential of Legume-Cereal Intercropping to Advance Phosphorus Availability in Alkaline Soil Rhizosphere of Arid Climate

Hamdi W., A. Souid, A. Maatalah, F. Telahigue, A. Bouajila, N. Hamdi, and R.-I. Zoghlami

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In alkaline soils of arid region with P deficiency, is a crucial problem owing to the low solubility and bioavailability in the rhizosphere, it is assumed that legumes plant species increase inorganic P availability. A field experiment was conducted at the Institute of Arid Regions Medenine Tunisia (IRA), to compare at the full vegetation stage: plants growth, pH variation, P availability, mass microbial and P uptake by plants with sole-cropped a durum wheat, variety *_simeto_* (DWs) and a chickpea cultivar chickpea, variety *_Amdoun1_* (Cka1), intercropped DWs-IC - Cka1-IC and soil bulk. Results Olsen-P and total-P in the rhizosphere were increased in both sole cropping and intercropping systems compared with soil bulk and non rhizosphere soil. Also the highest increase of Olsen-P and total-P were respectively indicated in Cka1 (32.5 and 30.1%) and following by Cka1-IC (30 and 20%) accompanied by a significant pH acidification in the rhizospheres soil of Cka1 in sole cropping (-0.73 units) and Cka1-IC intercrop systems (-0.37 units) compared to soil bulk and enhanced biomass plant growth (shoots and roots) DWs-IC.

The land equivalent ratio (LER) was greater than 1, indicating that it is more beneficial to DWs-IC as opposed to growing then DWs. This intercrop (DWs-IC) presented the highest shoots and roots biomass dry weight (15%) than DWs in sole. Moreover soil mass microbial P (SMBP) increased in Cka1 sole (62%) and in intercropping (49%) compared soil bulk.

KEY WORKS: Alkaline soil, legumes-cereals, phosphorus, rhizosphere.

ISFERALDA Project: Using Organic Amendments Based on Date Palm Residues to Enhance Soil Fertility in Oases agroecosystems

Morvan X., B. Boumaraf, V. Kavvadias, M. Moussa, L. Hafouda, S. Mahtali, F. Bendjeddou, A. Zaakir, M. Gommeaux, N. Karbout, R.I.- Zoghlami, E. Le Guyader, V. Miconnet, K. Guimeur, A. Tirichine, A. Abid, and B. Marin

Soils in drylands of North Africa are generally considered as low fertility soil, notably because of their low organic matter content. In these regions, oases are the main driver of the economy. Date palm cultivation is the main source of income for farmers. Within the oases, only a minor part of the by-products of date palm cultivation is valorized. Their valorization as bioresources, with a potential effect on soil fertility, has received little attention to date. In this context, ISFERALDA project aims to increase the climate change resilience of the agro-ecosystem while providing comparable or higher incomes to local farmers in semi-arid and arid areas.

The project aims to develop the use of organic amendments based on traditional production (composting, pyrolysis) and on local agricultural wastes, particularly date palm residues, in agreement with the objectives of circular economy. Innovative farming systems will be developed and will contribute to a sustainable management of date production, generating income and creating jobs, while improving environmental parameters.

The innovation potential of the project is based on a multidisciplinary and strongly integrated approach.

A socio-economic analysis, based on surveys, will familiarize farmers with the economic interest of producing and using the proposed organic amendments.

The proposed research activities include a detailed description of each amendment studied, laboratory experiments to describe and explain the evolution of the soil properties depending

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on studied amendments, and field experiments, in five different sites representative of the drylands in Algeria and Tunisia.

Contacts with stakeholders, particularly farmers, will promote the acceptance of these practices if they are deemed beneficial from an economic and agronomic point of view. They will allow the dissemination of this new knowledge to the main actors of the agricultural sector and of this method on a regional and national scale in the whole Mediterranean basin.

Short-Term Effect of Organic Amendments on Chemical Properties of Soils under Oasis in Arid Regions of Tunisia

Omar Z., A. Bouajila, I. Sassi, N. Karbout, and N. Chniguir

Arid and semi-arid regions are characterized by low fertile soils that are prone to be degraded by several phenomena. Applying organic amendments to recover degraded soils properties is a strategy to restore their fertility by enhancing soils physicochemical and biological quality. Thus, the present research aims to investigate the short-term effect of organic amendments on chemical properties of arid soil. This study was conducted out in sandy soils developed under oases ecosystem from Touzeur, from the South west of Tunisia, where two organic amendments, namely, Ceres (cattle manure + oases biowaste) and Palm Power (citric acid + poultry manure) were applied to the soils at a rate of 2 kg/m². The results indicated that all applications of organic amendments significantly reduced soil pH, while they enhance the soils electrical conductivity (EC) and calcium carbonate contents. Cation exchange capacity (CEC) tends to decrease with all used organic amendments contrary to assimilated phosphorus.

After 1 year of all applied organic treatments, soil organic matter (SOM) and total nitrogen increased, while they significantly decreased after 6-months of Palm Power application. The application of organic amendments to sandy soils in arid regions may, globally, enhance their chemical properties and restore their fertility by rising their soil organic matter, which influences all over soil properties. The positive impact of the organic amendments on such soils that was observed after 1 year of organic treatment addition at a low rate may encourage farmer to adopt this strategy to accelerate their soils rehabilitation.

KEYWORDS: organic amendments; restoration; SOM; chemical properties; sandy soils, arid regions.

WEFE-NEXUS to Ensure Water, Food, Energy and Environmental Security in the Wadi Jir Watershed (Matmata, Tunisia)

Abdelli F., S. M'hemdi, F. Nardi, M. Ben Zaied, R. Belayadi, M. Guied, M. Ouessar, E. Caporali, M.-C. Rulli, R. Rossetto, M. Bonamente, F. Tessari, L.-R. Sinobas, X. Schneider, S.-D. Marcu, C. Cudennec, and M. Bahnassy

The purpose of this poster is to give an overview about the NEXUS-NESS project and the Tunisian NEL "Wadi Jir watershed -Matmata".

The main objective of the Wadi Jir watershed NEL is to mobilise and engage all relevant stakeholders to co-define and co-test specific Water-Energy-Food-Ecosystem Nexus plans (WEFE Nexus plans) for fair and sustainable allocation of resources. Through the NEL, local and regional stakeholders will be engaged and mobilised through participatory workshops

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applying the Responsible Research and Innovation (RRI) Roadmap for identifying needs, prioritising them, ideating and framing a WEF-E-Nexus future, co-defining a common WEF-E-Nexus common vision, co-design an action plan for moving towards this vision, implement actions, measure, and adjust the action plan and intensify actions to move even closer to the WEF-E-Nexus common vision.

The Wadi Jir watershed NEL is located in the region of Matmata and it is represented by the Wadi Jir catchment (146 km²) and the spreading perimeter of new Matmata (9,21 km²). The study area belongs to the region of southeastern Tunisia (governorate of Gabès). It covers administratively the delegations of new Matmata and Matmata.

The Three Grand NEL challenges:

- 1- Identification of the best water allocation and adapted crop for sustainable food production and ecosystem conservation,
- 2- Ensuring self-sufficiency in water and energy needed,
- 3- Ensuring rural development (tourism, HMAP production).

Sustainable Approaches to Land and water Management in Mediterranean Drylands: SALAM-MED

Ben Zaied M., C. Ceseracciu, E. Bresci, M. Centritto, N. Lamaddalena, E. Zaghoul, S. Solomos, Z. Kallas, S. Wahbi, A. Del Campo, H. Henchir, A. Merella, A. Galante, J.-M. Fures, Y. Brahimi, T. Arbasi, P.-P. Roggero, and M. Ouessar

Land degradation and desertification in Mediterranean (MED) dryland socio-ecological systems emerge from the structural coupling of ecological and socio-economic processes, where climatic pressures are combined with weak adaptive capacity. The sustainability of rural livelihoods in endangered drylands depends on the capacity of local stakeholders to adopt systemic innovations.

The SALAM-MED project is designed to identify, test and validate “nature-based” practical solutions to enhance the resilience of endangered MED drylands or to restore degraded ecosystems in arid and hyper-arid land. The concept is framed in a systemic innovation process for sustainable development empowered by six Living Labs (LL) in Egypt, Greece, Italy, Morocco, Spain and Tunisia. The hotspots encapsulate a wide range of societal, agricultural, forestry and environmental conditions. The LL approach relies on social learning and knowledge-sharing processes for the generation of new scientific+local hybrid knowledge.

The SALAM-MED hotspots represent MED agricultural and forestry ecosystems across a gradient of aridity indices (AI). In Valencia (ES, AI=0.45), the effectiveness of the C.A.F.E. approach is being tested to address sustainable forest management in contrast to abandoned forests affecting the hydrological cycle of watersheds providing freshwater to rural and urban societies over 50% of Southern Europe’s land. The Messina LL (GR, AI = 0.5), will represent the over 8 Mha of olive orchards in the MED. The Sardinian LL (IT, AI=0.5) is representative of silvopastoral systems in dehesa-type habitats covering some 15Mha in the MED. Water harvesting, microbial consortia and smartAg technologies will be tested and validated in the hyperarid desert agriculture of the wadis in Matrouh (EG, AI<0.05). The out-scalability of Managed Aquifers Recharge and their role in the restoration of sustainable agriculture are

studied in Medenine (TU, AI=0.05-0.2), where drought and abandonment are the main drivers of land degradation. Smart grazing management, Subsurface Water Retention and Water Harvesting technologies are combined to reverse land degradation in the Argan forests at Essaouira (MO, AI=0.15).

Nutrients Inputs by Aeolian Deposition in the Sahelian Soil

Marécar R., B. Marticorena, G. Bergametti, C. Galy-Lacaux, R. Losno, J.-L. Rajot, S. Chevaillier, A. Féron, S. Triquet, and M. Diaz-Alvez

Mineral dust emitted from soil by wind erosion is a major atmospheric specie because of its radiative and biogeochemical impacts. Dust emission affects the soil fertility, by a loss of nutrients in source regions while its deposition can represent a significant nutrient input, in particular for remote oceanic eco-systems. The Sahel is a dust source region but it is also a region where large amount of Saharan dust is transported and deposited. Estimating the balance of soil loss and deposition in this region is challenging. To quantify the input of nutrients that mineral dust deposition represents for Sahelian soils and to identify the sources of these deposits a dedicated instrumental setup was deployed for two years in two Sahelian sites of the INDAAF Network : Bambey (Senegal) and Banizoumbou (Niger). Atmospheric particles have been analysed in terms of elemental composition and carbon content. Both the insoluble and the soluble fractions of atmospheric deposits have been collected and analysed. A focus was made on the nutrients important for soil fertility in the region (P, N, C, Ca). Other elements (Fe, Al, K, Ca, ..) were used to identify the sources of the deposited aerosols.

The elemental analysis of the dust samples reveals a seasonality in the dust in the composition. In the dry season, dust composition is similar in Niger and Senegal. In the wet season, mineral dust exhibits the typical signature of sahelian soils (enriched in Fe, depleted in Ca) in Niger, but in Senegal it suggests a regional source enriched in Ca. The composition of aerosols and deposition are consistent for most of the analysed elements. The analyse of the soluble and insoluble fraction of dust deposition allows to estimated the total annual amount of P, C,N and Ca deposited on Sahelian soil that can contribute to soil fertility.

Preliminary study on the potential re-use of humin (derived from lignite) as an organic amendment under arid climate conditions: Effect on soil properties and barley (*Hordeum Vulgare*) growth

R. Dakhli

The increase of saline–drought environments due to climate change alongside to soil poor quality will affect crop productivity around the world by 2050. In this study, we have investigated soil quality and barley growth under arid and saline conditions after the application of humin derived from lignite. Accordingly, a macrocosm study has been assessed in pot experiment with three replicates. Humin has been applied at 0 (S0), 20 (S+H20), 30 (S+H30) and 40 g.kg-1 (S+H40). After one year of of addition, soil TOC, N, P, Ca²⁺, Mg²⁺ and K⁺ increased in a dose-dependent manner, showing higher contents in the soils amended with the highest rate (40 g.kg-1). Subsequently, soil CMB and NMB have been enhanced in the amended soils, indicating no inhibitory effects towards the increase of soil salinity and the accumulation

of Na⁺ (1569 mg.kg⁻¹). Barley growth has also been positively influenced by the application of humin, showing high straw and grain yield in S+H40 (2.84 and 2.37 t.ha⁻¹) compared to unamended soils (0.41 and 0.47 t.ha⁻¹). Moreover, the addition of humin has improved barley resistance to salinity stress, which has been evidenced by higher proline and stomatal conductance particularly in S+H40. This highlights the unavailability of Na⁺ for plant uptake, probably due to high soil TOC responsible for Na⁺ retention. Accordingly, we recommend the application of humin derived from lignite at 40 g.kg⁻¹ to improve soil quality and the productivity of barley under aridity and salinity constraints.

KEYWORDS: humin, lignite, organic amendment, retention, salinity.

Session 4: Environmental Monitoring and Assessment in Drylands

Evaluation of the Impact of Temperature Humidity Index (THI) on Growth Traits of Tunisian Local Kid under Arid Conditions

Atoui A. and N. Sghaier

The study aims to evaluate the effect of temperature and humidity on the weight of kids from a Tunisian local goat breed. Growth recording from 2010 to 2019 were merged with temperature and humidity data provided by the state meteorological agency. A total of 4,173 body weights in the caprine herd of the Arid Areas Institute of Médenine were used. Different models including alternatively the effects of heat load as a temperature-humidity index (THI), the average temperature (Tavg) and the maximum temperature (Tmax) on weight were used. Heat load on the day of recording or the average heat load of the 7 days previous to the day of weighing (THI7, Tavg7, Tmax7) were tried. Heat load was modelled either as a class effect (c) or through quadratic (quad) or cubic (cub) Legendre polynomials. Overall, 18 models were used. All models included effects of age and weight of dam, the interaction sex*type of birth and year of recording, plus random animal effects. Models using cTHI and cTavg7 provided the best goodness of fit, with Tmax models showing the worst performance. Heat tolerance thresholds were estimated at 21/20, 25/28, 68/66 for Tavg/Tavg7, Tmax/Tmax7, THI/THI7, respectively, from the cubic polynomial fit. Slopes of decay in expected weight after the threshold were around 300 g/degree of Tavg or THI above the threshold. According to these results, heat stress is limiting the growth of kids in this local breed of goats. Tavg and THI seemed to provide a better way of measuring heat load compared with Tmax. Average of heat loads in the period previous to recording of weights showed better results than heat load on the same date, but not for all the studied variables.

KEYWORDS : Goats, Heat tolerance, weight, arid area.

Building and Transmission of Agricultural Know-How between the Jebalias of Beni Khedache and the Surrounding Foothills. What Socio-Economic and Environmental Impacts?

Aridhi O., A. Hanafi, and T. Melki

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The jebalias of Beni Khedache have throughout history built up an important know-how in the valorization of natural resources. This know-how is manifested by the management of watersheds to collect fertility and practice olive farming to preserve natural balances and maintain family incomes. However, and after the saturation of agricultural areas in the mountains, a part of the _jebalias_ took advantage of the waves of privatization of collective lands in the foothills and in the plain to occupy these new areas and bring their know-how with them. There followed an important dynamic of these lands until then pastoral. To analyze this territorial dynamic and its impact, we have drawn up a Land cover / Land use map between 1985 and 2020, which was supplemented by a socio-economic survey of around fifty farms. The results showed (i) a strong olive extension in the foothills and in the plain, particularly since the end of the 1990s with the privatization of the last collective lands in the region. They also showed (ii) that despite the transfer of agricultural know-how from the _jebalias_, the different natural conditions in the foothills and in the plain did not make it possible to obtain the same economic results since olive production is much lower and is more exposed to the risks of prolonged droughts. In addition, the extension of olive plantations in the foothills and in the plains has sometimes ended in convincing failure, manifested by the drying up of several plantations, particularly those far from fertile soils and waterways. But despite these constraints, this dynamic does not seem to stop and agricultural know-how seems to continue to spread even at the level of the sandy plains.

KEYWORDS: Agricultural know-how - Transmission - Jebalias – Beni Khedache - Southern Tunisia.

Mapping Land Use Changes Based on Multi-Dates Landsat Imagery in Dahar Region, Southern Tunisia

Chenib A., B. Essifi, A. Ghram-Messedi, and A. Zerrim

In pre-Saharan Tunisia, characterized by extreme climatic aridity, desertification has become, for several decades, the main environmental problem, which has threatened the availability of natural resources and human wellbeing. With the growing availability of remote sensing data, land use mapping and related geospatial applications are crucial decision support tool for natural resource management and sustainable development. In this study, we focus on identifying Land Cover/Land Use (LCLU) changes in Dahar region, southeastern Tunisia, based on multi-date Landsat imagery: ETM+ for 2003, 2005 and 2012, and OLI for 2015, and the percent of normality on precipitation data. This paper aims to map the changes of natural steppic vegetation, agricultural landscapes, sand encroachments and their impact in the study area. Ten LCLU classes were derived using a Maximum Likelihood (MaxLike) supervised classification coupled with ground truth data. The Change Detection, applied between normal years (2005-2015) and humid years (2003-2012), has revealed that the Sand Encroachment_ is the most dominant category, occupying more than half of the study area. On the other hand, agricultural activities, Arboriculture behind Jessour_ and _Arboriculture behind Tabia_ classes, have showed around 20% regression from 2003 to 2015. As for Arboriculture and Degraded Rangelands, we have noticed have recorded a slight increase during this period. Similarly, Desertic Rangelands.

However, the extent of Mountain Vegetation and Sparse Vegetation classes have almost remained unchanged (24% and 4% of the total studied area respectively). The interpretation of land use and change maps has proven their suitability for improving and sustaining land management, and particularly soil degradation in southern Tunisia.

Moreover, the spectral and spatial characteristics of Landsat imagery has highlighted the ability of remotely sensed data to identify desertification risks, assess land condition, and monitor LCLU changes in Dahar of Tataouine.

Using Earth Observation for Sustainable Natural Resources Management: MISBAR Joumade Mansouri F.

The Global Monitoring for Environment and Security and Africa project aims to promote the development of local capacities for access to Earth Observation and its exploitation.

The project proposal « EARTH OBSERVATION FOR SUSTAINABLE LAND AND WATER MANAGEMENT IN NORTH AFRICA» was developed by OSS in collaboration with regional and national partners, specialized in remote sensing. The overall objective is to support decision-making in the field of sustainable management of natural resource and water through the provision of products and services based on Earth Observation (EO) data and techniques.

Two services were developed in the GMES&Africa project: MISLAND and MISBAR.

1/ MISLAND : Monitoring integrated Services for Land Degradation.

2/ MISBAR: Monitoring integrated services for best assessment for natural resources.

The study case is about using MISBAR service to calculate burnt forest areas at Nabeul region in Tunisia. The forest is prone to fires which can be very serious every summer, because of the high temperature and the mistakes made by some people during picnics.

The work consist in several steps as mentioned below:

1/ choose the study region on the platform.

2 / choose the time series that cover the study period.

3 / determine the existing prepared data set / or prepare a new one.

5 / check the date of correspondence to the fires set off

6 / export to GIS software

7 / calculate the burnt areas

Using the service is very useful to know the exact areas affect by fires, and be able in short time to transfer the information to the Ministry of agriculture specially the Forests General Directorate, and to be able to schedule the areas for future reforestation program.

Using Earth Observation for Sustainable Natural Resources Management: MISLAND Joumade Mansouri F.

The Global Monitoring for Environment and Security and Africa project aims to promote the development of local capacities for access to Earth Observation and its exploitation. The project proposal « EARTH OBSERVATION FOR SUSTAINABLE LAND AND WATER MANAGEMENT IN NORTH AFRICA» (GMES&AFRICA) was developed by OSS in collaboration with regional and national partners, specialized in remote sensing. The overall objective is to support decision-making in the field of sustainable management of natural

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resource and water through the provision of products and services based on Earth Observation (EO) data and techniques.

Two services were developed in the GMES&Africa project: MISLAND and MISBAR.

A/ MISBAR: Monitoring integrated services for best assessment for natural resources.

B/ MISLAND: Monitoring integrated Services for Land Degradation using several indicators cited below

1/ SDG 15.3.1 : Proportion of land that is degraded over total land area (Land productivity, Land cover, Carbon stock, SDG Indicator).

2/ Vegetation lost and gain

3/ Forest change (Forest loss, Forest Carbon, Forest Fire Risk, Forest Fire Assessment)

4/ Desertification (MEDALUS)

5/ Soil erosion (Wind Erosion, Water Erosion, Combined Erosion)

6/ Coastal Erosion

At Nabeul level, the study was trying the different indicators developed and to see how much it can give information needed in short time and confirm the land reality specially such as the land lost by urbanism on farm lands, gain and lost vegetation, and forest fire using Earth observation.

In training sessions, we proposed to add an indicator FOREST FIRE RISK that can help to prevent fire, to act in time and organize the disaster regional committee work.

FOREST FIRE RISK uses data from the Earth Engine version of the Fire Information for Resource Management System (FIRMS) dataset. The near-real-time active fire locations are processed using the standard MODIS MOD14/MYD14 Fire and Thermal Anomalies product.

The Assessment of Biological Diversity of Endangered Date Palm in the Oasis of Nefzaoua ***Benabdallah H., A. Ben Aoun, A. Laajimi, F. Abbassi, J. Faghim, F. Guesmi, T. Triki, M.-S. Belkadhi, and A. Ferchichi***

The study of oasian agro-system biodiversity of Nefzaoua was carried out through the prospection of 53 oases. The diversity evaluation of date palm floor showed that 36.32% of oasian plots were characterized by a null diversity ($H=0$) and the cultivation of the same variety which is "Deglet Nour" representing 90, 29% of total date palm trees. The hierarchical classification of 21 cultivars of date palm cultivars based on 16 morphological parameters, revealed 6 distinct groups. This distinction is essentially based on fruit maturity, on fruit consistency and harvesting mode.

In our study, we estimate that the morphological characterization and measurements of different varieties date palm has detected a significant varietal diversity, this is in addition to molecular characterization: in this case, the genetic data was obtained using eight highly polymorphic SSR loci.

Remote Sensing Data for Drought Impacts Assessment on Olive Plantations in Southern Tunisia

Dhaou H., D. Ouerchefani, and N. Ben Mechlia

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Dealing with rainfall variability is becoming a major concern for water scarce countries like Tunisia in light of climate projected changes. During the last decade, remote sensing has been increasingly used for drought impact assessments. However, there is a real challenge for using satellite data in areas having sparse vegetation.

Among these are the regions of southern Tunisia where olive cultivation with wide spacing (24mx24m) represents an important agricultural activity. This work aims to investigate the use of remote sensing derived indices for characterizing the growing conditions of olive trees in the areas of Zarzis and Benguedane, over the 2000-2018 period. Using Landsat images(TM, ETM+ and OLI), we compared the temporal variation of several vegetation indices (NDVI, EVI, TCI, VCI,..) for April and June to cumulative rainfall and SPI over the periods starting in September and ending on the month preceding the satellite observation. A good degree of coherence can be seen between the NDVI and the VCI indices in the detection of the olive trees response to rainfall variability. Moreover, the results showed the performance of the combined use of SPI and VAI in monitoring drought impact on olive tree in arid areas.

Mapping Market Gardening Crops in Merguellil Plain using Sentinel 2 and Google Earth Data

Kassouk Z.

Mapping of landuse and crops over space and time contribute to improve the management of water and soil over agricultural territories. the aim of this work is to improve crop mapping in arid region of merguellil plain, center tunisia. proposed classification scheme consists of several main steps: (1) texture indices of entropy, contrast, variance, homogeneity and uniformity were calculated from a googleearth image (may 2019) to resort to a suitable fine-resolution object; (2) the extraction of a large set of radiometric indices (vegetation, soil, water) from 39 sentinel2 imagery collected from september 2018 to august 2019, (3) stactical analysis of spectral indices related to crop phenology , (4) object-based featurng of both reference areas (for training acquired during spring 2019, five field surveys were conducted in merguellil plain (161 samples of crop market gardening and more than 300 samples from other crop type a data base was settled in order to elaborate the crop type map for summer market gardening.) and segmented objects; (5) random forest (rf) classifier and object oriented approach. the overall accuracy is 81.77% and kappa index is 0.74. bare soil, winter market gardening/fallow land, market gardening, citrus trees are moderately accepted with values than 0.66._

Perform Land Cover Mapping in Arid Region by Processing Multisource Satellite Imagery and Machine Learning

Kassouk Z., H. Zayani, R. Gaetano, X. Augusseau, and Z. Lili Chabaane

Accurate and reliable land cover mapping using remotely sensed data and image classification methods has a significant role in dry land since it can comprehensively improve water management, and sustainable natural resource and agricultural management. This research is mainly focused on the determination of landuse from SPOT-6, a time series of Sentinel-2 and a Digital Terrain Model (DTM) by using an object-based image classification method with

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random forest (RF), in two arid regions Kairouan plain and Siliana in Tunisia and a set of training areas was created using polygons for the land cover categories.

Approach is based on a machine learning using the Moringa land cover processing chain. First, the SPOT image is segmented by using multi-resolution segmentation. Second, spectral features, textural features, and remote sensing indices were obtained for each image object. Multilevel land use maps follow a hierarchical nomenclature ranging from 5 classes at level 1 (Water Bodies, Forests, Hills and bare soil, Crop land, Urban) for the least detailed level to 19 classes. For the most detailed one where crop land is divided into four subclasses (Cereals, Bare soil, crops, trees, bare soil). The validation of these maps shows a good quality of the results with overall accuracy rates ranging from 85% to 94%. Produced maps could be useful for researchers and land managers (State services and local authorities).

Assessment of Nitrates Water Quality Test Strips in a Citizen Science Based Monitoring Program in the Medjerda Watershed (Northern Tunisia)

Riahi K., S. Chaabane, S. Khelifi, E. Slama, and M. Vanclooster

Efficient and effective monitoring strategies for the quality of water resources are strongly needed for the management of vulnerable hydrosystems. Citizen Science (CS) applied to Water Quality Monitoring (WQM) is considered nowadays such as an innovative monitoring approach that can partially overcome data gaps in traditional WQM systems. The main objective of this study is to assess the performance of a CS-based WQM program for nitrates based on test water quality strips for the Medjerda watershed in Tunisia. For this purpose, 33 citizens were selected to participate to the CS-program. In total, 137 samples were collected in 24 sampling sites in the Medjerda watershed. Each sample was read by at least one citizen. Five citizen types were identified according their educational, socio-economic background and recruitment modality (social media, training sessions,...). Statistical tests (Pearson correlation, determination coefficient, and α Cronbach) and multiple correspondence analyses were performed to assess the goodness of fit of citizens' data considering their socio-economic profile.

Results indicate a good agreement between observations based on the five citizen types and the analytical methods for nitrates.

Nevertheless, the nitrates reliability and accuracy using test strips seem to be sensitive to turbidity and citizen's typology. A compensation data equations model was developed to compensate for turbidity interference, considering each citizen type. Additional efforts in term of communication, training, feedback culture, and modality of motivation connection could help to enhance this participatory approach in order to reinforce conventional methods and tools in WQM.

KEYWORDS: Citizen Science, Water Quality Monitoring, Nitrates Test Strips, Data quality, Medjerda River, Tunisia.

Dynamics of Desert Vegetation in Dghoumes National Park, Arid Zone of Tunisia

Moumni M., J. Msadek, A. Tlili, and M. Tarhouni

The current state of the steppe and Saharan ecosystems, their ecological and socio-economic importance, the degradation of the environment and the need for sustainable development are

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all elements that strongly justify our research topic. This study was carried out in the Dghoumes national park (Tozeur governorate, southern Tunisia).

This region is characterized by extreme climatic conditions, which accelerate the processes of degradation of natural resources and require the application of appropriate sustainable management techniques for the preservation of its flora heritage. In this context, this study aims to observe the effect of the variation in climatic conditions (precipitation) as well as that of protection on the dynamics of the plant cover in relation to the disturbed environment of the park, with certain quantitative parameters (specific richness, recovery rate, productivity, etc.) and qualitative (true diversity). The results obtained indicate that the beneficial effect of protection is manifested by an increase in species richness, plant cover, density and productivity in the protected area and outside. Most of the monitored parameters are strongly correlated with precipitation. The resilience of the disturbed desert vegetation community remains possible but after long period of protection, a light grazing is recommended to maintain and regenerate the natural vegetation cover.

The Fig Cultivation Heritage in the Tunisian Arid Region Between Conservation and Sustainable Development. Case of the Beni Khedache and Toujene Mountains **Mena A. and A. Hanafi**

Like several arid regions of the Maghreb, the mountains of Beni Khedache-Toujene are home to a rich and diversified biological heritage made up of fig tree plantations. Associated with the cultivation of olive trees behind the jessour, these plantations have previously contributed to the natural and economic balance of these arid hinterlands. In order to make a diagnosis of this heritage and to analyze its capacity to develop family economies as well as the possibilities of its transmission to future generations, we carried out a survey in March 2022 of around fifty farmers and traders in the processing and sale of fig tree products. This survey was supplemented by interviews with all the regional services involved in this activity. The results showed (i) the richness of this heritage and its local specificity benefiting from a particular bioclimatic atmosphere but of which (ii) the economic valuation remains timid and does not bring clear economic support to households. But despite the difficulties it encounters at the farm and the product development levels, this activity could constitute a real opportunity for young investors in the region to boost the local economy. This must go through clear support from the State, particularly in terms of training, financial aid and certification of products (dried figs, etc.) like several other Tunisian regions and other products (eg: Figs from Djebba AOP, BioZelfene).

KEYWORDS: Fig tree - Heritage - Survey - Development - Beni Khédache - Toujene - Southern Tunisia.

Operational Monitoring of Land Use Changes' Impacts on Desertification Risks and Carbon Stock in Drylands: A Combined Geo-Socio-Environmental Approach **Fetoui M., A. Tlili Abderrazek, B. Essifi, F. Chouikhi, M. Abdeladhim, and M. Tarhouni**

In arid zones, observation data on spatial and temporal variability of above-ground biomass and their relationship with natural and human factors are poorly quantified and need further testing for effective fight against desertification and climate change mitigation.

Addressing these information gaps requires integration of ecological and remote sensing techniques alongside livelihoods and resource use assessments, using new and integrated methodological approaches.

To promote monitoring of land use changes and their impacts on desertification risks and carbon stock in arid zones, this paper propose a combined geo-socio-environmental approach and an integrated operational monitoring system, developed and applied in Tunisian arid zones. This approach is expected to identify the linkage between spatial indicators of desertification risks, determined by integrating biophysical and socio-economic data, and remote sensed land cover/land use changes. It offers the means to enable a rapid assessment of desertification risks and carbon stock, quantified in seven landscape types, according to the IPCC standard and spatialized for each type of land use change.

Findings show that 59 % of the studied area are under high risk of desertification following the land use changes recorded between 2004 and 2019. Three land use change types, which have the highest carbon sequestration rate and the lowest risks of desertification, are considered as the best practices that can maintain land's productivity and sustainability. Spatial distribution of carbon storage and desertification risks could inform decision making, enhancing land use strategies to mitigate climate change and provide adaptation options.

KEYWORDS: Climate change-Desertification-Land use/Land cover changes-Operational monitoring system-Tunisian drylands

Morphological and Biochemical Responses in Two Contrasting Medicago Truncatula Lines Submitted to Combined Drought and Phoma Medicaginis Infection

Maiza N., C. Jabri, I. Romero, N. Zaidi, N. Djéballi, M. Hanana, M.-T. Sanchez, and M. Badri

The main objective of the present proposal is to characterize the molecular mechanisms undergoing the responses of *Medicago truncatula* to combined drought stress and *Phoma medicaginis*. In order to achieve this objective, the following specific objectives are proposed: (i) Analysis of the morpho-physiological responses to combined effects of drought and *Phoma medicaginis* in the accessions of *Medicago truncatula*. To achieve the specific objectives, the following working plan is the morpho-physiological and biochemical evaluation of tolerance to drought and *Phoma medicaginis* in two contrasted lines of *M. truncatula* (Tunisia-Spain).

The results showed that the treatment factor explained the majority of the variation for the measured traits. It appeared that the line F83 was the most sensitive and therefore adversely affected by water deficit stress, which reduced its growth and yield parameters, whereas the tolerant line TN6.18 exhibited the highest aerial biomass production, a significantly higher increase in its total protein and soluble sugar contents, and lower levels of lipid peroxidation with greater cell membrane integrity. The infection with *phoma medicaginis* increase the tolerance of TN6.18 to combined stresses increasing the number of healthy leaves and the number of ramifications compared to the sensitive line F83 that exhibited the highest number of infected leaves compared to healthy leaves.

In conclusion, our results showed that the combined stress influenced the morphology, physiology, and metabolic features of the two contrasting *M. truncatula* lines TN6.18 and F83. However, the tolerant line TN6.18 displayed a higher performance in terms of shoot biomass production as protection from damage compared to the sensitive line F83. Additionally, the results suggest the highly synergistic direct effects of drought and *Phoma medicaginis* combinations in *M. truncatula*.

Plant Life Forms Types under Different Grazing Regimes in Tunisian Drylands

Msadek J., M. Moumni, A. Tlili, and M. Tarhouni

For decades, the regions of southern Tunisia with an arid bioclimate have been subject to a very rapid transformation of ecosystems.

Substantial human disturbance and climate change have led to significant land degradation with the spread of erosion and desertification. This study was carried out in the Mountain Rangeland Chain of Matmata. Some plant life forms types (Raunkiaer, Noy-Meir and Grime types) are used to highlight their adaptive strategies under three grazing regimes (grazing exclusion, seasonal and continuous grazing). Main results showed that plant life forms are strongly affected by the grazing regime since the Chamephytes, Arido-Active (*_AA_*) and Competitive-Stress-tolerant species (*_CS_*) are higher under seasonal grazing than control. All these species are qualified as less resistant to grazing. Whereas, Arido-Passive (*_AP_*), Ruderal-Stress-tolerant (*_RS_*) and Therophytes seem to be resistant to grazing. Studying the impact of grazing management on the plant life forms types is recommended to maintain the diversity of the plant community and to find the most adapted species under montane dryland conditions.

Remote Sensing and GIS-Based Modeling for Wind Erosion Assessment in Bouhamed Watershed

Ouerchefani D. and H. Dhaou

Various previous studies showed that the southern part of Tunisia, in particular the arid and semi-arid regions, are one of the regions most vulnerable to wind erosion. Comprehensive mapping of the seasonal severity and variability of wind erosion risk are always needed by public authorities as they may consider the results in their policy decision-making. Qualitative risk maps are also a suitable measure to raise awareness for soil erosion by wind.

The aim of this work is the identification and mapping of vulnerability to wind erosion in the Bouhamed watershed, based on remote sensing derived indices and modeling. The developed model shows good internal consistency and is sensitive to spatial and temporal variations of the factors taken into consideration; 2) as expected, among the factors used to explain the vulnerability of soil, erodibility is the most important; 3) It is difficult to identify long-term trends although certain areas (intermediate) have strong indications of vulnerability, regardless of the season; 4) the diachronic analysis of soil indices confirms the seasonal nature of vulnerability levels. It shows strong correlation of the vulnerability with the surface moisture and vegetation cover.

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Prediction of Land Use/Land Cover Change in the Semi-Arid Bayech Catchment Southwestern of Tunisia using Remote Sensing and GIS

Zaineb A., A. Khatteli, M. Moussa, and M. Ouessar

Prediction of Land use and cover (LULC) change using remotely sensed imagery has attracted huge attention. For several decades, multiple researchers have investigated different approaches. The complex nature of the land-use change process, due to human-nature interactions and the singularities of satellite images, demands a well-studied approach. As well as, the southwestern of Tunisia is characterized by a rapid and significant degradation of vegetation cover, which is manifested mainly by sand erosion representing a serious threat to the infrastructures. The objective of this study was thus to analyse the hydrological response of dryland catchment to changing land-cover in the Bayech basin. For this, historical and future LULC change scenarios in the Bayech watershed are implemented into a calibrated Molusce model. Four LULC scenarios have been developed that represent baseline, current, and future periods corresponding to the map of 1989, 2009, 2020, and 2047. The predicted increase of agricultural and urban land by decreasing mainly forest land will lead till 2047 to an increase of 1.24% in surface runoff and a decline in groundwater flow.

The applied combination of LULC prognosis with process-based hydrologic modeling provides valuable data about the current and future understanding of variation in hydrological parameters and assists concerned bodies to improve land and water management in formulating approaches to minimize the conceivable increment of surface runoff. Land-cover change and Normalized Difference Vegetation Index analysis also showed improvement in vegetation-cover, enhancing water-retention capacity of the soil upstream. Appropriate policies and strategies would therefore be desirable to address contesting interests on scarce water resources in the face of climate change.

KEYWORDS: Prediction, Land use, land cover change, remotely sensing imagery, southwestern of Tunisia.

Evaluation and Comparison of Rainfall Data for Semi-Arid Bayech Basin with GPM IMERG/TRMM 3B42 Rainfall Products

Zaineb A., I. El Ghoul, M. Vanclooster, and M. Ouessar

The performance of the Tropical Precipitation Measurement Mission (TRMM) and its successor, Global Precipitation Measurement (GPM), has provided hydrologists with a source of critical precipitation data for hydrological applications in basins where ground-based observations of precipitation are sparse, or spatially undistributed. However, as their performance varies from region to region, it is of interest to evaluate the accuracy of satellite-derived rainfall products at the basin scale using rainfall observations.

In this study, we evaluated and demonstrated the performance of the GPM and TRMM rainfall datasets against the rainfall observations over the Bayech basin. We performed the analysis on a monthly time scale from 2001 to 2019, using multiple statistical evaluation criteria and graphical methods. While both GPM-IMERG and TRMM showed good agreement with ground-observed rainfall data at a monthly time scale.

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Furthermore, the modeling results illustrate that both satellite precipitation products tend to underestimate precipitation during wet seasons and overestimate them during dry seasons, while they have a better spatial distribution of precipitation measurements performance, which shows the importance of their use for basin modeling and potentially for flood forecasting in dryland catchment areas. The study thus concluded that TRMM or GPM-IMERG rainfall data can be used as a surrogate in the absence of ground-based observed rainfall data for monthly agro-hydrological studies.

KEYWORDS: Rainfall, TRMM, GPM, modeling, Tunisia

Monitoring of Land Use-Land Cover Changes and Assessment of Soil Degradation Using Landsat TM and OLI Data in Zarzis Arid Region

Katar A., H. Aichi, and Bouajila Essifi

Land Use/Land Cover Change (LUCC) is recognized as a crucial driver of environmental change on all spatio-temporal scales. Zarzis region is reputed for its olive groves, vital for its socioeconomic development and because of severe climatic factors, it has a vulnerable ecosystem.

Our study focuses on the monitoring of land use dynamics underpinning climate change and on the spatiotemporal assessment of the vigor of olive groves. Analysis of Landsat 5 TM image acquired in 2007 and Landsat 8 OLI image acquired in 2014 was performed under IDRISI software, by a remote sensing-based Land Change Modeler (LCM) method.

Our results have shown a clear improvement in the vigor of the olive trees, mainly attributed to an increase in rainfall during the years 2010 and 2012. We have identified areas where land degradation has been attenuated both with Tabias, as a soil and water harvesting technique and with alley cropping between olive trees, as a promising recent agronomic practice. This analytical study is relevant for sustainable development.

Keywords: Remote sensing Climate change Land Change Modeler Olive groves IDRISI Landsat 8 OLI

Hydrochemistry for the Assessment of Groundwater Quality in Mateur Plain, Northeastern Tunisia

Riahi C., M.-F. Ben Hamouda, M. Khouatmia, and K. Regaya

The alluvial aquifer of this research is located in the Mateur plain, Northeastern Tunisia. Unfortunately, this aquifer suffers from the influence of agricultural activities and the salinity of neighboring Ichkeul Lake. To understand the impact of those elements on the hydrochemistry of the aquifer, thirty-two groundwater samples were collected from boreholes and shallow wells. The values of Ca/Cl and Ca/Mg. Water quality indexes (WQI) and high values of NO₃ and F⁻ indicate that there are some samples that are unsuitable for drinking. The saturation index reflected that calcite was oversaturated thanks to the availability of Ca and HCO₃ ions. The spatial distribution of the groundwater salinity expressed in Electric Conductivity (mS/cm) highlights the high level of salinity located next to Ichkeul Lake and the center of the plain, as a result of surface water penetration. However, in the upstream zone of Mateur aquifers. We observe good quality water; with an EC varying from 1.4 mS/cm to 1.7 mS/cm. Groundwater

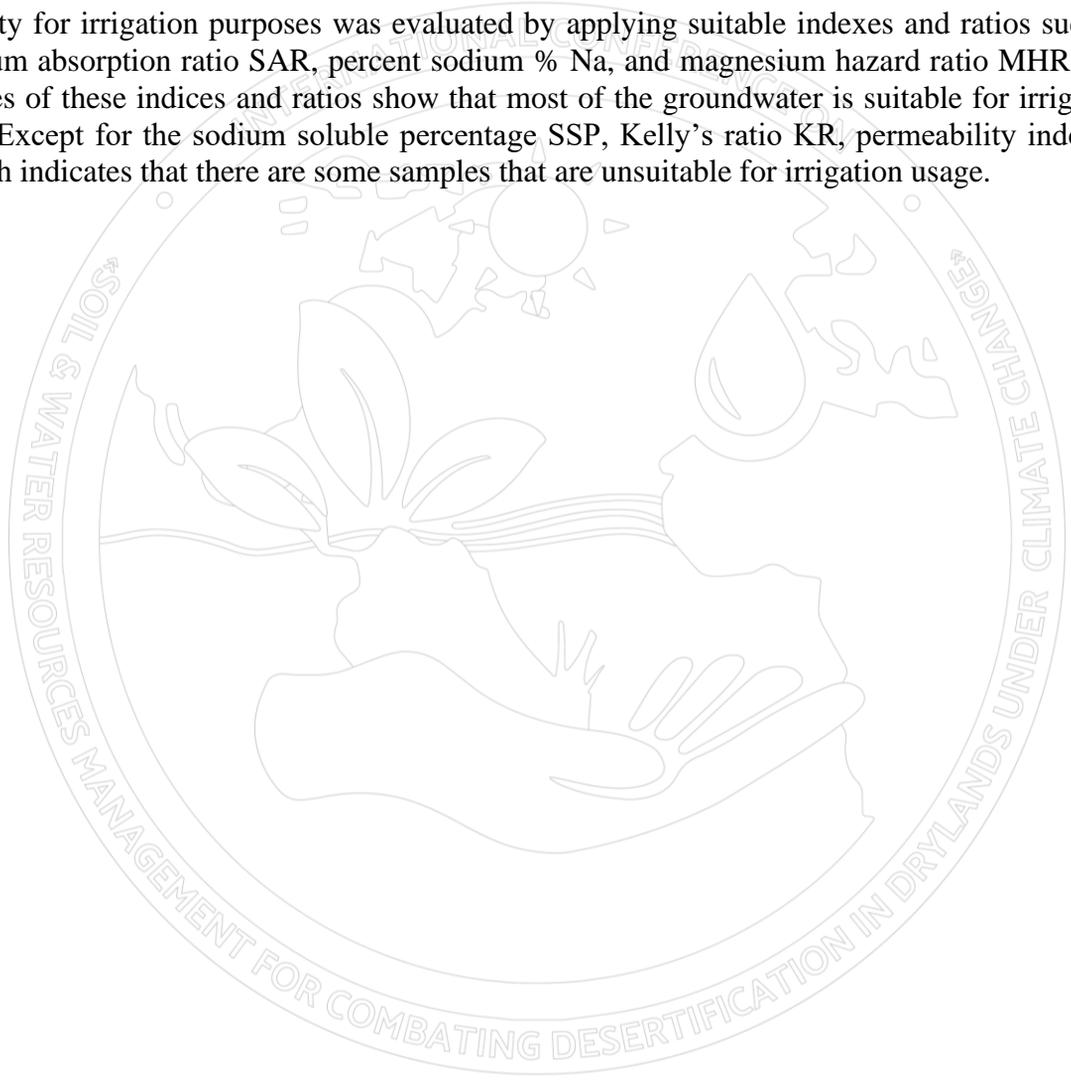


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quality for irrigation purposes was evaluated by applying suitable indexes and ratios such as sodium absorption ratio SAR, percent sodium % Na, and magnesium hazard ratio MHR. The values of these indices and ratios show that most of the groundwater is suitable for irrigation use. Except for the sodium soluble percentage SSP, Kelly's ratio KR, permeability index PI which indicates that there are some samples that are unsuitable for irrigation usage.



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