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Wetting Front Movement under Trickle Irrigation: Field Experiments and Modeling

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One of the main characteristics of trickle irrigation system is that water leaving an emitter enters the soil and moves both laterally and vertically. There has been much speculation on the shape and moisture distribution within the wetted soil volume. This knowledge is important in the design, operation and management of a trickle irrigation system. Field experiments were conducted to investigate the effect of soil texture, discharge rate and the volume of applied water on the surface wetting radius and the depth of the wetted soil volume under point source irrigation. The results indicated strong relationship between the surface wetting front and elapsed time for sand and sandy loam soil. In both soils, the average surface wetted radius is more a function of the total water applied than of the application rate. Simple equations were developed to estimate the width and the depth of the wetting pattern. Comparisons were made between the observed experimental data with those theoretically calculated by the developed equations. Good agreements were obtained between observed and predicted data. However, more experimental and field observations are required to improve the accuracy of the equations.

Keywords. Trickle irrigation, surface wetting radius, vertical advance of wetting front, predictive model.

Water Resources Development in the GCC Countries: Challenges and Opportunities

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The countries of the Gulf Cooperation Council (GCC) are categorized as one of the poorest region in terms of water resources, this has led these countries to head towards the sea since the mid of the last century to desalinate its water utilizing the energy sources available in these countries. It was natural for the GCC countries to depend more and more on desalinated water with increased level of living standards and growth of population. However, the main reason for such increase in water consumption was due to wastage and careless consumption patterns in addition to the lack of proper management of the already limited water resources. Natural water resources in the GCC countries are very limited, unevenly distributed and with variation in quality. Usable surface water is almost non-existent in this region due to unrestricted pumping in most of the GCC countries, the quality of the limited groundwater resources in these countries are being deteriorating and its level is depleting. Moreover, most of groundwater in the region is fossil groundwater and cannot be replenished naturally.

Most of developed countries and some developing countries have already succeeded in proper planning for their water resources, so that every water type can be utilized optimally for the targeted consumer. This means that costly water of higher quality will never be consumed by a sector that can do with a lesser quality water. Unfortunately, this is not the case in most of the GCC countries where huge amounts of treated waste water (almost 70%) is dumped in the sea while the costly desalinated water and very limited groundwater are extensively used for agriculture and industry.

This paper will describe the water resources in the GCC countries that are being utilized to meet the consumer demands and the current management practices of these resources. The paper will discuss any effort that has already been exerted to upgrade these management practices and the challenges facing such efforts along with other challenges facing the development of water resources

in the region. The opportunities for better handling of water resources in the GCC countries will also be explained. Finally, the paper will discuss some practical solutions for better management of the water resources in the GCC countries aided by some case studies.

Water Resource Management in Arid Zones of UNESCO (IHP) Contributions

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The international Hydrological programme of UNESCO (IHP) started as the International Hydrological Decade (IHD, 1965-1974) and was followed by the International Hydrological programme (IHP) in 1975. Since its inception, much progress has been achieved regarding methodologies for hydrological studies and training and education in the water sciences. Although the general objectives remain valid, greater emphasis is being put on the role of water resources management for sustainable development and the adaptation of the hydrological sciences to cope with the expected changing climate and environmental conditions. Another important objective is to integrate the developing countries into the worldwide ventures of research and training.

IHP, UNESCO's intergovernmental scientific co-operative programme in water resources, is a vehicle through which Member States can upgrade their knowledge of the water cycle and thereby increase their capacity to better manage and develop their water resources. It aims at the improvement of the scientific and technological basis for the development of methods for the rational management of water resources, including the protection of the environment.

Arid and semi-arid areas face globally the greatest pressures to deliver and manage freshwater resources. It has been estimated that some 80 countries, constituting 40% of the worlds population were suffering from serious water shortages by the mid 1990s and that in less than 25 years tow-thirds of the worlds' people will be living in water stressed countries, most of these in North Africa, the Middle East and West Asia (Geo-3, 2002). Already several countries in the area show a deficit in water budgets, water tables are in decline and prolonged droughts currently affect many countries in semi and areas such as Southern Africa, northern China, India, the western coast of South America and Australia. Problems are exacerbated by population growth, expansion of agricultural activities, salinity increases and agricultural/urban pollution. Other marginal areas such as southern Europe and the Great Plains of the

USA also suffer from water stress, over-abstraction of groundwater and desertification. It is difficult to assess with any accuracy the water balance in semi-arid areas as compared with water-rich countries. Rainfall is less predictable and of highly variable intensity and extent, flood events are difficult to quantify and estimation of recharge to aquifers is particularly difficult. Moreover it is becoming clear that much of the water being abstracted from deep aquifers is non-renewable, being a legacy from wetter climates in the past.

UNESCO's contribution to Water Resources Management in Arid and Semi-Arid Zones has been initiated since the fifties through its famous Arid Zone Programme. This initiative continued since then through the International Hydrological Decade and all six phases of the International Hydrological Programme (IHP: 1975-2007). It has also been tackled by the various phases of the UNESCO's Man and Biosphere Programme (MAB) since its initiation in November 1971 to date.

The intended power point presentation is foreseen to review various phases of IHP and MAB contributions to Arid and Semi-Arid Zones with special focus on two current projects, namely: The Global Networks and Water Resources Management in Arid and Semi-Arid Zones (G-WADI) and the project on Sustainable Management of Marginal Drylands (SUMAMAD).

Water Harvesting with Special reference to Egyptian Experience

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Water harvesting is an ancient method of obtaining water. The term “water harvesting” used to describe the process of collecting and storing water from an area that treated to increase precipitation runoff.

A water-harvesting system is the complete facility for collection and storing precipitation runoff. It is composed of a catchment or water-collecting area, a water storage structure, and various other components such as piping, evaporation control, and fencing. Collecting runoff from the roofs of buildings and storing the water in cisterns or tanks still used in some places as a means of domestic water supply.

No single method or system is best suited for all sites or water needs. In the Northwest Cost Zone, Arab republic of Egypt, there are two main storage structures, i.e. Cisterns and Reservoirs, depending on the type of soil as well as the environmental conditions.

The cisterns are constructed below ground at the lowest level of a collection basin or of a small stream to entrap surface or stream runoff, while the concrete reservoirs are constructed in friable soils not suitable for cisterns excavation.

**Integrated Water Resources Management; The System
of Systems for Sustainable Development:
The Egyptian Experience**

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Egypt's global water resources system is a composite one which includes surface, ground, non-conventional and a few rainfall. The transported surface water through the Nile River predominates other sources. It forms 95% of Egypt's total water resources and recharge the shallow groundwater aquifer. Agricultural developments in the Nile Valley and Delta have exhausted the fertile clay deposit soil areas and for further land potential it should be searched in desert fringes and/or away from the geographic surface Nile system.

The water policy to 2025 is based on adding another 3.8 million feddan (almost 50% of the irrigated area) to the existing area. The strategy aims to resettle new communities in remote desert areas, in order to relief population pressure, as an integral part of the national development policy. At present, a number of mega projects are witnessed and others are still in the planning stage. Toshka in the south, Sinai in the north east, Delta fringes in the west of Delta, the north coastal zone on the Mediterranean Sea and others. Indeed each project has its unique physical, climatic, social, economic and environmental characteristics, but they are all converging towards one national goal for multipurpose sustainable development as one whole global system that must be managed in a monolithic aggregate approach.

However, each project has its self management strategy as separate economic unit to optimize the use of its input resources. At this point it deemed clear that the overall management of such sub-systems in one system process can be termed integrated water resources management. Hence, the targeted objective is to globally maximize national economic and social welfare in a sustainable clean ecosystem, by coordinated development and management of water, land and related resources.

The paper discusses and describes in brief the development projects to focus on their objectives and constraints. Also it explains the water policy and strategy in Egypt to reclaim desert lands and introduce the concept of the integrated water resources approach in practice from the economic and engineering perspectives. The main points of strength and weakness faced in practice are stated and mitigation measures are indicated.

**Using Under Ground Brackish Water in Cultivation of Saline
Sandy Land Under Dried Condition
of South Sinai Governorate**

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More than 90% of the world's water is seawater and more than half the world's underground water supplies are saline, and the proportion is increasing as fresh water supply was depleted. Under dry land condition of South Sinai salinity is one of the most critical problems facing improving agriculture. Agriculture is suffered from both salt-affected soil beside saline underground water used for irrigation. Clearly there is a need for cultivars of different crops that can be grown under saline conditions. Number of economic crops were tabulated according to their tolerance to salt concentration and their expected yield percentages .The applicability of saline water for irrigation depends upon the concentration, composition of salts dissolved therein and the degree to which plants can tolerate salts. Sodium is the major toxic cation. It exerts many on plant growth. One harmful effect of sodium is that it disrupts potassium nutrition. Tritical (*triticosecale* spp.) is classified as moderate-salt tolerant crop, however varital differences are existed. Therefore, field experiments over 3 years were carried out at Beer-Abou Kalam Experimental Station, Tour-Sinai, South Sinai Governorate, aimed at evaluation some quantitative and qualitative characters of some tritical strains from ICARDA to saline condition. Primary trait was conducted aimed at screened some genotypes. Results concluded that variation in salt tolerance has been observed among different stains. The most promising strain were sown in two field experiment. Growth, yield, yield component characters were determined. Seed quality was also taken into consideration. Results showed that genotype x environment one of the most important factor in crop production..

Water Desalination: Trends and Evaluation

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The desalination industry proved to be a viable and sustainable source for fresh water supply for domestic, industrial, and agriculture use in many countries in the world. However, water desalination is an expensive industry and many nations with limited national income can not afford the required capital and running costs. Nevertheless, it is necessary to emphasize that all people, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs.

Over the second half of the past century, the industry has evolved from a limited number of small-scale desalination units to huge production plants and transportation lines capable of supporting urban and industrial activities for large population centers. Success of the desalination industry is proved to be a result of continuous research and development and adoption of such developments on industrial. One of the major developments, which proved to have a strong and positive impact on the industry and the unit product cost, is the increase in the production capacity of the plant. Searching for better operation and lower production cost, the producers have adopted several other industrial trends; Such as high temperature operation,

use of heat pumps, use of titanium, aluminum, and inexpensive composites, and energy recovery units in membrane processes. The evaluation also addresses several of the new innovations, which remains to be adopted on industrial scale. Increase in the plant capacity remains to be one of the leading techniques, where technical difficulties in increasing the capacity are approached by innovative solutions. Also, use of heat pumps, such adsorption and absorption cycles, promise to be of very high advantage in enhancing the process performance. An outline is provided for other important facets of the industry, which includes education, training, privatization, and technology transfer.

The Use Clay Deposits in Drip Irrigation System for Water Conservation

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Water research studies in Saudi Arabia clearly showed severe depletion of groundwater. Therefore, the scientifically applied research program related to water saving and conservation in agriculture is essential, where agricultural activities account for more than 85% of the total water consumed. This study aims to investigate the effect of four irrigation levels, two irrigation methods and three clay deposits on water use efficiency (WUE) of squash and the distributions of salts and roots in sandy calcareous soils. A field experiment was conducted at the college experimental station in 2002 and 2003 seasons. It consists of three clay deposits, three rates (C0=0, C2 = 1.0 and C3 = 2.0%), four irrigation levels (T1 = 60, T2 = 80, T3 = 100 and T4 = 120 % of Eto) using surface (IM1) and subsurface (IM2) drip irrigation.

Results indicated that squash fruit yield was significantly increased with the increase in irrigation water level for each season. Generally, WUE values were increased as linearly with applied irrigation water and decreased at the highest irrigation level. Types of clay deposits significantly affected fruit yields compared with the control. The yield increase was 12.8, 8.35 and 6.4% for Khulays, Dhurma and Rawdat clay deposits, respectively. The differences between surface and subsurface drip on fruit yields and WUE were also significant. Results indicated that moisture content of subsurface treated layer increased dramatically, while salts were accumulated at the surface and away from the emitters in subsurface drip irrigation. Intensive root proliferation is observed in the clay amended subsurface layer compared with non amended soil. The advantages of subsurface drip irrigation were related to the relative decrease in salt accumulation in the root zone area where the plant roots were active and water content was relatively higher.

Keywords: Drip irrigation; Subsurface drip irrigation; Clay deposit; Squash yield; Sandy soils.

**Wastewater Treatment Efficiency and its Reuse
for small Communities**

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Considering the socio-economic, the strong demographic and urban pressures, pollution sources, both multiples and diverse increase, thus threatening water resources, which are already limited.

To the urban effluents are added the industrial effluents and to the people water needs are added the industrial and agricultural needs.

Water treatment must first protect health and contribute to the improvement of the quality of life. It is noticed that the diseases that are caused by waste waters kill annually 25 millions of people, especially in developing countries. 80% of these diseases are due to a lack of water improvement. The object of waste waters purification is to protect environment from a pollution whose consequences are extremely expensive at short term.

Indeed, Moroccan people are now aware of the economic and social value of water. They know that water purification is no longer a social welfare but an economic investment for the whole of their country.

Besides the classical purification methods that exist in Morocco for more than 20 years and which are energetically and financially expensive, natural

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purification solutions that have been used for more than a century , are nowadays used and technologically adapted to the present needs.

Therefore, it is in this context that we present two experimental studies:
The first one concerns the development of a wastewater treatment plant for a small community. Wastewater treatment plants techniques present the advantage to be rustic (low cost technology with reduced management and the use of local materials like sand or gravel)

Treatment efficiency and drawback reduction can be obtained by using selected media for filtration

The second study is based on the building up of a station for the treatment of waste waters, with a capacity of 750 m³, the equivalent of 10.000 per inhabitant.

The station of purification is composed of a clarifying and anaerobic basin and five sand filters. The capacity of this station increases with the establishment of an aerobic system (bacterial bed) between the tank et the sand filters.

**THE SAUDI GEOLOGICAL SURVEY (SGS) HYDROGRAPH
METHOD FOR USE IN ARID REGIONS**

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This report aims at developing a new approach for the prediction of surface runoff peak discharge amounts in arid and semi-arid regions. However, aridity or semi-aridity is important but as it is implied in this report these are the regions where complete storm rainfall and corresponding runoff measurements are not available. This is the situation in many parts of the Kingdom, and therefore it is necessary to develop a new approach, which will suit the conditions in the Kingdom with a set of suitable constants depending on the available measurements even though they may not be complete. The specific methodology developed in this report is referred to as the Saudi Geological Survey (SGS) approach in order to reflect the works along these lines within the Survey. The basis of the methodology has two phases, namely, logical and then empirical. Logical part is valid for any part of the world whether humid or arid but the empirical part is very specific for the location, which is considered in this report as the southwestern part of the Kingdom. This report deals with the rainfall characteristics and geomorphologic features in wadi Baysh in the southwestern part of the Kingdom. The necessary logical and empirical formulation for predicting the peak discharge amount and the time to peak are developed with the consideration of measured regional flood discharges. Furthermore, the unit hydrograph methodology is also presented with applications to some of the Wadi Baysh subbasins.

For this purpose dimensionless unit hydrograph is obtained, which is special for the region.

**WATER LOSSES MANAGEMENT TOWARDS A SUCCESSFUL
MANAGEMENT OF WATER RESOURCES**

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Water is becoming more and more scarcer specially in countries such as our middle eastern countries. While huge efforts are spent on developing new traditional and non traditional sources of water, little is made in the field of the management of water losses in the distribution system. The fact that water authorities are becoming more and more aware of the problem of leakage is a fact which can not be denied, but no clear policies have been adopted.

The paper in hand will help in clarifying the importance of developing a clear view of the losses problem in distribution systems, and its sources such as leakage in the network, slippage in the water meters, and illegal connections to the system etc.... Furthermore, it will clarify the ever confusing question (which comes first: technology or management?). The paper will illustrate clearly that an organized and well directed losses management plan will enable the water authority of managing its network more efficiently and with less cost.

Furthermore, the paper establishes the basis on which a five-year plan for the management of losses within a network can be built, and pinpoints the necessary steps needed in order to push forward such plan. Also, it illustrates the necessary steps needed to maintain the levels of losses at a pre-agreed level. The pre-agreed losses target will be based on establishing an economical target, which beneath it, the effort for losses reduction becomes inefficient economically.

The paper concludes by describing different approaches for developing an awareness of the problem of leakage within the conscious of both the public and authorities workers, which is an essential condition for the success of the losses management plans.

**Water resources management:
Utilizing rainwater through rainwater harvesting and dams
& reservoirs – the case of Saudi Arabia**

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Significant progress has been made in developing technologies and best practices for conserving, purifying, recycling, and desalination water, all actions that effectively increase freshwater availability. The author envisages how best the Kingdom of Saudi Arabia can make use of the rainwater by conservation techniques.

This paper aims to move from crisis to vision and make water as everybody's business by focusing on the conservation of rainwater in areas in the Kingdom of Saudi Arabia where rainfall is frequent by rainwater harvesting and by building low cost dams. The author has explored the practices adopted for conservation of rainwater by rainwater harvesting technique, which is gaining popularity in areas of water scarcity. The author also explored the different types of dams constructed in the Kingdom and their potential uses. In the process he brings out how the construction of smaller capacity dams having more depth could serve better in short period of time.

It is hoped that this paper also would Endeavour to certain extent the water sector of the Kingdom of Saudi Arabia to pursue these concepts for implementation in the near future that will benefit the public.

Key Words: Water, Conservation, RWH, Dams

Reduction of Agricultural Water Losses by combining Effects of soil Layering and Pre-hydrated Polymer

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Water losses at the agricultural sector is becoming a concern global wise. In arid and very dry region, like Saudi Arabia (SA), with limited water sources, water losses are unbearable. Agricultural water losses in irrigated cultivated lands of the KSA are 50% of the irrigation water, when 25% of that is evaporation losses from the soil after irrigation due to capillary, and 25% are losses by deep percolation below the root zone. Moreover, ground water may be influenced negatively by deep percolation water. The cultivated soils of Al-Hass oasis, as well as most SA soils consisted mainly of sands and silts with some calcareous concretions and evaporites. Sandy soils have low water holding capacity, excessive percolation rates and evaporation rates. This results in reducing the efficiency of water and fertilizer use by crops. Recently, promising new type of polymer being used in United Arab Emirate, shown water retention of soil, increased exponentially with increasing additions of that hydro-gel polymer to sandy soil. The highest concentration (i.e, 0.4%, W/W) used changed the water retention capacity and its change in water potential with regard to its water content from typical sand to a loam or even silty clay. The objective of the research was to introduce a new technology, of a combined effect of soil layering and pre-hydrated polymer, to reduce sandy soil evaporation and deep percolation rates. Three local farms were selected in Al-Hassa irrigated area, with varying electrical conductivity of irrigation water (2.00, 4.16 and 6.1 dS/cm). The coefficient factor © of the evaporation rate capacity (ERC) of the pre-hydrated polymer was ranged between 25 to 40% of the applied irrigation water. When using the pre-hydrated hydro-gel with 2.0 dS/cm EC, ERC of the three soils reduced significantly by more than 50% from the norm. Deep percolation rates, of three soils, were reduced by 46%

**USE OF SEA WATER FOR WHEAT IRRIGATION:
II. EFFECT ON SOIL CHEMICAL PROPERTIES,
ACTUAL EVAPOTRANSPIRATION AND WATER
USE EFFICIENCY**

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A greenhouse pot experiment was conducted to study the influence of using diluted sea water on salinity build up in a calcareous soil (Typic Torripsamments Mixed Hyperthermic) cultivated with wheat plant. The modes of saline water application included irrigation with water having 6720 ppm (1:5 diluted sea water) 8768 ppm (1:3 diluted sea water) and a tap water as a control having 256ppm. Chicken manure application was done as a soil amendment while water management practices were done as the following irrigation frequencies namely (a) irrigation with diluted sea water along the growth period, (b) irrigation with diluted sea water until the flowering stage then with tap water and (c) irrigation with saline water for three times and once with tap water along the growth season. Certain chemical properties of the studied soil were evaluated during the growth period and after harvesting of wheat plant. Actual evapotranspiration (ETa) ratio and water use efficiency (WUE) were calculated for the various plant growth stages.

The obtained results indicated that frequent alternation of saline and fresh water at a sequence of 3 to 1 caused considerable attenuation of salinity build up as indicated by increasing the levels in the soil. Such increases reached about five folds comparing to those irrigated with tap water. Increasing water salinity increased soluble cations and anions but with different rates. For instance, So^4 concentration in soil extract showed a considerable increases as the time increases, reaching 6 folds of those found for the soils irrigated with tap water. Also, SAR increases reached 288,325 and 57% for the vegetative, the yield formation and the harvesting stages, respectively. On the other hand, increasing salinity level of irrigation water led to decrease the actual evapotranspiration (ETa) and water use efficiency (WUE) values of wheat plant comparing to plants irrigated with tap water. Regarding the effect of irrigation frequency on

reducing soil salinity, the lowest values of EC and SAR as well as soluble ions were associated with (c) frequency while the highest values were associated with (a) frequency. Also, irrigation frequency (c) gave highest values of ETa and WUE as compared to the other two irrigation frequencies. Chicken manure application increased soil EC values. Where they reached 33.23 and 55% relative to the control treatment at the three growth stages, respectively. Chicken manure addition lowered SAR values but increased ETa and WUE ones.

Key words: Diluted sea water – calcareous soil – chicken manure – water management – irrigation frequencies – EC – SAR – Eta – WUE.

OVERVIEW OF HYBRID DESALINATION SYSTEMS - CURRENT STATUS AND FUTURE PROSPECTS

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Hybrid desalination systems combining both thermal and membrane desalination processes with power generation systems are currently considered a good economic alternative to dual-purpose evaporation plants. Hybrid (membrane/thermal/power) configurations are characterized by flexibility in operation, less specific energy consumption, low construction cost, high plant availability and better power and water matching. In this paper the state-of-the-art of simple and fully integrated hybrid desalination systems is reviewed.

In recent years, the concept of simple hybrid multistage flash-reverse osmosis (MSF/RO) configuration has been applied to a number of existing or new commercial desalination plants. The SWCC Jeddah, Al-Jubail and Yanbu existing Power/Water cogeneration plants are expanded for more water production by combining with new SWRO desalination plants. The simple hybrid desalination arrangement enabled the increase of the water to power ratio and utilized effectively the available intake/outfall facilities. A large hybrid 100 MIGD SWRO/MSF desalination plant was recently built in Fujairah, UAE. In this paper, salient features of commercially available hybrid desalination plants will be highlighted.

A promising approach for pretreatment of seawater make-up feed to MSF and SWRO desalination processes using nanofiltration (NF) membranes has been introduced by the R&D Center (RDC) of SWCC. NF membranes are capable to reduce significantly scale forming ions from seawater, allow high temperature operation of thermal desalination processes, and subsequently increase water productivity. This paper provides an overview of research endeavors carried out by RDC to develop NF/MSF and NF/SWRO/MSF hybrid desalination systems. The developed fully integrated systems result in high water productivity and enhance

thermal performance compared to the currently used simple hybrid desalination arrangements.

Key Words: Desalination, Hybrid systems, MSF, SWRO, NF

EVALUATION OF ANTISCALANTS FOR NF MEMBRANE IN AN NF-SWRO SYSTEM

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Operation of nanofiltration (NF) pretreatment section at high recovery in an NF-SWRO seawater desalination process is expected to result in considerable economic and environmental benefits, which is mainly hindered by the presence in seawater of scale forming components such as CaCO_3 and CaSO_4 . Previously, the NF product recovery was limited to about 65% and only sulfuric acid was used to prevent scale formation on the NF membrane surfaces. Since, it is recognized that higher NF product water recovery leads to a increase in water production and therefore in overall reduction of water cost, a total of three different proprietary antiscalants were used to increase the product recovery in a seawater NF pilot unit without scale formation. A general purpose threshold scale inhibitor (antiscalant A), a specific sulfate inhibitor (antiscalant B) both phosphonate based and a carboxylate based (antiscalant C) were evaluated at various concentrations and pH. The chemical and biological analyses were carried out on a routine basis for the seawater feed, permeate as well as the reject. Moreover, the NF permeate was fed to a SWRO pilot unit to evaluate the total NF-SWRO recovery. The study demonstrated that only 70% NF product recovery was achieved using both antiscalants A and C, while 77% NF product recovery was achieved by using antiscalant B. The percent rejection of hardness ions as well as total dissolved solids (TDS) by the NF membranes was almost similar regardless of the antiscalants used. Moreover, in all the cases, the percent rejection of calcium and magnesium ions decreased with time, contrary to sulfate and bicarbonate rejections, which remained steady during the entire trial period. The total recovery of NF-SWRO with antiscalant was found to be about 38.5% compared to about 32.5% recovery from NF-SWRO without antiscalant.

Key words : Nanofiltration, seawater, antiscalant, SWRO.

BOIFOULING POTENTIAL IN OPEN SEA AND ADJACENT BEACH WELL INTAKE SYSTEMS

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Intense solar radiation and elevated water temperature are characteristics of the Red Sea particularly in the southern part. These factors make coast water conducive to biological growth. Consequently, seawater reverse osmosis (SWRO) desalination plants sourced from open sea intake systems are subject to membrane fouling. Chronic membrane fouling in one such plant on the southern Red Sea coast of Saudi Arabia has necessitated the search for an alternative beach well intake system. The beach well system consists of three wells located within a distance of 20–30m from coast and about 75m from each other. Measurements of bacterial growth rates, bacterial biofilm formation, inorganic and organic nutrients were carried out in the beach wells waters and compared to those of the adjacent coastal seawater. Beach wells showed significantly higher bacterial growth rates and inorganic nutrients but significantly lower biofilm formation and organic nutrients than seawater. Therefore, presence of organic nutrients is a determinative factor in biofilm formation and subsequent membrane fouling. The present data indicate that feed water for the plant could be directly sourced from beach wells without significant fouling problems. Well waters also have got additional favorable characteristics for better plant operation, such as reduced silt density index (SDI) values (< 1) and a constant favorable temperature of about 33 °C.

Keywords : Open sea intake, Beach well intake, Biofouling, Nutrients

**Do we Adequately Understand the Potential Value of our
Regional Aquifers?**

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The possibility of differences in hydraulic properties in depth in arid area regional aquifer systems is posed with the inference that aquifer potential can be over-estimated without adequate characterisation of these properties. The occurrence of effective modern recharge is questioned and the need to properly assess specific yield in the groundwater mining scenario is emphasised. The need to assess the added value of aquifers as storage facilities is discussed.

REVERSE OSMOSIS AS A SOLUTION FOR WATER SHORTAGE IN IRAN

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Large increases in water demand with very little recharge have strained Iran's ground water resources resulting in serious decline in water level and quality. Both thermal and membrane desalination technologies have been used in Iran. Electrodialysis (ED) and reverse osmosis (RO) processes have been used to provide water for domestic and industrial purposes. Application included both brackish and sea water desalination with plant size ranging less than 100 m³/day to 10000 m³/day with total cumulative installed capacity exceeding 100 000 m³/day.

The domestic and industrial wastewater may be used as resources for producing water. This is scientifically possible using appropriate technologies such as membrane processes in general and reverse osmosis in particular. The produced water is a great resource for industrial and agricultural applications. This strategy minimizes the water crisis.

The objective of this paper is to summarize the experience gained from operating reverse osmosis plants over a long period. To achieve this objective, design and operational data from some of these plants were analyzed. Difficulties have been reported in all plants development stages including design, installation, start up, production, fouling control, cleaning, etc. Some of these problems are minor. However if they are not addressed properly, their impact on plant performance can be significant.

Keywords: reverse osmosis, desalination, membrane technology, brackish water

**Advances in Flood Frequency Analysis
with Historical Information**

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The precision of estimators of flood quantiles and of flood risk is limited by information available to determine the frequency of rare events. Thus hydrologist are well advised to use understanding of flood processes; available at-site records; physiographic information about a watershed with models developed using regional hydrologic data; and historical, botanical and paleohydrologic information about rare floods at the site of concern. Monte Carlo and analytic studies have documented the potential value of historical and paleoflood data giving the magnitude, or just upper and lower bounds, on the sizes of floods; and the more parameters to be estimated, the more valuable such historical data. This lecture also explores the value of historical and paleoflood information with Bayesian Markov Chain Monte Carlo (MCMC) methods for evaluation of the posterior distributions of flood quantiles, flood risk, and parameters of both the lognormal and log-Pearson type III distributions. Bayesian methods allow a richer and more complete representation of large flood records and historical flood information and their uncertainty (particularly measurement and discharge errors) than is computationally convenient with maximum likelihood, weighted moment, and expected moment estimators.

2- Arid Environment

TREATMENT TECHNIQUES OF OIL-CONTAMINATED SOIL AND WATER AQUIFERS

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Many operations in the petroleum exploration, production and transportation have the potential to affect the environment in different degrees. Leakages from pipelines, oil wells, underground storage tanks of gas stations, improper disposal of petroleum wastes and stranded oil spills are the major sources of surface and groundwater contamination. The removal of hydrocarbons from contaminated soil and water aquifer is an essential practice because of environmental and health concerns, and in order to avoid further contamination of surface and groundwater. There are different methods applied to remove the hydrocarbons from the soil and water environment including commercially oil and gas technologies such as vertical and horizontal wells.

However, the efficiency of these methods depends on several factors, such as the amount of spilled oil and the penetration depth of the oil into the soil, the type of oil and polluted soil and the age and degree of contamination. Contamination of groundwater resources can result from migration of hydrocarbon through sedimental soil and watercourses, therefore, surface spill or subsurface leakage of petroleum products has been of concern to many industries and governments.

The objectives of this study are to highlight the importance of the oil removal from contaminated sites and to present different approaches and techniques applied to treat the oil-contaminated soil and water aquifers and their applications as well as limitations.

REVIEW ON THE USES OF APPROPRIATE TECHNIQUES FOR ARID ENVIRONMENT

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In the desert, limited resources are available. In the barren land of a desert, resource needs of a common man are water / food, energy and good environment. Many well established appropriate techniques in other parts of the world can be successfully and effectively extended to the arid places.

This paper reviews the sustainable appropriate techniques in two parts. First part reviews 'Production of the Resources'. With brackish water, passive arrangements of green house, solar still, humidification and de-humidification of air will yield water. Techniques of Ocean Thermal Energy (OTEC) and fog harvesting are the recent trends in water production. For large quantity potable water production, standalone wind mills can support SWRO plants. Pot in pot arrangement with wet sand can store fresh vegetables in a good condition for three weeks without refrigeration. Solar photovoltaic systems with Thermo-Electric (TE) units can meet the requirements of cooling or heating. More plantations are encouraged to reduce the environmental temperature.

Second part reviews the 'Conservation of Natural Resources'. Recovery of water and energy from the process industry, solar powered absorption refrigeration units and modern power plants are significant. Drip

irrigation and rain water collection leads to conservation of water. 'Desert coolers' with very little water and electricity provide comfortable living in hot and dry environment. Small wind powered ventilation systems are suitable for small housing or an office. Energy conserving designs of modern air-conditioned buildings conserve energy and provide good ventilation. Plastics are not bio-degradable. Plastic bags thrown in open over a long period of few decades form an impermeable layer in sand.

Damages caused by the layer would be totally non-recoverable. Use of bags made of bio-degradable materials like paper or cloth is encouraged.

FORECASTING GROUNDWATER CONTAMINATION USING ARTIFICIAL NEURAL NETWORKS.

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Water is one of the basic and fundamental requirements for the survival of human beings. Nearly 80% of all the diseases arise as a result of using unsafe and contaminated water. Groundwater contamination has long been a deep concern to environmentalists due to its harmful effects on human health.

The presence of different effluents in groundwater should be known as accurately as possible so that necessary arrangements can be made to provide treatment to this contaminated water. Artificial Neural Networking (ANN) model was used for future prediction of the quantities of different effluents. The model was applied to real data from groundwater in Faisalabad, the largest industrial city of Pakistan. The city has more than 8000 big and small industrial units. Satiana road sullage carrier in Faisalabad city, receiving effluents of a large number of textile mills, laundries and other factories was selected for the future prediction of quantities of heavy metals (Fe, Cu and Pb) in groundwater due to seepage from carrier. The data for both the lined and unlined channel was obtained from Pakistan Council of Research in Water Resources. The results obtained from the model were compared with actual values as well as the World Health Organization Standards.

CLIMATIC CHANGES AND THEIR IMPACT ON DESERT ENVIRONMENT

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The chief feature of the desert climate is aridity and evaporation exceeding precipitation. There is a strong surface heating in the day and a continuous abundant sunshine. Humidity is low and cooling at night is intense. There are a few torrential downpours of convectional character succeeded by many totally rainless days. Fog and dew conditions appear along the western coasts, winds are dry, stormy, hazy and incessant. Adaptations are therefore, necessary for all forms of life to survive.

Vegetation is sparse. Thickets of xerophyllous structure develop on moist soils. Grass vegetation disappears during drought. Extensive surfaces have no visible vegetation for years. Wildlife is scanty.

The inhabitants are sturdy and live a simple lifestyle. They live in dispersed hamlets and in small communities. Houses are located away from wind routes. These are low mud – bricks with large space within. The roofs have grass and rooms are large but windows are small. The people are skilful in hunting, collecting water, nomadism and food gathering. The traders move in caravans on pack-animals in the cool nights directed by the bright stars on the clear sky.

There is increased rate of heat-loss at night causing shivering. Day heat increase causes perspiration, which is seriously enhanced by high temperature and low humidity. Fat is avoided while the staple food is the grain and dairy products. Mirages are common and the people show emotional behaviour. There is a boost in the sales of ice – cream, soft – drinks, heating – fuels in winter, and light – clothes during hot periods. Populations is sparse and emigration rare.

Semi – subsistence agriculture based on irrigation is practised. The soil is generally porous and saline. Herds show low milk and meat production. They suffer discomfort. No pathological restriction for camels and donkeys – trypanosomiasis.

The activities of rain and wind have produced landscapes and landforms, which are of interest to geomorphologists

SITE TESTS TO DETERMINE THE BEHAVIOR OF PHENOLS IN GROUNDWATER

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Phenols are substances which poorly or just barely sorb to the gravelly-sandy material of an intergranular porosity aquifer. In order to determine their behavior in intergranular porosity aquifers under aerobic conditions, long term monitoring (6 years), as well as four short (5 days) and long (over 30 days) site tests were undertaken to study the behavior of phenols and a selected tracer in groundwater. In addition to the phenols and tracer, certain tests included the study of intermediate products of phenol degradation and the corresponding physical, chemical and biochemical conditions prevailing in the aquifer.

Each of the tests was undertaken as a research project with a view to defining either the upgrade or development of a groundwater source of the infiltration type. The parallel injection of a tracer (chloride ion was selected) significantly assisted to confirm the poor sorption affinity of the aquifer skeleton material to phenols, as well as to identify the rate of phenol degradation in groundwater under specific conditions.

The paper presents the results of the tests performed and the relevant conclusions and comments.

Key words: Phenols, gravel, sand, aquifer, site test, tracer, intermediate products, degradation, infiltration.

A SULPHURIC ACID GENERATOR INSTALLED AT THE FARM LEVEL TO REHABILITATE SALINE-SODIC SOILS IN ARID ENVIRONMENT: THE MOROCCAN EXPERIENCE

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In West Asia and North Africa (WANA) region, water resources are the most limiting factor for agricultural production. Irrigation is necessary to produce agricultural products in order to feed its growing population. However, if irrigation has improved the yields of the major crops and the wellbeing of the rural population in irrigated areas, it induced soil Salinisation and degraded the land quality.

Located in the upper NW corner of Africa, Morocco is essentially an arid country. 93 % of the country is in semi arid, arid and desert climate. The average arable land per capita is in the order of 0.3 ha. More than 85 % of the arable land is under rainfed agricultural production facing severe and frequent drought. At present 1.1 million ha are presently under irrigated intensive cropping. However, soil salinity is recognized the main and most rapid process of land degradation in irrigated perimeters. The total area of salt affected soil in Morocco is estimated to 350 000 ha. Inappropriate irrigation techniques associated to the excessive evapo-transpiration processes have led to salt accumulation not only in the soils but also in the groundwater. The recycling of such brackish waters during the successive droughts of the last 30 years has aggravated land degradation (desertification).

A recent technique based on irrigation water acidification using a Sulphurous Acid Generator (SAG) was applied in pilot intensive cropping farms in several irrigated regions of Morocco. It is a practical method to change the quality of irrigation water. It was especially designed to improve the quality of sodium affected soils and waters. This technique has proved to be very effective and promising in rehabilitating salty and alkali soils in Morocco. Irrigating with SAG treated water allows an important reduction of the soil salinity and sodicity after few weeks of irrigation. The ESP of the soil was considerably reduced,

resulting in improved soil permeability and soil structure. It is a very cost effective technology (0.2 USD/acidified m³).

The SAG technique has a very high potential use in arid and semi arid irrigated calcareous land in the WANA region for the reclamation of salt affected soils.

**A Methodology for Regional Estimation of
Evapotranspiration and irrigation Water Requirements in
Center Pivot irrigation Schemes – a case Study in Al-Busaytaa,
Northern Saudi Arabia**

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The implementation of center pivot irrigation systems in desert environment has encountered a harmful effect on the non-renewable ground resources of the Kingdom of Saudi Arabia. It has been recognized that the implementation of the regional water conservation plans for center pivot irrigation is required for sustainable agriculture in Saudi Arabia.

This work illustrates a new methodology for estimating the irrigation water requirements for center pivot irrigated agriculture in a regional scale. The technique merge irrigation water requirements, scheduling techniques, crop identification and the spatial distribution of center pivots in a water resources management frame. The developed method was applied to Al-Busayta irrigation scheme Northern Saudi Arabia. The irrigated crops and their relevant acreages were identified using the Landsat image data. Correction and redesign of irrigation water requirements is performed for the whole crop patterns in the

irrigation. The monthly quantity of discharges required for crop water requirements are estimated and compared with well discharge. When the demand discharges of crop are more than the well supplied discharges then irrigated area is calculated to balance the supply and demand. The irrigated area of the center pivot has to be reducing for peak season calculated area. The crop demand discharges relationship is revised according to the estimated irrigated area. The monthly center pivot operation time is estimated as per crop water demands. Using this method, almost a full control on the ground water delivery for irrigation is performed.

The applied method has resulted in enormous water saving of 35%. The developed methodology is of a great assistance to the water resources specialists and governmental agencies to monitor water delivery for irrigation.

The effect of temperature and salinity on seed germination of *Anabasis setifera* Moq. (Chenopodiaceae) from Saudi Arabia.

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Anabasis setifera Moq., a halophytic perennial shrub in the family Chenopodiaceae, is widely distributed in salt marshes and inland salt marshes in Saudi Arabia. Experiments were conducted to determine the effect of temperature and salinity on seed germination and its recovery of germination from saline conditions after being transferred to distilled water. Seeds of *A. setifera* were germinated at five alternating temperatures (15/5, 20/10, 25/15, 30/ 20 and 35/25 C) and four constant temperature (5, 15, 25 and 35) and nine different concentrations of salinities (0, 100, 200, 300, 400, 500, 600, 700 and 800 mM NaCl) at 25/15 C. The seeds germinated best at the relatively low temperatures and inhibited at the higher temperatures. The seeds can germinate at very high salt concentrations (9.5% 700 mM NaCl at 25/15 C). Seeds recover after being transferred to distilled water and recovery was higher from higher salinity concentrations (94.5% and 75.5% at 800 and 700 mM respectively at 25/15 C). This result indicates that undoubtedly that inhibition of germination in this species was due to an osmotic effect.

Keywords: *Anabasis setifera* Moq., Germination, halophyte, temperature, salinity, Saudi Arabia.

The role of Biotechnology in developing plant resources in deserts environment

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Plant tissue culture technique is one of the applications of biotechnology by which plants can be mass multiplied using vegetative and sexual tissues. Micropropagation for plant mass production, rehabilitation of destructed vegetation and studying the micro environmental stresses *in vitro* are some of the purposes of tissue culture. Biotechnology also involves the study of the plant biodiversity through DNA fingerprinting and genetic engineering through gene transfer. This paper illustrate some of the present tissue culture studies achieved on some desert plants that are considered as multipurpose and water saving plants in Saudi Arabia. Performance of twelve cultivars of Date palm (*Phoenix dactylifera* L.) was studied at different stages of *in vitro* conditions. The problems encountered with the culture of 'Ajwah' and 'Nabtat Sultan' were compared to the easy cultures of 'Mosaifah', 'Barhy' and 'Maktoumy'. DNA fingerprinting was carried out on date palm cultivars produced through field and tissue culture. Tissue culture was also applied on some wild sand dune plants such as Ghada (*Haloxylon persicum*) and Erta (*Calligonum comosum*) for mass production, results indicates that Ghada can be easily produced compared to Erta, however slow growth of both plants are considered as obstacles. Some species of Acacia were also micropropagated. The results showed that some species were easy *in vitro* growing as in the case of Samar (*Acacia tortilis*) Salam (*A. ehrenbergiana*) and Talh (*A. gerrardii*) at the time some other Acacia were difficult to initiate as in the case of Syial (*A. Seyal*) and Sinigal (*A. senegal*). These difficulties were persisted throughout *in vitro* and acclimatisation stages in green house conditions. This study was directly involved in the utilisation of desert plants which require less watering, for planting and landscaping programs in the local deserts of Saudi Arabia and similar conditions.

Towards a more safe environment: Phytoremediation of some heavy metals from contaminated soils in Egypt.

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Hyperaccumulation is an ecophysiological adaptation to metalliferous soils. These plants often accumulate only a specific metal; they grow slowly and have a small biomass. Interest in metal-hyperaccumulating mechanisms has come from development in phytoremediation, a new technology that uses high biomass metal-accumulating plants to extract toxic metals from contaminated soils. The mechanisms of metal accumulation, which involve extracellular and intracellular metal chelation, precipitation compartmentalization and translocation in the vascular system, are poorly understood. Well-known metal-binding proteins include metallothioneins, metalloenzymes and various metal storage carrier and channel/transport proteins.

In this study, three soils were tested with some plant species in pot experiment in three replicates. Obtained results indicated that there are highly affinity between certain heavy metals with specific plant.

EXPERIMENTAL STUDY OF THE TRANSPORT OF POLLUTANTS IN GROUNDWATER

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A quantitative understanding of the transport of pollutants in groundwater is of great importance from the environmental perspective. Some environmental pollution scenarios involving groundwater contamination are very real. For example, one may encounter a situation where an underground storage tank is leaking hydrocarbons into an aquifer at a constant rate. Similarly, an overturned oil tanker spilling fuel that might flow through the sandy soil and find its way to the groundwater aquifer leading to its contamination. Especially in the Kingdom where fossil-water resources are not very abundant and, therefore, their contamination is something which scientists and engineers of the Kingdom can least afford not being ready to handle. The first step in this direction is to understand the flow and transport mechanisms of pollutants in groundwater to quantify their effects before any effective *in situ* remediation or extraction strategies could be suggested.

Experimental study in a laboratory is carried out in order to gain a quantitative understanding of the main transport mechanisms of pollutants in groundwater. In this connection, residence time distribution (RTD) studies were carried out in a saturated but homogeneous porous medium with superimposed ambient water flow to simulate the groundwater flow. The porous medium was constructed using a non-porous and inert plastic resin in order to eliminate the internal and external mass transport resistances, thereby simplifying the mathematical model and the subsequent processing of the data. To this end, experiments were carried out using a non-reactive salt tracer instead of a pollutant to avoid the disposal and safety problems associated with their handling. The main focus of the present experimental study was to investigate the effect of the molecular diffusivity of the tracer on the dispersive transport or the spread of the pollutant. This was achieved using two different salt tracers of significantly different diffusivities. Pulse injections of tracers were made and their concentrations were monitored *in situ* downstream with the help of specially designed conductivity probes. The data thus obtained were processed in conjunction with the one-dimensional dispersion model to obtain the degree

of dispersive transport as function of water flow for both cases of salt tracers of different molecular diffusivities.

Spectral reflectance of alfalfa Grown Under Different Water table Depths

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The main objective of this study is to determine the growth response and water use efficiency of alfalfa (*Medicago sativa* L.) grown in the field under four water table levels and two rates of water supply under the climatic condition of Al-Hassa oasis in Saudi Arabia. The potential use and management of water table depth, to function as sub-irrigation system without increasing the accumulation of salts in the root zone is a valuable agricultural resource in arid regions. Therefore, the water table should be maintained at optimum depth to save both water and energy.

Plant water stress can limit productivity and has an effect on plant physiology and canopy architecture. Changes in water status of a canopy can have indirect effects on remotely sensed optical reflectance and thermal emittance, which can be measured in the field and related to crop conditions.

Biophysical and spectral measurements were taken in the field of alfalfa grown inside concrete lysimeters. These include biophysical variables, such as: leaf area index, dry matter content, soil moisture content, and monitoring of water table depth.

Moreover, measurements of reflected radiation from the alfalfa canopy in the field by a high resolution spectroradiometer were taken at full cover during the growing season.

Results from this study showed that alfalfa grown at water table depth between 100-150 cm was better than that grown at shallow (50 cm) or very deep water table (deeper than 150 cm). Spectral response of alfalfa was positive and showed that remotely sensed data could be used to detect water stress of alfalfa grown under the climatic and environmental condition of Al-Hassa.

This study may provide information and knowledge that can lead to better management of irrigation water and help farmers to conserve water by applying only the right amount of irrigation water. In addition, transferability of results among other agricultural crops in different areas. Moreover, detection of crop water stress in early stage by application of remote sensing technique. This study also might help in design of proper drainage depth suitable for forage crops with respect to soil and climatic condition.

Distribution of Different Fractions of Heavy Metals in Desert Sandy Soil Amended with Composted Sewage Sludge

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An experiment was conducted to assess different fractions and surface accumulation of Zn, Cu, Pb, and Ni in desert sandy soil amended with two rates of composted sewage sludge (20 and 40 g.kg⁻¹) were applied to the surface of soil columns. A sequential extraction method was used to determine the soil fractions and surface accumulation of Zn, Cu, Pb, and Ni in treated sandy soil. Both doses of sludge added to soil resulted in a marked increase in the total amount of studied metals. Heavy metals accumulation were found in the surface 5 cm of the treated soil with maximum amount at a sludge rate of 40g.kg⁻¹ where Zn>Cu>Pb>Ni. Most movement and amount of Zn, Pb, and Ni recovered from soil were predominantly limited to a depth of 15 cm while reached to 25 cm for Cu. At soil depth lower than 25 cm, total values of heavy metals became equal to those of untreated soil sample. The water-soluble fraction of metals were relatively small comparing to the total soil content. Extractable fraction of organically bound Cu was high compared to the other elements. The amount of metals extracted by DTPA extraction followed the same pattern exhibited by the total amounts. Data revealed that the bulk of heavy metals accumulated in the top 15 cm soil depth. Little if any movement of metals had occurred below that depth. Results showed also that more than 90% Ni, Pb, Zn, and 78% Cu, of

corresponding total DTPA extractable metals from the whole soil column, were readily extracted by DTPA from the surface 15 cm soil.

Key Words: Sandy Soil, Sewage Sludge, Heavy Metals, Distribution, Fractionation

Introducing *Cereus* into an Arid Region as a New Fruit Crop

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Introducing new crops with high water use efficiency in the Middle East and North Africa will participate in curb rising demand of water. *Cereus* species characteristics fit with most of the requirements of a drought tolerant crop with very high water-use efficiency. *Cereus hexagonus*, *C. peruvianus*, *C. peruvianus monstrose*, *C. validus* were introduced as fruiting cacti into an arid desert, characterized with high temperatures and rare rainfall. *C. pachanoi* was introduced as a rootstock for other species. Cuttings were obtained from private nurseries in California. *C. peruvianus* cuttings survived storage up to eight months. Horizontal position of the cuttings during storage of *C. peruvianus* encouraged the development of lateral branches. Plants were propagated, acclimatized and then transplanted into the field in the desert. Growth and development of the introduced cacti were assessed under the new environment. All the introduced species grew successfully except *C. validus* that was eliminated during the first summer. *C. peruvianus monstrose* characterized with dramatic contraction of the stem in the very dry condition. The main stem of *C. peruvianus*, *C. peruvianus monstrose*, *C. hexagonus* and *C. pachanoi* grew 9.2, 10.2, 8.1 and 15 cm/month, respectively. *C. peruvianus* developed the highest number of sprouts. *C. peruvianus* and *C. peruvianus monstrose* were the most promising in the new environment in terms of its high adaptability and healthy growth. The introduced species could be ideal for establishing crop plantations in the arid deserts.

Towards a more safe environment: IV. Disposability of uranium by some clay sediments in Egypt.

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Due to the increase concerns about the environmental pollution problems, it is so important in waste disposal management to perform an accurate exploration of geological barriers, which must be suitable for waste materials disposal. Clay sediments play an important role as natural adsorbents to immobilize heavy and nuclear metals contaminants.

For the present study, the clay samples were collected from either clay exploitation localities or from nearby radioactive mineralization in Egypt. Obtained results indicated that uranium adsorption and desorption differ importantly in accordance with the source of clay sediment used. In addition, its adsorption increases by increasing uranium initial concentration. The obtained data were found to fit of Langmuir equation isotherms.

Adsorption maxima (B) for uranium were high for Abu Tartur bentonite followed by El Hafafit vermiculite and was the least for Kalabsha kaolinite. However, the binding energy (b) that affects the adsorption process can be arranged in the opposite direction. Desorption of uranium by HCl, NaOH and tap water show clear ability of the different sediments to release uranium. This was a function of leaching solution and binding energy. Finally, the mineralogical changes in the clay sediments through adsorption and desorption processes were investigated.

Key words: adsorption-desorption – clay sediments – uranium - nuclear pollution-I.R

Towards a more safe environment: III. Phosphatic clays as solution for Pb²⁺ removal from wastewater

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To immobilize the pollutants from wastewater in situ, two phosphatic clays collected from different areas in Egypt and used to remove heavy metals from two different sources of industrial wastewater. Obtained results indicated that the phosphatic clays were very effective in retaining Pb²⁺ and were moderately effective in attenuating Cd²⁺ and Zn²⁺. Desorption data suggested that large fraction of metal removed by phosphatic clays stayed intact under a wide variation in extracting solution pH. Moreover, the slowest desorption rate was recorded for Pb²⁺.

In situ immobilizations consider a promising technique that has the potential to remove metals from wastewater. In that concern, two important factors need to consider when applying this technique: The first, is that the clay must be effective and selective under different composition of wastewater. The second is the immobilized metals should be stable and non-leacheable under varying water conditions.

Phosphatic clays with heavy metals especially Pb²⁺ was suitable to achieve these two factors.

Possible mechanism for heavy metal removal especially for Pb²⁺ by phosphatic clays proves its accordance with characterization of both clay and wastewater.

Key words: Heavy metals- Industrial wastewater- Phosphatic clays

**Effect of Human activities on Vegetation Diversity
in Siwa Oasis**

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The effect of four human activities (burning, grazing, continuation of cultivation and the waste products flow from the olive factories) are studied. These human activities inhibit the vegetation diversity, performance of the plants, height, sociability life forms and phonological states. Overgrazing was the most activities affect on vegetation diversity and floristic composition of the stands studied. These human activities causes disappearance of some species compared with the control stands. Salinity was the important factor limits the species diversity.

Key words: vegetation, species diversity, fire, overgrazing, continuation of cultivation, waste products, performance, sociability, life forms, phonological state.

3 - Remote Sensing

**IRRIGATION PLANNING WITH TREATED
WASTEWATER USING GEOGRAPHIC
INFORMATION SYSTEM
THE CASE OF SANA'A WASTEWATER TREATMENT
PLANT**

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Yemen in general and Sana'a in particular, are facing a critical water shortage due to unregulated and uncoordinated water use. Moreover, there is a potential risk of groundwater contamination as a result of unregulated wastewater disposal, cesspits tanks. Consequently, carrying out institutional projects of reuse treated wastewater in irrigation can manage these risks.

The main objective of this study was to determine the possible reuse of treated wastewater for irrigation and the extent of the agricultural area that could be irrigated with the treated wastewater. Geographical Information System facility with land interpolation was then used to select suitable crops and irrigation water requirement.

The whole available data of treated wastewater and soil was collected from the concern authorities and research centers in Sana'a, Yemen. The nutritional value and the relatively low SAR make the treated wastewater suitable for irrigation purposes. But some of trace elements such as arsenic, boron, cobalt, molybdenum and nickel concentrations exceeded significantly the USEPA guideline for long term. And the bacteriological test results exceeded the WHO & USEPA guidelines. In spite of the low treatment efficiency of the Sana'a WWTP, especially the microbiological parameter, reuse of this water in irrigation has less environmental problems compared to other means of wastewater disposal. Moreover wastewater provides nutrients for crops and organic matter for soil conditioning.

The use of water in agriculture should be judicious, precise and sustainable. Application of GIS can be a useful tool in irrigation management under water scarcity. In this paper a procedure to estimate the total water requirement for a command area of 2,500 ha under various crops and soil types was presented. ArcView GIS was used to plan for suitable crops and estimate irrigation water requirements based on the soil types and farmers' crop preferences. The soil map was the base map layer for this work. Then the soil characteristics such as salinity, texture and the suitable crop types were overlaid to produce the crop blocks map and consequently the crop water requirement map. The total water demands for each irrigation block were calculated by summing the three components, viz. percolation loss through the soil, maximum evapotranspiration of the crop and leaching requirement. By considering the crop coefficient k_c for different growth stages throughout the year, the peak water requirement occurs in May and was found to be 5,595 m³/ha/month.

The flow to the Wastewater Treatment Plant (WWTP) is estimated to be 50,000 m³/day or 1, 500,000 m³/month by the year 2005. This amount is available for irrigation use. The possible irrigated area using the current wastewater of this project was estimated to be between 337 ha and 421 ha depending on the irrigation schedule and operation system of the lagoon storage/balance.

Keywords: Irrigation planning, water scarcity, treated wastewater, GIS, crop water requirement.

Assessment of Land Development Impacts on River flow Regime using Remote Sensing and GIS

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With rapid land development and limited water resources, good quality water becomes an important commodity that every economic sector is competing for. Land cover changes due to development consequently increase impervious ground surfaces. This in turn will decrease infiltration rate and increase runoff rate. On the other hand the exponential increase in the population should be met by providing suitable tools to manage the limited water resources. Understanding how the land use change influence the river basin hydrology may enable planners to formulate policies to minimize the undesirable effects of future land-use changes. Hence, there is a need to investigate the relationship between the land use change and the stream flow regime. Satellite remote sensing, GPS and GIS, as relatively new tools in water management technology were integrated with a hydrological model to evaluate the effects of land use modifications on hydrology of a tropical watershed.

This study was conducted in the Upper Bernam river basin (200 km²). TM LANDSAT images were used to generate the land use maps, GPS was used for ground truthing and GIS was used for displaying, storing, analyzing, retrieving and generating spatial and non-spatial data. Using the land use maps, soil map, slope map and antecedent moisture conditions (AMC), appropriate curve numbers (CNs) were assigned for each sub basin. Runoff hydrographs were obtained by running the HEC-1 computer model, the hydrographs from each sub basin was routed to the outlet point using Maskingum method. The model was calibrated and validated by means of four criteria RMSE, MAE, U and R² obtaining values of 0.15, 0.11, 0.08, and 0.90, respectively. It was found that the change in weighted CN between the years 1989 -1990 is 2.5% and this leads to 10% increase in the peak flow. The model can be run for any future development plans in land use to investigate the hydrological impacts of land development.

Keywords: Land development, water resources, GIS, GPS and remote sensing.

**Water for the World : Water resources, its availability,
demand and problems as seen from Space**

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More and more we are becoming aware of the need to preserve the Earth sensitive ecosystem, to minimise the harmful effects of our human activities on the environment and to husband and conserve natural resources.

One of the most urgent global concerns is the availability of potable water to everybody. The water resources of the earth are unequally distributed, areas with abundance of water but little population are faced by regions with high population density but few water reserves only. Cyclic and seasonal changes of precipitation, hazardous quantities of rainfall on one side and long lasting draughts on the other side impact men and natural environment. Human activities have an additional impact on the availability and the quality of water.

It is a holistic task to overlook and assess the innumerable water phenomena, their existence, their interconnection and impact to the natural conditions and to human beings and vice versa.

Only space technology with its Earth observation instruments and science is able to provide us with the necessary global synoptic and regular information, to understand and assess natural processes and to bring them into correlation with human demand, influence and safety. An information which is needed to develop strategies and technologies to solve the world wide water problems and to guaranty the right on water to everybody.

Water resources in developed and emerging countries, hydrological water forecast, ground water availability, municipal water supply, pollution control, irrigation and drainage, power generation, industrial use, recreation activities, flood control, hazard management and bilateral and international water treaties are only a few of the questions which at least can be answered partly by Earth Observation from Space.

The presentation gives an overview and illustrates some of the most pressing questions in a top-down approach from the global view to local situations on the different continents. It shows possible contributions of space technology to water issues.

A GIS-Based Computer Program for Estimating Irrigation Water Requirements in Saudi Arabia

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Based on the technique of geographical information systems (GIS), a computer program was developed to estimate the irrigation water requirements in the kingdom of Saudi Arabia (KSA). Consecutively, the basic elements and fundamental information and data were identified and collected. A map of KSA with a scale of 1:4000000 was obtained and scanned with an acceptable resolution. The digitized map was geo-registered to the national geodic datum. In addition to the geographic locations (coordinates) of stations, the historically recorded climatic parameters were collected for 52 agro-metrological weather stations distributed over the entire Kingdom. The 52 stations, along with main regions, cities, and villages were digitized from the geo-registered map of KSA. The collected weather data, temperature; humidity, wind speed; and solar radiation, cover the period from year 1984 until year 2000. A database of the historically collected weather parameters and values was established using a database program. The mathematical equations used to calculate the irrigation water requirements were conveniently and consistently formulated using visual programming. The determination of irrigation water requirements comprises of the calculation of the reference evapotranspiration (ET) using Penman-Monteith model and the computation of crop water requirements obtained by multiplication of the reference ET and the crop coefficient.

The developed computer program allows the user to select one or more zones from KSA digital map for which the irrigation water requirements are to be determined. The user is allowed to perform calculations for the total irrigation water requirements, the crop water requirements, and/or the reference evapotranspiration. The user is required to provide the crop characteristics such as the growing stages and their lengths, in addition to the leaching requirements and the irrigation efficiency. Also, the developed program displays the values of the reference evapotranspiration, the crop evapotranspiration, and the total irrigation water requirements on the digital map of KSA at the

selected locations for comparisons. Detailed reports can be browsed and either saved or printed for reviewing and checking purposes. Furthermore, it gives the user the opportunity to show the results on the geo-registered map depending on the needs and aims of the purpose of calculations. The specialists and investigators could review the detailed calculations in a more exhaustive manner.

The developed computer program was intended to thrust the technology and to be user friendly. The panels and interfaces were developed and written in Arabic language, with blessing of God, to contribute to a wide spectrum of users. This work is expected to support decision makers in water affairs, specifically in irrigation water, in the Kingdom of Saudi Arabia. One of the more important requirements of the developed program is the maintenance and periodic update of the climatic parameters on which the forecast of irrigation water requirements depends.

A Simulation Model For Flooded Areas of the River Nile Using Remote Sensing and GIS

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Sudan is a large country and the Nile, which is one of the most remarkable and the second longest river in the world, runs a long distance from south of the country to the north.

The Nile is known for its marked seasonal and manual variations. The variation in discharge is illustrated by the fact that more than 80% of its manual flow occurs from August to October. It is interesting to note that manual discharge of the Nile for the year 1913-1914 was 41 milliard cubic meters as compared to 151 milliard cubic meters in 1878-1879.

Due to the history of the Nile in the Sudan, many surrounding areas were damaged during periods of floods, causing many economical problems for the inhabitants of the flood plains.

This study for the high discharge across the Nile and its effects to the surrounding areas according to the topography.

The study was carried for the upper reach of Dongola station, where continuous record for the period 1960-1990 will be used together with the topography of the area. Remote sensing and GIS some techniques had been applied.

The results produced different maps showing the flooded areas according to the hazards of flood wave.

These results will help the planner and decision makers to take the proper measures, which will alleviate the continuous disasters of floods and relieved loss in life and property.

Applications of Remote Sensing to Hydrology and Hydrogeology

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An adequate and continuous supply of water for drinking, agriculture, and industry is basic for all societies. Significant deviations from normal water supplies generally bring disaster in the form drought or flood. To avoid the problems resulting from excess and shortage of water, societies have invested enormous sums of money and employed hydrologists and civil engineers to develop systems to control and distribute water. With nearly three-quarters of the Earth being covered with oceans. It is not a question of a global shortage of total water, but the challenge is to overcome the uneven distribution of water in space and time on land areas and to supply adequate quality to meet local needs.

For example, about 20 per cent of the Earth's land area is classified as arid and an additional 15 per cent is classified as semiarid. Here, water has been the limiting factor in the development of agriculture and most industries. Yet, even these dry areas are periodically devastated by floods. The requirement placed on technology is to supply, at an affordable cost, a dependable supply and quality of water where and when it is needed.

Systems to control water supplies have consisted of wells, canals, levees , and dams Because available information is almost always inadequate, wells have been dug that fail to produce adequate quantities or quality of water, dams have leaked or totally failed, and waste waters have contaminated drinking water. These disappointing results could have been avoided if sufficient hydrologic, geologic and climatologic information for resource planning had been available.

The purpose of this report is to inform hydrologists and water resource planners, primarily in developing countries, of the general capabilities of remote sensing techniques to obtain hydrologic data and to examine remote sensing as a possible aid in operational hydrology in the future.

**AN ASSESMENT OF THE SPACE IMAGERY
CAPABILITIES TO WATER RESOURCES
MANAGEMENT-CASE STUDY: AL-HAMMAD SEMI
ARID PLATEAU, SYRIA**

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AL-Hammad plateau extends over a large area in the South and South Eastern part of Syria ,the North-Eastern part of Jordan, Northern part of Saudi Arabia , and the South-Western part of Iraq. Its altitude ranges among 600-1000m above the sea level, its maximum height in Rutbah uplift at Jabal Aneizeh, the meeting point of Jordan, Iraq and Saudi border. Beyond the AL-Oulab area, the eastern part of Syria, the plateau passes into the badiat AL-Sham plain, which slopes gently towards the Euphrates River. It includes the closed drainage basins in Syria, Jordan, Iraq and Saudi Arabia. The base level of the ephemeral drainage systems is a line of Sabkha extending from Wadi Sirhan to Eastern Jabal El-Arab which coincides approximately with the major axis of a large sedimentary depression modified by comparatively recent volcanic flows. Most of the other wadis are related to the Rutbah uplift. Tilting in Neogene times of the AL-Hammad plateau has produced a radial drainage pattern.

The water resources of the AL-Hammad region, which is located in an area where the prevailing climate is arid to semi-arid, are limited and maybe described as scarce. The proper assessment, planning and development of water resources are key elements in the overall social and economic development of the region, as a whole improper management and planning of water resources either because of lack of data or because of inadequate studies, has often resulted in over development, water quality deterioration and water supply problems in many areas.

Remote Sensing techniques were used to delineate the boundaries of different surface features, such as the permanent water bodies, mud, flats, etc. The extraction of details from satellite imagery depended on the spectral contrast between the object and its surroundings.

Landsat TM, SPOT-XS and Radar-SIR-B imagery were used to extract lineaments maps at a scale 1:50 000, and a drainage maps at a scale of 1:50 000 showing the major water bodies .

Lineaments reflecting the regional tectonic trend were all clearly displayed on the Landsat-TM imagery as straight to curvilinear topographic breaks. These lineaments are associated mainly with ridges, valleys, and drainage features. It was found that terrain elements were, in general, more readily distinguished on the radar imagery than with SPOT-XS data, although, almost all the same features could be detected on both types of imagery. According to these investigations, unlike SPOT-XS, the radar imagery tended to mask most anthropogenic disturbances and vegetation differences, leaving largely topographic information. It has shown that a radar image can make a significant contribution in rock-type discrimination over Landsat data . The results of the study show that AL-Hammad lineaments, recognized on Landsat-TM, SPOT-XS, and Radar-SIR-B images, were caused by major faulting zones that affected the crystalline basement. Basalts are one of the main units of the crystalline basement in the region, where water shortage is a serious problem. Study of lineaments, particularly those aligned over significant distances with the main geomorphologic trends in other basaltic terrains of the region, may likewise lead to sites of groundwater .