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Arabian Gulf University

United Nations Water Learning Center (UN-WLC) of the Arab Region at the Arabian Gulf University (AGU) in "Integrated Water Resources Management (IWRM)" Diploma Program

Students Graduates
&
Abstracts Book

First (2008-2009), Second (2009-2010), Third (2010-2011), Fourth (2012-2013), Fifth (2014-2015), Sixth (2016-2017), Seventh (2018-2019), Eighth (2021-2022), Ninth (2023-2024) Batches, and Tenth batch (2024-2025)

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The summary of each of the participants' applied research findings is documented in this book. The complete project report can be requested from the **UN-WLC for the Arab Region** at the Arabian Gulf University (AGU), Kingdom of Bahrain.

For more information on the UN WLC for the Arab Region at AGU please visit:
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Introduction

The Arab World countries are situated in one of the most water-stressed regions of the world with extremely poor endowment of water resources. However, the scarcity of renewable water resources is not the only distinctive characteristic of the region, inadequate management levels and the continuous deterioration of its natural water resources have become equally distinguishing features during the past few decades as well. The Arab countries have witnessed unprecedented population growth and accelerated socio-economic development activities in the past three decades, and were associated with a substantial increase in water demands placing an increasing stress on the region's limited water resources. With water demands out-stripping available water supplies, the Arab countries are experiencing a chronic water imbalance, which is expected to increase in the future, due to many pressing driving forces, including population and economic growth, escalating urban water demands and food demand, unsettled and politicized shared water resources, and climate change. The dilemma is exacerbated by a continuing rise in water demands, in conjunction with the fact that all of the region's annual surface water resources are already being exploited, and its groundwater resources are being depleted as well. These conditions pose major threats and implications not only for the future development of these countries, but also for the sustainability of their past economic and social achievements.

The supply-driven approach to water management has demonstrated its inability to deliver a substantial degree of water sustainability or security to the water-stressed Arab countries. Despite the strenuous efforts made by these countries to maintain water supplies, they still face serious water deficits due to continuously increasing water demands. Fortunately, all of the Arab countries have realized that efficient development and management of water resources require water policy reforms, with an emphasis on supply and demand management measures, improvement of the legal and institutional provisions, and enhancement of stakeholder participation and the role of the private sector. Furthermore, weaknesses in the institutional arrangements and individual and institutional capacities, particularly in the field of management and planning, represent one of the major obstacles in water resources management in many Arab countries, and need to be enhanced through intensive education, capacity building and training.

With about 88 per cent of total water consumption in the region being used in the agricultural sector, there is an urgent need to integrate agricultural policies with water policies. These policies should take several factors into account including the availability and limitations of water resources, and the consequences of over-exploitation for agriculture and other sectors. The efficient use of water resources in agriculture is possible through improving irrigation techniques, which is one of the most urgent needs and prerequisites for sustainable food production in the water-scarce Arab region. Moreover, it is clear that the majority of the Arab countries cannot provide for all of their food needs due to the lack of agricultural capacity in these countries. However, Arab Food Security could be achieved through regional agricultural integration that combines the relative comparative advantages of all the Arab countries, such as land and water resources, human resources, and financial resources. Countries could join together in agricultural projects aimed at achieving food security for the region as a whole, using advanced agricultural methods supported by active R&D in agricultural production.

Rapid urbanization in almost all of the Arab countries challenges efforts to meet increasing domestic water demands, especially for those countries with scarce public. Domestic water consumption in the Arab region has been escalating in the past few decades, a trend expected to persist in the Arab region in the future. Currently, domestic water consumption represents about 7 per cent of the total water used in Arab countries. Although a relatively large percentage of people in the Arab region have access to improved drinking water and sanitation, these services are not always reliable, especially in lower-income countries and lower-income areas within the countries. Currently, in the Arab region, approximately 83 million people do not have access to safe drinking water and about 96 million people need access to sanitation services. Most of these people live in lower income countries, are under occupation, or are riddled by war and conflict. It is estimated that the total financial cost of providing the water supply and sanitation services required to halve the proportion of the population without sustainable access to safe drinking water and sanitation by the year 2015, under MDG7, would be about 100 billion and 62 billion United States Dollars, respectively.

Moreover, most of the Arab countries experience large percentages of non-revenue waters, reaching in some more than 50%, which compounds the problem of urban water supply. On the other hand, average per capita domestic water consumption in the Arab region is about 200 liters/day, but varies significantly among the countries of the region. For example, domestic water consumption in the Gulf Cooperation Council (GCC) countries ranges from 300–750 liters/capita/day, which ranks as the highest in the world. The rise in per capita water consumption in these countries is attributed to many factors including the absence of proper demand management and of a price-signaling mechanism. Government policies have primarily focused on the supply side of water production, coming from aquifers or desalination

plants. Water tariffs in the region are generally quite low, representing no more than 10 per cent of the total cost on average, with no incentives for consumers to save water.

In the Arab region, groundwater is a vital and essential source for all sectors. The groundwater dependency ratio reaches more than 80 per cent in some countries. Even in the relatively surface water-rich countries, groundwater utilization and reliance is emerging and is on the rise due to the steady increase in water demands, and groundwater dependency is expected to increase with time. Groundwater resources therefore require careful planning and management so that they can continue to sustain human socio-economic development and the various ecosystems that depend on them. However, these resources are facing critical conditions in most of Arab countries due to over-exploitation, which has led to water level declines and salinization due to saltwater intrusion. In addition, these resources are threatened by numerous point and non-point sources of pollution generated from anthropogenic activities. As the quality of groundwater deteriorates, either through over-exploitation or direct pollution, its uses diminish, thereby reducing groundwater supplies, increasing water shortages, and intensifying the problem of water scarcity in the region. It is expected that the loss of groundwater resources will have dire consequences on the Arab countries' socio-economic development, increase health risks, and degrade the environment. Therefore, it is of paramount importance to the region that its groundwater resources are carefully planned and managed in order to sustain their service to the socio-economic development and their various dependent ecosystems.

In many countries of the Arab region, groundwater resources are non-renewable, and thus the sustainability of these resources is problematic, and requires clearer definition. Sustainability of these resources should be interpreted in a socio-economic rather than a physical context, which means that full consideration must be given not only to the immediate benefits, but also to the negative impacts of their utilization, and to the question of *what comes after the water sources are fully depleted*. Therefore, exit strategies need to be identified, developed, and implemented by the time that a non-renewable aquifer is seriously depleted. An exit strategy scenario must include appropriate and balanced socio-economic choices on the use of aquifer storage reserves, on the transition to a less water-dependent economy, and on the replacement of water resources.

The issue of management of shared water resources among countries outside the region, as well as between the countries within the region, represents another major challenge facing the region, A framework for cooperation in the management of shared water resources should be developed, building on experiences gained from cases such as the Nubian Sandstone Aquifer and the North-Western Sahara Aquifer System.

While the increase in the reliance on desalinated water in the Arab countries is inevitable in the future, desalination technologies are largely imported, which makes them expensive to operate and expand. Furthermore, desalination and treatment industries and projects provide limited added value to the Arab countries economies. There is an urgent need for cooperation among the Arab Countries to investment in R&D for these technologies, with the aim of acquiring and localizing these technologies in the region, reducing their cost, increasing the reliability of the water source they produce, increasing their value for the Arab countries' economies, and reducing their environmental impacts.

In the past few decades, municipal wastewater has become an increasing source of water with considerable potential in alleviating water scarcity in the Arab countries, as their volumes increase proportionally with increasing urban consumptions. With proper treatment and optimum allocation, they can be used to supplement water demands in the agricultural and industrial sectors, as well as in managed aquifer recharge schemes. However, the use of these waters is associated with health and environmental risks that need to be assessed thoroughly (among other less concerns).

Finally, it is expected that climate change will impose further stresses on the freshwater resources in the Arab countries and intensify their vulnerability, and would exaggerate if the current population growth and agricultural policies continue. Therefore, it is imperative to consider the potential impacts of climate change in water resources planning by integrating the appropriate adaptation measures in the countries' water programs.

Under all such conditions, the definition of the term "Sustainable Water Management" is becoming more complex and more elusive; water resources planners and managers in the Arab countries are continuously confronted with the issue of the definition of sustainability strategies in the management of water resources. For example, sustainability of desalination needs to be defined in a multitude of areas, including the reduction of their cost, increasing their reliability as a water source, acquiring and localizing desalination technology and increasing its added value to the region economies, and reducing their environmental impacts. Moreover, sustainable water management needs also to be defined within the

various sectors relying on these resources as their main input (i.e., urban water supply, agricultural, industrial sectors, as well as the environment). There is a need to translate the general definition of sustainable water management of "managing water resources while taking into account the needs of present and future users", into more "practical and operational" definition that takes into account the unique characteristics and specificity of the water sector in the region and the various water-dependent sectors, including political, economic, social, technological and environmental considerations. In other words, there is a need to look at water management in a new holistic way, with the overall objectives of securing long-term water supplies while meeting strict criteria for socio-economic, financial, and environmental sustainability and public health requirements.

Furthermore, the water management challenge in the region is being compounded by its multiple nexuses with the various development sectors, such as water and human health, water and environment, water and food, water and energy, and many other interdependencies, which carry within them many cross-cutting issues of human rights, social, economic, legal, technical, political, and security nature. All of these nexuses, interdependencies, cross-cutting issues need to be addressed if effective and sustainable water resources management needed to be achieved. It is therefore important to address much more explicitly the various linkages of the water sector with other sectors like energy, food, health, and economic development as a whole, and that water professionals should think and act beyond the boundaries of the water sector to achieve effective and integrated water resources planning and management.

The UNU Water Learning Center for the Arab region aims at the sustainability of Water Resources Management Systems within IWRM framework through a capacity development curriculum and conducting research that emphasizes an integrated water resources management approach that considers quantity and quality of resources, their spatial distribution, interests of users in the different economic sectors, institutional arrangements, and formulation of national/regional objectives within existing constraints. It focuses on translating the general definition and the principles of IWRM into more "practical and operational" definition in the water resources management, that takes into account the unique characteristics and specificity of the water sector in the region and the various water-dependent sectors, including political, economi
c, social, technological and environmental considerations. The aim is to besides looking for more balanced ways of allocating water and influencing demand, adequate attention is made to subjects such as economics, social analysis, policy analysis, institutional, legal, and management frameworks, water law, and capacity building.

UNU Water Learning Center for the Arab Region at the Arabian Gulf University

Overview

The UN Water Learning Center (UN WLC) at AGU is a partnership project between the United Nations University)-International Network on Water, Environment and Health (UNU-INWEH) and the Arabian Gulf University (AGU), based on their common principles, complimentary objectives and a mutual interest in close cooperation in education and capacity development related to Integrated Water Resources Management (IWRM). The establishment of the regional center at AGU is made by the signing of the "Agreement of Cooperation between UNU/INWEH and AGU" for "**The Establishing of a Regional Center of the UN WLC for the Arab Region**", signed in 2007 by both parties. The funds for establishing the center were provided kindly by the Arab Fund for Social and Economic Development.

The Arabian Gulf University was selected to host the regional center for the Arab region due to its regional status (AGU is a regional university founded and funded by the six GCC countries), and due to its expertise and experience in post-graduate education, training, research, and contractual studies in the water-related fields (two specialized Masters Programs related to water: Hydrogeology & Groundwater Resources Management and Water Resources Management; three water-related Masters Programs: Environmental Sciences & Natural Resources, Environmental Management, and Desert Cultivation Technologies & Soilless Culture, as well as its experience in distance-learning (The Distance Learning and Training Master's Program).

The objectives of the established Regional WLC for the Arab Region at AGU are to improve water resources management and water services in the Arab Region and to improve training and education in the water sector. The Center offers a core curriculum in IWRM customized to the Arab Region water conditions and issues; train students, trainers and decision makers in water resources management within an IWRM framework and perspective; identify regional and country needs in water resources management; and establish regional electronic network of young water professionals.

The targeted participants of the program are water resources professionals working in the water-related agencies and private sector in the Arab Region. The launching of the program was made in November 2007 (soft launch), the official launching was made in March 2008, and the IWRM program started its first batch in 2008. Since its establishment, the Center has graduated eight batches (from 2008/2009 to 2023/2024), with a total number of 122 participants.

The UNU-INWEH IWRM Diploma consists of 10 courses, which total 250 hours of presentations (equivalent to lecture time) and is conducted in a mixed mode system (i.e., face-to-face and distant learning). The IWRM Overview course (Course 1; 10 days) and the final Applied Session (Course 10; 5 days) are delivered at the Center in AGU. During the period of the last Course (i.e., Course 10), the final comprehensive exam of the Diploma is administered, and students are required to present and defend their research project in front of the program instructors panel, as well as the other students. Moreover, a mid-program visit at AGU (after Course 5; 5 days) is made where the students take A Mid-Program Exam and present their project research proposals in consultation with their assigned supervisors. The rest of the Courses (i.e., Course 2, 3, 4, 5, 6, 7, 8, and 9) are delivered as Distance Education courses, with participant-instructor interaction made by e-mail and web-based conferencing system. **The following is a brief description of the 10 Courses**:

1. **An Introduction to IWRM**: This course provides an overview of the concepts involved in IWRM and a brief summary of the other courses. **The water conditions and the main issues and challenges of water resources management in the Arab region are presented and discussed**. A simplified process for implementing an IWRM plan is also included as an example of the mechanisms and problems that might be encountered. A broad examination of critical concepts and knowledge needs related to IWRM, including essential human and institutional capacities development, with the course structure and content linked to, and driven by, the subsequent eight courses. **Moreover, dynamic modeling of a water system using WEAP (Water Evaluation and Planning) model is demonstrated in a hands-on exercise**.
2. **Water Transfer**: The natural components and processes of the hydrologic cycle, temporal variance, global and regional processes and impacts of anthropogenic alterations on the water cycle. Water and the Atmosphere, Water and Land, Water and the Riparian Environment, and Water Budgets.
3. **The Terrestrial Ecosystem**: Changes and impacts that occur as a result of land use change and development. Biomes, Drylands, Life, Succession, Biogeography, Populations and Growth, Predation, Nutrient Cycling, Biodiversity, Watershed Changes, Forestry, Agriculture, Mining, Urbanization, Dams and Diversions.

4. **The Aquatic Ecosystem**: Concepts, processes, analytical approaches and procedures that relate to our understanding of the structure and function of the aquatic ecosystem. Freshwater, Stream Ecology, Biological Community Characteristics, Stream Corridor Functions, Estuaries, Lakes, Marine Ecology, Wetlands, Watershed Change, and GIS application in water resources management.
5. **Aquatic Ecosystem Health and Impact Assessment**: Aspects of anthropogenic impact and change to the physical, chemical, biological and ecological components of the aquatic environment. Principles of Aquatic Ecosystem Health, Biological Monitoring Processes, Restoring Aquatic Ecosystems, Restoration, Toxicology, and Ecological Risk Assessment (ERA).
6. **Water Use**: The many human uses of water, both consumptive and non-consumptive, and their implications for the hydrologic cycle, ambient water quality and both ecosystem and human health. Agriculture, Industrial and Public water use, standards and monitoring.
7. **Non-Conventional Water Resources**:
    a. **Desalination**: Introduction to Desalination, Desalination in the Arab Countries (history and trends), Desalination Technologies, Desalination Issues and Challenges (Financial, Economic and Environmental).
    b. **Wastewater**: The discharge of wastewater to natural and artificial catchments, potential impacts, methods of treatment and mitigation, the urban water cycle and methods to evaluate and choose appropriate technologies. Rural, Urban, and Industrial Point and Non-Point-Sources.
8. **Governance and Community Based Approaches**: Legislative, regulatory, legal, jurisdictional, community and individual responsibilities and arrangements of IWRM. Gender issues, the requirements and benefits of capacity building, public education and community involvement. Water Laws, Government's Role, Policy Development, Issues and Dilemmas, Community Participation, Consensus Building and Conflict Resolution, Policy Instruments.
9. **Organizational Infrastructure and Management**: This course deals with the organizational and management structures and procedures needed to deal with Integrated Water Resource Management. Management and operations, financing, budget analysis, budget cycles, capital expenditures, policy analysis, community involvement. Personnel training and human resources planning. Management & Operations, Laboratory & Information Management, Public Health & Public Health Administration, The Programming Cycle & Project & Contract Management, Special Planning.
10. **Applying IWRM**: Customized case studies, practical illustrations of the concepts and procedures of IWRM, and investigative techniques for students to assess their own IWRM needs, conducted in tutorial format in the Center. Students' projects include a scientific approach to a water problem in own country, including literature review, problem statement, objectives, methodology, results and discussion, conclusion and recommendations. These might include preparing a water budget for a watershed/sub-watershed, performing a water demand analysis and future projection, performing and writing a report on a specific Risk Assessment, performing an Environmental Impact Assessment, using one or more mathematical models to examine and evaluate a problem, writing a complete project (programming, identification, formulation, financing, implementation and evaluation), writing a project grant/loan proposal for GEF or World Bank.

For Further Information, please contact:

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First Batch: 2008-2009

First Batch Students

No.	Name	Country	Project Title
1	Ali Mahdi Al-Aswad	Bahrain	Comparison between Centralized and Decentralized Schemes in the Management of Wastewater in Bahrain
2	Fadhel Abdulla Ghuloom	Bahrain	Evaluation of Industrial Water Demand in Bahrain
3	Fadi Jamal Obaid	Bahrain	Evaluation of Losses in EWA Water Distribution Grids
4	Raed Rashid AlHammad	Bahrain	
5	Mohamed Jafer Redha	Bahrain	Assessment of the Environmental Impacts of Desalination Plants in Bahrain: A Case Study of Sitrah Power and Water Station
6	Mohammed Jassim Al-Aradi	Bahrain	Using System Dynamics for Simulating Water Quality Status in Tubli Bay, Bahrain
7	Hameed Abd-Ali AlMahal	Bahrain	
8	Muneer Ebrahim Hajjaj	Bahrain	The Pros and Cons of Water Privatization in Bahrain
9	Sayed Ahmed Salman AlHallay	Bahrain	كفاءة إدارة المياه في القطاع البلدي بمملكة البحرين
10	Sideeqa Ali Al-Jazeery	Bahrain	Irrigation Efficiency of Date Palms Using Treated Sewage Effluent in Bahrain Farms
11	Waleed Mohammed Al-Murbati	Bahrain	Impact of Brine and Chemical Discharges on the Marine Environment: A Case Study of Addur SWRO Desalination Plant, Bahrain
12	Yaqoob Ahmed Abd ElNabi	Bahrain	تدهور المياه الجوفية في هيئة الكهرباء والماء
13	Hesham Elsayed El-Shazely	Egypt	Development of an Environmental Plan for Restoration of Rosetta Branch in the Nile Delta
14	Yasser Mahmoud Salah El-Din Rizk	Egypt	Irrigation Water Management Improvement of Old Lands of the Nile Delta of Egypt
15	Ahmad Fawaz Atoum	Jordan	Qairawan Watershed Management Plan, Jerash, Jordan
16	Buthainah Oqlah Batarseh	Jordan	Community Participation Framework for the Qairawan Watershed Management, Jerash, Jordan
17	Asim Abdulla AlKhalid	Kuwait	Assessment of Proportional Contribution by Anthropogenic Recharge Sources to the Problem of Shallow Water in Urban Areas of Kuwait
18	Samer Kalbouneh	Palestine	Selection of Appropriate Cropping Patterns as Tool for Water Resources Management in Palestine: Date Palm as Salinity Tolerant Crop in Jiftlik-Jordan Valley
19	Nasser Ghaith AlKuwari	Qatar	Wastewater Management in Qatar
20	Ayad Nooar AlDalbhi	Saudi Arabia	Investigation of the Pollution Sources to Houses Drinking Water Storage Tanks Burayadh City, Saudi Arabia
21	Fahad Abdualkarim Al-Fada	Saudi Arabia	Constraints of the Reuse of Tertiary Treated Wastewater in Buraydah City, Saudi Arabia

Comparison between Centralized and Decentralized Schemes in the Management of Wastewater in Bahrain

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Management of wastewater represents a challenge to decision makers in light of the increasing population growth and limited financial, human and land resources. In Bahrain, the design capacities of wastewater treatment facilities is estimated at 223,000 cm/day (81.4 Mcm/year) produced from 11 plants, with the main capacity of 200,000 cm/day (70%) exists at Tubli plant. The wastewater collection network coverage reached 92% in 2008 serving the capital Manama, Maharraq, Northwest, Central, Western and Eastern regions, and is expected to achieve full coverage by 2020. High population growth and urbanization rates are placing immense pressures on the capacity of Tubli plant, as the amount of waste received sometimes reaches 289,000 cm in excess of its designed annual capacity.

Tubli plant treats a daily volume of 120,000-130,000 cm to a tertiary level and 100,000 cm at a secondary level. The secondary treated effluent of 100,000 cm and 70,000 cm of the treated effluent with high concentration of suspended solids is being discharge daily into the Tubli Bay with significant coastal and marine environmental and health implications. On the other hand, large volumes of the tertiary treated wastewater of 95,730 cm/day (35 Mcm/yr) is being reused to irrigate 413 farms covering 2,242 hectares with a future plan to increase the volume to 200,000 cm/day (78 Mcm/yr) to irrigate 2973 hectares by the year 2012. The continued disposal of waste without the expansion of the Tubli plant capacity is expected to have major impacts on the coastal and marine environment and poses public health risks on the surrounding community. However the plant expansion option may require large investments, large land area, rehabilitation of the collection system to reduce leakage, and appropriate number recharging wells for groundwater artificial recharge purpose.

Decentralized schemes options in different parts of the world are receiving increased recognition as an effective wastewater management alternative including Bahrain. The objective of the research is to assess the status of the existing treatment facilities, compare the advantages and disadvantages of the centralized and decentralized wastewater schemes, and then suggest a suitable scheme for Bahrain taking into consideration the existing and future environmental, socioeconomic, and cultural conditions. The methodology consisted of the evaluation of the existing plants characteristics with focus on Tubli plant current capacity and its generated waste volumes, operation and maintenance, treatment costs, network coverage and reuse amounts. In addition, a discussion on comparative advantages of centralized and decentralized schemes based on the Ministry plan and international experiences is made.

The analysis indicated that the Ministry of Public Work is debating the option of expanding the capacity of Tubli plan to reach 350,000 cm/day by the year 2015 and is also evaluating the option of implementing a decentralized schemes for different size plants to be located in different region of Bahrain as well as the design option of a new plant at Al Maharraq with a daily capability of 100,000 cm/day by the year 2013. The analysis indicated the major advantages of centralized scheme are the economy of scale in terms of low treatment cost estimated at US$0.13/$m^3$, transportation cost of US$0.04/$m^3$ in comparison to the water supply production cost of US$0.79-0.87/$m^3$, the availability of reuse irrigation network and the availability of large volume of treated wastewater at a one location. The advantage of decentralized schemes may consist of low investment in construction and maintenance costs, smaller number of pumping stations and network collection pipes, better control of leakage due to the age of network, future expansion follow the normal population trends, optimal reuse program, enhanced recharging well spacing for disposal of excess treated wastewater, less odor from low generated volumes and smaller size land requirement. The implementation of decentralized schemes could pose a challenge in terms of design criteria, administrative measures and cost of land resources. The study recommends the evaluation of the current wastewater treatment policy and program to assess the current practices and undertake detailed analysis to evaluate the option of decentralized small size wastewater treatment projects taking into consideration population growth, future urban plan and the availability of adequate financial and human resources.

Evaluation of Industrial Water Demand in Bahrain

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The Kingdom of Bahrain is located in an extreme arid zone, has limited nonrenewable groundwater sources, supplemented by desalinated and the reuse of treated wastewater sources that are being used to meet the total water requirements. During the last four decades, increased socio-economic development has contributed to the widening of the gap between available supplies and demands, resulting in the depletion and quality deterioration of groundwater and increased investments in desalination and wastewater treatment facilities. The country population has increased from 0.62 million in 1998 to 1.1 million in 2008, an average growth rate of 2.9%. The total water demands have increased from 65.2 Mcm in 1952 to 335 Mcm in 2007, with an allocation of 44.2% to the municipal (148.1 Mcm), 47.7 % to the agricultural (160 Mcm) and 8.1% to the industrial sectors (27.1 Mcm). The municipal water supply system partially provides water to the industrial sector. Industrial and commercial consumption from the desalinated municipal water supply was estimated at 7.4%.

In general, there are limited information on the actual industrial water consumption according to the type of industries and their operational and productive scheme, which presents a challenge to decision makers to formulate effective water management strategy. Even though industrial water demand is relatively small and ranges between 5-7% of the total water consumption in the GCC countries, water conservation can increase water use efficiency as well as reduce industrial pollution. Demand management measures for industries that depend on domestic supply can help reduce investment in water supply system and contribute to more water availability for the domestic consumption. Thus, the objective of this research is oriented towards evaluating the past, current and future trends of industrial water consumption, and suggest demand management measures that can enhance water use efficiency in this sector. These objectives were achieved through the evaluation of different data sources to delineate the trends according to the existing water sources and the type of management measures being implemented with focus on the water tariff.

The analysis indicated that industrial water demand increased from 12.1 Mcm in 1952 with water mainly available from groundwater source and increased to 27.1 Mcm in 2007 mainly from the municipal water supply system. The number of factories increased from 19 in 1953 to 193 in 2007. By extrapolation, the demand is estimated to reach 39 Mcm in 2025. The existing industries consisted of aluminum, food, beverage, pharmaceuticals, clothing, petrochemicals, constructions and small industries with some of them having their own water supply facilities. The analysis indicated that the industrial sector has increased its reliance on municipal water supply as the consumption increased from 0.043 Mcm in 1997 to 1.44 Mcm in 2000, to 1.61 Mcm in 2008, even though the number of factories has decreased from 254 in 1997 to 193 in 2008. Water conservation measures in the industrial sector in Bahrain consists only of the introduction of industrial water tariff in 1985 for water taken from municipal water supply system; however the tariff was reduced in 1985 to encourage industrial activities. The existing two tier tariff was not effective in reducing consumption in comparison to the actual production and operation and maintenance costs. The study indicates the introduction 1985 tariff showed an increase in the water demand.

The research revealed that there is a lack of information on the water consumption by different industries as well as absence of conservation efforts to enhance water use efficiency in the industrial sector. It is recommended to establish a data base, the implementation of financial and technical incentives for implementing demand management measures focusing on the introduction of effective water tariff, recycling of grey water, water saving technology and awareness program for those involved in the operation and management of factories.

Evaluation of Losses in EWA Water Distribution Grids

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In many urban centers including Bahrain, high water demands and lack of investment in the rehabilitation of water distribution supply networks have contributed to network losses. Network losses have been attributed to damages from construction activities, unbalanced pressure differences, illegal connection and faulty metering. In Bahrain the water supply network has been experiencing high losses estimated at 31.6%, 35.7%, 22.8%, 24.6% and 34% with corresponding leakage rates of 25, 27.6, 18.3, 17.6 and 22.3% in 1993, 1996, 2000, 2005 and 2008, respectively. The network losses represent the difference in volume measured at the main distribution point near the sources and the meter reading at the consumer connection, while the leakage represents the amount of water seeped from a section of the network at a given location. The leakage rate in Bahrain in 2006 was estimated at 16.5% compared to 32% in Mecca, 62% in Manila, and 4.7% in Singapore. The implementation of a leakage program in Bahrain has reduced the losses through replacing old pipes, elimination illegal connection, installation of meter on main pipes, enhanced maintenance and public reporting. However, the program did not achieve good results as it did not take into consideration pressure influence.

This research evaluates the application of a hydraulic model to identify areas of high leakage and pressure distribution and compare the model prediction with field leakage values. The method stressed on the application of the INFOWATER model to evaluate the impact of pressure distribution and selection of appropriate pressure control valves to reduce the amount of the leakage taking into consideration the model compatibility with the existing GIS software. The model was applied to a 5 km^2 area in Hamad Town covering five pilot zones (1203, 1204, 1205, 1206 and 1207) connected to about 71,000 residences with a population size of 35,000 persons, and land surface elevation ranges from 30 cm to 42 m above sea level. The network consisted of a distribution main pipe with diameters of 80-600 mm covering 63 km length and lateral of 12-50 mm covering 96 km with 8 storage tanks and pumping levels of 69.5-78 m. The model simulation indicated two periods as having high water consumption rates at 8 am at a flow rate of 38 liter/second and 5 pm at a flow rate of 47 liter/second. Comparison between pressure distributions of the selected zones and leakage incidents record (as reported by the public) indicated that high leakage rates corresponded with zones with high pressure.

The existing distribution of the network pressure far exceeds the designed pressure which represents one of the major causes to the high water losses. Model simulation suggested the installation of pressure control valves at some connection points at zone 1203, which would reduce the pressure in the range of 10-25 m with significant impact in lowering the leakage rates. For the other zones: 1204, 1205, 1206 and 1207, the corresponding pressure ranges should be at 10-30, 11-20, 8-30 and 9-16 m, respectively. The pressure control can be within the range of 30-61 m. A reduction of losses by 10% can result in a saving of 64 Mcm/yr. The current rehabilitation practice of replacing old pipes will result only in a temporary solution. It is recommended that calibration of the developed model prediction with field values using pressure valves connected to the SCADA system is made. It is also recommended to

transfer information from a large number of monitoring points to the control command center that can control the opening and closing of pressure valves to maintain pressure balance.

Assessment of the Environmental Impacts of Desalination Plants in Bahrain: A Case Study of Sitrah Power and Water Station

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Accelerated socio-economic development activities in Bahrain have contributed to the increase in the domestic water demand with more reliance on desalinated water to provide adequate supply and improved water quality. The population increased from 0.62 million in 1998 to 1.1 million in 2008, with an average growth rate of 2.92 %. The domestic water demands were 5.1 Mcm in 1952, 44.3 Mcm in 1980, 135 Mcm in 2000, and has reached 173 Mcm in 2007, and is expected to reach 259 Mcm in 2030. The per capita daily water consumption increased from 363 liter in 1980, 426 liter in 2000, and has reached more than 500 liter in 2006. The water distribution network coverage reached more than 95%. Desalination capacity was 8 Mcm in 1975, increased to 42.9 Mcm in 1984, 89.2 Mcm in 2000, 197 Mcm in 2006, and has reached 235 Mcm in 2009. The actual production of desalinated water was 36.7 Mcm in 1984, 78.1 Mcm in 2000 and has reached 122.6 Mcm in 2006. The used desalination technology consists of the Multi-Stage Flash (MSF), Multi-Effect Desalination (MED), and Reverse Osmosis (RO).

The disposal of the desalination brine with certain physical and chemical characteristic into the coastal and marine zones has negative environmental impacts; the concentrated brine can have different degree of pollution impacts on the receiving environment. In this research the environmental impacts of the Sitrah desalination plant's brine discharge was evaluated through the collection and analysis of water samples collected from the surrounding areas of the brine outlets.

The methodology consisted of water field sampling and laboratory physical and chemical analyses in order to compare water quality parameters variation of the measurements in different locations including outlets with the Bahraini standards for desalination brine discharge. Sitrah desalination plant discharges its brine into the eastern coast of Bahrain. The plant was built in 1975 to produce 8.3 Mcm desalinated water and 100 Mega Watt (MW) power through two MSF units, four sets of boilers and steam turbo generator, and equipped with two sea water intakes and four brine outfall culverts. The plant capacity was expanded through phases II (25 MW gas turbine with waste heat recovery boiler and auxiliary boiler and MSF unit) and phase III (have three identical MSF units) built during the period 1984-1985 to increase its total water production capacity to 41.5 Mcm. The plant brine discharged to the sea has high temperatures and salinity and residual chemicals being used for the operation, maintenance and cleaning processes. A sampling grid consisting of 18 points is designed in a series of four parallel longitudinal profiles in the direction of the brine outlet that extended 150 m into the sea. The samples were taken one meter below sea level at 9 am and 3:30 pm during low and high tides for a one day evaluation. A reference ambient sample point (background) was set at a 50 m distance from the end of the brine outlet. The evaluation was made for 12 parameters: temperature, conductivity, total suspended solid, total dissolved solid, chloride, sodium, potassium, iron, copper, turbidity and chlorine.

The analysis indicated an inverse relation between temperature and distance. The analysis indicated that the brine discharged temperature was 7 C^0 higher than the sea ambient temperature and the difference could reach 15 C^0 during the winter season. The effect of temperature in the case of low tide is slightly higher than during high tide; during low tide, the temperature variation was 36.6-40.6 C^o with ambient 32.8 C^o while for high tide it was 32.5-39.4 C^o with ambient at 32.5 C^o. The residual chlorine at the outfall was within the range of 0.06-0.2. The salinity also showed inverse relation with distance. The maximum salinity of 5800 μs/cm during high tide was observed near the outlet compared to a value of 5300 μs/cm at the sea water intake. In general high salinity was observed around the brine outlets and decreased with distance until it reached the mixing

zones (200 m) of the seawater conductivity. Heavy metals of Copper and Iron levels at the outlets were in the range of for 15-78 μg/l for copper and 20-85 μg/l for Iron, which were higher than their baseline values (cooper 32.78 μg/l and iron 8.15 μg/l), and thus exceeded Bahrain standard. Turbidity ranged from zero at the intake to a high 4.37 NTU value at outfalls, but decreased outward until it reached the mixing zones. There is no change in PH values between the outlet and intake areas. The TSS values were the same for outlets and inlet during both low and high tides. The study recommended further investigation of the impacts of the discharged brine on the marine environment for different seasons with improved sampling representation and detailed physical and chemical analysis.

Using System Dynamics for Simulating Water Quality Status in Tubli Bay, Bahrain

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Tubli Bay is an important environmental feature of Bahrain and has rightly been identified as a site of international importance. However, during a period spanning the past 50 years or so, there has been significant evidence of deterioration of the bay, and today it is a sad reflection of its former glory. The aim of this paper is to identify the main causes and the possible responses in related to the environmental degradation of Tubli Bay. A DPSIR analysis to indentify the direct and indirect causes, its various impacts and analyzing responses effectiveness is made. The analysis indicated that the main causes of the bay degradation is Tubli wastewater Treatment Plant where it is discharging about 150,000 m^3/d of partially treated (secondary) effluent. The discharge of the effluent to the bay contributes to high concentration of Total Suspended Solid (TSS), Chemical oxygen demand (COD), Biochemical oxygen demand (BOC), Ammonia (NH_3), Nitrate, Total Dissolve Solid (TDS) and Turbidity. The increase of the flow and its associated concentrations of the above parameters for the coming 50 years are calculated and investigated using several scenarios. A dynamic model using Stella Software is developed to model the wastewater flows and their impacts. These scenarios represented the engineering solutions and non-engineering solutions. A comparison between all scenarios was made to investigate the best scenario to mitigate the impacts of the wastewater on the bay. The best solution to solve the degradation problem of the bay effectively and on sustainable basis are to combine both non-engineering and engineering solutions.

The Pros and Cons of Water Privatization in Bahrain

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Socio-economic development activities in Bahrain have contributed to increases in the domestic water demand with more reliance on desalinated water to provide adequate supply and improved water quality. The population increased from 0.33 in 1980, 0.43 in 1990, and 0.62 in 2000, and to 1.1 million in 2008, with an average growth of 2.9%. Domestic water demands were estimated at 5.1 Mcm in 1952, 44.3 Mcm in 1980, 135 Mcm in 2000, and reached 173 Mcm in 2007. Domestic demand is expected to reach 259 mcm in 2030. The gross per capita daily provided from the main water distribution point at the sources was at 363 liter in 1980, 658 liter in 1990, 556 liter in 2000, and reached 578 liter in 2006. Water distribution network coverage reached more than 95% and partially provides water to the industrial sector. Desalination capacity was estimated at 8 Mcm in 1975, increased to 42.9 Mcm in 1984, 89.2 Mcm in 2000, 197 Mcm in 2006, and reached 235 Mcm in 2009. The actual production of desalinated water was estimated at 3.3 Mcm in 1980, 39.5 Mcm from the Sitrah desalination plant and reached 39.5 Mcm by the addition of Ras Abu Jarjur RO plant. The production in 1990 increased to 57.5 Mcm by the addition of Addur plant and increased to 90.1 by the production from the private Hidd plant in 2000, and again increased to 109.5 Mcm in 2005 by the private ALBA plant. The total production reached 132.3 Mcm in 2007.

Privatization of the water supply system has been receiving increasing attention in different parts of the world due to lack of government financial resources, conservation of water sources through improved use efficiency, and the need for enhancing system performance to increase consumers' satisfaction. Experiences from different parts of the world provided mixed results of benefits and adverse impact of tariff on the poor. In Bahrain, initiatives of water production privatization started in August 2002 as the Ministry of Electricity and Water has decided to buy desalinated water from ALBA private company, and later in January 2006 by selling of the water production facilities of the Hidd desalination plant to HPC private company. The water authorities bought water from these two private companies through purchasing agreements. The third privatization is expected to take place in 2011 by buying water from IWPP private company as build and operate facilities scheme. The privatization scheme followed the French model where the production assets become privatized while keeping the other components (water transmission and distribution facilities) as public government assets.

The objective of this research is to evaluate the financial benefits from the transformation of public asset to the private sector and assesses their operation. The methodology consisted of the evaluation of the investments made in the production, transmission and distribution faculties, the total cost to product one cubic meter in comparison to the water tariffs, and the cost of water purchasing from the two private companies.

The analysis of the financial data indicated that in 1993 water production, estimated at 58 Mcm, resulted in a production cost of 15.8 million Bahrain Dinars (BD), with 6 million BD for the transmission cost and 9.43 million BD for distribution cost with a corresponding total supply cost of 0.28 BD/m^3 with a tariff of 0.056 BD/m^3. In 2001, the produced 90 Mcm was achieved by a production cost at 17.58 million BD, while the distribution cost was at 7.08 million BD, with a total of 24.6 million BD. The corresponding total water supply cost was estimated at 0.307 BD/m^3 compared to a water tariff of 0.19 BD/m^3 charged to the public. In 2004, when the private company ALBA was involved, the cost was estimated at 0.268 BD/m^3 compared to a water tariff of 0.06 BD/m^3. The involvement of the other private company, HPC, showed that the total supply cost was at 0.309 BD/m^3 with a water tariff of 0.061 BD/m^3. The analysis indicated that the major cost component was associated

with the production as it represents almost more than 50% of the total cost. The water production cost was much higher than the prevailing water tariff which has encouraged waste of expensive desalinated water. The annual average water production from government facilities before the initiation of privatization for the period 1985-1999 was estimated at 54.4 Mcm, with an average annual production cost of 17.5 million BD resulting in a unit cost of 0.322 BD/m^3. The average unit cost from purchasing was estimated at 0.225 BD/m^3 from ALBA and 0.201 BD/m^3 from HPC, in comparison to the government cost of 0.322 BD/m^3. The analysis clearly indicated that purchasing of water from the two private companies resulted in cost saving of 30% from ALBA and 37% from HPC. The water bought from ALBA in 2007 reached 8.18 Mcm and cost the government 1.81 million BD and sold to the public at a subsidized rate of 0.025 BD/m^3. The study recommended that the government to continue providing water to the public at a subsidized rate in order to achieve its social objectives of adequate and safe water supply, continue partial privatization initiatives with overall government control of water allocation and customer services, the designation of a water production facilities for emergency use, improve the regulatory practices and improve contract negotiating to minimize risk.

كفاء إدارة المياه في القطاع البلدي بمملكة البحرين

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تقع مملكة البحرين في منطقة شديدة الجفاف, وتصنف ضمن الدول ذات الفقر المائي المدقع, وذلك بسبب شحة مواردها الطبيعية المائية. وبسبب الزيادة السكانية والنمو الاقتصادي والاجتماعي وارتفاع مستوى المعيشة وما صاحبه من زيادات كبيرة في الطلب على المياه, لجأت البحرين إلى المياه غير التقليدية وعلى رأسها المياه المحلاة, لتلبية الاحتياجات السكانية في القطاع البلدي. ولقد اعتمدت البحرين على المياه الجوفية كمورد مائي وحيد متوفر للاستخدامات المختلفة حتى مرحلة متأخرة من السبعينات, ومع اكتشاف النفط في بدايات القرن الماضي ودخول المنطقة عصر رفاه اقتصادي بسببه, متزامنا مع النمو السكاني الكبير والازدهار في شتى مجالات التنمية, أدى ذلك إلى تصاعد مستمر وكبير في الطلب على المياه لتلبية الاحتياجات السكانية والأنشطة التنموية المختلفة.

وفي العقود الماضية ولمواجهة ضغوط الطلب على المياه, تبنت البحرين سياسة مائية تعتمد على التركيز على جانب إدارة العرض من خلال زيادة الإمدادات المائية للقطاعات المستهلكة للمياه. وبالرغم من الجهود الحثيثة التي تبذلها البحرين لسد حاجات السكان من خلال سياسة تزويد الإمدادات، إلا إنها تواجه فجوة مائية ونقصاً متزايداً وانقطاعات متكررة في السنوات الأخيرة, نتيجة للزيادة المضطردة في الطلب على المياه الناجمة عن المتغيرات الديمغرافية كالنمو السكاني والتوسع الحضري, بالإضافة إلى أنماط الاستهلاك والنمو الاقتصادي ومحدودية إنتاجية محطات التحلية وخطوط النقل وشبكة التوزيع. يعاني قطاع المياه البلدية في مملكة البحرين من ضعف في مستوى الإدارة المائية أدى إلى الاستهلاك المفرط للمياه, وضغط على الإمدادات المائية المتاحة لتلبية متطلباته.

هدف هذا البحث إلى إجراء دراسة شاملة للاستخدامات المائية في القطاع البلدي وتحديد القضايا الرئيسية فيه واقتراح الوسائل الممكنة لرفع كفاءة هذا القطاع بما يحقق استدامته, لتحقيق أهداف التنمية الاجتماعية والاقتصادية والصحية في البلاد. ويستنتج البحث بأن محاولة الاستمرار في تلبية متطلبات القطاع البلدي بالمعدلات الحالية من خلال التركيز على إدارة العرض بالتوسع في إنشاء محطات التحلية, سيزيد من الأعباء الاقتصادية بالإضافة إلى التأثيرات البيئية السلبية. وتم اقتراح بعض الحلول التي تجمع بين إدارة الطلب والعرض, والتي من الممكن أن تساهم في توفير الخدمات المائية للسكان لأطول فترة ممكنة, وهي: التحكم في معدل النمو السكاني، رفع الوعي المائي لدى المستهلكين، التوسع في بناء محطات التحلية، تطبيق نظام تعرفة جديد، تشجيع استخدام المياه الرمادية، تخفيض معدل التسربات من شبكة المياه، استخدام تقنيات الترشيد.

Irrigation Efficiency of Date Palms Using Treated Sewage Effluent in Bahrain Farms

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In Bahrain, total water demands have increased from 65.2 Mcm in 1952 to 335 Mcm in 2007, with 160 Mcm or 47.7% of the total water use allocated to the irrigation sector. The irrigation water consumption is being satisfied by groundwater abstraction, supplemented by tertiary treated wastewater. Reuse of treated wastewater in arid regions, such as Bahrain, with scarce water resources provides a viable option to manage water efficiently and reduce the supply and demand imbalance. The Tubli wastewater production is estimated at 73 Mcm with only 35 Mcm is being reused for irrigation purpose conveyed to many farms free of charge, while a small amount is being reused for urban landscaping. The quality of treated wastewater meets the Bahrain reuse irrigation standard and is in line with the WHO guideline. The treated wastewater quality characteristic for the main parameters were reported as TDS=2204 mg/l, Nitrates=0.67 mg/l, Chlorine=1220 mg/l, Sulfate=284 mg/l, suspended solid=4.9 mg/l, BOD= 0.18, Fecal coliform bacteria=0.04 cfu, and total coliform=0.02 cfu.

In Bahrain, the size of irrigated areas is estimated at 2,900 hectares with their water supplies being provided from groundwater and treated wastewater sources. Large volumes of tertiary treated wastewater (95,730 cm/day; 35 Mcm/yr) is being reused to irrigate 413 farms covering with an area of 2,242 hectares, representing 77% of the total irrigated area in the country. Historically, reuse of treated wastewater was in irrigating 165 farms covering 713 hectares in 2005, with additional 130 farms (490 hectares) in 2006, and additional 108 farms (230 hectares) in 2008. The investment in the reuse program was estimated at 1.79 million Bahraini Dinner (US$ 4.7 million). Future reuse plans consist of increasing reuse volume to 200,000 cm (73 Mcm/yr) to irrigate 2,973 hectares by the year 2012. The irrigated farms are located in the western, northern and central regions. The wastewater treatment cost is estimated at US$0.13 /$m^3$, transportation cost at US$0.04/$m^3$, in comparison to a water supply production cost of $0.79-0.87/$m^3$. The availability of good quality of treated wastewater at the farms provided free of charge has encouraged farmers to irrigate their fields in excess of the water requirement, leading to very poor irrigation efficiency. The application of excess wastewater can have harmful effects on plant productivity, soil salinity, faster movement of nutrients and pesticide to groundwater water resources and loss of opportunity for using saved water in the expansion of irrigated areas.

Enhanced management of water resources in the irrigation sector requires reasonable estimation of the irrigation efficiency in order to identify appropriate means to save treated wastewater for further expansion of irrigated areas and increase productivity. Thus, the objective of this research was oriented towards evaluating the irrigation efficiency in a number of date Palm farms receiving treated wastewater in order to demonstrate to the farmers the need to conserve water for future irrigated area expansion, as well as assess the water allocation criteria of 71 cubic meter/hectare/day, set by the Ministry of Municipalities and Agriculture. The research methodology consisted of daily monitoring for a period of two months of the actual flow received by 12 selected farms with sizes ranging between 0.13 to 20.02 hectares, irrigated by flooding method. The irrigation efficiency is estimated as the ratio of the volume of treated wastewater supplied to the date Palm crop to the water allocation quota at 71 cubic meter/hectare/day designated as the standard water requirement by the agriculture authorities in the ministry.

Evaluation of the collected data indicated that some farms received significant amount of water in excess of the crop requirement. The majority of the farms received more than 100% of what they need based on the established hectare requirement by the ministry. The irrigation efficiency ranged from 62 to 1320%. Some

of the farms with irrigated areas of less than 1 hectare have received large volume of treated wastewater that ranged from 44 to 773 m^3/day. The analysis indicates that three farms have high utilization rates estimated at 169% or 155 m^3, 489% (44 m^3) and 1104% (773 m^3), with corresponding areas of 0.97, 0.13 and 1.0 hectares, respectively. This large variation in the amount of water used and the low efficiencies may be attributed to the influence of the soil type, timing of irrigation, type of crop, weather condition, level of the labor skill, application of traditional flood irritation method instead of drip irrigation, illegal water trading and the availability of water free of charge. The analysis indicates that the set water allocation criterion (71 cubic meter/hectare/day) does not achieve the water conservation objectives and differential among crop requirement. The study recommended further evaluation of the Ministry criteria according to reliable field measurements, re-evaluation of the allocation amount of treated wastewater according to crop requirements, soil characteristic, and method of irrigation, and improvement of farmer skills through on field training on efficient irrigation practices.

Impact of Brine and Chemical Discharges on the Marine Environment:
A Case Study of Addur SWRO Desalination Plant, Bahrain

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Desalination has become the main source of water supply in many countries. In the GCC countries, with more than 30 large plants, desalination is one of the major sources of fresh water for the last four decades. Most of these plants are built on the Arabian Gulf coastline and discharge their brines to the sea (the Gulf itself). In the Kingdom of Bahrain, currently there are seven large desalination plants in operation. Five of these plants, with installed capacity of 158 MGPD, supply water for domestic use, while the others are mainly for industrial process water. Just like any other industrial facility, desalination plants generate wastes in different forms and quantities. For such plants and regardless of the technology involved brine, also known as concentrate, is the main liquid waste. It is process by-product and characterized by high salinity and is likely to contain a range of trace chemicals. When the desalination plant is a thermal one, then the brine is also of high temperature. For this particular reason, RO plants are probably less harmful to the environment. This study objective is to assess the point source quality of the Addur Seawater RO (SWRO) desalination Plant brine; identify the main pollutants and their possible sources in the Plant's effluent; determine the average pollutants concentrations; study the compliance of the brine discharge with environmental regulations in terms of physical, chemical and biological parameters as stated in the Bahrain Standard for Industrial Effluent, issued by the Directorate of Environment Assessment & Planning; Public Commission for the Protection of Marine Resources, Environment & Wildlife in 1999.

The results indicated that Addur SWRO Desalination Plant brine is, on average, 18.8% higher than the ambient seawater salinity. However, during a near field (into the sea) survey it was found that the brine has totally neutralized after about 10 to 15 meters. In any case such increase in salinity is unlikely to be harmful to marine environment. Moreover, during the ten months monitoring program of the Addur SWRO Desalination Plant, it was found that all physiochemical and chemical parameters were complying with the Bahrain Standard for Industrial Effluent of 1999. There was, however, one time where the temperature difference between brine and seawater (in 23 June 2009) and residual Chlorine (in 8 June 2009) have exceeded the limits. While he temperature increase was very minimal (only 0.7 ºC above the limit), the 7.6 ppm Chlorine is considered to be very high. Therefore, Chlorine monitoring in the outfall shall continue in order to reveal the reasons for such unaccepted value and hence prevent its reoccurrence.

تدهور المياه الجوفية في هيئة الكهرباء والماء

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نتيجة للنمو والتطور الاقتصادي والعمراني وزيادة النمو السكاني، اتجهت هيئة الكهرباء والماء في مملكة البحرين إلى تحلية مياه البحر لمواكبة هذا النمو. ولقد بلغت الطاقة الإنتاجية الحالية للمياه المحلاة في المملكة 143 مليون جالون منها 90 مليون جالون من محطة الحد و25 مليون جالون من محطة سترة و21 مليون جالون من محطات رأس أبو جرجور والدور و7 ملايين جالون من محطة ألبا لكلسنه الفحم. من جهة أخرى تبلغ كمية المياه الجوفية المتاحة في المملكة 30 مليون جالون وأن المجموع الكلى للمياه المتوفرة يصل إلى 173 مليون جالون في اليوم/ في حال عمل جميع المحطات بطاقتها القصوى، في حين أن معدل الاستهلاك اليومي بلغ 140 مليون جالون في اليوم، وقدر الاستهلاك المتوقع حتى سنة 2020 بـ 205.5 مليون جالون في اليوم.

تكتسب المياه الجوفية أهمية قصوى في مملكة البحرين بصورة عامة كونها لا تمتلك أية موارد مائية سطحية حيث تم استخدام المياه الجوفية كمورد مائي وحيد حتى مرحلة متأخرة من السبعينات، وضمن نطاق هيئة الكهرباء والماء أهمية خاصة، حيث تعتبر المياه الجوفية مهمة كونها تستخدم في عمليات الخلط مع المياه المحلاة من أجل تزويد المستهلكين بمياه صالحة للشرب وجميع الاستخدامات الأخرى الحيوية واللازمة. لقد كانت معدلات الاستخراج للمياه الجوفية من قبل الهيئة كبيرة بحيث كانت تستهلك قرابة 35 مليون جالون يوميا عام 1984، وقد ظهرت عواقب هذا الاستنزاف بشكل ملموس في هبوط منسوب المياه الجوفية بمعدلات كبيرة، وبروز مشكلات بيئية سلبية تهدد بفقدان هذا المورد الهام، إذ تشير معدلات الملوحة إلى تدهور واضح في نوعية المياه الجوفية إلى الدرجة التي أصبحت فيها غير صالحة لمعظم الاستخدامات، فقد غزت المياه مياه البحر المالحة طبقات المياه الجوفية بسبب الاستنزاف الجائر مما أدى إلى حدوث تملح كبير للمياه الجوفية وحاليا تتراوح الملوحة بين 4000 إلى 10000 مليجرام في اللتر.

إن مشكلة استنزاف المياه الجوفية من قبل الهيئة تحمل قدرا من التعقيد، وينعكس مثل هذا التعقيد على طبيعة السياسات المائية التي تتصدى لهذه المشكلة. وعلى الهيئة أن تطرق أبوبا شتى وتختبر حلول وبدائل متعددة وتسعى في نفس الوقت إلى تنمية موارد مائية بديلة أو مرادفة لمواردها المتاحة لكي يتسنى لها تحقيق موازنة بين ما هو متاح من مياه جوفية وما هو مطلوب لسد احتياجات التطور العمراني والتنموي الكبير الذي تشهده المملكة منذ أكثر من ثلاثة عقود. على الهيئة أن تجد الحل المناسب لسد الفجوة ما بين العرض والطلب حاليا والمستقبلي بصفة مستدامة، ففي ضوء المعطيات الديموغرافية والاقتصادية الحالية تواجه الهيئة مستقبلا يتزايد فيه العجز المائي باستمرار، والذي يظهر بجلاء في تناقص حصة الفرد من المياه للفرد الواحد، كما ويجب عليها الحفاظ على المياه الجوفية قدر الإمكان للأجيال القادمة والحد من ارتفاع ملوحة هذه المياه بسبب الاستنزاف المستمر.

تكمن أهمية هذه الدراسة كونها تركز على قطاع يعتبر من القطاعات الحيوية والمهمة ويعتبر من أحد مستنزفي المياه الجوفية في المملكة والذي يزود المستهلكين بالمياه المحلاة. وسوف تتركز على المياه الجوفية وكمية استنزافها وجودتها على فترة زمنية طويلة لبيان التأثيرات الفعلية التي طرأت على هذه المياه وما هي خطط الهيئة المرسومة من أجل التقليل من استخراج هذه المياه على المدى القريب والبعيد. وتهدف الدراسة إلى دراسة أنماط استهلاك المياه الجوفية على مدى السنوات الماضية، والعوامل التي تقف وراء الاستخدام غير المستدام للمياه الجوفية، وتأثير الاستغلال المفرط لهذا المورد الهام، ووضع توصيات للحد من استنزاف المياه الجوفية من قبل الهيئة

وكشفت الدراسة عن أن نسبة الملوحة في المياه الجوفية في جميع محطات الهيئة تراوح ما بين 3500 ملليجرام لتر إلى 12000 ملليجرام لتر، وان نوعية المياه الجوفية بدأت في التدهور مع بداية 1985 نتيجة لأنشطة التنمية المكثفة، وبأن أفضل نوعية للمياه الجوفية لحقول الهيئة موجودة في منطقة الهملة وهي المناطق الشمالية الغربية من البحرين، حيث تتدفق من طبقات المياه الجوفية في المملكة العربية السعودية. ويمكن تلخيص أهم القضايا التي تواجه الهيئة في تلبية احتياجات المياه على النحو التالي: التدني المستمر لنوعية المياه الجوفية بسبب استنزافها من قبل الهيئة وتملحها، وكذلك تلوث الآبار الجوفية بسبب الأنشطة الإنسانية القائمة، بالإضافة إلى تقلص مناطق المياه؛ تعاظم الطلب على محطات التحلية لتغطية الاحتياجات المائية المتزايدة للمشاريع التنموية، واضعا عبئا ثقيلا على هذه المحطات ومؤثرا على كفاءتها الإنتاجية بسبب عدم القيام بأعمال الصيانة الدورية لهذه المحطات حسب الجدول المعد من قبل الهيئة؛ عدم وجود وزارة تخطيط مستقلة بذاتها من أجل التنسيق بين جميع الوزارات والهيئات الخدمة والتي يمكن لها رسم سياسة مائية واضحة بحيث توجه كل هيئة بالقيام بإنشاء محطات جديدة وفق إطار زمني معين وحسب الاحتياجات المتوقعة، وعدم وجود إدارة مائية متخصصة في شئون المياه وتوزع الجهات المختصة بقضايا المياه في أكثر من هيئة أو وزارة حكومية.

Development of an Environmental Plan for Restoration of Rosetta Branch in the Nile Delta

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Population increase, urbanization and industrialization expansion has put significant pressures and challenges to water resources management in Egypt. Reuse of treated wastewater in agriculture has become a critical issue for decision makers in Egypt. Nitrogen discharges from untreated wastewater increase phytoplankton production which is associated with serious surface water quality problems. An assessment of the Nitrogen discharges to the Nile River at Rosetta branch is presented to describe the status and trends of water quality and the Nitrogen parameter along the branch. The different Nitrogen forms were simulated using QUAL2K water quality model.

Two different scenarios were proposed and assessed to avoid the deterioration in the Rosetta branch water quality during the low demand period. The first is based on a dilution approach to dilute the organic loads and to achieve the local guidelines regarding Ammonia and organic-Nitrogen. The second scenario is to divert the wastewater from Abo Rawash Wastewater treatment Plant (WWTP) to dessert lagoons and reuse it for wooden trees (afforestation). It is concluded that the second scenario reduced the concentrations of Ammonia and organic-Nitrogen and made it to comply with the Egyptian guidelines at the water supply intakes. This scenario could be considered as the best and sound solution from an environmental and economic perspective. This indicates that the reuse of wastewater from Abo Rawash WWTP in irrigation can solve the high ammonia concentration problem, which arises every year, and also can save about 0.9 billion m^3 per month in the low demand period and improve the Nile River water quality.

Irrigation Water Management Improvement of Old Lands of the Nile Delta of Egypt

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Egypt annual share of water has been fixed at 55.5 Billion m^3 since the 1959 Nile water agreement between Egypt and the Sudan. On the other hand, population is growing at about 1 million inhabitants a year. Therefore, water resources in Egypt are becoming scarce. In view of the water scarcity threat, conservation measures are undertaken at various levels within the Egyptian water system. Egypt is gifted with good soils, good climatic conditions, and a perennial source of irrigation water - the Nile. These gifts provide excellent conditions for agricultural production and the application of intensive agriculture. There is, however, considerable potential for increasing the agricultural productivity and quality of high-demand crops in the old lands through the wider adoption of improved technologies and cultural practices.

At present, agriculture consumes about 84% of the total water used in Egypt (Abu-Zeid and Rady, 1992). This means that this sector has the greatest potential for improving water use efficiency for even relatively small changes in on-farm water use at individual farms will result in sizable savings on a national scale. The main objective of this study is to propose new concepts to improve the IIP (Irrigation Improvement projects) and extend it to include water management improvement to achieve a real water saving. Moreover, recommendations are introduced to improve the performance of IIP in the future. A case study of Baher El-Nour Command area was chosen to compare water consumption for two scenarios. The first is cultivating lands by wide ridges and comparing it with narrow ridges. The other scenario is using laser land leveling to improve the IIP and extend it to include water management improvement to achieve a real water saving. The study indicated that using new techniques for cultivating some crops like sugar beats by wide ridge is gaining more production and more water saving.

Qairawan Watershed Management Plan, Jerash, Jordan

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The Qairwran watershed is located in Jerash Governorate in the northern highlands of Jordan with an elevation of 550-1100 m above sea level. The size of the catchments is about 36 km^2 with a population of 38,900 inhabitants scattered in three large settlements: Jerash, Suf and Suf Camp. The town of Jerash has a population of 9,737 with many cultural sites and commercial centers, the Suf camp is located in the middle of catchments having a dense populated refugee camps with a population of 12,411, and the Suf population is distributed trough out the upland small villages, rainfed orchards and grass land. The average per capita water consumption was estimated at 71 liter per day for the three settlements. The water resources consists of intermittent run off from frequent rainfall events (340 mm) of the two major Dayr and Suf wadis, 17 karsts springs discharging 3.3 Mcm/yr, and groundwater abstraction from 6 wells (depth 120-400 m) taping two aquifers that are being utilized to meet the domestic water supply and irrigation water requirement. Water supply and sanitation services are being provided by the government. Accelerated development activities (housing, road and agriculture activities) are contributing to increases in water demand and groundwater pollution levels. The karsts limestone contributes to fast movement of different pollutants from leakage of partially and untreated wastewater, irrigation return flow, pesticide movement and olive oil and other small industries wastes.

The concerned Ministries and pubic authority have recognized these challenges and have introduced a water management plan, legislation and groundwater protection zones at the national level, and have recently implemented at Qairawan a pilot watershed management plan. The major concern of the watershed community is the increases in the spring pollution levels resulting from unwise human activities especially from the disposal of untreated wastes including wastewater into large number of limestone sinkholes located near populated areas. This research focuses on assessing the sources of pollution and their impact on water quality specially water from springs, gauging the community perception of the water situation and level and sources of pollution, and formulate a watershed plan to reduce pollution and protect water sources. The methodology assessed the existing state through reviewing previous studies carried out by the government and donors and use field questionnaire information to assess community participation and their role in the management of their watershed.

The analysis indicated that spring discharges, water supplies from government wells, roof-top water harvesting system are the main domestic and irrigation water sources. The water supply was available once a week and the water quality was monitored once a year. Some portion of the community is served by a water supply network and sewer network, however most of the houses have cesspits. The analysis indicated that out of the 5,000 houses and businesses surveyed, 4,622 has cesspits and 2,605 connected to the sewer network. Dwellings used natural caves as a mean of disposing untreated wastewater. Low carrying capacity of the existing sewer network has caused manhole overflow, sewerage leakage was common and illegal dumping of cesspit effluent was taking place. All these practices have contributed to the increased pollution level. Moreover, pollution was taking place from the application of fresh organic manure, infiltration from manure piles and high rate of fertilizer and pesticides application.

The major pollution souses were the active cesspits and lack of their cleaning, the high application of chemical fertilizer and fresh manure, live stock grazing near water sources, slaughter houses wastes, disposed liquid wastes from commercial activities, illegal dumping, olive oil mill wastes, construction materials, contaminated surface run off from urban areas and many agriculture activities. The major pollution sources were from bacteria and nitrates caused from wastewater and fertilizers and pesticides applications. The Fecal

coliform and E. Coli found in the water samples collected from springs and wells exceed the Jordanian standard of 2000 MPN/100 ml. Ground water sources has elevated of bacteria count. Nitrates range from 28 to 70 mg/l, exceeding the drinking water standard of 50 mg/l. It was found that 8 springs out of 17 have nitrate level ranging from 50 to 233 mg/l, organic pesticide concentration of 0.01mg/l and low organic carbon (TOC) and oil grease. The geology of the watershed, being karst limestone with many natural caves a and sinkholes and the underground channels were contributing significantly to the fast movement of pollutants to the water sources. It is recommended that the watershed management plan should focus on the design and implementation of protective measures such as: elimination of cesspits and their regular cleaning, implementation of protective zones, rehabilitation of water supply and sewage network and expansion of their coverage, elimination of illegal dumping practice, improved livestock management, introduction of the concept of organic farming and pest management practices, and improvement of agricultural extension service programs through awareness and training.

Community Participation Framework for the Qairawan Watershed Management, Jerash, Jordan

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The Qairwan watershed is located in the Jerash Governorate in the northern highland of Jordan. The size of the catchments is estimated at 36 km^2 with a population of 39,000 scattered in the three large settlement of Jerash, Suf and Suf Camp. The water resources consists of surface runoff from two major wadis generated from frequent rainfall events (340 mm), the discharge of a large number of springs and pumping from the shallow groundwater aquifers that are being utilized to meet the domestic water supply and irrigation water requirements. Water supply and sanitation services are being provided by the government. Increased human activities (housing, road and agriculture activities) are leading to increases in water demand and groundwater pollution levels. The geology of the watershed being karsts has contributed to rapid movement of different pollutants from leakage of partially and untreated wastewater, irrigation return flow, movement of pesticide and olive oil wastes and other small industrial wastes.

Effective watershed management to achieve rational utilization and protection of the limited water sources calls for the implementation integrated approach including the active participation of the local community in the planning and decision making process. However the design of appropriate community participation program requires the availability of basic information on how stakeholders perceive conservation and protection of water and water related issues and assess their willingness to play an active role in the management of the watershed management. Thus, the objective of this research is to gauge the community knowledge of the existing water supply shortage and sources of pollution, their satisfaction with the level of services, effectiveness of government program in addressing their priorities and their role in the planning and implementation process. The methodology consists of design of an elaborate survey using a well structured questionnaire. The sample size of 40 participants covered many issues dealing with demographic characteristic, level of education, income, quantity and quality of water, cost of water provision, knowledge of the sources of pollution, adequacy of water supply and sanitation coverage including conditions of the existing network, duration of water supply availability, cooperation with government agencies, and the government response to their need.

Analysis of the questionnaire results indicated different education levels in the community as only 39% of the participants have a university degree, 32% secondary and 22.5% with primary education. Large family size of 7 members was observed with average monthly income of 475 JD and a monthly water tariff bill of 13 JD. Half of the respondents indicated that they are familiar with the water sources as well as the cause of pollution. Because of the shortage of water and lack of trust in the quality of water, more than 60% buy bottled water and depend on tanker water as a supply source and relay on water harvesting techniques to store water during time of needs. The respondents are well aware of the sources of pollution with 75% indicated that pollution takes place from cesspool, 48% from leakage, 40% from farming and industrial wastes, 13% due to pesticides and fertilizers movement, and 35% attributed the cause to the lack of government implemented measures. Small percentage 3-5% was associated to human ignorance, over-pumping and olive and slaughter house sources. More than 63% expressed dissatisfaction with the duration of the service (rationing), quantity of water availability and timing of delivery, water pressure, water losses and high cost of services connection. However, 55% of the respondents were satisfied with the government level of water and sanitation service coverage, but indicated lack of commitment by employees. Regarding the community involvement, 40% showed their interest to participate and share responsibility in the protection of water sources.

The respondents recommended the implementation of awareness and training programs on the type of pollution and protection measures, availability of water saving devices, increasing the provision of adequate water quantity and better quality including taping sources outside the watershed, and rehabilitation of the network. They indicated that awareness efforts to be oriented towards different segments of the community with focus on school and women groups and religious leaders. Future activities should solicit the view of the community first and select appropriate means to increase their participation in the planning and management processes.

Assessment of Proportional Contribution by Anthropogenic Recharge Sources to the Problem of Shallow Water in Urban Areas of Kuwait

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Groundwater table rise in many urban areas are caused by a number of factors: high water consumption rates, leakage from old water supply and wastewater networks, absence of collection or and septic tank systems, landscaping and gardening, irrigation return flow, infiltration from high rainfall rate, and the presence of impervious layer at a shallow depth. Water table rises close to ground surface can result in major environmental and health impacts with damages to structure foundations of building and road, buried utilities services, settlement problems, collapses of both cohesive and granular soil, occurrence of hydrogen sulfide gas, stagnant shallow pools with bad odor and toxic elements, and the pollution of shallow aquifers. Most of these problems have been experienced in Kuwait city due to the very high per capita water consumption rates in excess of 500 liter/day, extensive landscaping practices and the horizontal urban expansion. Kuwait prevailing geotechnical condition add another complication factors specially near the coastal zones due to the precipitation of chloride and sulfate deposits from the upward movement of groundwater by capillary fringe influenced by high evaporation rates at the surface. Previous rehabilitation efforts consisted of the implementation of dewatering technique in selected areas to lower the water table up to 4 meter without detailed evaluation of the quantification of the mode of movement and amount according to sources.

The water table rise problem continues to persist in some areas due to the lack of knowledge on the identification and quantification of the infiltration-recharge according to the water source. The availability of such information on the infiltration-recharge characteristic can help identify the causes of the problem and the design of appropriate rehabilitation techniques. The objective of this research is to estimate the contribution of various recharge sources that are contributing to the water table rise through the application of chemical and isotopic techniques with more emphasis on the later method. The application of the isotopic fingerprint techniques through sources signature can trace the origin of water, flow direction, the infiltration-recharge rates, travel time and velocity, the degree of mixing of different sources and hydraulic connections. The methodology called for evaluation of geological and hydrological conditions, followed by field water sampling and laboratory analysis and the evaluation of the results to delineate the different water sources in a given area.

The three areas of; Kifan, Al-Adylia and Al Khaldia were selected based on existing well distribution, the interconnection among the areas, the susceptibility to water rise and availability of both pumping and monitoring wells. Sources signatures are to be identified from the collected water samples. Existing reports provided background information on water levels and quality, soil and aquifer characteristics, water supply and sewage networks coverage, surface drainage system and irrigated areas. The water samples were collected from the wells and water supply, wastewater and irrigation sources for the analysis for chemical and isotopic signatures (C_{14}, H_2, H_3, O_{18} and B_{11}) in order to measure temperature, TDS, ,PH, oxidation and reduced potential, dissolved oxygen, color and odor, major anions and cations, inorganic nutrients, organic (TOC and TPH), and trace elements. The isotopic analysis would lead to delineation of origin, age, resident time, flow velocity and mixing process. The isotopic analysis to be carried out at international laboratories, while the detailed chemical analysis was carried at the Kuwaiti Institute for Scientific Research (KISR). The analysis focused on the correlation of the recharge sources signature and result of the chemical and isotopic analyses as well as the correlation between the spatial distribution of relevant elements and location of the recharge sources.

Evaluation of the chemical analysis of the groundwater source alone did not provide clear delineation of the fractionation of recharge from different sources. It is expected that the isotopic analysis complimented with chemical results will provide reliable information on the amount of recharge from different sources. Both chemical and isotopic

analysis would provide detail information on the water movement and delineation of their sources needed to design the appropriate rehabilitation system.

Selection of Appropriate Cropping Patterns as Tool for Water Resources Management in Palestine: Date Palm as Salinity Tolerant Crop in Jiftlik-Jordan Valley

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Large areas in the middle and southern part of the Jordan River valley are characterized by being saline in regard to soil and water (especially in the areas near the Dead Sea Basin). The salinity problem is aggravating with time; more and more wells in the Jordan Valley area are recording escalating levels of total dissolved solids. Due to this, farmers in these areas are abandoning the cultivation of their lands, or use high cost modern techniques (such as reverse osmosis for water desalination) to plant their lands. This is affecting the socioeconomic status of the residents and a lower than average income is noticed in such areas. Date Palm trees are considered to be tolerant to high levels of salinity in soil and water that allows it to survive such high levels with no or minor reduction in yield, in addition, date Palms prefer hot climate which is prevailing in the Jordan Valley. In spite of the high economic return from Date Palms for the local market and for exporting, the cultivation of commercially effective varieties of Date Palms is considered relatively new in the Jordan valley although the crop has been naturally cultivated for long time. Modern cultivation varieties and techniques are still exclusive to farmers with high resources who can pay for the costs of acquiring the expertise for Date Palm growing and to take the risks if these plantations failed. This research aims at discussing the suitability of water resources available at Jiftlik in the Palestinian Jordan valley area for the cultivation of Date Palms as an alternative cropping pattern to cope with the salinity problem. An estimate of the potential of this new crop compared to available brackish water is also presented based on the local crop requirements and a realistic leaching fraction. In addition, potential locations for the cultivation of Date Palms are suggested.

Wastewater Management in Qatar

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Qatar is a peninsula with an area of 11,000 km^2 with a moderate relief and an elevation that does not exceed 110 meter above sea level. Most of its area is covered by limestone, sand dunes and sabkhas, and limited annual rainfall ranging between 40 and 80 mm. The main water sources are desalinated water, groundwater from the shallow alluvial, Um Radhuma, and Dammam aquifers, treated wastewater, and very limited intermittent runoff. Desalinated water is the main water supply sources supplemented by a small amount from groundwater. Qatar population increased from 0.1, 0.55, 0.825 and 1.8 millions in the years 1978, 1995, 2005 and 2010, respectively. In the last 5 years the population growth rate was at 5.3%, and the country population is expected to reach 2.03 million in 2013 and 3 million in 2026. High domestic water demand is being experienced due to the improved standards of living, high population growth rates estimated currently at 7% mainly from the influx of large number of expatriates due to accelerated economic development activities, high urbanization rates and the availability of water free of charge to the Qatari nationals. The domestic per capita water consumption reached 740 liter per day in 2007 with significant increase in the generated wastewater volumes. Desalinated water production increased from 85 Mcm in 1990 to 163 Mcm in 2000 and reached 340 Mcm in 2009. The domestic water demand increased from 85 Mcm in 1990 to 158 Mmcm in 2004 and reached 302 Mcm in 2009. In 2009, the high water consumption generated an estimated wastewater volumes of 73 Mcm with 16.5 Mcm treated to a tertiary level.

The large volumes of generated wastewater presents a management challenge to decision makers as the treatment facilities are operating at a rate in excess of their capacity and forcing the wastewater authority to dispose of untreated wastewater to remote areas outside Doha city. The research objective focused on assessing the current wastewater management practice, identify major constraints and challenges, and to suggest management measures to reduce the impact on the environment. The methodology consisted assessing the current water consumption, identify the wastewater components specially plant capacity and collection network, estimate the amount of wastewater generated and received treatment, and evaluate the manner being used to handle excess wastewater.

The analysis indicated that wastewater facilities consisted of two treatment plants (Saliyah and Nauija) that were operated continuously around the clock, 12 packaged treatment units, 176 pumping stations and 1,723 km gravity network serving 44,800 houses. The wastewater generated was estimated at 47 Mcm in 2004, and reached 73 Mcm in 2008, which is in excess of the existing treatment capacity of 32 Mcm. The additional wastewater made necessary to transfer untreated wastewater to two large lagoons at AbuNakhla lagoon located 15 km and Kraana located 85 km from the capital. The leakage from the sewer network and storage of untreated wastewater in the two lagoons represents a major environmental risk contributing to soil and groundwater pollution around the disposal areas. The un-sewer parts of the city are being served by tankers to transport effluent to the two lagoons. The management plan calls for the expansion of the existing two treatment facilities as well as construction of new plant north of Doha, along with the expansion of the network. The excess treated wastewater to be reused in landscaping and groundwater recharge after meeting the strict Supreme Council and Natural Reserve standards.

The study recommends the formulation and implementation of a wastewater master plan that can enhance coordination mechanism among water supply and wastewater authorities, increasing reuse volumes of treated effluent in urban landscaping, implementation of demand management measures and increase awareness through media and educational programs to reduce the generated wastewater volumes, involvement of private sector in the financing, operation and maintenance of wastewater facilities, and enforcement of strict environmental standards as well as evaluating the option to invest in new treatment technology appropriate for arid environment.

Investigation of the Pollution Sources to Houses Drinking Water Storage Tanks Burayadh City, Saudi Arabia

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In Saudi Arabia, economic activities in combination with social development have contributed to increases in water demand especially in the irrigation sector with water supply being provided from groundwater and desalinated sources. High population growth rates, improvement in the standards of living, and high urbanization rates have contributed to significant increases in domestic water demand. Domestic water demands for Saudi Arabia have increased from 200 million cubic meters (Mcm) in 1970, 1.8 billion cubic meters (Bcm) in 2000, and 2.1 Bcm in 2010. The availability of financial resources has enabled the government to provide excellent water quality from desalination and increased the water supply network coverage. However, high urban expansion rates have placed immense pressure on the existing water supply network leading to water rationing due to limited supply in most of the major urban centers. The interruption of water supply has forced residents to build underground storage tanks to store enough supply for all the times of the day and also built a smaller size tank at the roof of their buildings. The roof top tank is supplied by pumping from the underground tank, and maintains adequate pressure and provide water for inside house uses. The underground tank, which stores large volume of water, is usually a concrete type with different degrees of protective insulation. However, these tanks can be exposed to pollution from nearby sources such as septic tank, overflow of sewer and seepage of polluted water from the unsealed opening of the tank. In addition, there is no regulation to monitor the status of water quality in these tanks. The two tank system is the common practice observed in the urban areas of Saudi Arabia.

Contamination of supply sources can pose health risks to the public. Limited studies were carried out to assess the quality of the water stored in the underground tank and the utilization of its water inside the house. This study focused on this issue by selecting the city of Buraidah, located in the Qassim region in the central part of the country. The population in 2006 was estimated at 0.52 million with 43,108 houses connection to the water supply and sanitation networks. The methodology consisted of water quality sampling and field questionnaire survey to evaluate water quality of the underground storage tank in regard to pollution sources, practice of tank cleaning, the utilization of water for drinking and cooking purposes and availability of small filtration system inside the house. The sample and questionnaire covered the major five sections of the city. The water quality evaluation consisted of the collection water samples (42 samples) from the underground tank to evaluate their chemical and biological characteristic. The water quality analysis consisted of nine chemical and biological parameters, represented by the TDS, NH_3, NO_2, Free Cl_2, PH, Total Fe, Turbidity, Total Coliform bacteria and E. Coli.

The water quality analysis indicated that the ranges of: TDS=435-636 mg/l, PH=6.8-8.09, NH_3 and NO_2 was nil, Fe=0.01-1.22, Cl_2 =0.05-0.31 mg/l and turbidity=0.06-32 NTU. Most of the values were within the range of the Saudi Drinking Water Quality Standards with variation for some of the samples, such Fe and Cl_2. The concentration of Iron was high in three samples, free Cl_2 was high in 12 samples, turbidity was high in three samples, Total Coliform bacteria present in six samples and E. Coli in one sample. The low count of free chlorine indicated that pollution may exist from the lack of regular cleaning.

The questionnaire provided further information about the construction method of the underground storage tanks in term of material and protective insulation, tank regular cleaning practice, water utilization from the ground tank for drinking and cooking purposes and field inspection of the condition of the tanks. Analysis of the questionnaire data indicated that 93% of the residents did insulate their storage tank with appropriate

protective material to prevent leakage from the surrounding areas near the tank in case there is a septic tank; 81% surveyed houses did not clean their tank on regular basis; 90% do not use the water from the storage tank for drinking purposes; 93% use the tank for cooking; and 67% have small water filtration system in their houses. The survey indicated the underground tanks are of concert type, while the roof top tanks are of fiberglass material. The study recommends the implementation of awareness program to encourage residents to undertake regular cleaning and proper protection of their underground storage tanks, as well as to implement a mandatory field inspection by the responsible authorities or outsourcing of inspection service to the private sector.

Constraints of the Reuse of Tertiary Treated Wastewater in Buraydah City, Saudi Arabia

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Economic activities in combination with social development have contributed to increases in water demands in Saudi Arabia, especially in the irrigation sector, satisfied mainly by mining of non-renewable groundwater sources. The increase in the domestic water demand in major urban centers have resulted in the generation of large volumes of wastewater, which are being treated to secondary and tertiary levels. Wastewater generated from the expansion of the major urban centers in Saudi Arabia have reached about 1.114 billion cubic meter (Bcm) in 2007 with 730 Mcm is receiving secondary and tertiary treatment from 54 major plants, while about 384 Mcm are untreated, and are disposed into septic tank, wadi channels and into the sea. A small portion of treated secondary and tertiary effluent, estimated at 240 Mcm is being reused mainly in agriculture and landscaping with 16 Mcm from this amount is reused in the industrial sector. The number of wastewater treatment plants in Saudi Arabia is expected to reach 70 plants by 2011 with the volume of generated wastewater to reach about 1.7 Bcm.

Effective management of water resources requires more reuse of the adequately treated wastewater in the irrigation sector in line with the reuse practices that are being carried in different parts of the world. In an arid region, such as Saudi Arabia, with high dependence on non-renewable groundwater sources, reuse of adequately treated wastewater in the irrigation and industrial sectors can help reduce the rate of depletion of groundwater sources, could be used to enhance groundwater storage by artificial recharge and to control saltwater intrusion, if reuse is made in or near the place of treatment could reduce the cost of transportation and disposing into the sea, and would definitely reduce the environmental cost of disposing to the marine environment. Thus, it is necessary that in different parts of Saudi Arabia where large urban centers exists, such Buraydah and Unyzah, with large agriculture areas that are being irrigated from the non-renewable Saq aquifer to benefit from available treated wastewater for irrigation, industry, and landscaping purposes.

In this study the reuse of the available excess treated wastewater from the plants located near Buraydah city was evaluated as a potential source for the irrigation sector. Buraydah city is located in the Qassim region of the central part of the country. The population of the city was estimated at 0.52 million in 2006, with water supply and sanitation networks covering most sections of the city. The wastewater treated facility located to the east of the city, tertiary treated about 25 Mcm in 2009, and the capacity is expected to reach 55 Mcm in the near future. A limited amount of about 50% of the available effluent, estimated at 12.7 Mcm, is being reused to irrigate limited farm areas, highways landscaping, and few recreation facilities, while the remaining volume of 12.3 Mcm is being discharged into the nearby wadi Al Rimah. The treated effluent is being conveyed to different areas through a distribution network managed by government agencies. The water is delivered free of charge and in unlimited quantity to these farms.

The objective of the study is to explore and evaluate the opinion of the farming community toward increased reuse of the tertiary treated wastewater to irrigate large areas with certain crops compatible with quality of the available treated wastewater. Positive response of the farmers can help design irrigation reuse schemes for the major cities of Buraydah and Unayzah and large number of surrounding towns to expand the size of irrigated areas and expand the treatment capacity of plant and wastewater collection network. The methodology consisted of the use of questionnaire information to assess the farmer's willingness to reuse treated wastewater. The questionnaire sample size consisted of interviewing 80 farmers in the agriculture areas east of the city that are currently receiving treated wastewater. The questionnaire focused on the issues dealing with willingness to reuse secondary treated effluent with no reservation, the reuse to irrigate alfalfa and palm

trees or all kind of trees without proper government supervision and the provision of treated wastewater at a very small symbolic cost.

The analysis of questionnaire information indicated that large percentage of the farmers, 67%, are interested in receiving and using treated wastewater but with some reservation, while only 13% of the farmers were very reluctant in reusing wastewater. The majority of the farmers (88%) were interested in reusing the treated effluent to irrigate alfalfa and 90% to irrigate date palms. In general 75% of the farmers were interested in increasing the reuse practice in the irrigation of their farm under the supervision of the responsible government authority, as well as availability of the treated effluent at no cost. The study recommended the implementation of awareness programs to build the farmer confidence in the reuse process and suitability of the quality irrigate certain crops that have no health risks. It also recommended to increase the coverage of the wastewater collection network, increase the size of the irrigated areas by using the excess effluent, and introduce water legislation to ban the issuing of permits for well drilling in areas that have access to tertiary treated wastewater.

Second Batch: 2009-2010

Second Batch Students

No.	Student's name	Country	Project title
1	Fadhel Abbas Ebrahim	Bahrain	Ensuring Adequate Water Resources and Storage Infrastructure to meet Agricultural Needs
2	Isa Ahmad Al Malood	Bahrain	دراسة مدى تغير تقبل المجتمع البحريني لاستخدام مياه الصرف الصحي المعالجة
3	Sameera Ebrahim Ghareeb	Bahrain	Effect of Treated Wastewater on Accumulation of Heavy Metals in Two Vegetable Crops in Bahrain
4	Sayed Saeed Al-Ghani	Bahrain	دراسة الخيارات المتاحة للحد من مشكلة تحويل مياه الصرف الصحي الغير معالجة لخليج توبلي
5	Havan Hassan Salman	Iraq	نحو إدارة متكاملة لمصادر المياه في هور الدلمج، محافظة واسط، جمهورية العراق
6	Khalifa Mohammad Al-Fraij	Kuwait	استهلاك المياه المعبأة في دولة الكويت
7	Ahmad Mohammed Al Rawahi	Oman	Water Budget Review of Wadi Ma'awil Catchment Barka – Al Batinah Region
8	Riyadh Kanzooz AlBusaidi Hatim Said AlZadjali	Oman	استخدام المياه الرمادية كأداة لإدارة الطلب على المياه في سلطنة عمان
9	Tareq Hareth Mohammed Al- Kindi	Oman	قياس مستوى إدارة الموارد المائية في أسفل حوض وادي المعاول (مدينة بركاء) بسلطنة عمان باستخدام مؤشرات الإدارة المتكاملة للموارد المائية
10	Abdullah Mousa Abdulwahed	Saudi Arabia	Asbestos Cement Potable Water Network and Possible Health Effects on Jubail Industrial City Populations
11 12 13	Mazen Abu Abdullah Abdulrahman Metab Al-Zahrani Essam Obaid Al-Wagdani	Saudi Arabia	نحو إدارة متكاملة للموارد المائية في وادي ضيم غرب المملكة العربية السعودية
14	Mushabab Ali Mohammed Al-Qahtani	Saudi Arabia	تقييم الوضع الراهن والحلول المقترحة لبحيرة الصرف الصحي بشرق جدة
15	Saadi Abdullah Al Saadi Al Bagawi	Saudi Arabia	Reuse of surplus treated wastewater effluent from Treatment Plants in Jubail Industrial City
16	Abeer Ali Al-Asady	Yemen	Ground Water Protection in North Eastern Part of LC-Sana'a corp. of Sana'a city within Integrated Water Resources Management Perspective

Ensuring Adequate Water Resources and Storage Infrastructure to meet Agricultural Needs

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Traditional and emerging environmental threats are all interlinked. For instance, desertification leads to biodiversity loss, livestock increase and overgrazing leads to desertification, waste-dumping releases methane, which adds to the global warming problem, in turn leading to desertification, water scarcity, and many other ecological disasters. A sustainable management policy requires socio-economic, technical and institutional facts to be considered altogether. This approach has led to the emergence of the concept of "integrated management of water resources". The preservation and evaluation of a given water source for beneficial utilization can only be achieved through an integrated management system. Integrated basin management aims at preserving water quality by taking into account all the activities within the basin. The transition to sustainable development in the Kingdom of Bahrain is not an option to choose, but rather an imperative choice for the society survival and the well being of future generations. Government officials in Bahrain are well aware that the real challenge of mounting a national sustainable development program for the Kingdom is to foster, test, and disseminate ways to change the process of economic development, so that it does not destroy the national fragile ecosystems that support life and make it possible.

Bahrain suffers from a scarcity of water resources. The population is totally dependent on groundwater resources and on desalination facilities to meet its demand for freshwater. Domestic water increased at 1.6% annually in the period 1976-1986 and since then at 6% per annum. Average per capita water use in the country has doubled since the seventies to reach an average well above 500-liter per day in 2000, which is considered high compared to the world average. Nearly 82% of the water demand is met by groundwater abstraction, while desalinated water contributes to 13% and tertiary treated sewage effluents and agricultural drainage water accounts for 4% and 1%, respectively. Bahrain had in the recent past years a million palm trees, whereas currently palm trees do not exceed 400,000. This decline is attributed to salinization problem caused by groundwater overexploitation, and conversion of agricultural lands into commercial and residential uses.

Agriculture plays an important role in the livelihoods of Bahraini families, however, it consumes 70% of abstracted groundwater while its contribution to national economy is less than 1%. Two guiding principles or approaches have been followed to manage water more efficiently in agriculture. The first approach has dealt with the issue of reducing groundwater abstraction, while the other has concentrated on finding alternative irrigation water for agriculture and ever-growing landscape projects. A number of actions have been implemented to achieves these two aims. These include, enacting and strictly enforcing laws to reduce groundwater abstraction, increasing water use efficiency in agriculture, improving irrigation methods (modern irrigation techniques where 75% of agricultural area is under flood irrigation), replacing high-water requirement crops with others of less water demand, introducing tariffs for using groundwater,and using treated sewage effluent.

Currently 70% of sewage effluent resulted from main treatment facility is tertiary treated and being used in watering forage crops and landscapes. Current plans aim at fully utilizing recycled wastewater of the expected effluent of 200,000 m^3/day by 2010, which will save 20% of current annual groundwater abstraction. Officials are very much cautious about the use of recycled wastewater in agriculture. All necessary precautionary measures have been taken to rationalize such use in order to minimize the impact of soil and groundwater pollution on human health.

دراسة مدى تغير تقبل المجتمع البحريني لاستخدام مياه الصرف الصحي المعالجة

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تمثل ندرة الموارد المائية في مملكة البحرين مشكلة كبيرة في ظل زيادة عدد السكان و تغير نمط الاستهلاك، والذي يؤدي إلى ازدياد مستمر لمياه الصرف الصحي. في الواقع, أن مياه الصرف الصحي المعالجة هي أحد المصادر غير التقليدية للمياه ولكن ما زال هذا المصدر لا يلعب دورا محوريا في سد الاحتياجات المائية للمملكة ليستخدم في أغراض الصناعة مثلا أو غيرها من الأمور الحياتية. أن معالجة مياه الصرف الصحي معالجة جيدة و فعالة هي من أهم وسائل وطرق حماية البيئة المائية والأرضية من التلوث، وذلك عندما تتوفر المعالجة العلمية الصحيحة والتخلص الآمن من هذه المياه وإعادة تدويرها بأمان داخل المنظومة البيئية وتحقق سلامة الإنسان والحفاظ على بيئته وصحته. وتعد مياه الصرف الصحي بعد معالجتها مصدرا إضافيا للمياه في مملكة البحرين ولو بدرجات أقل من المصادر غير التقليدية الأخرى مثل التحلية، بالإضافة إلى أن معالجة هذه المياه يساعد في الحماية من التلوث البيئي. وقد تم التركيز في السنوات الأخيرة على ضرورة إعادة استخدام بعض مياه الصرف الصحي المعالجة للأغراض الزراعية وخصوصا في ري المسطحات الخضراء والحدائق في المملكة.

هدف هذا البحث إلي معرفة مدي تغير سلوك المجتمع البحريني نحو استخدام مياه الصرف الصحي المعالج, وذلك بمقارنة نتائج هذه الدراسة بدراسة مماثلة تمت منذ عشر سنوات. وأظهرت نتائج الدراسة أن 69% من أفراد عينة هذه الدراسة على معرفة بأماكن تصريف مياه المجاري من المنازل، وأظهرت مقارنة الدراستين أن تغيرا قد طرأ في سبب عدم الرغبة في استخدام مياه المجاري المعالجة، فبعد أن كان الخوف على الصحة هو السبب الرئيس بنسبة 59.2%، أصبح العامل النفسي هو الحاجز الرئيسي بنسبة 48.6%، مما يعني أن العينة أصبح لديها ثقة أكبر بكفاءة التقنيات المستخدمة على تنقية مياه المجاري وقدرتها على القضاء على الجراثيم والميكروبات، ولكن بالرغم من ذلك، يظل العامل النفسي عائقا رئيسا لاستغلال هذا المورد المائي. كذلك فأن رغبة الأفراد في استخدام مياه المجاري المعالجة تحت أي ظرف من الظروف و في أي مجال من المجالات سواء في الشرب أو الطبخ، زراعة الخضراوات المأكولة، ري الحدائق، الصناعة، أحواض السباحة، تغذية المياه الجوفية، والاستخدام الشخصي أو الاستحمام، لا ترتبط بجنس الأفراد أو بسنهم، إلا أنه يرتبط غالبا وفي المجالات العديدة بمستوى التعليم، ولكن هذا الارتباط يظل. وتنخفض رغبة الأفراد في استخدام مياه المجاري المعالجة كلما كان هذا الاستخدام متصل اتصالا مباشرا بجسم الإنسان نفسه كما هو في حالة الشرب و الطبخ، وأحواض السباحة وتغذية المياه الجوفية والاستخدام الشخصي أو الاستحمام، في حين ترتفع رغبتهم في استخدام هذه المياه كلما كان هذا الاستخدام بعيد عن جسم الإنسان كما هو في حالة استخدام هذه المياه لزراعة الخضراوات غير المأكولة، وكذلك في ري الحدائق و في الصناعة. كما تبين أن أغلب الأفراد على استعداد لدفع مبالغ إضافية تجنبهم استخدام مياه المجاري المعالجة في أي من المجالات سابقة الذكر تحت أي ظرف من الظروف، مما يدل على أن انخفاض سعر المياه المعالجة لا يزيد من رغبة الأفراد في استخدام هذه المياه في أي من المجالات.

Effect of Treated Wastewater on Accumulation of Heavy Metals in Two Vegetable Crops in Bahrain

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The Gulf Cooperation Council (GCC) countries are located in a desert region, which is characterized by high temperatures, high evaporation rates and low and erratic rainfall. Irrigated agriculture is by far the largest water user with an average of 78% of the total water use in these countries. Most agricultural water (85%) comes from groundwater, which is largely non-renewable. Due to its over-exploitation and quantity and quality deterioration, there is a sharp decline in the availability of groundwater to be used for irrigation in the GCC region.

The use of treated sewage effluents (TSE) as water and nutrient source have been introduced as a viable irrigation water source in Bahrain. Use of treated wastewater was largely limited to irrigation of landscape areas to reduce the risk associated with heavy metals in TSE to human health. The present study aimed at evaluating heavy metal content in two popular vegetable crops irrigated with TSE as compared to irrigation with groundwater. Two popular leafy vegetable crops were selected for this study: girgeer (*Eruca sativa*) and radish (*Raphanus sativus*). The vegetables were irrigated with both groundwater and TSE. Plant samples were collected for analyses of heavy metals content. Water samples were also analyzed for heavy metals content. The results indicated that the vegetable of Girgir under TSE application uptake of heavy metals was more than the vegetable of Radish, but both were lower than the recommended concentration threshold levels of trace elements for crops production of WHO.

دراسة الخيارات المتاحة للحد من مشكلة تحويل مياه الصرف الصحي الغير معالجة لخليج توبلي

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لقد بدأ إنشاء شبكات الصرف الصحي في مملكة البحرين منذ مطلع العام 1971م، ومنذ ذلك الوقت وعمليات الإنشاء للشبكات الجديدة وتمديد الشبكات القائمة في تواصل مستمر وبشكل منتظم وخصوصا في الخمسة عشر سنة الماضية التي شهدت زيادة هائلة في النمو السكاني وصاحبتها طفرة عمرانية كبيرة في مختلف مناطق المملكة. إلا أنه من الملاحظ أن تطور مشاريع البنية التحتية وبشكل أساسي شبكات الصرف الصحي لم يكن بالمستوى الذي يتناسب مع التطور والتوسع العمراني والزيادة المفاجئة في التعداد السكاني للمملكة، ومن الطبيعي أن يصاحب الزيادة السكانية والتوسع العمراني والنشاط الاقتصادي تسارع في معدلات الطلب على المياه البلدية مما ينتج عنه زيادة في معدل تدفقات مياه الصرف الصحي من جميع القطاعات المستهلكة للمياه البلدية (القطاع السكني، القطاع التجاري، القطاع الصناعي). ونظرا لارتفاع كل من منسوب المياه الأرضية ونسبة الملوحة فيها (وذلك لتداخل مياه البحر عليها)، وكذلك لطبيعة المناخ السائدة في المملكة الذي يتميز بالحرارة الشديدة والرطوبة المرتفعة، فإن جميع هذه العوامل قد ساهمت وبشكل كبير إلى تأثر شبكة الصرف الصحي وتدهورها مما أدى إلى حدوث مشكلة تسربات المياه الأرضية وبكميات كبيرة إلى شبكة الصرف الصحي. وتصل نسبة هذه التسربات إلى 55% من كمية المياه المتدفقة عبر الشبكات إلى محطة توبلي لمعالجة مياه الصرف الصحي، وهي نسبة كبيرة إذا ما قورنت بالنسبة المسموح بها التي تعد مقبولة وهي تتراوح بين 15-30%. أن النسبة العالية للتسربات تعد من أهم المؤشرات على تدهور الشبكة وكثرة الأضرار الموجودة بها، كما أن لهذه التسربات تأثيرات سلبية كبيرة على أداء الشبكة وملحقاتها.

يستعرض هذا البحث الوضع الحالي لكمية مياه الصرف الصحي المتدفقة إلى محطة توبلي للمعالجة لستة مناطق للشبكات (شبكة A، B، C، D، E، F)، وتحديد كمية ونسبة مياه الصرف الصحي ومياه التسربات الأرضية كل على حده من جميع هذه الشبكات. كما يتم استعراض هذه الكميات من المياه على فترات من الزمن وتوضيح تأثيرها على محطة توبلي بشكل عام وعلى كمية المياه المحولة إلى خليج توبلي من دون معالجة، كما يتم اقتراح الخيارات الممكنة من اجل إيقاف عملية تحويل مياه الصرف الصحي الغير معالجة إلى خليج توبلي .

وقد توصلت الدراسة إلي أنه من الضروري القيام بإشراك القطاع الخاص للاستثمار في هذه المشاريع من اجل ضمان التمويل المالي لهذه المشاريع العاجلة وكذلك لتخفيف الأعباء المالية الملقاة على كاهل الحكومة, و هذا ما تسعى له وزارة الأشغال حاليا. كذلك من الضروري القيام بالبحث عن الكوادر المؤهلة لتوظيفها من أجل إدارة هذه المشاريع الكبيرة والحساسة, حيث أن وزارة الأشغال تعاني من نقص شديد في الكوادر الإدارية والفنية في الوقت الحالي. كما أنه من الضروري التوصل لنظام متفق عليه بين الوزارات المختصة والجهات التشريعية لتطبيق تعرفة على خدمة الصرف الصحي والتي يمكن حسابها كنسبة من تعرفة المياه البلدية مع مراعاة الجوانب الاجتماعية المرتبطة بذلك. هذه الآلية من شأنها أن تؤدي إلى ترشيد استهلاك المياه البلدية و تبعا لذلك إلى تقليل ناتج مياه الصرف الصحي وفي المقام الأخير تخفيف الأعباء الهيدروليكية والأعباء الإدارية المالية لتشغيل و صيانة نظام الصرف الصحي و في المقام الأخير المساهمة في الحفاظ على الحالة الصحية والبيئية لخليج توبلي.

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يقع هور الدلمج في محافظة واسط بوسط العراق على مساحة 314 كم^2 وبمنسوب ماء 14.30م. تتعرض أهوار العراق لجملة من التحديات أهمها التجفيف، وتناقص كمية المياه الواردة من دول المنبع، وآثار تغير المناخ على الموارد المائية مما يتطلب العمل نحو تطوير هذه الموارد وتنميتها باستدامة. هدفت الدراسة إلى إجراء تقييم بيئي متكامل لهور الدلمج باستخدام إطار التحليل DPSIR شاملة تقييم الوضع الحالي له، وتحديد ما يتعرض له الهور من ضغوط وآثارها على النظام البيئي وما يقدمه من خدمات وعلى رفاه الإنسان، وتحديد السياسات التي تم إتخاذها في تنمية موارد المياه للهور. ولهذا الغرض تم التعرف على الموزانة المائية للهور، وتحديد نوعية مياهه من خلال تحاليل لعينات منها. بينت نتائج الدراسة تعدد الخدمات التي يقدمها النظام البيئي لهور الدلمج والتي تتمثل توفير نحو 879 طن من الأسماك سنويا، واختزال كلف نقل المياه, والمساهمة في زيادة الرقعة الزراعية وخصوصا للموسم الشتوي، وتوفير مساحة 157 كم^2 من نبات القصب، كما أنه موئل لنحو 25000 رأس من الجاموس, ومحطة للطيور المهاجرة, إضافة لدوره في خزن الكربون، وخفض حرارة البيئة المحيطة والمساهمة في تثبيت الكثبان الرملية المتحركة في المنطقة. توفر خدمات النظام البيئي لهور الدلمج 7850 فرصة عمل وتبشر بمزيد منها فيما لو تم تطويره لخدمة القطاع السياحي. قدمت الدراسة مقترحين هندسيين يهدفان إلى رفع منسوب مياه الهور، وزيادة مساحته، وسعته التخزينية من مياه الصرف الزراعي، والحفاظ على ملوحة لا تتعدى 4000ج م م . وتم تحديد التصميم الهندسي لكلا المقترحين وكلفة كل منهما.

استهلاك المياه المعبأة في دولة الكويت

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دأبت دولة الكويت على توفير خدمة مياه الشرب للمستهلكين بنوعية جيدة بالرغم من ندرة الموارد المائية لديها، واستلزم ذلك ضخ استثمارات كبيرة وجهود متواصلة من محطات تحلية وشبكات مائية متزايدة وأنظمة متعددة لمراقبة نوعية المياه. يبلغ سعر المياه من الشبكة العامة 0.23 فلس للتر الواحد وبالمقارنة فأن المياه المعبأة يزيد سعرها بأضعاف كثيرة عن مياه الشبكة حيث يبلغ سعرها100 فلس للتر. أن توجه استبدال مياه الشرب في الشبكة العامة بالمياه المعبأة لدى المستهلك يستلزم اعتبارات توازى قيمتها الاقتصادية ومعرفة الجوانب الصحية والاجتماعية والاقتصادية لهذه الظاهرة. بالرغم من تزويد دولة الكويت لقاطنيها بمياه شرب عالية الجودة وبتعرفه متدنية نسبيا نجد إن استخدام المياه المعبأة بالرغم من زيادة سعرها وعدم الاعتبار لجودتها منتشر بشكل كبير وبتزايد مستمر، ولذا فأن هناك حاجة لمعرفة أسباب هذه الظاهرة .

تعنى الإدارة المتكاملة بجميع أنواع المياه المنتجة على المستوى العام، كما تعنى بالتكلفة التي تقوم الدولة بتوفيرها على مستوى الفرد بالنسبة لخدمة المياه، وتعنى الدراسة بمعرفة أسباب ظاهرة التوجه المتزايد للمياه المعبأة وتأثيرها من الناحية الاقتصادية والصحية على الفرد. يهدف هذا البحث إلى توعية المواطنين والمستهلكين للأنواع المختلفة للمياه المعبأة ومعرفة أسباب ظاهرة التوجه المتزايد لها وانعكاس التكلفة الاقتصادية والاجتماعية على الفرد. هذا وقد توصل البحث إلى ضرورة إنشاء جهاز رقابي خاص للمياه المعبأة يعنى بمراقبة نوعية المياه المعبأة المستوردة والمحلية، وتوجيه مصانع المياه المعبأة بذكر المعلومات التالية على عبوات المياه: مصدر المياه المعبأة ونوعية المعالجة المستخدمة والمستويات المسموح بها لمياه الشرب المعبأة لمعايير الجودة المذكورة على العبوة. كما يوصى بإنشاء موقع على شبكة الانترنت يتضمن قاعدة معلومات عن جميع أصناف المياه المعبأة المتوفرة في الأسواق المحلية ونتائج اختبارات الجودة الدورية التي تجريها الجهات المختصة وأية تحذيرات أو معلومات عن جودة الأصناف المختلفة. أما على مستوى المستهلك للمياه المعبئة فيوصى بتوعية المواطنين بالمياه المعبأة وأثرها ونوعيتها والتقارير المتعلقة بها، وبخطر قناني المياه المعبأة وتكلفتها وتأثيرها على البيئة، وعدم استخدام قنينة المياه المعبأة لأكثر من مرة، والمحافظة على البيئة يرمى مخلفات المياه المعبأة البلاستيك في الأماكن المخصصة لها، وقراءة مكونات المياه المعبأة قبل الشراء والتأكد من مكوناتها. وأخيرا يقترح اعتبار المياه المعبأة من ضمن أنواع المياه المستخدمة والمتزايدة على مستوى العالم واعتبار التأثيرات الاقتصادية والبيئية من ضمن الخيارات المتعددة في حال التخطيط الشامل لتوفير مياه الشرب .

Water Budget Review of Wadi Ma'awil Catchment Barka – Al Batinah Region

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Wadi Ma'awil catchment in Barka, Eastern Batinah, is known to be of major importance to the area and the nearby towns in terms of its water supply and socio-economic activities. The area population relies totally on groundwater as the main source for their activities. Domestic, agricultural and all other uses of water depend entirely on groundwater, especially in the lower or northern part of the catchment, the study area of this research. However, heavy reliance on groundwater has lead to its over-exploitation. The main drivers for groundwater over-exploitation in the catchment are population growth and expanding agricultural areas to meet increasing food demand. The main pressures on groundwater are increasing water demands by the agriculture sector and the municipal sectors, and absence of control of well abstraction. The impacts of groundwater over-exploitation are socially, economically, and most important environmentally. It was important to investigate and search for the stakeholder's responses to the issue to suggest integrated recommendations.

In this study, the water budget for the study area was reviewed and calculated. Constructing a water balance for the catchment is absolutely an obligation because it is the only source, to know the quantity in case of emergency and focus deeply on the dimensions and characteristics of the basin. The model used is a simple conceptual model that calculates the storage of the basin by using an equation that adds all the input and output components in the catchment to show how much water is available as a surplus or a deficit. The results indicated that groundwater is being depleted, and the deficit is very drastic, especially in the northern parts of the catchment. The groundwater storage cannot support the current consumption anymore as it is already over-drafted due to intensive agriculture that has evolved during the past three decades without strictly imposed legislations. Practical recommendations were introduced in order to restore groundwater levels and salinities and to sustain its service for the socio-economic development of in Barka.

استخدام المياه الرمادية كأداة لإدارة الطلب على المياه في سلطنة عمان

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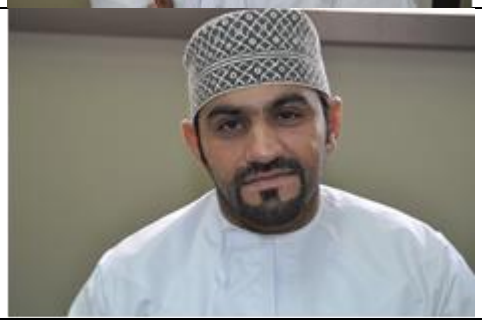

تعتبر الموارد المائية الطبيعية المتجددة محدودة جدا خاصة في المناطق الجافة وشبه الجافة ويفاقم هذه الندرة زيادة عدد السكان, وبالتالي زيادة الطلب على الموارد المائية المحدودة. وتعاني دول مجلس التعاون الخليجي بشكل خاص من قلة الموارد المائية التقليدية وتدنى كفاءة استخدام المياه وارتفاع مستوى الفاقد من خلال الاستخدامات المختلفة للمياه كعمليات الري التقليدية والتسربات وغيرها وتدهور مصادر المياه الجوفية بفعل الاستخدام المفرط لها وسوء نوعيتها. ويعتبر إعادة استخدام مياه الصرف الصحي المعالجة أحدى الطرق لتقليل الاستهلاك بالمجتمعات وكذلك المساهمة في تقليل الأضرار البيئية لمياه الصرف الصحي. لذا، فأن إعادة استخدام المياه لعدد كبير من مستهلكي المياه سيسهم في تنمية المجتمع وتحسين الحياة المعيشية من خلال الانتفاع والاستفادة بكميات كافية من المياه غير النظيفة التي تتم معالجتها لصالح المجتمعات الواقعة بالقرب من مصادر استهلاك المياه. وعلى الجهات المعنية بالمياه تعزيز إعادة استخدام المياه الرمادية شريطة أن تكون ضمن الضوابط والتشريعات البلدية المنظمة للمباني، لضمان إعادة استخدام هذه المياه وتقليل وتيرة الزيادة على طلب المياه، مما سيؤدي إلى تحقيق التوازن بين متطلبات التنمية (الطلب) وحجم المياه المتوفرة المتمثلة في العرض وفي نفس الوقت سيقلل من تكاليف المعالجة بمحطات الصرف الصحي.

ولتحقيق التنمية المستدامة لمصادر المياه بكافة أنواعها لابد من وضع إستراتيجيات مائية من خلال وضع برامج هادفة وخطط ترشيدية والتأكيد على أنها سلعة اقتصادية وليست هبة من الدولة لمواطنيها وإعداد وتنفيذ برامج توعوية تهدف إلى التقليل من الإسراف وإعداد برامج تثقيفية على كافة المستويات بهدف الدفع نحو الاستخدام الأمثل للمياه، والعمل على الحد من الفاقد من خلال تأهيل الشبكات بكافة أنواعها وتطبيق أساليب الري الحديثة والحث المستمر للمستهلكين وإصدار تشريعات وقوانين تحفظ نوعية المياه والبيئة تحافظ على المياه الجوفية من الاستنزاف.

ومن أهم التوصيات التي توصل إليها البحث: 1) إعداد خطط تفصيلية لاكتساب وتطوير وتوطين تقنيات تحلية المياه المالحة لما لها من فوائد اقتصادية واجتماعية؛ 2) عمل دراسات وأبحاث مستمرة في مجال معالجة المياه؛ 3) ترسيخ ونشر ثقافة التطوير المستمر بين العاملين في قطاع المياه وذلك لتطوير القدرات والمعارف ورفع الكفاءات من خلال توفير الوسائل والبرامج والمحفزات المادية والمعنوية؛ 4) وضع لوائح وأنظمة لعمل شبكة خاصة للمياه الرمادية في كافة المباني والتشجيع عليها؛ 5) إلزام عمل خزانات تجميعية للمياه الرمادية؛ 6) الكشف الدوري على شبكات توصيل المياه وتقليل الفاقد منها؛ 7) وضع لوائح وأنظمة لنوعية الأدوات الصحية المناسبة والتقيد بالأدوات الملائمة للترشيد المائي؛ 8) الاهتمام بزراعة محاصيل لا تتطلب استهلاكا مائيا كثيرا؛ 9) الحث على استخدام المياه الرمادية والتقليل من ري المزروعات بالمياه العادية؛ 10) الاهتمام بالتوعية عن طريق المدارس والجامعات ووسائل الإعلامية.

قياس مستوى إدارة الموارد المائية في أسفل حوض وادي المعاول (مدينة بركاء) بسلطنة عمان باستخدام مؤشرات الإدارة المتكاملة للموارد المائية

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خلال العقدين الماضيين، مرت ولاية بركاءبسلطنة عمانبمرحلة تنمية متسارعة في مختلف النواحي الاجتماعية والعمرانية والصناعية والزراعية وصاحبتها زيادات متعاظمة في الطلب على المياه وخصوصاً من القطاع الزراعي. وقد أدى الاعتماد الكبير على المياه الجوفية المتجددة وغير المتجددة، وغياب الإدارة الفعالة لها إلى الاستخدام المكثف لهذه المياه بشكل عشوائي واستنزافها وتدهور نوعية مياهها بشكل مستمر. وفي ضوء هذه المعطيات تبرز أهمية استخدام مؤشرات متكاملة وشاملة تقيس مستوى الإدارة المائية بولاية بركاء تشخصه من خلال تتبع وتحليل اتجاهات التغير كخطوة أساسية وأولية لتحديد مواطن القوة ليتم تعزيزها، ومواطن الضعف ليتم إصلاحها من قبل صناع القرار. وهدفت هذه الدراسة إلى التعرف على مدى تطبيق منهجية الإدارة المتكاملة للموارد المائية في ولاية بركاء وتقييم الوضع المائي ومستوى الإدارة المائية فيها واستخدام المؤشرات المقترحة في تحليل اتجاهات التغير والخروج بالاستنتاجات والتوصيات الملائمة. وتم إتباع المنهج الوصفي التحليلي وقياس مؤشرات الإدارة المائية المتكاملة المعتمدة على منهجية DPSIR لقياس مدى تطبيقها وموائمتها لظروف المنطقة وتحليل المؤشرات لتقييم مستوى الإدارة المائية في ولاية بركاء.

وقد أظهرت نتائج تحليل المؤشرات إلى عدم وجود التطبيق الصحيح لمفهوم الإدارة المتكاملة في مجال البيئة الممكنة والترتيب المؤسسي، وعدم وجود استراتيجيات مائية شاملة بعيدة المدى ومبنية على اعتبارات العرض والطلب، وضعف التنسيق بين صانعي القرار والقطاعات ذات العلاقة وعدم وجود سلطة عليا موحده تقوم بالتنسيق بين الجهات المتعددة، وقصور في جانب الوعي ومشاركة المجتمع المدني وانحصار ذلك في توعية المجتمع في جانب ترشيد الاستهلاك. كما بينت النتائج قصور عالي في جانب إدارة الطلب متمثلا في انخفاض كفاءة استخدام المياه في القطاع الزراعي وعدم وجود تعرفة لمياه الري للقطاع الزراعي. وتوصي الدراسة بتفعيل المؤسسة المسئولة عن المياه الحالية بحيث تكون قوية وقادرة للبدء والتنفيذ والتنسيق بين الجهات ذات الصلة وإشراك المجتمع في التخطيط، والعمل على الاستفادة القصوى لمياه الصرف الصحي المعالجة في مجال الزراعة للتقليل من الاعتماد على المياه الجوفية، وإنشاء قاعدة بيانات حديثة تضم كل البيانات المتعلقة بالموارد المائية بالأخص بيانات عن كميات المياه المستخدمة في الزراعة لتكون مرجعاً لصناع القرار والباحثين والمهتمين بالأمر، وتأهيل وتطوير الكوادر العاملين في مجال الإدارة المائية، ونشر الوعي في أوساط المزارعين ومساندتهم في استخدام نظم الري الحديثة الوفرة للمياه و زرع المحاصيل والأشجار التي لها عائد اقتصادي كبير وتستهلك مياه أقل.

Asbestos Cement Potable Water Network and Possible Health Effects on Jubail Industrial City Populations

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Asbestos cement pipes have been widely used around the world in many countries for many years, although installation of new asbestos cement water pipes has declined significantly over the past 15 years because of difficulties in handling, public awareness and the availability of better and inexpensive materials. Health effects resulting from continuous inhalation of asbestos dusts are well established and include asbestosis and mesothelioma, a highly characteristic lung cancer. There is a very good qualitative understanding of the effects of inhaled asbestos fibers and the physical characteristics of the fibers are considered to be very important in determining their ability to cause disease. Concern that ingested asbestos fibers could also lead to possible health effects has been studied in different parts of the world including laboratory studies on animals. The results of some of these studies have been used for comparison with the results of the case of the Jubail Industrial City, a major petrochemical complex located on the North Eastern shores of the Arabian Peninsula.

The objective of the is to investigate whether existing asbestos potable water network in Jubal Indusial City has any harmful impacts on the city populations in relation with the 1998 Royal Decree that prohibits the use of asbestos containing material all over the Kingdom of Saudi Arabia, and the supplementary Royal Decree issued in 2000, which orders all potable water networks operators in Saudi Arabia to schedule replacement of asbestos cement pipes as they complete a design service life of 25 years with an alternative material of construction. This study investigated the possible health effects of using asbestos cement potable water network in Jubail Industrial City, which is more than 25 years old by comparing the result of Jubail Industrial City case study with the result of different studies around the world.

With regard to the health impact, it has been speculated that asbestos fibers in drinking water and perhaps also in food, could increase the incident of cancers in population exposed over many years. The possibility that asbestos in potable water could cause diseases, especially cancer is a complex question, because the exposures are intermittent and the concentrations vary. However, epidemiological studies conducted in several areas with relatively high concentrations of asbestos fibers in drinking water supplies in the UK, Australia, USA, Canada and several European countries provide little convincing evidence of an association between asbestos in drinking water and induction of cancer.

Limited data indicate that exposure to airborne asbestos released from tap water during showers or humidification is negligible. Asbestos is a known human carcinogen by the inhalation route. Although well studied, there has been little convincing evidence of the carcinogenicity of ingested asbestos in epidemiological studies of populations with drinking-water supplies containing high concentrations of asbestos. Moreover, in extensive studies on animal species, asbestos has not consistently increased the incidence of tumors of the gastrointestinal tract. There is, therefore, no consistent evidence that ingested asbestos is hazardous to health. Based on the results of these studies and the fact that asbestos concentration in Jubail Industrial City Potable water is similar to that in many other countries, it is concluded that there is no significant real health risk from direct drinking of potable water. There could be a potential health risk due to asbestos inhalation if the potable water containing excessive amount of asbestos fibers is aerosolized or dries out and the residue becomes airborne. The quantitative extrapolation of the risk of developing these diseases to very low levels of exposure (orders of magnitude below levels of exposure in the population from which the standards for airborne asbestos have been derived) such as those that would be expected in the unlikely scenario described above, is considered insignificant. Therefore, the likelihood of asbestosis, lung cancer and mesothelioma, the principle hazard of exposure to airborne asbestos is judged no different than that in any urban city in North American or Europe.

نحو إدارة متكاملة للموارد المائية في وادي ضيم غرب المملكة العربية السعودية

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تتواجد مصـــادر المياه الجوفية في حوض وادي ضـــيم في رســـوبيات الأودية من الدهر الرابع، وهي مرتبطة بالدورة الهيدرولوجية الواقعة تحت تأثيرات مناخ البحر الأبيض المتوسط أثناء فصل الشتاء وكذلك الأمطار الموسمية في فصل الربيع. وآثار هذين المناخين المختلفين تغيرها الملامح الجيومورفولوجية الموجودة في المنطقة مثل أخدود البحر الأحمر ومنحدر الحجاز الذي يتجه شـــمالا وجنوبا. تكرار هطول الأمطار على امتداد منحدرات الحجاز يجعل مياه الأمطار تنســـاب لتغذي المياه الجوفية في الطبقات الرسوبية للأودية. هطول الأمطار غير منتظم وبكميات شحيحة، ولكنه يحدث في بعض الأوقات بكميات غزيرة وبشكل عرضي يؤدي إلى تغذية مهمة للمياه الجوفية. وعلى ضـوء السـجلات السـابقة لهطول الأمطار فأن من الممكن تقويم حجم مياه الأمطار الشـهرية التي تصـل إلى سـطح الأرض، وأن يتم الحسـاب بوسـائل فنية مؤكدة للتغذية الممكنة. ولقد تم القيام بهذا البحث للقيام بالتخطيط المسـتقبلي لتطبيق الإدارة المتكاملة لموارد المياه في الأحواض المشابهة لحوض وادي ضيم. وتوصلت الدراسة إلي أهم المشاكل الرئيسية الحالية في المياه الجوفية لوادي ضيم, حيث أوضـحت الدراسـات أن هناك انخفاضـا مستمرا في مستوى المياه الجوفية بسبب الضـخ العشـوائي الذي يتم في غياب اللوائح التنظيمية للسحب. وتتركز الآبار في مناطق معينة تم تحديدها من خلال خبرة المواطنين المحليين، ولذلك فان هنالك تداخلات بين الآبار بسبب السحب المفرط, وحجم المياه الجوفية المستهلكة سنويا في الوقت الحالي يقدر بنحو 2.47 × 10^{6}م^{3} / سنة يضخ ما نسبته 90% منها لري المزروعات.

تقييم الوضع الراهن والحلول المقترحة لبحيرة الصرف الصحي بشرق جدة

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تبلغ كمية المياه ببحيرة الصرف الصحي بجدة، التي تصل مساحتها 2.85 كم^2، حوالي 17 مليون م^3، كما تستقبل البحيرة كميات من مياه الصرف الصحي والصناعي يصل حجمها إلى حوالي 25000 م^3 يومياً، ولقد تبين أن هناك عوائق تمنع وقف رمي مياه الصرف الناتجة عن جدة نهائياً في البحيرة لعدم وجود محطات معالجة كافية لاستيعاب مياه الصرف الناتجة. ونظراً للتخوف من انهيار السد الترابي جنوب البحيرة والذي سيترتب عليه غرق بعض أحياء المدينة بجانب بعض الأضرار الصحية والبيئية، تقوم أمانة جدة بتنفيذ عدد من الحلول. ويهدف البحث الحالي إلى مناقشة الوضع الراهن للبحيرة والحلول التي تنفذ بها وبعض الحلول الأخرى المقترحة.

يتبين من خلال دراسة الخصائص الفيزيائية للبحيرة أن طول البحيرة يمتد لأكثر من 4 كم وبعرض أكثر من 1.7 كم، وقد شيد على البحيرة سدان أحدهما ترابي يقع على الجانب الجنوبي من البحيرة، وسد أسمنتي يطلق عليه السد الاحترازي ويبعد عن السد الترابي حوالي 10 كيلومتر غرباً. وتبلغ ارتفاع دعامة السد في الجانب الشرقي 122 مترا فوق مستوى سطح البحر، أما في الجانب الشمال الغربي فارتفاع الدعامة يبلغ حوالي 113 متر. ويصل ارتفاع السد إلى 10-15 متر وطوله إلى 2.7 كم، وحجم جسم السد الترابي القائم يقترب من 806,400 متر^3. وتبين من دراسة التنوع الحيوي وجود بعض أنواع الأسماك الملوثة بالبحيرة والتي تحمل العديد من الطفيليات والبكتريا، وقيام بعض المواطنين والوافدين برعي الإبل والأغنام بجوار البحيرة، وتوافد أعداد من الطيور بجوار وعلى سطح مياه البحيرة بحثاً عن الغذاء، وتواجد لبعض النباتات التي تنتشر في المناطق التي تتوفر بها المياه والتي تتحمل الملوحة.

توضح هيدرولوجية البحيرة أن المنسوب الحالي للمياه بالبحيرة 8.85 متر، وأن استمرار الوضع الحالي سيؤدي إلي انخفاض مياه البحيرة بمقدار 8,54 مليون م3 في السنة. وعند دراسة خطر فيضان بحيرة الصرف فقد تبين أن حدوث سيل يمكن أن يؤدي إلى غمر السد الترابي بمياه البحيرة يبدو أمراً غير وارد. وبدراسة الخصائص الفيزيائية والكيميائية لمياه البحيرة فقد تبين أن معظم المؤشرات التي تم تحليلها كانت أعلى بمياه المصب عنها بمياه البحيرة، وأن درجة الحموضة لا تساعد على ذوبان العناصر الثقيلة، وأن النشاط الحيوي بالبحيرة يكاد يكون معدوماً. وتبين من نتائج العناصر الثقيلة السامة أن عنصر الكروم قد أظهر تركيزات مرتفعة، وأن تركيزات جميع العناصر الصغرى والسامة كانت منخفضة بمياه البحيرة عنها بالمصب. تبين من تحليل رواسب البحيرة أن نتائج درجة الحموضة لا تساعد على ذوبان العناصر الثقيلة الضارة، وانخفاض تركيز العناصر الثقيلة الضارة بصفة عامة، وأن تركيزات العناصر الضارة التي تم رصدها صغيرة ولم تتجاوز المعايير المذكورة لوكالة حماية البيئة الأمريكية لجودة الحمأة التي يمكن إعادة استخدامها في الزراعة.

ووجد أنه يتم حالياً تنفيذ عدد من الحلول لتجفيف مياه البحيرة وهى: رفع كفاءة محطة المعالجة وزيادة طاقتها الاستيعابية إلى 60,000 م^3 يومياً بدلاً من 30,000 م^3 يومياً، والاستفادة من مياه الصرف المعالجة في مشروع للأراضي الرطبة (الغابات الشرقية)، وإنشاء خط ناقل للتخلص من فائض المياه المعالجة التي تتجمع خلف السد الاحترازي، وإنشاء خطين ناقلين إلى طريق الحرمين للاستفادة من المياه المعالجة في الزراعة. كما أتضح وجود خطط للطوارئ لجميع الهيئات المعنية، وقد اقترحت الدراسة عدد من التوصيات بنهاية البحث لتحسين الوضع القائم تتعلق بشبكة الصرف، ومحطات معالجة الصرف الصحي، والبحيرة أثناء وبعد تجفيفها، والسد الترابي، وكيفية الاستفادة من مياه الصرف المعالجة، وحماية البيئة المحيطة البحرية والجوفية، والمخلفات الصناعية.

Reuse of surplus treated wastewater effluent from Treatment Plants in Jubail Industrial City

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Jubail Industrial City is located on the Arabian Gulf in the eastern part of Saudi Arabia, established to accommodate large number of petrochemical industries. The city is directed by the Royal commission of Jubail and Yanbu, and due to privatization power and water utilities were transferred to Marafiq Company. The City has been provided with two wastewater treatment plants: the industrial treatment plant (IWTP) and Sanitary treatment plant (SWTP). Both plants are designed to reuse reclaimed wastewater for irrigation or discharge to marshlands. Due to the rapid growth of industries and population in the Industrial City, demand forecast studies predict relatively large quantities of surplus treated wastewater that is more than the need of city for irrigation water. This research will explore the possible ways to reuse the surplus treated wastewater in the Jubail Industrial City, which has very limited water resources, without causing significant environmental impact to public health and safety. At present, this water will be discharged to the marshlands for evaporation without any usage. If treated adequately, reclaimed wastewater could have alternative beneficial uses.

The objective of this study was to use the surplus of reclaimed wastewater in proper way instead of discharge it to an open land and to study all available options to reuse reclaimed water, such as increasing irrigation usage by increasing the landscaping area, transfer it to Jubail town for irrigation usage, reuse it for industries for cooling purposes, or using it for recharging the aquifers. The methodology of this research adopted the quantification of wastewater flow based on data provided by Marafiq and the demand of irrigation water based on the Royal Commission data for the next years. Reclaimed wastewater quality data with respect to the Royal Commission standards were reviewed and analysis was made for the current reclaimed wastewater and the best reuse option with respect of economy, society and environment was decided.

Ground Water Protection in North Eastern Part of LC-Sana'a corp. of Sana'a city within Integrated Water Resources Management Perspective

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In Yemen, groundwater is considered as the main water source for drinking, domestic uses, and irrigation purposes. Water lies in the core of the socio-economic development in the country. Yemen, as other countries in the region, is situated in an arid to semi-arid zone, which is known for its scarce rainfall and high evaporation rates. Pronounced differences in the topography affect climatic conditions and limit agriculture to areas of rainfall and groundwater availability such as the western mountains, basin areas, and *wadi* beds. Rainfall occurs only in the spring and summer seasons. Yemen's severely scarce water resources are under increasing pressures from domestic, agricultural, and industrial demands, and suffers from inadequate management and inefficient use practices. The main drivers for increasing water demands are relatively high population growth rates, accelerated urbanization, and rapid economic development that have increased the pressure on groundwater resources, and have led to a continuous process of degradation and depletion of this resource endangering its long-term sustainability. Furthermore, in addition to their over-exploitation, groundwater resources are under many pollution threats due to wastes resulting from anthropogenic surface activities. The aim of the present work is to study and discuss the issue of groundwater pollution in the North-eastern well field, located in the Sana'a basin, of the Sana'a Water & Sanitation of Local Corporation (SWSLC) by focusing on the pollution causes and how to protect the field and proposed management approaches instruments to control it within an IWRM perspective.

The results showed that integration and coordination among water-related institutions are very important to invest in long-term water projects. Risk management systems have to be initiated and developed to control industrial pollution, and application of economic instruments based on the "polluter pays" principle to protect the environment and groundwater need to be implemented. Each institution or company (private or government) has to be responsible for taking the required mitigation measures. Much attention has to be focused on subsidizing water supply schemes to make water affordable particularly for the poor. Anyone who damages the environment shall be responsible for all the costs and expenses arising out of removing the damage, in addition to the compensation for it. Raising the level of awareness of individuals and the society at large in relation to the issues of environment is crucial issue. All government institutions have to coordinate to take all measures and arrangements to ensure the safety of the environment, pollution control, and conservation of natural resources.

Third Batch : (2010/2011)

Third Batch Students

No.	Student's name	Country	Projects title
1	Naji Merhaby	Lebanon	الإدارة المتكاملة للموارد المائية و ضمانة حق الحياة في مدينة طرابلس (منطقة الضم والفرز) بلبنان
2	Salah Hamad	Libya	Water Resources of Al Jabal Al Akhdar Region, North East Libya: A Review of Current Situation and Future IWRM Plan
3	Ahmed Al-Saleh	Kuwait	المياه الملوثة وكيفية معالجتها وطرق إعادة استخدامها في دولة الكويت
4	Amany Mohammed Al-Ajmi	Kuwait	Environmental impact of Desalination Brine Discharge on Marine Ecosystem of Arabian Gulf
5	Bader Akbar Jber Akbar	Kuwait	Wastewater Management in the State of Kuwait
6	Meshal Saad Al-Enezi	Kuwait	توصيف الخزانات الجوفية (طبقة الدمام ومجموعه الكويت) في دولة الكويت
7	Salah Al-Saffar	Kuwait	الاستفادة القصوى من المياه المعالجة في دولة الكويت
8	Salim Said Rashid Al-Sidairi	Oman	الأمن المائي السكاني في سلطنة عمان، دراسة حالة محافظات شمال عمان

الإدارة المتكاملة للموارد المائية و ضمانة حق الحياة في مدينة طرابلس (منطقة الضم والفرز) بلبنان

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يقوم هذا البحث على دراسة العلاقة بين مفهوم الإدارة المتكاملة للموارد المائية وحق الحياة المتعلق حتماً بحق الصحة، كما يدرس من خلال المنهج التحليلي الوصفي واقع مدينة طرابلس الهيدرولوجي بشكل عام ومنطقة "الضم والفرز" بوجه خاص، ويسهم في إيجاد السبل الواجب إتباعها لضمان حق الحياة لسكان تلك المنطقة. وقد سلطت الضوء على مفهوم هذا الحق ودرست تطوره عبر التاريخ ومدى علاقته بالمياه، وبينت كيف يمكن لمبادئ الإدارة المتكاملة للموارد المائية الإسهام في كفالة حق الإنسان بالرفاه، وعرضت المشكلات المائية لمدينة طرابلس وسبل تفاديها ولا سيما أن الماء ضروري لحياة الإنسان وللصحة والبقاء ولإنتاج الأغذية والأنشطة الاقتصادية. يشتمل البحث على قسمين، تناولت في القسم الأول بإيجاز اللمحة التاريخية لمسيرة تطور حق الحياة وصولاً إلى دراسة موقف الديانات الوضعية للحق في الماء وارتباطاته بأمان ورفاه الحياة، كما قدمت دراسة تحليلية لموقف المجتمع الدولي من حق الصحة وعلاقته بالماء والصرف الصحي من خلال تحليل القواعد القانونية الوضعية والاتفاقيات الدولية والأممية التي أقرت أن الماء حق أساس من حقوق الإنسان سواء بشكل مباشر أو غير مباشر. أما القسم الثاني، فقد عرضت فيه مشكلات مدينة طرابلس المائية والواقع المائي لمنطقة "الضم والفرز" كنموذج لانتهاك حقوق الإنسان، وشرحت بالتفصيل كيف يمكن أن تكون الإدارة المتكاملة للموارد المائية الترياق الذي يؤدي إلى اعتماد سياسات غير تقليدية للحفاظ على الموارد المائية وحمايتها.

وخلصت في نهاية البحث إلى إن مفهوم الإدارة المتكاملة يشكل محور السياسات الهادفة للتوازن بين حماية حق الحياة للسكان وحماية الموارد المائية عبر تكامل بين تنظيم الكم المستخرج للاستهلاك من المياه الجوفية والحد من تلوثها عبر تسرب مياه البحر؛ إن التمسك بالحق الإنساني في المياه هو غاية في حد ذاته ووسيلة لاستنهاض حقوق أكثر شمولاً وردت في الإعلان العالمي لحقوق الإنسان وفي غيره من الوثائق الملزمة قانونياً وعليه فمن الواجب تطوير الهياكل الأساسية لتخزين المياه؛ ضرورة مشاركة المجتمع المحلي بمختلف فئاته في اتخاذ القرارات ذات الصلة. مؤسسيا، هناك ضرورة لإحياء المجلس الأعلى للمياه وتكليف مجموعة من الخبراء بنقل صورة واقعية عن الثروة المائية الإستراتيجية في لبنان والاحتياطي الدقيق منها. وإداريا وتقنيا يجب اعتماد جور صحية لا تسمح بتسرب الملوثات إلى المياه الجوفية، وتنظيم استخراج المياه الجوفية بما لا يتعارض والأمن المائي للأجيال القادمة، والمحافظة على أيكولوجية الأنهار من أجل توازن البيئة الطبيعية، وترشيد مستخدمي المياه بالثقافة للحفاظ والحرص على مصادر الماء.

Water Resources of Al Jabal Al Akhdar Region, North East Libya: A Review of Current Situation and Future IWRM Plan

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The aim of this research is to present an overview of the water resources of Al Jabal Al Akhdar (Green Mountain) region, located in northeast Libya, an area of unique environment with considerable vegetation cover from the rest of country, as it is the wettest part in the country largely due to its proximity to the Mediterranean and its upland character. Water resources in Al Jabal Al Akhdar area, like other areas of Libya, have not been adequately managed and mostly neglected, and experience large wastage and abuse. This has led to many negative consequences and water-related problems, such as shortage in the quantity of water and quality degradation.

The first part of the research focused on the status of water resources of the Al Jabal Al Akhdar area, which were reviewed based on the available relevant literatures and inquiries from water institutions. The main water resources were identified and classified and their status were previewed to highlight the major issues regarding resources management and their sustainability. In the second part, the main constraints and challenges facing water resources management were highlighted, and a plan for Integrated Water Resources Management (IWRM) adopted from Cap-Net training manual, where the planning procedures were followed, starting from initiating the planning process by defining the existing drivers. A work plan was developed through capacity building, political commitment and stakeholder participation to establish the strategic vision which is the "*sustainability of water resources and its utilization in an equitable and efficient manner and without endangering the environment*", in which water management strategy and options were identified. Finally, a proposal for water institutional reform and organizational framework was introduced to support the developed IWRM Plan.

المياه الملوثة وكيفية معالجتها وطرق إعادة استخدامها في دولة الكويت

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تعتبر مشكلة التخلص من المخلفات المنزلية والصناعية سواء الصلبة منها أو السائلة من المشاكل الناتجة عن التطور الحضاري في العالم. ومن أهم هذه المشاكل هي مشكلة التخلص من مياه الصرف الصحي والتي تعتبر من الملوثات الخطيرة. ولا شك أن التخلص منها بطريقة صحيحة قد أصبح علما قائما بذاته من أجل المحافظة على البيئة من التلوث وتوفير بيئة صحية للمجتمعات. لذا، تقوم دولة الكويت كباقي الدول المتقدمة بتنفيذ مشروعات ضخمة متكاملة لتجميع هذه الفضلات للتخلص منها بطريقة آمنه لا تضر أو تلوث البيئة وذلك وفق شروط ومعايير عالمية لضمان أفضل النتائج المرجوة حيث يتم معالجتها وتعقيمها للاستفادة منها في أغراض متعددة .

لقد كانت مشكلة مياه الصرف الصحية بدولة الكويت دائما موضع لاهتمام كبار المسئولين في الدولة نظرا لما تسببه هذه المشكلة من آثار بيئية خطرة, وخصوصا على البيئة البحرية. يهدف هذا البحث إلى استعراض الوضع الحالي والمستقبلي لإدارة مياه الصرف الصحي وبيان أهم المشاكل التي تواجه هذه الإدارة واقتراح الحلول المناسبة للاستفادة القصوى منها لتخفيف الإجهاد المائي في دولة الكويت. نظرا للتوسع العمراني السريع منذ بداية الخمسينات وزيادة التعداد السكاني وما صاحب ذلك من أنشطة متنوعة وصناعية استلزم ذلك إنشاء مشروع مجارى صحية متكامل، حيث بدأ العمل في تشغيل أول مشروع مجارى صحية بالكويت عام 1971 في محطة العارضية، وتبعها بعد ذلك إنشاء ثلاث محطات تنقية في الرقة والجهراء وفيلكا ومحطة تنقية أم الهيمان بالإضافة إلى إنشاء محطة تنقية الصليبية بدلا من محطة تنقية العارضية بنظام (BOT). ومن خلال الدراسات التي أجريت, لوحظ أن معدل استهلاك الفرد للمياه العذبة في دولة الكويت من أعلى المعدلات المسجلة في العالم وعليه خصصت الدولة ميزانيات ضخمة لمعالجة مياه الصرف الصحي للاستفادة القصوى منها لتخفيف ضغط الاستهلاك على المياه المحلاة من البحر لما في ذالك من ضرر بالغ على مياه البحر من زيادة الملوحة وملوثات المخلفات الكيميائية التي تصاحب عملية التحلية بالتقطير . هذا وقد توصلت الدراسة إلى أنه يجب فصل شبكة الصرف الصحي عن الصناعي وتوصي بإشراك القطاع الخاص في مشاريع البنية التحتية.

Environmental impact of Desalination Brine Discharge on the Marine Ecosystem of the Arabian Gulf

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Water use in the GCC is the product of both remarkable scarcity and remarkable development. The GCC has about fifth renewable water on average than the rest of the Middle East, but desalination and non-renewable aquifers have largely closed this gap. Currently, there are about 1,490 desalination units operating in the Arabian Gulf countries, which account for 60% of the worldwide desalting plant capacity. The dominant plant type is multi-stage flash (MSF), which accounts for 87% of the desalting capacity. The MSF desalination process has proved to be the simplest, most reliable, and most commonly used seawater system in large capacities. Desalting processes are normally associated with the rejection of high concentration waste brine from the plant itself or from the pretreatment units as well as during the cleaning period. A major problem might arise however, from the additives used in the pretreatment and from corrosion products from the plant.

In this study thermal and brine dispersion from coastal MSF desalination plants was discussed. The very limited water resources in the Arab countries represent a major challenge. One of the solutions is to desalinate the seawater using the desalination plants. The effluents from desalination plants may adversely affect the water quality in its vicinity. This in turn will affect the environment and the ecosystem in the surrounding areas. The major concern of these impacts surrounds the outfall brine discharge because of its physical and chemical features. High salinity and high temperature of the discharge brine could have several negative impacts on the surrounding environment. The impact of salinity is more critical for RO plants due to the higher recovery rates. Moreover, despite GCC countries account for 60% of global desalination capacity, there are many knowledge gaps and uncertainties regarding the impacts of desalination projects on the marine environment. The study recommended: there is a need for cooperation and experience exchange between the water research centers in this field which will definitely lead to the optimum use of desalination plants with a minimum impact on the environment; experience and information exchange on different desalination techniques used in the Arab is very essential; and environmental Impact studies need much more regional ecotoxicological studies, where local species characteristics are analyzed, and their vulnerability on local effluent characteristics are assessed.

Wastewater Management in the State of Kuwait

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As global economies continue to grow, the strain on the earth's natural resources becomes increasingly clear and perhaps one of the most related issues facing us today is that of water availability. Droughts, explosive population growth in arid regions, and the continuous view that water is an infinite resource are reasons for water shortages in many regions in the world. In particular, the countries located in arid and semi-arid regions, such as the Arab countries faces critical deficits in water supply. In response to this problem, some wastewater professionals are reusing treated wastewater and have found it to be a reliable alternative water source. Moreover, in search of new sources of water, treated wastewater is a dependable and sustainable water resource that can augment overall water supply significantly. Its use for agriculture is attractive for many types of crops. However, the development of recycled water sector in the region needs proper planning and investment and to be treated as an integral part of overall water resources management strategy and plans. The most common reasons for establishing a wastewater reuse program is to augment water supply with new water sources to meet increasing water demands and to find an economical ways to meet increasingly more stringent discharge standards.

The social and economic development witnessed in Kuwait over the last half century was supported mainly by seawater desalination. Other water resources, including brackish groundwater were also exploited. Currently, wastewater effluents are available and can be utilized for greenery and other acceptable purposes. The deliberate use of reclaimed wastewater must be in compliance with applicable rules for a beneficial purpose (landscape irrigation, agricultural irrigation, aesthetic uses, groundwater recharge, industrial uses, and fire protection). The urban effluent is the only resource which increases with time and can be treated and utilized within the water management plans of Kuwait. In this research, the case of two wastewater treatment plants (Um Al Haiman and Al-Sulaibiya) were presented thoroughly. Kuwait treated wastewater is now considered as a new non-conventional source of water that can be used to supplement total water resources, which consist mainly of groundwater and desalinated water. In Kuwait, the wastewater system consists of a collection network, estimated at 800 km, has a coverage of more than 98% of the country, with 5 treatment plants distributed over the whole urban area in the country, with a capacity estimated at 800,000 cubic meters/day.

The demand for water in Kuwait has been continuously increasing. In response to this, authorities aimed to treat and reuse domestic wastewaters to: alleviate the stress on depleting scarce groundwater, provide an relatively inexpensive alternative than desalinated water, reduce the environmental adverse impacts of desalination plants, and eliminate the dumping of wastewaters to coastal areas or terrestrial landfills. Reuse of wastewater effluent could both minimize the disposal of water to the environment and reduce the demand on fresh water supplies. Since the wastewater treatment plants are owned and operated by the Ministry of Public Work (MPW), continuous monitoring of the quality and characteristics of the wastewater streams at the plants are made by by the MPW. The MPW plans to reuse all treated effluent. In addition, the government has made it clear that treated sewage effluents represent a valuable water resource, especially for irrigation and should assist in making a significant contribution to the national policy for the beautification of Kuwait.

توصيف الخزانات الجوفية (طبقة الدمام ومجموعه الكويت) في دولة الكويت

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تطرح المشكلة المائية نفسها وبقوه عندما تتعلق بدولة الكويت كما في باقي دول الخليج وذلك لمحدودية مصادر المياه الجوفية وعدم تجددها، بالإضـــافة إلى التكلفة العالية لبناء محطات التحلية التي يعتمد عليها كمصـــدر رئيس لتزويد المياه البلدية، وكذلك ارتفاع الكثافة السكانية (بالنسبة لحجم الخزان). من خلال الدراسات السابقة ودراسة الوضع الحالي للمياه الجوفية في دولة الكويت يتبين حدوث هبوط وتغير كبير ملحوظ ومستمر في منسوب المياه الجوفية في دولة الكويت, وذلك بسبب سحب المياه الجوفية بمعدلات تفوق معدلات تجددها نتيجة للسحب العشوائي غير المدروس لهذا المصدر المائي المهم وذلك في طبقة الدمام وفي مجموعه الكويت. لإدارة المياه الجوفية بكفاءة يتم استخدام النماذج الرياضية الرقمية كوسيلة يحاول بها المهتم والدارس تجسيم تصوره للخزان الجوفي, بصورة دقيقة, ليسهل عليه بعد ذلك دراسة وتحليل سلوك الخزان الجوفي، ومن ثم اتخاذ القرارات المؤثرة على إنتاجيته أو استدامته.

الهدف الرئيسي من هذه الدراسة هو التوصيف الفيزيائي لطبقات خزان الدمام ومجموعه الكويت باستخدام نظم المعلومات الجغرافية, ليستكمل في مرحلة قادمة هذا التوصيف في بناء نموذج رياضي يمثل النظام الطبيعي لخزان الدمام ومجموعه الكويت, ليتوفر لإدارة موارد المياه في دولة الكويت أداة إدارية تدعمها في أدارة الخزان وتنميته وحمايته. وقد تم في هذه الدراسة إلى عمل أكثر من خريطة لدولة الكويت تمثل مناسيب المياه وسماكة الطبقات المياه الجوفية لدولة الكويت وأماكن الآبار والمناطق الزراعية والناقلية لكل من مجموعه الكويت وطبقة الدمام.

الاستفادة القصوى من المياه المعالجة في دولة الكويت

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تعتبر دولة الكويت من أفقر الدول في العالم من حيث الموارد المائية الطبيعية، فليس لديها من مصادر المياه الطبيعية إلا المياه الجوفية المائلة للملوحة، كما أنها تقع في منطقة صحراوية تؤدي الظروف المناخية فيها إلى زيادة معدلات الفاقد في الماء بالتبخر. وعلى الرغم من هذا فإن المياه الجوفية تتعرض للاستنزاف نتيجة استخدامها في الأغراض الزراعية والصناعية فضلاً عن الأنشطة البشرية المختلفة، والتي تتزايد بشكل مطرد مع تزايد عدد السكان. لذلك أنشأت دولة الكويت ضمن خطتها التنموية محطات عدة لتنقية مياه الصرف الصحي في مناطق مختلفة منها (محطة تنقية الرقة وأم الهيمان والجهراء والصليبية وكبد والخيران)، ويتم العمل على توسعة كل منها حاليا، حيث أصبحت الاستفادة من المياه المعالجة حاليا أحد البدائل غير التقليدية للموارد المائية المستخدمة في دولة الكويت. إلا أن الرغبة في التوسع في استخدام المياه المعالجة يحدها الخوف والتحفظ من الجانب الشرعي والنفسي عند المجتمع الكويتي بالإضافة إلى الجانب الصحي والبيئي, علماً بأنه لا يوجد تشريع على شكل قانون كامل وملزم أو لائحة تنفيذية تنظم عمل منظومة الصرف الصحي إلا في بعض مواد اللائحة التنفيذية لقانون الهيئة العامة للبيئة وهو القانون رقم (21) لسنة 1995، والخاص بإنشاء الهيئة العامة للبيئة. وقد تم اعتماد اللائحة التنفيذية لهذا القانون في عام 2001 م. الهدف من هذه الدراسة هو تحقيق الاستفادة القصوى من المياه المعالجة في دولة الكويت وإدراجها كمصدر مائي في الموازنة المائية للدولة.

بشكل عام، لا توجد أضرار صحية من استخدام المياه المعالجة ثلاثياً – التي تنتجها محطات الصرف الصحي في دولة الكويت – في إنتاج المزروعات من الخضروات والثمريات، إذا كانت أساليب الإنتاج تعتمد المعايير والضوابط البيئية المنصوص عليها، والظروف الصحية المناسبة. وإذا كان هذا للمياه المعالجة ثلاثيا، فبلا شك فأن المياه المعالجة الرباعية أكثر سلامة وبعداً عن الأخطار الصحية، حيث تخضع هذه المياه إلى درجة متقدمة من التنقية، ألا وهي التحلية. وبناءاً على فتوى وزارة الأوقاف والشئون الإسلامية رقم 15هـ/95 المؤرخة في 1996/1/7 م التي تنص على طهارة المياه المعالجة ثلاثياً، وبناءاً على مطابقة مواصفات المياه المعالجة ثلاثياً المنتجة في محطات التنقية التابعة لوزارة الأشغال العامة في دولة الكويت للمعايير المطلوبة الخاصة بالهيئات العالمية للبيئة بشأن إعادة استخدامها، فأن هذه المياه المعالجة رباعيا يمكن إعادة استخدامها بلا قيود. هذا وقد توصلت الدراسة إلي إمكانية استخدام هذه المياه في المجالات التالية: مكافحة التصحر وزيادة الرقعة الخضراء في المناطق الصحراوية وزراعة الغابات ومصدات الرياح؛ زراعة الأعلاف والزراعة الحقلية للخضروات والنخيل والورود والزراعات التجميلية وغيرها؛ غسيل الأسطح للمباني، غسيل الشوارع، السيارات، غسيل المعدات الخاصة بأعمال التنقيب عن النفط وغيرها؛ حقنها في الأرض كمخزون استراتيجي للبلد؛ عمليات التبريد للمباني عن طريق (Chillers)؛ مزارع اسماك البلطي وغيرها؛ للترفيه وعمل بحيرات للمراكب الصغيرة في المنتزهات العائلية، النوافير، وملاعب الجولف؛ تغذية المحميات الطبيعية للطيور والحيوانات البرية؛ استعمال المياه المعالجة في الإنشاءات والبناء بدل المياه المنتجة من البحر؛ استعمال المياه المعالجة للصناعات المختلفة (الحديد – الألمنيوم – الورق).

الأمن المائي السكاني في سلطنة عمان، دراسة حالة محافظات شمال عمان

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يقصد بالأمن المائي السكاني أو البلدي الاحتياطي أو المخزون الاستراتيجي المائي لدولة ما في حال توقف محطات التحلية عن العمل وعدم قدرتها على إنتاج المياه لتزويد السكان لأي سبب كان. ويتم قياس هذا الاحتياطي بعدد الساعات أو الأيام التي يمكن فيها استمرار تزويد السكان بالاحتياجات المائية الرئيسية المتعلقة بأغراض الشرب والنظافة (دون الكماليات) في حال حدوث هذا الخلل في محطات التحلية. وبالنسبة لسلطنة عمان فأنه بالإضافة إلى قلة مواردها المائية فقد تعرضت خلال السنوات الماضية لأنواء مناخية وما زالت الظواهر غير الطبيعية التي تتعرض لها السلطنة مثل توالي الأعاصير المدارية والمد الأحمر التي تؤدي إلى توقف محطات التحلية المصدر الرئيسي لتوفير المياه للسكان وكذلك الأنشطة الأخرى الصناعية والسياحية. في هذه الدراسة, تم دراسة كيفية تحقيق الأمن المائي السكاني في سلطنة عمان. وقد توصلت الدراسة إلي أن الأمن المائي للسكان من خلال توفير مياه الشرب هو من أولويات الدول لمواطنيها والمقيمين عليها، وبذلت سلطنة عمان جهودا جبارة في هذا السبيل. إلا أن هذه الجهود ينبغي لها أن لا تتوقف نظرا لاستمرار الزيادة السكانية وهي ستقود إلى ضرورة إتباع إدارة جيدة للموارد المائية, وإذا لم تبذل الجهود في الوقت الحالي سيكون القادم أصعب وأكثر كلفة. وتوصي الدراسة في المقام الأول بأهمية العمل على زيادة تخزين المياه ويأتي قبل ذلك العمل على زيادة الموارد المائية والتي أصبحت المياه المحلاة إحدى أهم ركائزها. ونظرا لتكلفة المياه المحلاة العالية توصي الدراسة بضرورة التركيز على تطوير قدرات العاملين في مجال التحلية سواء عن طريق ابتعاث لدراسة نظم تحلية المياه أو تدريبها في هذا المجال، وكذلك ضرورة وضع الأسس وتوفير الموارد المالية لتخزين كميات مياه إضافية بما يكفي لمدة 10 أيام أو 5 أيام على الأقل حسب الموارد المالية التي يمكن توفيرها لهذا الغرض. كما انه من الأهمية العمل على تفعيل مبادئ الإدارة المتكاملة للموارد المائية، وبالأخص مبدأ إشراك المجتمع في تحمل مسؤوليته والمساهمة في جهود الدولة بزيادة تخزين المياه في عقاراتهم والعمل على الترشيد خاصة خلال الأزمات والكوارث الطبيعية التي تمر بها السلطنة.

Fourth Batch : (2012/2013)

Fourth Batch Students

No.	Name	Country	Project Title
1	Emad Hallaq	Bahrain	Evaluating the Problem of Non-Revenue Water (NRW) in the Kingdom of Bahrain
2	Rasha Hosny	Egypt	Impacts of Grand Ethiopian Renaissance Dam on the Blue Nile in the light of Aswan High Dam Impacts
3	Essa Bu Hamad	Kuwait	Evaluation of Barley Sprouts Performance in Quaternary treated sewage water and different salinity levels
4	Mohamed Zaidan	Libya	تقييم موارد المياه السطحية شمال الجبل الأخضر باستخدام نظم المعلومات الجغرافية
5	Ahmed Abd alsaleh	Libya	تقييم الوضع الحالي للإدارة المتكاملة للموارد المائية في منطقة شحات، ليبيا
6	Najat AlMesmari	Libya	الإدارة المجتمعية للغابات والمساقط المائية لحوض وادي الكوف بالجبل الأخضر، ليبيا، دراسة حالة
7	Hadil Faidy	Palestine	The Impacts of the Separation Israeli Wall on Water Resources in Palestine
8	Bahira Rasras	Palestine	Linking Financial System and Water Resources Management in Hebron City, Palestine, Using GIS
9	Abdullah Bu Tuwaibah	Saudi Arabia	إعادة استخدام المياه غير التقليدية في أغراض الري وتأثيرها على محتوى التربة من العناصر الغذائية الضرورية الكبرى في نطاق مشروع هيئة الري والصرف بالأحساء، المملكة العربية السعودية
10	Hesham AbdulMohsen	Saudi Arabia	تقييم الإستراتيجية المتكاملة لإدارة مصادر المياه غير التقليدية بهيئة الري والصرف بالأحساء
11	Ataka Zabarah	Yemen	دور الإدارة المتكاملة لموارد المياه في الحفاظ على نظم المقاشم / البساتين في مدينة صنعاء القديمة، اليمن
12	Alia Al Otoum	Jordan	Management of Groundwater Resources in Abu Dhabi Emirate, Al-Ain Area Case Study

Evaluating the Problem of Non-Revenue Water (NRW) in the Kingdom of Bahrain

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The Kingdom of Bahrain is a small island in the Arabian Gulf which used to depend on natural ground water to supply water to its population. Rapid increase in population has led the government to build desalination plants to meet the increase in urban water demands. Resorting to desalination have increased energy demands, led to negative environmental impacts, and have raised the financial burden on the government. The Government has two choices to lower the demand and its associated costs: 1) Implementing demand management measures to reduce household consumption to a reasonable level; and 2) Reducing non-revenue water (NRW) to an acceptable international level. These interventions are more cost-effective than the continuation of building desalination plants. The latter option requires investigating NRW in terms of levels, means of reduction, benefits and programs, and is the objective of this research.

Currently (2009), the Kingdom has a high percentage of NRW reaching 39% with leakage representing 28% compared to the World Bank recommendation of lower than 25%. A budget of 5.2M BD/year for a period of 4 years is required to replace the old network and to reduce the level of NRW slowly to the international standards. This will have the benefit of delaying the decision of building a new desalination plant in the Kingdom. Proper water management should result in bringing the water of the highest quality at the minimum cost, and reducing the water loss due to leakage should be one of the cost minimizing targets and should be prioritized. Establishing a leak control program is a must for managers and decision makers, which include field testing program for leak detection and reducing water pressure in the network to reduce leakage percentages.

Impacts of Grand Ethiopian Renaissance Dam on the Blue Nile in the light of Aswan High Dam Impacts

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The River Nile is the longest river in the world. The total area of the Nile basin is about 2.9 million km^2, and the river traverses eleven African countries. It is unique among the large exotic rivers of the world in that today it flows for almost 2700 km through the Sahara Desert without any significant tributary inputs.

The needs of water resource management and flood control strategy of the twentieth century witnessed the development of major river impoundments in the basin. Aswan High Dam (AHD) is considered one of the largest water infrastructures in this period. After the construction of AHD, the trap of sedimentation in the upstream portion of the Dam has resulted in significant alteration and changes in the downstream reach. These changes occur in several areas, such as: Bank stability and bank erosion, sedimentation, environmental effect, coastal zone, Morphology, and flow pattern.

The Blue Nile originates from Lake Tana on the Ethiopian Plateau; a region of high summer rainfall at about 1800 m above sea level with annual inflow of the Blue Nile is about 50 BCM, Suspended sediment inflow 140 M ton and suspended transport yield of 480 $t/km^2/yr$ for the Blue Nile a above El-Deim Station.
Ethiopia now is trying to build a lot of dams on the Blue Nile, without taking into consideration the effect of these dams on the downstream reach, especially on Sudan. Impact of the Grand Ethiopian Renaissance Dam will be studied, as a case study of these dams, in the light of the impacts of AHD on Egypt using the previous studies which have been conducted in these areas and evaluate the impact of any proposed similar water infrastructure on the downstream reach. Reservoir sedimentation has been selected as an example of these impacts, and its possible impact on downstream reach (on Sudan).

Eizeldin (2012) stated that the reservoir trap efficiency and reservoir useful time can be determined using both Nile reservoirs capacity inflow ratio; For example (Renaissance Dam Reservoir) the initial volume of the reservoir (C_o) = $74km^3$, average annual inflow of water (I) = 50 BCM, inlet sediment (Qs_{in}) = 280 Mt\year, and appropriate average value for the sedimentation factor (β) = 0.035 (0.015 to 0.056); the Expected trap efficiency (TE) is equal 97% at the beginning of the operation.

Evaluation of Barley Sprouts Performance in Quaternary treated sewage water and different salinity levels

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Arid and semi-arid regions facing scarcity in fresh water resources, digging illegal well leads to degradation in water quality of groundwater to high content of dissolved salts, using alternative source of water like treated sewage water at quaternary stage is ideal for fodder production in which consume large amount of water to during the season. Barley crop (*Hordeum vulgare L.*) is popular as a forage in the Gulf Cooperation Council Countries. An experiment was conducted at a room temperature and humidity average of 65% using complete randomized block design with three replicates to evaluate yield, water use efficiency, water use, dry matter content, germination percent and nutritive value irrigated with quaternary treated sewage water and different levels of NaCl concentration solution under soilless cultivation methods. High grade of commercial Barley seeds with 95 germination percent were soaked in 20% house bleach to disinfect the seeds from germs, then sown with rate of 4.57 kg/m^2 in trays. Barley seeds were irrigated daily with quaternary treated sewage water(T_1) or, tap water as a control (T_2), NaCl solution with TDS of 3000 ppm, 6000 ppm, 9000 ppm, and 12000 ppm (T_3, T_4, T_5, and T_6 respectively). Experiment was terminated at the ninth day to collect data of water use, water use efficiency, plant height, dry matter and nutrition value. Result shows that using quaternary treated sewage water to irrigate Barley sprouts have no significant difference in yield with tap water or 3000 ppm NaCl solution, and the yield noticed to be decreased affected by increase the salinity in the water. Quality of the fodder irrigated with quaternary sewage water has no big differences withother treatment. Producing commercially fodder for livestock using quaternary treated sewage water in soilless cultivation method increases the water use efficiency through the year.

تقييم موارد المياه السطحية شمال الجبل الأخضر باستخدام نظم المعلومات الجغرافية

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يهدف هذا البحث إلي دراسة شبكة أحواض الجبل الأخضر الواقعة شمال شرق ليبيا وتمثل مصدر رئيسي للمياه السطحية الموسمية. تمت دراسة الأحواض على أساس الخصائص المورفومترية والمكانية باستخدام تقنيات نظم المعلومات الجغرافية والاستشعار عن بعد، واستخدام نموذج الارتفاعات الرقمية (ASTER) وذلك بتحليل الخصائص المكانية والمورفومترية لمناطق الاحواض باستخدام برنامج(ARCGIS) وبرنامج الاحواض الساكبة (WMS) بغرض معالجة نموذج الارتفاعات الرقمية. وتم تحديد خمسة مساقط مائية (الكوف ,بالعارض, المملوح, المهبول, العربية)، حيث يتناقص ارتفاعها فى القيمة ويزداد الميل كلما اتجهنا شمالا.

تم إجراؤه التحليل المورفومترى، استنادا إلى تصنيف ستراهلر (Strahler) والذي اظهر نقص فى تعداد الرتب مع زيادة قيمتها ونسبة التشعب التي تظهر نقص متماثل فى قيمتها من رتبة إلى الرتبة التي بعدها، حيث تدل القيم العالية على الجيولوجيا التكتونية العالية بمنطقة الاحواض..كما تم دراسة إشكال المساقط المائية بمعادلات رياضية مختلف، وكان اقرب شكل للمساقط المائية هو الشكل البيضاوي مع كثافة تصريف تقريبا متساوية لكل المساقط المائية ماعدا المسقط المائي ذو الميل الحاد مقارنة بالمساقط المائية الأخرى. كذلك، صُنفت كثافات التصريف ككثافة تصريف خشن. وأظهر طول التدفق العلوي الارضى قيم منخفظة دالا على انخفاض التضاريس.

ونظرا لاهتمام العديد من المؤسسات في ليبيا بهذا الموضوع، فقد تم الاستعانة ببعض الدراسات السابقة والمحدودة، إلا انه فى ظروف عدم التكامل بينها فقد كانت عملية الحصول على البيانات منها ليست سهلة. كما تم اقتراح سيناريو للمؤسسات المتخصصة في حصاد المياه لمواجهة التحديات والمعوقات التي تواجه إمكانية الاستثمار والتنمية وفقا لمفهوم الإدارة المتكاملة للموارد المائية من اجل الاستغلال الأمثل لهذه الثروات.

تقييم الوضع الحالي للإدارة المتكاملة للموارد المائية في منطقة شحات، ليبيا

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شهدت منطقة شحات خلال العقود الأربعة الماضية نمواً سكانياً صاحبة تطور عمراني شمل إنشاء منظومات إمداد مياه الشرب ,حيثُ اعتمدت في معظمها إلى وقت قريب على مصادر المياه الجوفية .ونتيجة للطلب المتزايد على المياه فقد تم اللجوء إلى المصادر غير التقليدية كالمياه المحلاة لسد هذه الاحتياجات .ولكن بالرغم من كمية المياه التي تفوق بكثير معدل الاحتياج المائي للقطاع البلدي إلا أن الوضع الحالي للمياه يمكن وصفه بالحرج في ضوء الاستهلاك غير الرشيد للمياه وتخصيص الآبار الجوفية من دون وضع شروط أو قيود عليها.
كما شمل التطور العمراني أيضاً منظومات لتجميع ومعالجة والتخلص من مياه الصرف الصحي لغرض حماية الصحة العامة والبيئة , إلا أنها لم تكن بالمستوى المطلوب وآلت إلى التدني بعد وقت قريب من مباشرة عملها، مما يضع بعض التساؤلات التي تطرق إليها البحث بشكل مختصر عن تأثر المياه الجوفية بالتلوث نتيجة الأنشطة الإنسانية.

هدفت هذه الدراسة إلى تسليط الضوء على الوضع المائي الحالي لمصادر المياه واستخداماتها في القطاع البلدي ,وكذلك تحليل الأوضاع المائية وتقييم مستوى الإدارة المائية ,ووضع توصيات واقتراح بعض الحلول التي من شأنها أن تساهم في إدارة مصادر المياه بشكل مستدام وفقاً لمفهوم الإدارة المتكاملة للموارد المائية. ولتحقيق هذه الأهداف فقد ركزت الدراسة على تجميع البيانات عن حالة الموارد المائية في المنطقة، حيث تم تحديد وتقييم الموارد المائية المستغلة وعمل الموازنة المائية في القطاع البلدي، كما تم تقييم مستوى الإدارة المائية وذلك بأتباع بعض المؤشرات الرئيسية التي تعكس مدى مستوى الإدارة المائية في منطقة شحات. ومن ناتج تقييم الإدارة المتكاملة للموارد المائية فقد اتضح أن معظم المشاكل المتعلقة بالمياه في المنطقة هي مشاكل إدارية في الأساس قبل أن تكون فنية ,وكذلك وجود خلل في التشريعات المائية، لذلك يجب الإصلاح الشامل لقطاع المياه في ليبيا من خلال تهيئة بيئة تمكينية ملائمة تشمل جميع السياسات والتشريعات المائية مع تفعيل دور المؤسسات المائية لعمل قاعدة بيانات وتمكين مشاركتها ومشاركة أصحاب المصلحة في اتخاذ القرار.

الإدارة المجتمعية للغابات والمساقط المائية لحوض وادي الكوف بالجبل الأخضر، ليبيا، دراسة حالة

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هدف البحث إلى تقييم الوضع الراهن للموارد المائية الذي يؤثر على كثافة الغطاء النباتي في الجبل الأخضر، شمال شرق ليبيا، والتي تعتبر غنية نسبياً في مواردها المائية حيث تحظى بأعلى معدلات لهطول الأمطار عن عموم البلاد، وتتجمع المياه السطحية في العديد من الأودية الموسمية .دُرِسَ حوض وادي الكوف الواقع في منتصف الجبل الأخضر كمنطقة ممثلة لبيئته، ووضع بعض الحلول للمشاكل المرتبطة بإدارة الموارد المائية التقليدية وانعكاساتها على الغطاء النباتي الطبيعي، بالإضافة إلى تطوير الرؤية المستقبلية للإدارة التي من شأنها أن تعزز إمكانية الاستثمار السليم للمياه السطحية لدعم الاستخدام المستدام من خلال تقنيات حصاد المياه السطحية المختلفة. توفر كميات كبيرة من المياه (Forested catchment) بالرغم أن المستجمعات المائية للغابات المستخدمة في تلبية الاحتياجات المنزلية والزراعية والصناعية، والتي يتأثر توافرها وخاصة جودتها بالغابات، إلا أن هذا المورد لم يعامل كأحد الموارد الطبيعية الهامة . لذا فقد اقترح استخدام نظام إدارة أكثر شمولا وتكاملا في المنطقة للحفاظ على هذه الموارد الطبيعية معتمداً على الإدارة المجتمعية .وتم تقديم الإطار المؤسسي بشكل تفصيلي شاملاً مشاركة أصحاب المصلحة، وفقاً لنظام الإدارة المتكاملة للموارد المائية.

وأوصى البحث بضرورة تنمية القدرات على المستوى المؤسسي HIMA . ونظام إدارة الحمىIWRM والمجتمع المحلي، و تفعيل دور المرأة ، وزيادة الوعي البيئي للمجتمع بإتباع نظام مفهوم الحمى ومنهج الإدارة المتكاملة للموارد المائية على أساس المشاركة لكل أصحاب المصلحة من أجل تحقيق التنمية المستدامة. كما أوصىالبحث باستخدام التكنولوجيا المتقدمة لدعم أدوات اتخاذ القرار مثل نظم المعلومات الجغرافية والاستشعار عن بعدGIS .

The Impacts of the Separation Israeli Wall on Water Resources in Palestine

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The physical construction of the Separation Wall is new, but the philosophy or purpose behind the Wall is not. The Wall's first phase has a multidimensional impact which works to ensure Israeli domination over natural resources; both water and land. The overarching category that highlights the significance of water in the first phase is twofold. First, the location of the Wall's first phase and its path above the best Palestinian potential abstraction areas of the Western Aquifer reflects Israel's goal to complete its control over the richest groundwater sources in Palestine. Second, as water is crucial to a sustainable future Palestinian state, Israel's overall control on water resources consistent with its water policies will lead to further impoverishment, landlessness and existential and national threat to Palestine.

The erection of this wall causes great negative impacts that have strategic dimensions on the Palestinians. The erection of this wall will isolate some of the Palestinian rural communities from the West Bank thus becoming in completely isolated areas, and the entering and exit to and from these areas will be extremely difficult, and also caused to the cutting of large areas from the agricultural lands, thus preventing its owners from entering to their lands in addition also to the Israelis control on so many wells that are being utilized for domestic and agricultural purposes. As a whole, we can say that this wall has negatively affect the social, economic, and political situations, cause the Israelis control on the Palestinian water resources and the agricultural lands creates big and serious obstacles that makes it hard for the Palestinians to manage their water resources and denying the right of the Palestinians to utilize their natural resources which will negatively influence the whole Palestinian life. There is no real-time data that shows the actual impact of Wall construction on surface water in the West Bank. However, it is highly expected that the distribution of the surface runoff on the watersheds will be disturbed and consequently changed. In depth investigations are needed to evaluate how, how much, and where the water resources of Palestine are impacted. Water quality is also expected to be affected as a result of active and prolonged vehicles movement in addition to surface soil disturbance. Field studies and researches are highly needed at this stage to assess the real impact of the Wall on the water resources. So here we start to focus on studying on these impacts.

Linking Financial System and Water Resources Management in Hebron City, Palestine, Using GIS

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Geographical Information System (GIS) has been utilized as a useful tool for improving the processes and effectiveness of the water distribution management in Hebron city, which suffers from water scarcity, especially during summer season. The objective of the study is to establish a link between the financial system and the water supply management system in the city. The water distribution network have been automated in a GIS environment, divided into service zones, and is used to analyze all available municipal water supply data to determine some useful parameters and to develop a number of indicators that can be utilized in the analysis of the water distribution network and to help improving water distribution. These included linkage between consumption derived from billing system with property size and service zone, which can help in determining the level of water distribution management in Hebron Municipality and find the best way to improve the processes of water distribution management, such as service zone for best network, distribution-maintenance and fees collection. The indicators that have been used are: population, number and use of units, number of subscriptions, number and capacities of domestic wells, and length of water pipe lines in each pressure zone. The study recommends the installation of a number of water networks and encouraging citizens to subscribe to the municipalities water supply service. It is also recommended that citizens are encouraged to build collecting wells or install tanks for water harvesting and zones including high water consumers such as hotels and industries are separated from other domestic subscribers.

إعادة استخدام المياه غير التقليدية في أغراض الري وتأثيرها على محتوى التربة من العناصر الغذائية الضرورية الكبرى في نطاق مشروع هيئة الري والصرف بالأحساء، المملكة العربية السعودية

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تهدف هذه الدراسة الى تقدير تركيز العناصر الكبرى (N.P.K) في نوعيات المياه المختلفة (مياه جوفية ، صرف صحي معالج ثلاثيا ، مخلوطة (جوفية + صرف صحي معالج ثلاثيا + صرف زراعي)) والمستخدمة في الري بمشروع هيئة الري والصرف وتقدير القدرة الإمدادية للتربة الزراعية من هذه العناصر في اعماق مختلفة (0-30 ، 30 -60 ، 60-90 سم) في مناطق الدراسة وعلاقة ذلك بكميات العناصر المغذية الكبرى (N.P.K) في المصادر المختلفة والتي تضاف مع كميات مياه الري والموجودة بالتربة القابلة لإفادة النبات ومقارنتها مع الاحتياجات السمادية لمحصول النخيل وتحديد كفاية أو عدم كفاية هذه الكميات لسد الاحتياجات للمحصول بالتوصية السمادية التي تنتهجها ادارة الارشاد الزراعي بمشروع هيئة الري والصرف والتي تتمثل في اضافة (5 كيلوجرام نيتروجين على ثلاث دفعات ، و 3 كيلو جرام فوسفور على دفعتين ، و 3.5 كيلوجرام بوتاسيوم على ثلاث دفعات بإضافة 75 كيلو جرام سماد عضوي لكل نخلة عند الري بمياه جوفية) للخروج بتوصية سمادية تتلاءم مع النتائج المتحصل عليها وأثرها على المُزارع من حيث الجدوى الاقتصادية والمحافظة على البيئة.

وبينت النتائج ان تقديرات التراكيز للعناصر الغذائية الكبرى (N.P.K) في نوعيات المياه المستخدمة في الري (المياه المخلوطة ومياه الصرف الصحي المعالج تزيد بمقدار (2-3 مرات) عنها في المياه الجوفية) وهي تتراوح بين ((13.52 ،11.3 ،5.0) (mg/l)) بالنسبة لنيتروجين على التوالي كما ان تراكيز قيم الفسفور هي ((11.0 ،7.4 ،3.0) (mg/l)) وقيم البوتاسيوم هي ((26.0 ،28.0 ،11.5) (mg/l)) وهذه القيم تعتبر في الحدود الامنة لاستخدامها في اغراض الري الزراعي.

كما ان تراكيز العناصر المغذية الكبرى (N.P.K) في الترب المروية بمصادر المياه المختلفة تكون اكبر في الطبقة السطحية وتقل كلما زاد العمق وفق الاتي الترب المروية بمياه جوفية ((28.31 ،21.3 ،16.0) (mg/kg) (N)) ((7.3،11.8 ،5.5) (mg/kg) (P)) ((15.6 ،11.4 ،9.8) (mg/kg) (K)) ، الترب المروية بمياه صرف صحي معالج ((62.3 ،40.1 ،30.9) (mg/kg) (N)) ، ((27.5 ،21.2 ،15.0) (mg/kg) (P)) ، ((27.0 ،18.0 ،12.4) (mg/kg) (K)) ، الترب المروية بمياه مخلوطة ((65.0 ، 38.5 ، 22.3) (mg/kg) (N)) ، ((19.8 ، 14.9 ، 11.9) (mg/kg) (P)) ، ((22.0 ، 17.3 ، 11.8) (mg/kg) (K)).

وحسب التوصية السمادية لمحصول النخيل التي تنتهجها ادارة الارشاد الزراعي فان كمية السماد المعدني التي يضيفها الُمزارع في الهكتار الواحد لكل موسم نمو عند استخدام مياه جوفية في الري تبلغ (1107 كجم) بقيمة مالية (3690 ريال). وبناءَ على النتائج المتحصل عليه يمكن التقليل من اضافة الاسمدة المعدنية (النيتروجين والفسفور) والاستغناء عن اضافة عنصر البوتاسيوم الى التربة عند استخدام مصادر المياه غير التقليدية. فان المُزارع الذي يستخدم مياه ري مخلوطة يحتاج ان يضيف في الهكتار الواحد لكل موسم نمو كمية من السماد المعدني تبلغ (303.5 كجم) بقيمة مالية (1425 ريال) وبالتالي نسبة ما يضيفه المُزارع من السماد المعدني عند الري بمياه مخلوطة (27.4 %) من الكمية التي تضاف عند استخدام مياه جوفية في الري ليوفر (61 %) من القيمة المالية ، والُمزارع الذي يستخدم في الري مياه صرف صحي معالج ثلاثيا يحتاج ان يضيف سماد معدني في الهكتار الواحد لكل موسم نمو (461 كجم) بقيمة مالية (1710 ريال) وبالتالي نسبة ما يضيفه المُزارع من السماد المعدني عند الري بمياه صرف صحي معالج ثلاثيا (41.6 %) من الكمية التي تضاف عند استخدام مياه جوفية في الري ليوفر (53.7 %) من القيمة المالية ، مما سينعكس على المُزارع بشكل ايجابي بالحصول على الانتاج الاعلى بأقل المصروفات وعدم الاخلال بالتوازن البيئي.

تقييم الإستراتيجية المتكاملة لإدارة مصادر المياه غير التقليدية بهيئة الري والصرف بالأحساء

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هدف هذا البحث إلى تقييم استراتيجية هيئة الري والصرف بالأحساء في إدارة مياه الرى فى التحول من الأعتماد الكلي على المياه الجوفية إلى المصادر غير التقليدية لمياه الري (مياه الصرف الصحي المعالجة ثلاثياً ومياه الصرف الزراعي). وبينت نتائج البحث أنه فيما يخص التحول من الإعتماد على المياه الجوفية كمصدر أساسى لتوفير مياه الري أن الهيئة قد قطعت شوطاً لا بأس به في توفير المصادر البديلة للمياه الجوفية من مياه الصرف الصحي المعالجة ثلاثياً بكميات تزداد من عام لآخر وفى نفس الوقت يقل أعتمادها على المياه الجوفية كمصدر أساسي لمياه الري، وبأن المياه الجوفية التي كانت تمثل 100% من مصادر مياه الري بالمشروع عام 1974م أصبحت حاليا (2012) تستخدم كمصدر مساند للمصادر غير التقليدية لمياه الري بالمشروع وتمثل ما نسبته 12% فقط من أجمالى كميات المياه المستخدمة لأغراض الري الزراعي بالواحة، في حين أن كميات مياه الري المستخدمة من المصادر غير التقليدية تمثل النسبة الباقية من إجمالى كميات المياه المستهلكة للري في نطاق مشروع الري والصرف بالأحساء، ما يعد توفيرا كبيرا نسبيا في كميات المياه الجوفية غير المتجددة. كما نجحت الهيئة خلال العشر سنوات الماضية (2003 – 2013) في تطبيق برامج المراقبة والمتابعة لنوعية المياه المعالجة والتحقق من مطابقتها للمواصفات والمعايير الواردة باللائحة التنفيذية لاستخدام المياه المعالجة من خلال خطتها بتطوير مختبرات مراقبة الجودة وتأهيل الكوادر الوطنية المتخصصة في هذا المجال، ما كان له الأثر الإيجابي في استخدام هذه النوعية من مياه الري والتى لها خواص كيميائية أصبحت تتفوق على المياه الجوفية كمصدر بديل من حيث تركيز الأملاح الذائبة (1000-1100 مجم/لتر)، وكذلك محتواها من العناصر الغذائية الضرورية. من جهة اخرى نجحت الهيئة في إيجاد قناعة ورضى عند المزراعين وكسر الحاجز النفسي لديهم وبالتالى تقبل استلام واستخدام هذه النوعية من مياه الري، وذلك من خلال تنفيذ برامج توعية كان لها الأثر الايجابيى في تغيير بعض المفاهيم الخاطئة لديهم حيال استخدام المياه المعالجة. أما فيما يخص تغيير البنية التحتية للمشروع من نظام النقل والتوزيع بالقنوات المكشوفة إلى نظام النقل والتوزيع بالأنابيب المغلقة، ونظام التحكم الآلي لتوزيع مياه الري على المزارع المستفيدة، فقد قامت الهيئة بتنفيذ البنية التحتية للمشروع في 10% من المساحة الكلية المروية وجاري العمل على تنفيذ إجمالى مساحة قدرها 70% من مساحة المشروع. ومن المتوقع أن يسهم ذلك في رفع كفاءة استهلاك المياه بالمشروع وتوفير ما نسبته 39% من كميات المياه المستهلكة لري نفس المساحة من خلال توفير فواقد النقل والتوزيع، ورفع الكفاءة الحقلية لنظام الري المتبع، ما سوف ينعكس إيجابياً على ترشيد استخدام كميات المياه من المصادر المتاحة ورفع كفاءة الاستخدام لأعلى حد ممكن. ومع تغيير البنية التحتية للمشروع وتطبيق نظم الري الحديثة بالمزارع من المتوقع انخفاض الاحتياج المائي الكلى من 12.6 إلى 6.7 م^3/هكتار/يوم، إي ما يساوي 59 م^3/هكتار/يوم، وبذلك تكون الكمية المتوقع توفيرها سنوياً حوالي 69 مليون متر مكعب (46.83%) على اعتبار أن المساحة المروية حالياً 3200 هكتار.

دور الإدارة المتكاملة لموارد المياه في الحفاظ على نظم المقاشم / البساتين في مدينة صنعاء القديمة، اليمن

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تواجه اليمن تحديات سياسية واقتصادية واجتماعية عديدة ومن ابرز هذه التحديات مشكلة نقص المياه حيث تعتبر اليمن من أفقر عشر دول في المياه, ومن هنا تكمن اهمية الحصاد المائي وترشيد استهلاك المياه ومعالجة المياه العادمة واعادة استخدامها للزراعة , وتم اختيار ثلاث مدن يمنية تاريخية من قبل منظمة اليونسكو وهى شبام حضرموت وزبيد وصنعاء القديمة كموروث ثقافي عالمي و مقاشم/بساتين (قطعة ارض تم وقفها من قبل الاسر الغنية لصالح المسجد لزراعتها مقابل نظافة المسجد) صنعاء القديمة من ضمن صنعاء القديمة, ومشكلتها انها تتعرض الى الضغوط البشرية Anthropogenic والطبيعية Natural pressures التى باتت تهدد استدامتها . وكذلك تهديد رفاهية السكان القاطنين حول المقاشم/ بساتين , مما يتطلب اتخاذ خطوات جادة نحو حماية بيئة المقاشم/ بساتين والموارد الزراعية الناتجة منها عن طريق ادارة متكاملة تحافظ على استدامتها وتراعي مصالح السكان حولها ولاسيما ان هناك ضغوط راهنة على المقاشم تتمثل في البناء على ارض المقاشم /بساتين وتدهورها ونضوب مياة ابار المساجد مما ادى الى تصحرها نتيجة عدم استخدام مياه المطاهير فى ري المقاشم /بساتين.

وتهدف الدراسة الحالية الى الحفاظ على استدامة موروث تاريخي وثقافي وقد تم استخدام
اولاً: المنهج الوثائقي الذي تم فيه الأطلاع على الدراسات السابقة
ثانياً: توثيق المعرفة التقليدية لنظام المقاشم عن طريق وصف منظومة مائية فى احدى مقاشم صنعاء القديمة .
ثالثاً: تقييم الوضع الحال لمقاشم مدينة صنعاء عن طريق المسح الميداني.
رابعاً: إجراء تقييم بيئي متكامل لحالة المقاشم تم فيه التعرف على حالة المقاشم S ، وأسباب تدهورها D&P، وآثار التدهور I، وسبل حفظها R .
أستبيان للسكان المحليين
مقابلة للجهة المسؤلة عنها –الاوقاف-
تحليل السياسات، السيناريوهات المستقبلية
السياسات المقترحة لحماية المقاشم.
دور الادراره المتكاملة لحماية المقاشم

واستنتجت الدراسة
من خلال الزيارات الميدانية ان المقاشم/بساتين صنعاء القديمة تتعرض للاندثار وهناك 5% من عددها تحول الى مبانى و2% تحول سوق و 2% تحول الى موقف سيارات و49% منها متصحره و42% منها مزروع جزء منها.
ونتائج الاستبيات الذى تم على 25فرد من سكان مدينة صنعاء القديمة 44% ذكور، و 56% أناث متوسط عمر 47 سنة , تم سوائل العينة هل سيتم زراعة المقاشم اذا تم توفير الماء وافاد 92%من العينة بنعم و4% بلا.
واوضحت تحاليل DPSIR ان انة يوجد سياسات ولكن هناك تضارب فى تنسيق المهام بين الجهات المختصة وعدم تمكين الجهات المختصة من تنفيذ أعمالها.
ولاستدامة المقاشم لابد من عمل الاتى

- المصادقة على قانون الحفاظ على المدن التاريخية للمحافظة على صنعاء القديمة من ضمن قائمة التراث الانسانى العالمى.
- الادارة المتكاملة لموارد المياه في منضومة المقاشم من حيث:
  - حصاد مياة الأمطار المصدر الوحيد لتغذية حوض صنعاء المائى.
  - إعادة إستخدام مياه الوضوء فى رى المقاشم/بساتين صنعاء القديمة وخاصة للمساجد التى تم ربطها إلى شبكات الصرف الصحي, وتغيير نظام الرى بالغمر إلى نظام الرى بالتنقيط لتوفير المياة.
  - عمل محطات مصغره فى المقاشم لتكرير المياة الرمادية للمنازل المجاوره (خاصة إنه سيتم إعادة تأهيل شبكة الصرف الصحي لصنعاء القديمة بعد إنتهاء عمرها الإفتراضي).

Management of Groundwater Resources in Abu Dhabi Emirate, Al-Ain Area Case Study

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Lack of sufficient quantities of water in the United Arab Emirates (UAE) is one of the major problems facing sustainable development. The arid climate of the country and heavy pumping of groundwater play a significant role in the water resources availability. The continued reduction of water storage will hinder the development in the country.

To avoid this problem, integrated water resources management (IWRM) strategy should be implemented. This paper aims to assess the level of the groundwater resources management system in Abu Dhabi Emirate (Al Ain as a Case study) and to identify management gaps and challenges which help decision makers in achieving sustainable groundwater resources management.

To achieve the above objectives, the following steps were used: collecting data on water recourses and water use, applying groundwater management assessment tools on Al Ain area, identifying the main gaps and challenges facing ground water management, and proposing management policies and interventions. Based on this study, the following results were noticed: Al-Ain groundwater resources were found to be in stage 3; i.e., experiencing an unstable development, which is categorized by uncontrolled abstraction with irreversible aquifer and conflict between stockholders; the current management level is not adequate (from 0 to 2 instead of 3); Abu Dhabi Emirate has adequate technical tools; and there is a clear management deficiencies or gaps in the institutional instruments and management actions.

In conclusion, the necessary management level and interventions are inadequate and lag behind the level of the critical groundwater development stage. In addition, there is a major deficiency in the institutional instruments (i.e., water rights, regulatory provisions, water legislation, stakeholder participation, awareness and education, and economic instruments) and management actions (i.e. prevention of side effects, resources allocation, and pollution control) as compared to technical tools. In other words, the major challenge in Al Ain area is a management challenge and not a technical challenge.

Fifth Batch: 2014-2015

Fifth Batch Students

No.	Name	Country	Project Title
1	Fadia Tashtoush	Jordan	SWOT Analysis of the Agricultural Sector in Bahrain
2	Al-Anoud Al-khatlan	Kuwait	The Potential of Using Treated Sewage Effluent from Askar Wastewater Treatment Plant in landscaping (Coastal zone management of Askar village)
3	Bashar k. Alfadhli	Kuwait	A comparative Study between the Quality of Tap Water and Bottled Water in the State of Kuwait
4	Eiman Mohammad Mansoury	Kuwait	Assessment of irrigation performance for fodder crop production in Abdaly area
5	Ghada Sadiq AL-Haddad	Bahrain	Performance Assessment of Distillers in Sitra Power and Water Station
6	Sami I. AlAboud	Saudi Arabia	Benchmarking Approach for the Evaluating of Water Utilities in the Gulf Cooperation Council

SWOT Analysis of the Agricultural Sector in Bahrain

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Supervised by
Dr. Abdelhadi Abdelwahab
Prof. Ahmed Ali Salih

Freshwater is increasingly seen as a key constraint on food production. At the global level, agriculture alone accounts for about 80% of the fresh water use. As population keeps increasing, more food needs to be produced, and consequently requires more fresh water demands. Therefore, there is an immense pressure to reduce agricultural water use to fulfill the growing demands of the domestic and industrial sectors.

In Bahrain, as in the other GCC countries, the agricultural sector has attracted rising concerns and development focus due to supply shocks, increasing food demand and prices, and experienced impacts of climate change. Bahrain cannot achieve self-sufficiency due to its limited water resources, limited arable lands, and unfavorable climatic conditions, but there are serious food security concerns that the gap between what is imported and what is produced locally should be narrowed. Therefore, Bahrain should establish an efficient local agricultural production system that can maximize food production to reduce food imports with optimum use of water resources.

The objective of this research is to evaluate the current status and performance of the agricultural sector in Bahrain by conducting a SWOT analysis, to identify strengths and weaknesses, and explore opportunities and threats of the sector.

The results indicated that the agricultural sector in Bahrain is in need of further initiatives and support. Achieving maximum agricultural development, despite the limitations, can be realized by expanding the use of treated waste water (TWW) for irrigation, introducing irrigation water saving techniques and practices, adoption of new production techniques like soilless agriculture, cultivation of less water demanding fodder crops, conducting agricultural research that focuses on improving irrigation water use efficiency and deficit irrigation techniques, training of the agricultural man-power sector, and motivation of the private sector to invest in modern agriculture. Better marketing of local agricultural products and more cross-sectoral planning and integration, across the entire agricultural production chain and water management sector is also required. Institutionally, the regulations on groundwater utilization needs to be enforced, together with better monitoring of quality and level through coordination between the different sectors involved. Market chain analysis is needed to realize full benefit to farmers and consumers.

The Potential of Using Treated Sewage Effluent from Askar Wastewater Treatment Plant in landscaping (Coastal zone management of Askar village)

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The discharge of untreated and partially treated sewage water is the main source of organic, microbial and heavy metals pollution to the marine environment. Accordingly, arid and semi-arid countries are increasingly attempting to integrate wastewater in their national water policy and plans. In Bahrain, about 301,300 m3 of sewage are produced daily, with most of the sewage treatment plants (STPs) receiving influent more than their design capacity. Askar STP is receiving 40% above its design capacity, which leads to the discharge of the excess amounts to the coastal area, either as untreated or partially treated. The objectives of this research are to investigate the potential of utilizing treated wastewater in irrigating the landscapes of King Hamad Highway, which is located adjacent to Askar STP and is subjected to sand drift, and to reduce the pollution in the Askar surrounding marine environment.

Seven water samples were collected from the study area. Colilert method was the only test which applied for the whole 7 samples and it was to analyze the total coliform and E.coli. Additional analyses were applied only for station no.3 which is located at the STP outlet to test the ability of using this effluent for landscaping. These tests are Salinity using Electrical Conductivity, Ca, Mg, Na and K elements using ICP_OES. The pH and Nitrogen values were provided by ministry of works. Sodium Adsorption Ratio (SAR), daily nutrients loss and water requirement for trees were calculated. Software JMP was used for statistical analysis.
The results indicated that, expectedly, the maximum total coliform the E. Coli concentration was at the STP outlet (5,044,666 MPN/100ml and 1,198,000 MPN/100ml) both exceeding the standards of the Royal commission for Jubail and Yanbu.

The volumetric rate of 410 m3/day of Askar effluent can fulfill the water requirements for 2,733 trees, which requires about 150 liters/day/tree. Moreover, this treated wastewater contain high amount of nutrients that is lost without beneficial use. The average content of N, Ca, Mg, and K were 7.7, 18, 1 and 5 Kg/day, respectively. The average SAR and EC were calculated at 4.42 and 0.76, respectively, which are acceptable values for irrigating the landscape area along the highway to combat sand drifting. In conclusion, untreated sewage represents a serious environmental issue to the coastal areas, while it can be used safely for irrigating the landscape. It is recommended that that partially treated wastewater is used in irrigating landscape crops with restriction by using selective methods of irrigation with good personnel hygiene.

A comparative Study between the Quality of Tap Water and Bottled Water in the State of Kuwait

Bashar k. Alfadhli e-mail: bashar2u@gmail.com, Supervised by **Prof. Waleed AlZubari** **Prof. Ahmad Ali Saleh**	

Although the government provides tap water with good quality drinking water for its population with continuous non-interrupted supply, many people prefer to use bottled water. This research investigated the microbiological quality of drinking water (micro-organisms count, in colony forming units, CFU) and the salinity (Total Dissolved Solids (TDS), mg/L) for samples from tap water and bottled water. The results showed a clear variation between the TDS measured in bottled water and that indicated on the bottles labels. Moreover, some bottled waters had a microbial contamination; however, it is suspected that this contamination is made by human errors in experimenting. It is recommended to decrease bottled consumption for a number of reasons, the most important of which is that there are no guarantees on the proper storage of these water in terms of heat and humidity, as observed by field investigation and research, and that the cost of bottled water sold in Kuwait are far more expensive than the cost of the tap water which is highly subsidized and is within the drinking water quality standards.

Assessment of irrigation performance for fodder crop production in Abdaly area

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Supervised by
Dr. Abdel Hadi Abdel Wahab
Prof. Alaa Al-Sadek

This study aims to estimate crop water requirements for the green fodders grown in Abdaly area in the State of Kuwait . The data was collected from Abdaly administration statistics and field visits to the Abdaly farms.
Data revealed that the total number of farms is about 2800, out of which 1,064 cultivate green fodder using flood irrigation as the major water application technique in total area of about 2,247 hectares. Alfalfa constitutes about 41.5% of the total area, while Blue Panic mainly occupies the remaining area (58.5%). Cropwat software was used to calculate the reference crop evapotranspiration (ETo) from five-year average climatic data. The leaching requirement was also calculated using the average irrigation water salinity levels and the tolerable salinity limits of the two fodder crops at the root zone. The effective rainfall was calculated using a general formulae that considers 20% moisture losses for any rain event that is greater than 10 mm. The net irrigation requirements were calculated by adding the seasonal water requirements of the two crops minus the seasonal effective rainfall plus the leaching requirements. Actual field water application was estimated from pump operation time, discharge volume and number of irrigations throughout the season.
The results showed that the estimated actual field water application is about 363 MM3/year, while the crop water requirement is about 59 MM3/year. This means an irrigation efficiency of about 16%, which is below the 24% indicated by FAO data in Bahrain. However, such figures must be treated with caution since the lack of comprehensive data dictated the use of several assumptions that will affect the accuracy of the estimations. The study calls for the need to conduct detailed research on irrigation water use and management to integrate the other factors that may directly or indirectly affect the use of such valuable land and water resources in the State of Kuwait.

Performance Assessment of Distillers in Sitra Power and Water Station

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Sitra Power and Water Station (SPWS) is one of the oldest desalination plant in the Kingdom of Bahrain .The station is comprised of three phases ,where phase I consisted of 4 boilers,4 steam turbines and 2 Multistage Flash (MSF) distillers commissioning in 1976 and phase II consisting of 1 Gas Turbine (G.T) and it's Heat Recovery Steam Generator(HRSG), Auxiliary Boiler (AB) and 1 Multistage Flash (MSF) distillers commissioned in 1984. In 1984/1985 and as part of the desalination sector expansion plan, phase III was commissioned comprising of three identical MSF units. It is owned and operated by the Electricity and Water Authority (EWA), and being kept in operation since then which involves continuous investment to cater for the maintenance and operation costs. This research focused on the assessment of the distillers performance of SPWS, covering a 5-year operation period (2010-2014) and comparing the results of the assessment with a previous assessment that was carried out earlier for a 4-year period (2006-2009) of operation. The evaluation aspects considered for of SPWS's distillers are the: Availability, Reliability, Capacity Factor, Environmental Indicators, and the Quality of Water Produced. The cost of desalinated water produced by the station is the crucial factor in evaluating the desalination plant economics and reliability, especially when the plant gets older in operation. In the other hand, the cost of the desalinated water in Bahraini Dinars for the year 2014 is calculated and compared with the tariff paid by (EWA)to Hidd Power Company (HPC); Private sector, which is using thermal desalination technology as SPWS. The results indicate that increase in the maintenance cost of the oldest low performance desalination units (Dist. 1A,1B) and the reduction in the availability and capacity factor due to the aging effects are obvious and impacting negatively on all the performance indicators of SPWS. It is found that SPWS is still able to supply water with the required quality; however the design quantity is not always met.

The comparison between the two assessment periods indicates that the average Availability Factor has decreased from 83 to 81%; this is mainly due to the increase in the total unplanned outage rate, especially the forced and maintenance outages, which drastically increase in 2013 and 2014 . The water unit production cost is calculated to be about 483.88fils/m3, which is not much higher than the tariff paid to HPC especially when the age is taken into consideration; fuel (natural gas) is found to be the largest component of the cost (about 67% of the total cost). The environmental indicators showed that all the flue gases emissions are below the standards limits except the NOx emission on the Heat Recovery Steam Generator (HRSG) where it is always higher than the standard. Thermal marine pollution occurred few times during the year. SPWS can be taken as a proof of the technical and management capabilities of the public sector in running the plant for more than 40 years. It is recommended that EWA moves toward improving the performance of SPWS. Moreover, in plants where the criteria of intake and outfall constructions are not followed, the environmental laws regulating the operation need to be enforced.

Benchmarking Approach for the Evaluating of Water Utilities in the Gulf Cooperation Council

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Supervised by
Prof. Waleed AlZubari
Prof. Alaa Al-Sadek

Developing the performance of public organizations, there was the appearance of Benchmarking approach, to measure and evaluate the performance of these organizations, and to identify weakness, as compared to others, and work on them, and to achieve excellence of the Quality performance. The extensive application in the past years in many countries like the United States, Britain, and Japan. Despite the importance of benchmarking of the water sector in the GCC countries to evaluate performance and access to best practices and new ways to develop, but it did not take the it's right of the studying and application in these countries. This study highlighted the importance of benchmarking, and how important it is, and how and patterns, and to know how we can take advantage of benchmarking in leading and evaluating performance, And applied to the Water Management Branch Ras Tanura Area. The study shown that the effective application of benchmarking in the water utilities require change the prevailing organizational culture, so that they are encouraging cooperation and mutual benefit, and conduct internal or external comparison with similar facilities in their performance in the services they offer.

Sixth Batch: 2016-2017

Sixth Batch Students

No.	Name	Country	Project Title
1	Fahd Yahia AlFaifi	Saudi Arabia	Institutional structure for the management of the wastewater system (reuse) in Saudi Arabia
2	Nasser Mharab AlEnezi	Saudi Arabia	Assessment of the level of groundwater resources management in Saudi Arabia (semi-renewable) saq aquifer case study in nefi area (Saq Aquifer outcrop)
3	Abdulla Salem Ahmed AlKayoumi	UAE	Functions of water regulatory agencies and water pricing
4	Ahmed Ali ElGabri	UAE	Non-revenue water in the Ain Water Distribution company
5	Waleed Zaher Khamis Al Alawi	UAE	Non-revenue water in the Ain Water Distribution company
6	Abeer Abdulaziz Al-Temimi	Kuwait	Drinking Water safety Plan in Kuwait
7	Huda Abdulaziz Al-temimi	Kuwait	using soil conditioners in enhancing irrigation efficiency
8	Kawthar Ismael Sultan	Kuwait	Beneficial Impacts of treated wastewater reuse in agriculture on groundwater water levels and salinity
9	Anwar Jaber ALOsaimi	Kuwait	Assessment of the impact of the desalination brine discharge on the marine environment in Bahrain, Al-Dur RO plant case study
10	Nora M Al-Enezi	Kuwait	Stochastic urban water demand forecasting using Monte Carlo Simulation
11	Maryam Juma Marzooq	Bahrain	Quantification of the energy input in the water supply cycle
12	Ghadeer Mohamed Redha Kadhem	Bahrain	Optimum locations for groundwater artificial recharge with storm runoff water using GIS techniques and multi-criteria decision making
13	Saad Hassan Saad Al-Housali	Yemen	Assessing the Role of WUA's in Groundwater management in Sana'a Basin
14	Ahmed Al-Aghbari	Yemen	Water Security: The fragmentation of meanings, approaches and stakeholders, in the Kingdom of Bahrain
15	Marwa Faisal Salman Mohamed	Sudan	Water harvesting projects in Sudan and the role of community participation in its sustainability

دراسة تحليل عملية إدارة إعادة استخدام المياه المعالجة في المملكة العربية السعودية

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تقع المملكة في منطقة تتمتع بمناخ جاف وتتسم بندرة الموارد المائية، وفي الوقت ذاته شهدت المملكة في العقود الماضية زيادة في معدلات النمو السكاني والحضرنة بسبب ارتفاع معدلات التنمية الاجتماعية والاقتصادية، مما أدى إلى زيادة الطلب على المياه في القطاع البلدي. ولقد صاحب هذه الزيادة ارتفاع في كميات مياه الصرف الصحي التي تحتاج معالجةً لحماية الصحة العامة والبيئة. وحالياً، تعتبر مياه الصرف الصحي المعالجة مصدراً مائياً غير تقليدي ومتجدد يرتبط بمعدلات استهلاك المياه البلدية. ولذا، فإنه من المفيد إعادة استخدامها في ظل ندرة المياه لتخفيف الضغط على الموارد المائية الأخرى (المياه الجوفية والمياه المنتجة من محطات التحلية). إلا أنه حالياً لا تزيد نسبة إعادة استخدام مياه الصرف الصحي المعالج عن 17% من إجمالي المياه المعالجة، ويلقى الجزء الأكبر منها في البحر أو في المناطق غير المأهولة بالسكان مسبباً ضرراً بيئياً، كما يمثل فرص ضائعة وخسارات مالية واقتصادية.

يستعرض هذا البحث قطاع مياه الصرف الصحي والوضع الحالي لعملية إعادة استخدام مياه الصرف الصحي المعالجة، ويقوم بتحديد المعوقات الفنية والإدارية والمؤسسية التي تواجه عملية إعادة استخدام مياه الصرف الصحي المعالجة والتعرف على سبل تذليلها. ويسلط البحث الضوء على الهيكل التنظيمي الحاكم للقطاع حالياً وكيفية عمله ويستعرض التجارب والخبرات الناجحة لكل من الأردن وسنغافورة ويستخلص الدروس المستفادة منها لتعظيم استخدام مياه الصرف الصحي المعالجة. ويقوم البحث بإجراء التحليل الرباعي لنقاط القوة والضعف والفرص والتهديدات (SWOT) من خلال استبيان تم استيفاءه من قبل ذوي العلاقة من قطاعات المياه والزراعة والصناعة والقطاع الخاص والبحثي (17 شخص) ومن ثم إجراء تحليل مصفوفة (TOWS) باستخدام استراتيجيات تستخدم نقاط القوة لزيادة الفرص، وتستخدم نقاط القوة لتقليل التهديدات، تقلل من نقاط الضعف وتعمل على تجنب التهديدات، وتستفيد من الفرص لتقليل من نقاط الضعف.

ومن تجارب الدول ونتائج تحليل الاستبيان يرى البحث بأنه يجب تأسيس جهاز مسؤول عن بلورة استراتيجية لإعادة استخدام المياه المعالجة يمثل فيه كافة الشركاء وأصحاب المصلحة ويتوفر له السلطات الضرورية والمخصصات المالية اللازمة لرفع كفاءة استخدام المياه المعالجة. وبأن مجالات إعادة استخدام المياه المعالجة تشمل التبريد والاستخدامات الصناعية وإنشاء الأحزمة الخضراء حول المدن لتخفيض تلوث الهواء وحماية المدن من الغبار وتثبيت التربة. كما يقترح أن يكون هذا الجهاز مسؤولاً عن طرح حزم استثمارية وتفعيل الشراكات بين القطاعين العام والخاص وفى ذلك يمكن استخدام الأدوات الاقتصادية والحوافز المالية بالإضافة إلى اقتراح القوانين اللازمة لرفع كفاءة استخدام المياه المعالجة.

تقييم مستوى إدارة المياه الجوفية (شبه المتجددة) في المملكة العربية السعودية
دراسة حالة: خزان الساق الجوفي بمنطقة حقل مياه نفي

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تعتبر المياه الجوفية سواء المتجددة أو غير المتجددة من أهم الموارد المائية الطبيعية والرئيسية في المملكة العربية السعودية، حيث يتم الاعتماد عليها بشكل كبير في خدمة التنمية الزراعية والاجتماعية والاقتصادية. إلا أن معظم هذه المياه معرض للاستنزاف والتلوث بواسطة الأنشطة السطحية. يهدف هذا البحث إلى تقييم مستوى إدارة المياه الجوفية (شبه المتجددة) في المملكة العربية السعودية باستخدام منطقة حقل مياه نفي في خزان الساق الجوفي بالرياض كدراسة حالة ممثلة للمياه الجوفية في باقي مناطق المملكة ذات الطبيعة المشابهة، وإظهار نقاط القوة ووضع مقترحات لمعالجة نقاط الضعف والثغرات الإدارية المطلوبة لتحسين مستوى الإدارة بها. عند مقارنة مرحلة استغلال المياه الجوفية والاحتياجات الإدارية المناظرة لها لخزان الساق الجوفي في المنطقة تبين أن كمية المياه الجوفية المسحوبة من الخزان الجوفي أعلى بكثير من كمية المياه التي تغذي الخزان، مما يدل على أن الخزان الجوفي في المنطقة يمر بعجز ويعاني من تنمية غير مستقرة، ويدل على ذلك الانخفاض المستمر لمستوياته المائية، والذي إذا استمر لفترات طويلة سيؤدي إلى تدهور نوعية المياه الجوفية وخسارة جاهزيتها للاستخدام المباشر. ولقد تبين أن مستوى الإدارة المائية لا يتناسب مع الوضع المائي للخزان، حيث توجد فجوة كبيرة بين ما يجب القيام به وما يتم حالياً في جميع المجالات، مما يهدد استدامة الخزان الجوفي. وحاليا يتم تطبيق الأدوات الفنية والوسائل المؤسسية والإجراءات الإدارية المطلوبة في أدنى مستوياتها أو تكاد تكون غير موجودة. كما يلاحظ أن التركيز على الجوانب الفنية أكبر من الجوانب الإدارية. ولذا، هناك ضرورة قصوى لرفع مستوى التدخلات الإدارية لتتناسب مع الضغوط الواقعة على المياه الجوفية، يوصي البحث بإجراءات وتدخلات إدارية عديدة رفيعة المستوى على المستويات الفنية والمؤسسية والإدارية، مع التركيز على إدارة الطلب والحماية من التلوث وتحديد مواقع التغذية سواء من مياه السيول أو المياه المعالجة، وتطبيق طرق الري الحديثة لرفع كفاءة الري، واستخدام المياه المعالجة للري، والزام المزارعين بتركيب عدادات على آبارهم لقياس كمية المياه المستهلكة تمهيداً لوضع تعرفة مناسبة، ويمكن التدرج في هذا بحيث تكون رمزية في بداية الأمر لإعطاء المستهلك الشعور بالقيمة الاقتصادية لها، وكذلك مشاركة المنتفعين في مسئولية إدارة الخزان الجوفي، ومتابعة حقل آبار مياه نفي وبناء قواعد بيانات خاصة بالموارد المائية، وتحديث البيانات بشكل دوري ومستمر، والعمل على بناء نموذج رياضي يساعد في عملية اتخاذ القرار في إدارة الخزان الجوفي.

The Impact of Tariff Changes on Water Consumption and Recommendation for Tariff Design in Al-Ain, UAE

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The project discusses the importance of proper tariff structure and the impact of tariff changes on water consumption in Al Ain City in the Emirate of Abu Dhabi. Water rates are important for sustainable future and conversion of national resources. In Al-Ain, Water tariff changes happened in 2015 for the first time in twenty years since the establishment of all sector companies. The tariffs increased for all classes of customers, except in agriculture which remains the same. The water tariffs increased for both the residents including the nationals and non-national residents as well as government customers. The study aims at contributing to understanding consumer's behavior in response to economic tools in Al-Ain by analyzing the impact of tariff changes between 2015 and 2016 on all customer classes and makes a comparison of the impacts of tariff during the period of 2014-2015. The objectives of the project include assessing the impact of tariffs change on customers' water consumption and to observe the price-demand elasticity. The data from the Customer Care and Billing (CC&B) Department within the Al Ain Distribution Company (AADC) has been collected to perform the analysis. The collected data in the form of rates and fields were screened. This included the (CC&B) data which comprised of the premise IDs, water consumption reads for 2014, 2015 and 2016 and the premise types.

The tariff rate data for 2014, 2015 and 2016 were also screened towards giving more ccurate results. The screening process entailed comparing and validating the customer datasets so as to have consistent data readings that did not move considerably over the three year period between 2014 and 2016. The analysis was carried out on all customer groups except agriculture as agriculture did not have any tariff changes in both 2015 and in 2016. After the tariff impact analysis, the best practices in worldwide utilities that are similar in nature to AADC have been assessed. The best practices show how tariffs are structured towards reaching the utilities long-term objectives. Therefore, this project illustrate the impact of tariff changes, demonstration of best practices in tariff setting and high level recommendation for the suggested tariff reform.

Non-Revenue Water in Al Ain City, UAE, Alain Distribution Company Case Study

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UAE is situated in an arid region where water is scarce. Increase in Non-Revenue water (NRW) leads to depletion of water resources, negatively impacts the environment and economy of the country. Therefore, understanding NRW and its management approaches using case studies in utility companies is the first step in managing and controlling NRW. In this study we have reviewed and analyzed all available data related to NRW, annual reports on NRW, and management and control efforts of NRW in Alain Distribution Company (AADC), UAE. The AADC is obliged to report on annual basis the Leakage and loss control to the Water Regulators. The company follows the International Water Association (IWA) Model for their assessment and reporting of NRW. The AADC has a record of 10.53% of NRW to the system input volume. We have acquired the basic knowledge of NRW and its components such as System input, Unmeasured Volume and Distributed volume of water as key elements in the assessment of NRW and its source data. In addition, we have gained insights and understanding of areas where the attention is required like Customer metering and Bursts analysis, pressure management, active leak detection, influence of leakage and key performance indicators to benchmark with other utility companies in the world.

Effect of soil conditioners on soil salinity and water use efficiency

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Most of the soils in the Gulf Cooperation Council Countries are characterized by limited water holding capacity due to sandy textures, low organic matter. Furthermore, it is generally affected by salinity and/or sodicity with primary and secondary cases of salinity arising from low quality water, high evaporative demands (about 3,000 mm/year) and temperatures. Therefore, to mitigate such adverse conditions for crop production, soil physical and chemical properties must be improved or modified before profitable agricultural production may be achieved. Thus, soil conditioners have been used as an effective technique to improve water conservation of sandy soils by improving water holding capacity, reducing infiltration rate and cumulative evaporation. An experiment was carried out at the laboratory and greenhouse of AGU to evaluate the effects of adding super-polymer absorbent (SAP) on soil physical properties and plant water uptake. The first part of the experiment dealt with soil physical properties as modified by the addition of 0.0, 0.2, 0.4 and 0.6 percent of SAP by weight. Furthermore, plants were grown in pots each filled with 8 kg of soil in the greenhouse. Three rates of SAP were used: 0.0, 0.1, and 0.5% by weight and mixed with the soil. Plants were irrigated with irrigation water of EC adjusted to 0.0, 2, 4 and 6 dS/m. Water uptake and water use efficiency were calculated in hourly basis using six pots of plants (3 with and 3 without SAP) placed in two sensitive automated balance with data logger. Rosemary plant was used as a check crop.

The results indicated that SAP application has significantly improved the soil bulk density at all the used mixing rates compared with the control (no SAP application). The highest reduction in bulk density was observed with the highest rate of SAP (0.6%). The effect of SAP on water holding capacity (moisture curve) was significant with 125% increase in soil water content at field capacity and 110% increase at permanent wilting point under 0.6% addition of SAP. The application of SAP also significantly reduced the soil hydraulic conductivity (from 0.48 under no SAP to 0.16 cm/min under 0.6% SAP application). Plant leaves analysis for Nitrogen content (N%), indicated significant differences with the highest N level under the highest SAP level compared with the zero and 0.1 SAP levels. Regarding plant fresh weight, the highest weight was obtained under 0.5% SAP compared with 0.1 and zero SAP%. Higher water use rates were observed under SAP application compared with no SAP application indicating the positive effects of SAP in improving the water holding capacity of the soil. Thus, more water was available for the plants to satisfy evapotranspiration demands. Regarding water use efficiency, the ratio between the summed actual plant evapotranspiration and the summed measured applied water indicated 86 versus 75% for the SAP and zero SAP applications respectively. It may be concluded that the application of SAP has improved the soil physical properties and consequently improved plant water uptake and growth. However, the economics of using such soil conditioner at large scale needs to be carefully studied.

Assessing the Impacts of Treated Waste Water Use in Agriculture on Groundwater Quality and Level in the Kingdom of Bahrain

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TSE use in the agricultural sector has increased from 0.7 Mm3/year in 1987 to 28.6 Mm3 in 2014. Examination of the published research indicated steady reduction in groundwater level between the year 2000 and 2010 at both Alat and Khobar members of the Damam formation that represents the main source of groundwater in Bahrain. Similarly, there was increase in the water level between 2011 and 2014. The quality of Damam groundwater can be affected by other factors than excessive abstraction for agricultural uses as the later activity can affect the quality through contamination of the aquifers in several areas as indicated by the study of Elshoweiy et al. (2014). Superimposing ground water level with TSE utilization indicated lag time leading to the supposition that administrative measures in reducing groundwater abstraction and TSE utilization in agriculture require time for groundwater level and quality to improve in the Kingdom of Bahrain. Recent analysis of 12 farms groundwater sources in 2017 indicated that the EC is still high in certain places but the minimum was 4.5 and the maximum was 18.2 dS/m. Further analysis indicates that groundwater quality cannot be directly related to utilization of TSE as most of the farms with conjunctive use of the two sources have high groundwater EC and vice versa. This suggests that a more detailed study is needed to understand the effect of TSE application on groundwater level and quality.

Assessment of the impact of the desalination brine discharge on the marine environment in Bahrain, Al-Dur RO plant case study

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Desalination has become the only viable source of fresh water for Bahrain, as well as other GCC countries, to meet their drinking water supply due to the shortage of conventional water resources on one side and the accelerating rates of population and urbanization. However, such reliance is associated with a number of environmental externalities, such as air and marine pollution, which need to be minimized. A first step in this process is to characterize the impact of these emissions and discharges and then to design a mitigation plan to reduce their impacts on the environment. The objective of the study is to investigate the impacts caused by the effluent discharge from Al Dur desalination plants on the Bahrain's marine environment. The surrounding marine area of the Al-Dur seawater reverse osmosis plant was characterized in terms of salinity. The methodology consisted of carrying a field sampling of the salinity at two locations, surface and bottom, and at two period low and high tides. The survey results have shown that the desalination plant outfall area has an increase in the salinity due to the discharge of the desalination reject water, with a clear high salinity plume formed at the bottom of the seabed. It is observed that the salinity increase is less during the high tide than at low tide due to dilution. To fully characterize the impacts of the desalination plant on the surrounding marine environment and ecosystem, it is recommended that other physical and chemical parameters surveyed and monitored, in addition to selected biological communities and organisms of ecological relevance and sensitivity to salinity and temperature.

Stochastic Municipal Water Demand Forecasting using Monte Carlo Simulation Method in the State of Kuwait

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The accelerated water requirements to meet the needs of the rapid population and socio-economic development will lead to increasing water shortage and increasing the cost of water supply, and will make water sector unsustainable in Kuwait. In order to fill in the gap between the accelerating demand and supply, constructing more desalination plants remains the main solution. Moreover, in order to overcome the many future uncertainties in the water sector, there is a need for long-term probabilistic forecast model for the State of Kuwait, starting by identifying the quantitative nature of uncertainties through assigning probability distribution functions to each explanatory variable within the forecast model. The demand model and the specified variable uncertainties are subsequently nested in a Monte Carlo Simulation, forming a probabilistic demand model. The research aims in general at developing a water demand probabilistic forecast model for Kuwait. The presence and magnitude of these uncertainties should be explicitly represented within forecasts, allowing decision makers to understand how uncertainties in future socioeconomic conditions affect water supply. A probabilistic model that quantified uncertainties for the population growth, per capita municipal water consumption and physical leakage was presented in this research. The results may help to provide Kuwait's water authority with helpful guidelines on planning future water production. Regardless to the fact that some projection period was limited to four years, a number of conclusions can be obtained and may help in the planning for a much longer period. It is clear from the study that the demographics are the limiting factors and are always subject to change. Finally, a stochastic modeling approach using Monte Carlo method is recommended in any future modelling exercise in regards to the possible impact of management interventions and policies and their effectiveness in achieving a sustainable water sector. Moreover, to assess whether or not future expansion plans for the wastewater treatment plants in Kuwait are needed or not.

Quantification of the Energy Use in the Municipal Water Supply system in the Kingdom of Bahrain

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This research focused on quantifying the specific energy of the municipal water supply cycle in the Kingdom of Bahrain, which consists of three stages; production stage, transmission stage and distribution stage in the Kingdom of Bahrain. Government and private water production stations use various types of desalination technologies, which are thermal and membrane based technologies in order to produce freshwater from sea water and brackish groundwater. Transmission and distribution networks are government assets for Electricity & Water Authority (EWA). The transmission network receives the desalinated water from the production stations and convey it to the blending stations, forwarding stations and distribution stations. The distribution stage, the last stage, delivers potable water to customers. In this system, although gravity is the main method to transmit and distribute water in Bahrain, there are also pumps used in the transmission and distribution networks, which consume energy as well. Site visits, interviews and phone calls with the concerned engineers were arranged in order to compile data related to the energy consumption in the municipal water cycle. Also, detailed calculations were performed to measure the used energy in kilo-watt hours to produce, transmit and distribute a unit of water cubic meter. The results indicated that production plants consumes energy intensively in the Kingdom of Bahrain, estimated at about 97% of the total energy consumed in the municipal water cycle, while the rest is consumed by the transmission and distribution networks in this order. For future studies, it was recommended to calculate the thermal energy to compare desalination technologies specially, among thermal desalination technologies. Also, reactive energy should be calculated for big consumers of energy like production plants and stations which contains pumps and motors.

Rain Water Harvesting and Optimal Locations for Managed Aquifer Recharge in the Kingdom of Bahrain Using GIS and MCDM Techniques

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The Kingdom of Bahrain is suffering of a sharp shortage in natural water resources. Rapid increase population and urbanization, fast socio-economic developments have significantly increased the demand for water, causing over-usage of the already scarce groundwater resources. This has led to a significant decline in groundwater levels, a radical storage reduction, and serious degradation in groundwater quality. In response to the water shortage conditions, the Kingdome of Bahrain has adopted relying on the non-conventional water resources, such as desalination and treated wastewater. Relying only on these to non-conventional sources that are depending on recently economic abundance could cause harm and sharp decline in water supplying at the long term if any occurrence of an emergence economic crisis in future. Therefore, the Kingdom of Bahrain has to have alternative plans to supply water by managing its resources. Using new techniques of maintaining and storing water on the aquifer for the future, could help to mitigate any water shortage crisis. One of the well-known non-conventional techniques of managing water resources efficiently and sustainability is aquifer recharge which could enhance and increase groundwater availability. The engineered system of aquifer storage and recovery (ASR), is a good technique whereby surface water is moved to aquifers via water harvesting or injection wells that serves to bolster groundwater resources. This research provided an overview of the previous literatures addressed rain water harvesting and artificial groundwater recharge and the main criteria and best GIS techniques used in selecting optimal locations for artificial recharge , to contribute towards better water resources management. Aim of this research is to focus on the most suitable method to investigate the optimal and best locations of rain harvesting for groundwater recharge in the Kingdom of Bahrain. Multi criteria decision making (MCDM) has been implemented by using geographic information system (GIS) environment and techniques. Data of this research were gathered from different resources and weighted overlay analysis has been used to apply the MCDM with its sequential steps.

An ordinal scaled map of the optimal and best locations of rain water harvesting and artificial aquifer recharging has been generated and discussed as a scoping study of the area of investigation. Optimal location of the rain water harvesting and artificial aquifer recharging was on the Mamtallah location south west of the kingdom of Bahrain main Island. Results of best locations were very closed to what has been succeeded in previous experiences of groundwater recharging in the Kingdom of Bahrain. This research has improved that using GIS in detecting best locations for water resources management planning and scoping studies is very effectiveness, particularly in implementing MCDM. To enhance the results of this research there were some recommendations such as using high resolution data and facilitating data sharing to the researchers to participate in decision making toward integrated water resources management.

Assessing the Role of Water User Associations in Groundwater Management in Sana'a Basin

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population grew from about 26 million in 2009 to 32 million in 2016, and is expected to reach 53 million by 2031 assuming a growth rate of 3.7 percent Over the last 40 years, the rapid growth in demand for higher value products and the transformational role of groundwater have driven growth and employment in agriculture. Now productivity is stagnating and water availability is declining. At present, the available water in Yemen of 115 m3 per capita per year is among the lowest in the world, and is likely to decline to 55 m3 per capita per year in 2031. The situation in the Sana'a basin is even worse because of the presence of Sana'a city with over 2.5 million people relying on groundwater for their drinking water. The Water Law of 2002 considers the participation of the rural communities (the farmers as main water users) essential to achieve the needed reduction in groundwater abstraction. This research will The documentary the history of the establishment of the Water Users Association in Yemen taking Sana'a Basin as a case study, and approach will be used for this research to assess their status of Water User Associationsrole during the last 6 years in the management of groundwater in the basin, and identify to observe developments, their strengths and weaknesses. The research examines the effectiveness of the works of WUAs in conserving water resources of the in Sana'a basin. The research provides an account of the role of the institutional framework in managing water resources.

This research documented the history of establishing Water Users Associations (WUAs) in Yemen taking Sana'a Basin as a case study, and assess their role during the last 6 years in the management of groundwater in the basin, and identify their strengths and weaknesses. Thus the research was subdivided into many parts, where the first part explained what means by WUA, where the second part defined the role of WUA as a global concept, to sum up the third part listed the mean findings, best practices and lessons learned. Based upon examples from Yemen, the farmers' awareness on water scarcity is growing but there are many reasons for them not to act. With support of the Sana'a basin Water Management Project (SBWMP), 56 WUA's have been registered between 2002 and 2010 with the aim to reduce groundwater abstraction. Those WUAs were working properly during the projects live where the project continued to support their activities. Since these WUAs were newly born and did not have a complete dose of training to give them the ability of continuity against the low level of community awareness and the limited financial capabilities of communities to adopt their vision. That was resulted in failure of most of the newly established WUAs. Currently, only 20 percent of these WUA's are operational and progressing towards significant reductions in crop water use. Two important lessons can be drawn from the SBWMP experience for this project: much more attention is needed to set up an association based on good governance and principles of equitably and incentives for farmers to change their crop production are very important.

Water Security: The divergence of understanding among stakeholders and the role and position of desalination, in the Kingdom of Bahrain

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Achieving water security is one of the fundamental concepts of sustainable development. Achieving water security is one of the fundamental concepts of sustainable development. In Bahrain, similar to other Gulf nations, the country commits to the provision of municipal water through increasingly relying on massive engineering projects in the form of desalination plants, which was introduced in 1975 and has developed very rapidly to counteract the shortage and quality deterioration in groundwater resources. Desalination is resorted to meet water quality requirements for drinking/domestic water standards. Until the mid-1980s, the municipal sector relied mainly on groundwater and was augmented by desalinated water in small ratios. However, due, in part, to population growth and enhanced living standards as a result of economic growth, a significant expansion in desalination plants occurred and desalinated water has become the main component of municipal water supply with little augmentation by groundwater. The ratio of desalinated water has risen from 7 percent in 1980 to 90 percent in 2014, which significantly improved the quality of the municipal water supply in the Kingdom. The project aims to investigate the factors that influence this short-term perspective of the concept. Furthermore, the project aims to investigate the broad perspective of the water security concept by examing the institutional capabilities of water management institutions to cope with rising demand and the effectiveness of imposing technological instruments, such as desalination on top of the water management system that is criticized of leakage, non-revenue water and imposing low-tariffs. The research started by giving a background of how the water issues evolve greatly around desalination production. Three prominent themes surfaced in the discourse around water security in Bahrain. These are, firstly around the importance of groundwater as a strategic storage against emergency incidents. Secondly, the aspiration of Energy and Water Authority (EWA) to achieving water security through increasing the share of desalination in the municipal water supply as a reliable source and expanding its municipal water strategic reserves. Thirdly, the securitization of the desalination plants against physical damage and potential water intake pollutions, and fourthly the uncertainty of energy sources for desalination in the future. This is discussed through exploring the eminent challenges that face the desalination sector.The

Assessment of Success & Failure of Participatory Approach in Water Management

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As the available water resources is growing less vs. the increasing demand to satisfy basic needs; the call for water use efficiency became of vital importance. Water saving techniques, modern irrigation technologies were introduced, while the community participation was popularly applied to assure the sustainability of the programs and promote the sense of the ownership for the local people as it does care for gender equality and poor people. The study aimed to emphasize the importance of participatory approach as a key factor of sustainability of water resources management with focus of attention on case studies from Sudan (Author's hometown) in order to allow for better allocation of research and development funds on IWRM projects in terms of knowledge sharing, out-scaling and up-scaling. The main driver of the approach is the local people. Thus, the results of applying the method will basically depends on the structure of the community; their livelihood, education and to what extent they can learn and utilize modern technologies and being committed to water laws and regulations. Developed countries shows good example in the implementation, while the experience of applying the participatory approach in a developing country (Sudan) indicates the need not to rush the good results and take it a step by step since the capacity building either for the officers or for the local community and the contentious evaluation is essential and it takes time and effort. The study also reflected how the governments can play a vital role in the success of the implementation by clear visions and strategies with adequate legal framework and enforcement of water laws & regulations, while hasty decisions only lead to the failure of the programs. After all, the experience shows that involving community in water management is fundamental. But nevertheless, the questions at all times will be "How to achieve the effective participation?" and "How to overcome the limitations of the participatory approach?" Well! Effective participation can be reached by considering the approach on a wide-scale and start to think of it as an objective of the development rather than a methodology to achieve some objectives (Economic). After which people's motivation, collaboration, degree of self-determination will be gained. As for the limitations of the participatory approach it cannot be eradicated but at least it can be minimized by careful handling and appropriate procedures.

Seventh Batch: 2018-2019

Seventh Batch Students

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	Jasim Abdulrahman Ahmed Alkhaja	Bahrain	Status of the Wastewater System in the Kingdom of Bahrain
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Establishing a Benchmarking system for the Wastewater Services Utility in the Kingdom of Bahrain

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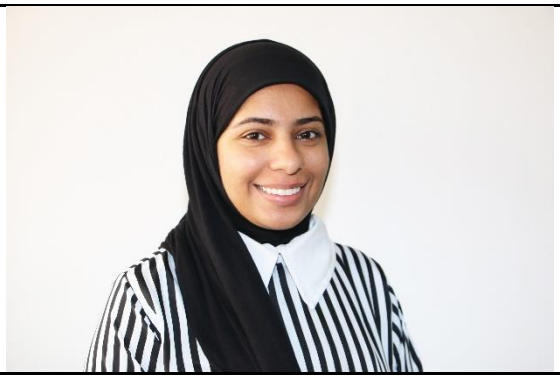

Many effective benchmarking projects already exist or are being established in many countries, such as the United States, the United Kingdom and Japan. There is a growing interest in benchmarking the water and wastewater utilities in the Gulf Cooperation Council (GCC) countries, but there is limited experience in benchmarking and its applications within these countries, especially in the wastewater sector. Currently, there is no benchmarking system for evaluating the performance of wastewater utility and services in the Kingdom of Bahrain. This research underscores the importance of benchmarking, the effective impact of its application in the wastewater sector and presents some successful international benchmarking applications in the water industry. Special attention is given to the International Water Association (IWA) benchmarking performance indicator system, its structure and components, data confidence-grading scheme and implementation method. The research builds on an earlier study titled "Benchmarking System for the Wastewater Sector in Bahrain" conducted by a national team from the wastewater sector (Sanitary Engineering Affairs- Ministry of Works, Municipalities and Urban Planning (MOWMAUP)) and academia (Arabian Gulf University (AGU)), which attempted to develop and implement a benchmarking system suitable to the Sanitation sector in Bahrain. This research intends to make a deeper reflection of the IWA's Performance Indicators for wastewater services and their application by analyzing the outcomes of the previous benchmarking study and suggesting follow up and complementary measures to enhance the implementation process, consisting of development of a governance structure for a benchmarking team for Sanitary Engineering Affairs – MOWMAUP, the main wastewater service provider in the Kingdom of Bahrain, identifying the roles and duties of the members, and modeling the results using a specialized benchmarking software (SIGMA Lite). In order to achieve a suitable benchmarking system for the wastewater utility in Bahrain, it is recommended that benchmarking workshops, involving potential members of the wastewater benchmarking team be conducted. In addition, it is recommended to use the developed software tools in the implementation of benchmarking, and to continue data gathering for more Performance Indicators to have better evaluation of wastewater utility performance.

Status of the Wastewater System in the Kingdom of Bahrain

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Bahrain is an arid country with acute water shortage problems. the tertiary treated wastewater has become an integral source for crop irrigation and landscaping, yet Bahrain is lacking the full utilization of the tertiary treated wastewater which waste a renewable source of water under the scarce water conditions in Bahrain. This research provides full details on the wastewater system in Bahrain (collection, treatment and reuse) including the legislative and institutional framework in order to show the legislative, institutional and operational gaps in the wastewater system and suggest solutions to overcome the deficiencies in managing the treated wastewater. It was suggested in this research to prepare a treated wastewater reuse safety plan to help mitigate any future problems related to the reuse. In addition to that it was suggested to have a treated wastewater management unit to manage the full treated wastewater reuse in agricultural and landscape irrigation, industrial uses and Managed Aquifer Recharge

Current and Future Challenges of Water Resources in Egypt

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The average per capita freshwater availability in Egypt has been steadily declining from about 1,893 m^3 per year in 1959 to about 900 m^3 in 2000 and 700 m^3 in 2012. This puts the country below the World Bank's water scarcity threshold of 1,000 m^3 of renewable water available per capita per year. Per capita water availability is expected to continue dropping to 505 m^3 by 2025, below the international water poverty limit. According to the government, Egypt's population is predicted to reach about 110 million by the year 2025, further increasing the competition for water. Developments in Sudan, Ethiopia and other riparian countries could impact water availability to Egypt. The main goal of this study is to assess the current and future challenges of water resources in Egypt. Economic growth is also threatening the quantity and quality of Egypt's water resources, exacerbating the existing issue of shallow groundwater contamination from industrial chemicals and excessive fertilizer and pesticide use. In addition, farmers still overwhelmingly practise inefficient flood irrigation, which results in evaporative loss and over-irrigation, causing soil damage and rises in groundwater tables. According to the Ministry of Water Resources and Irrigation, Egypt already uses 127 percent of its water resources and needs 20% more water by 2025. This means that 27% of the water used is imported via food and other products (virtual water), and this could rise to 47% by 2025.

The United Nations predicts that Egypt could be water scarce by 2025. Assuming continued population growth and taking into account the land reclamation projects in the desert and the fact that more than 50% of the cereals consumed are already imported, Egypt cannot meet its food demand by relying on Nile water for irrigation. Adding to this precarious situation, surface water evaporation in Lake Nasser is thought to exceed the earlier estimated amount. The current average evaporation rate is 7 mm and it is expected to be 7.3 mm by 2050. In other words, Egypt is already utilizing most of the Nile's flow, and it plans to use even more. According to the Ministry of Water Resources and Irrigation, there is a deficit in the national water budget of more than 20 BCM per year. In addition, Egypt is affected by climate change, which is impacting the entire Nile basin. Economic developments in upstream countries and measures they might take to adapt to climate change are likely to put more pressure on water resources in Egypt. Several studies have shown that the Nile is highly sensitive to temperature and precipitation changes, mainly because of its low runoff/rainfall ratio (4%).

To overcome the shortage, the government relies on water reuse techniques, particularly for irrigation. Currently, 10% of irrigation water is reclaimed agricultural drainage water. Reused wastewater amounted to 2 BCM in 2017. The government plans to upgrade the existing secondary wastewater treatment plants to save a total of 11.67 BCM water through tertiary wastewater treatment and reuse. However, the technologies used in these plants are energy-intensive and not always appropriate in developing countries due to social and economic issues. Reusing of wastewater for domestic uses is likely not acceptable by local users in Egypt, let alone for using it for drinking purposes. Moreover, these treatment techniques are not economic. Furthermore, improper treatment and reuse of poor quality treated water can lead to soil pollution as well as surface water and groundwater contamination. The government recently committed to extend the use of natural methods such as wetland and soil aquifer treatment techniques, which are known to be highly efficient and cost effective.

Cost Recovery of Irrigation Water Al Ahssa Oasis, KSA

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In Saudi Arabia, the agriculture sector consumes around 88 percent of water, while it accounts for only 2.33 percent of GDP. Irrigation water is used inefficiently, mainly through traditional flooding and furrow irrigation techniques. The Saudi Government provides generous subsidies to the agricultural sector to increase self-sufficiency levels in certain commodities. Since 2000, the Saudi government has encouraged efficient irrigation water use by providing incentives for the use of water-saving technologies such as drip irrigation and soil moisture sensing equipment. In contrast, Saudi Arabia has not implemented tariff policies to ration the use of irrigation water. Low-cost recovery and a rapidly growing population, water subsidies became a weighty burden on the government. The research depends on published and unpublished data issued by Saudi Irrigation Organization (SIO), World Bank reports, Food and Agriculture Organization of the United Nations (FAO), and other related publications. According to the document analysis results, SIO needs to take gradual steps in applying a cost recovery scheme. Raising the awareness of farmers about the benefit of such a scheme should be the first phase. Another careful consideration is when and how to apply this scheme. Literature suggests that partial cost recovery is typical and an excellent starting point. The cost recovery system should be transparent so that the government can identify needed subsidies. The high management level of SIO would benefit from working with the Saudi National Water company, providing water for the domestic sector, and learning from their experience in this field. Also, SIO needs to create cost centers across its branches, thus enabling SIO to calculate the specific costs related to its O&M and capital investment to determine the right ratio of cost recovery. Finally, and since it is not a profit-generating public institute, SIO may consider doing more research on its intangible benefits to the government, society, economy, and environment to justify the required funds for its irrigation projects. These research projects will support SIO to continue playing its role and enable Saudi Arabia to modernize the agricultural sector.

Developing Water Management Model for Jazan Dam Irrigation Project

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In the past, it has been the practice to use flood water in a pond irrigation system by setting up earth or stone barriers to retain water. Rainfall and transfer to farmers' land is a primitive method that helps to saturate the land and water storage so that it can be cultivated later. Except if floods often come overwhelmed by roadblocks and water goes to the sea. Water often floods the land so that it cannot be cultivated. Accordingly, the dam was built in 1970 to alleviate the floods and hold them in the dam basin to prevent their danger from life and property. In addition to controlling the stored water and drain it according to the needs of agriculture and irrigation to develop the region and grow agricultural and social. As a result of the Dam Construction, the land of the area, especially the coastal plain extending along the Red Sea, consisting of dredged silt with water to fertile agricultural land is not threatened by the flood and gives two crops per year. The following Map-1 shows where Jazan Dam is located with deferent scales.

This research sheds light on the existing irrigation project in the Jazan Valley Dam area and the water demand of the three agricultural areas that have the right to benefit from the water produced from the dam. Flood irrigation method is used in these areas in separate seasons throughout the year. The research will discuss ways to create a plan for supply and demand of water in the aforementioned areas. To enable the General Organization for Irrigation to properly have clear overview on the water needs for the agricultural areas under this study and determine the quantities required throughout the year. This study discusses the available water sources and their ability to provide the required quantities, taking into account there are three main crops planted in these areas.

In this research, it is seen how useful a simple tool can predict the water demand for specific region. Water demand estimation for irrigation project can help which crops could withstand available water quantities. It also helps the decision maker which crops should be planted based on the available parameters related to climate, water resources. By defining the water demand during the year, peak demands could be identified and action plan could be set properly. Even though, it cascade down to the maintenance plan for any infrastructure and when it should be isolated for maintenance. It is shown how presence of supply/demand plan can help SIO to take inconsideration the emergency supply when it should be available.

To make supply/demand estimation more accurate, several parameters need to be taken in consideration studying the soil types, water salinity and other parameters. Several parameters in this research. Linkage to Geographical Information System (GIS) and Supervisory Control and Data Acquisition (SCADA) would even make the benefit more. Supply/Demand plan can even be cascaded to a scale of the farm itself. Also it can be automated in dashboard to let the farmers update their crops selected to have an instantaneous update in the water supply plan.

Utilization of RS and GIS tools towards integrated water harvesting systems in un-gauged Wadies Case study: Khor Arbaat, Sudan

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Water harvesting projects in Sudan are essential for providing water to remote areas far from the Nile River. The use of these techniques in watersheds has consequences on the downstream and upper stream areas depending on the location and type of project or technique used. The use of dams, for example, have its observed consequences on the stream course and have a direct influence on the up and downstream areas of watershed users. So the integrated study of the areas in terms of its potential for different possible uses and techniques provides a handy tool for informed-decision-making. But the field study of watersheds is very expensive and may not be possible or feasible when it comes to water harvesting projects. However, using remote sensing technology and GIS programs make it possible to characterize water and agricultural potentials regarding suitable locations for water harvesting projects. In this study, a map has been drawn up to determine the appropriate locations for water harvesting projects in khor Arbaat based on; slope information, rainfall and surface runoff information as well as information on vegetation cover and different land uses. Two detailed maps have been prepared, the first map is showing the optimal possible locations for water harvesting projects for domestic uses while the other one is showing the optimal possible locations for water harvesting projects for agricultural uses. The difference between these two maps is the type of soil where the preferred soil in the first map is the clay soil because water harvesting techniques for domestic uses depend on storing water in reservoirs locally known as “Hafirs”. In the second map, the water harvesting techniques for agriculture uses depend on good infiltration rate therefore, the sandy clay soil is preferred. Provision of such information in ungauged watersheds with scarce data on rainfall, soil and land use is substantially helpful in reflecting the possibilities and potentials available for informed decision-making and contributing towards better and comprehensive integrated management of watersheds.

Performance of Diam in Reducing Water Distribution Losses in the Dhakhliya Governorate, Sultanate of Oman (2015-2018)

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Water losses are one of the main challenges water utilities are facing and striving to reduce to their minimum economic levels. This research presents the international best practice for reducing water losses in the water supply distribution network and the relevant indicators used to describe the water system conveyance efficiency. It describes the water system components and how the water is flowing and distributed in such system. Then, it presents the strategy, programs and activities carried out by Diam in the Dhakhliya Governorate for water losses reduction. Diam has made major investments in its water supply infrastructure in order to monitor and assess the water system. In addition, Diam has developed its staff competency and skills to address the issue of water losses through establishing a leak detection team and a support team, which continuously conduct system analysis and evaluation. The study demonstrated that Diam efforts were effective in reducing the percentage of water losses, where all water loss indicators have shown improvements, despite the rapid increase of the number of consumers and the volumes of supplied water It is concluded that the combination of loss reduction programs and activities is required and essential to achieve significant reduction in water losses in the network, since these programs and activities are interrelated and are overlapping with potential synergies and enforcement among each other. In order to further improve water losses reduction it is recommended that Diam maintains its investment in the distribution network infrastructure, with special emphasis on establishing DMAs and human resource capacity development, in addition to strengthening its NRW data recording and documentation.

A Road Map for developing Water Safety Plan for Drinking Water in Kingdom of Bahrain
Managing drinking-water quality from catchment to consumer

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Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. Safe drinking water is essential for human health and socio-economic development. The United Nations considers universal access to clean water a basic human right and an essential step towards improving living standards worldwide; Sustainable Development Goal 6.1 calls for achieving universal and equitable access to safe and affordable drinking water for all by 2030. In other words, water supply from production (desalination plants/groundwater wellfields), through transmission and distribution, and eventually to consumers' household have to be protected from any potential pollution rendering it unsafe for consumption. Such approaches are called “Water Safety Plans (WSPs)”. The aim of a WSP is “to consistently ensure the safety and acceptability of a drinking water supply”. The main objective of this study is characterizing the water supply system in the Kingdom of Bahrain, identifying its major hazards and hazardous events and present a road map and recommendations to policy and decision makers on the formulation of a national water safety plan for the Kingdom of Bahrain. The study followed the methodology and procedures provided by the “Water Safety Plan Manual: step-by-step risk management for drinking water suppliers”, developed by the WHO and IWA in 2009. Strong effort and initiatives took place by Electricity and water authority in coordination with Arabian Gulf University and related water utilities and agencies, such as the Ministry of Health, SCE, Civil Defense, and Agricultural Engineering and Water resources to prepare in-house WSP based internal resources and Engineers who have been trained by WHO expert on how to build WSP on international standards. Some gaps were discovered during this study where some measures need to be implemented in the current system for example early detection of the nuclear radiation in sea water and heavy metal contamination. Last three modules of WSP could not be covered during this study due to time frame of these Diploma. More effort is expected to complete the roadmap for developing Water Safety Plan for Drinking Water in Kingdom of Bahrain by preparing managements procedures, developing supporting programs and finally review the WSP regularly and follow up the incidents

Evaluation of the Electricity Consumption at Tubli Water Pollution Control Centre in the Kingdom oF Bahrain

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This study aims to evaluate the electrical energy consumption during the wastewater treatment at the Kingdom of Bahrain. It focuses on the electricity consumption of the pumps in the Tertiary Treatment Plant in Tubli Water Pollution Control. The study determines the power factors according to the technical specifications of the pumps. In addition to that, FLUKE 434 Series Ⅱ Energy Analyzer was used to measure the active, reactive, and apparent powers as well as the power factors. The results showed high amount of energy losses due to low power factors which resulted in relatively high reactive power demand. The study concluded that the capacitor bank technology can reduce the severity of the reactive power problem.

Assessing the Sustainability of the Municipal Water Supply System in the Kingdom of Bahrain

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The Kingdom of Bahrain has been experiencing rapid economic growth which is associated by high rates of urbanization and population growth as well as water demands. To meet municipal water demands under its limited natural resources, the Kingdom has resorted to desalination, which is associated with considerable economic, financial and environmental costs. The research aimed to assess the sustainability of the current municipal water management system in the Kingdom of Bahrain, by identifying its main challenges and their causes, and investigate future practical management interventions to minimize the demand-supply gap on long-term basis. To achieve that, a dynamic model for the municipal water system has been developed by using WEAP program and used in estimating the quantities of supply and demand for the period 2019-2035 under the assumption of continuing the current management approach and conditions, which emphasis supply-side management (Reference Scenario). Then the model was used to measure the effectiveness of some administrative interventions to reduce the costs based on the strategic targets of the GCC Unified Water Strategy 2035. The modeling results indicated that by the year 2035: 1) Reducing per capita water consumption to 91 m^3/year will lower the supply by 91.2 Mm^3; 2) Reducing leakages in the water network to 10% will lower the supply by 63.375 Mm^3; and 3) Applying both interventions at the same time will lower the supply by 116.025 Mm^3. Therefore, there is a large potential to save water and energy and their associated economic and financial costs, and to reduce negative environmental impacts of the water sector by shifting towards these demand management and efficiency options to complement the current supply-side management approach. It is recommended that this work is further developed using stochastic modeling approach to address the uncertainties in future population growth, per capita water consumption, leakage percentage, and to model the seasonal variations of the water system.

Comparison between MSF and RO Technologies in the State of Kuwait

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The demand for freshwater has been a major issue in Kuwait. Desalination techniques have contributed to solving the shortage problem by producing fresh water from the sea or ocean water resources. Hence, desalinated seawater technology has been mainly employed as an important alternative source of clean water to supply water for domestic and industrial regions. Desalination plants could have many negative impacts on the surrounding environment. The main impact is surrounding the outfall brine rejected because of its physical and chemical features. Desalination of seawater in Kuwait has been given high priority as a source of potable water. Water demand is escalating at a rapid rate under the increasing population pressure and rise in the standard of living. Kuwait is adopted on the burning of fossil fuel to desalinate water which produces a huge amount of GHG emissions that affect air pollution and contribute to global warming. Furthermore, the high salinity and temperature discharge of the desalination plant outfall which changes the water quality and causes many impacts for both biota and a biota. This Research reviews comparison between MSF and RO desalination technologies, environmental impacts, energy consumption, cost and abatement of impact in Kuwait. The results show that the concentration of RO brine is much than in MSF brine whereas the temperature of MSF brine is very high comparing to RO brine temperature which is in the same range of ambient water temperature. On the other hand, the energy costs are extremely different of the two desalination methods. The capital investment and energy cost are the main two factors affecting the cost of the desalination technology, while other factors such as operation and maintenance cost are nearly at a fixed rate. The two main factors affecting the desalination technology are capital investment and energy cost. In fact, the most cost-effective technique is reverse osmosis while is used for smaller unit size. Furthermore, the cost of RO technology has steadily decreased with time. In addition, MSF consumes more energy than RO as thermal and electrical energy. Consequently, the GHG emissions of the MSF is much higher than RO. To avoid and mitigate environmental impact there are many tools and approaches such as, environmental impact assessment, switching to renewable energy as an energy source of the desalination processes. However, the desalination situation in Kuwait is more complicated than other regions in the world due to the freshwater scarcity, availability of fossil fuel and the lack of renewable energy technologies, so that the switching to renewable energy in desalination sector will take more decades and efforts.

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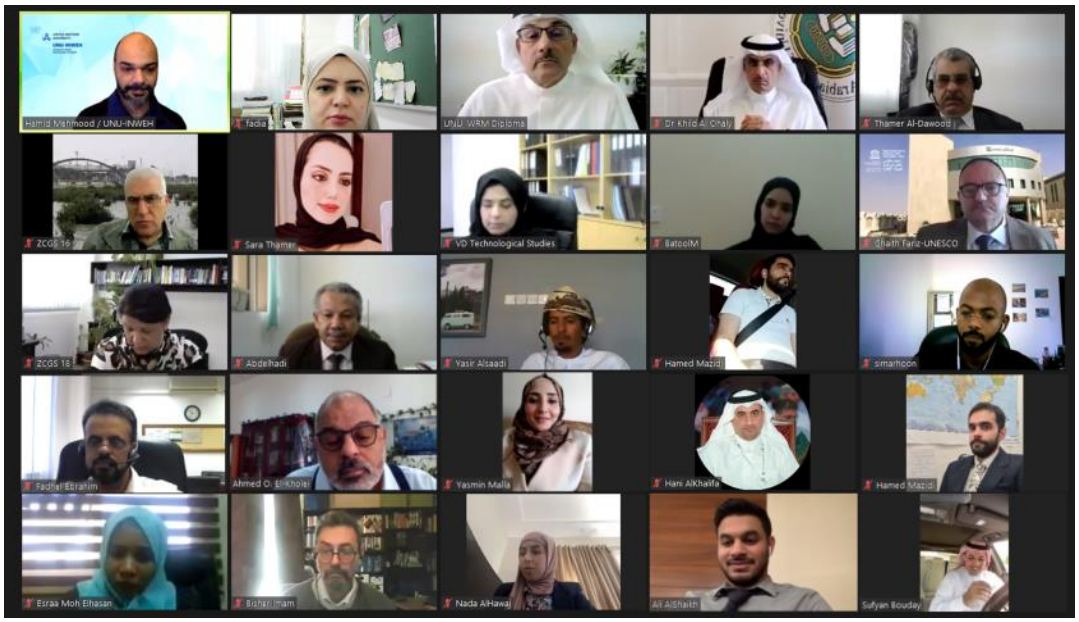
تقع إمارة الفجيرة على الساحل الشرقي من دولة الامارات العربية المتحدة، وتمتاز بالبيئة الجبلية ووفرة العيون والأفلاج المتنوعة، والبيئات الطبيعية، وتعتبر العيون والينابيع الطبيعية أحد أهم هذه البيئات نظراً لغنى تنوعها الحيوي ووفرة ما تقدمه من خدمات. ولقد أدى قيام العديد من الأنشطة البشرية والتنموية بصورة مطردة واستهلاك الموارد المائية إلى تدهور البيئة وإحداث خلل في النظم البيئية. تهدف هذه الدراسة إلى إجراء تقييم بيئي متكامل للمورد المائي الجوفي في إمارة الفجيرة للتعرف على الأسباب المباشرة وغير المباشرة لهذه الحالة والضغوطات التي تعاني منها، وآثارها السلبية، والاستجابة والسياسات الخاصة بإمارة الفجيرة التي يتم القيام بها للحد من تدهورها، كما تم تحديد الجهات المسؤولة عن إدارة المورد المائي الطبيعي وأهم الأنشطة التي تقوم بها، واستعراض النظم البيئية المختلفة في إمارة الفجيرة والخدمات التي تقدمها لرفاهية الإنسان. ولقد بينت الدراسة أنه بالرغم من وجود التشريعات الخاصة بحماية المورد المائي الجوفي، إلا أنه لا يوجد برامج حماية ومبادرات وتقييم للمياه الجوفية ولم تول اهتمام مباشر من قبل المؤسسات المعنية بحماية هذا المورد الطبيعي، وكذلك عدم وجود جهة مخصصة لإدارة المورد المائي الجوفي، وعدم كفاية الترتيب المؤسسي المطلوب للتعاون والتنسيق بين القطاعات المختلفة من خلال عدم تبادل البيانات والمعلومات والخبرات. ولقد نتج من القوى الدافعة/المحركة عدة ضغوط أدت الى العديد من المشاكل، أبرزها انخفاض منسوب الماء الجوفي، وتداخل المياه المالحة في الطبقات السفلى للمياه الجوفية. ولقد أدت الضغوط البشرية الناجمة عن الزيادة السكانية والتوسع الحضري إلى زيادة الاستهلاك، كما وجد أن الأنشطة الصناعية تمثل أهم الأسباب في تدهور حالة المورد المائي، حيث وجد أن مصنع الاسمنت فقط يستهلك حوالي 1000 متر مكعب يوميا، ويتم استغلال هذه المياه بدون وجود عدادات لقياس الاستهلاك، تم معرفة ذلك من خلال زيارة ميدانية له وهو مستمر في ذلك منذ خمس أعوام. ويشير ذلك إلى عدم كفاية الخبرات الإدارية لدى الجهات المسؤولة عن إدارة المورد المائي. وقد تم الخروج بمقترح للسياسات تهدف إلى تنظيم إدارة المورد المائي الجوفي، من أهمها إعلان مناطق العيون والينابيع محميات طبيعية، ووقف السحب الجائر، وتعديل القرارات الخاصة بالموارد المائية الطبيعية مع الاخذ بالاعتبار احتمال حدوث الكوارث الناجمة عن السيول والامطار بسبب ظاهرة تغير المناخ، واستخدام التقنيات الحديثة والنماذج الرياضية لمحاكاة المياه الجوفية ونظم المعلومات الجغرافية والاستشعار عن بعد، والالتزام بالمراقبة الدورية وعمل سجل خاص يقيم صحة المورد المائي الجوفي.

Eighth Batch: 2021-2022



Eighth Batch Students

No.	Name	Country	Project Title
1	Aishah Abdulla Al-Yammahi	UAE	Integrated Modeling and Future Water Scenarios of the Ham Watershed in UAE using WEAP
2	Ali Mohamed Al-Shaikh	Bahrain	Evaluating Pricing Policy and Tariff of the Municipal Water Supply in the Kingdom of Bahrain
3	Batool Mohammed Al-A'ali	Bahrain	Sludge Management in Bahrain: A Preliminary Investigation on the Potential Uses and Safe Disposal
4	Esraa M Elhasan Mohammed	Sudan	Identifying and Mapping Areas Susceptible to Flood and Flooding Risk using Weighted-Flash Flood Potential Index –WFFPI, Case Study: Khartoum, Sudan
5	Fadhel Abbas Ebrahim	Bahrain	Maximizing Product Water Recovery of Ras Abu Jarjur RO Desalination Plant: Technical, Economic and Environmental Viabilities
6	Feras Fahad Al-Mansour	Saudi Arabia	Managing Treated Wastewater Reuse in All Sectors (Agricultural, Industrial, and Municipal) in Saudi Arabia: Setting the Priorities
7	Hamed B. Al-Mazidi	Kuwait	Treating and Utilizing Second Generation of Wastewater from Sulaibiya Wastewater Treatment & Reclamation Plant (SWWT&RP)
8	Hani Hussain Al-Khalifa	Saudi Arabia	Management of Produced Water in the GCC Countries– A Review of Best Practices (Technical, Economics, and Environmental Perspectives)
9	Nada Abdul-Ghani Al-Hawaj	Bahrain	Exploring the Potential of Adopting Smart Water Quality Monitoring in Municipal Water in the Kingdom of Bahrain
10	Naser Salem Al-Katheeri	UAE	Mapping Flash Flash Potential using GIS and the Flash Flood Potential Index (FFPI) in Ras AlKhaima, UAE
11	Saleh Mohammad Al-Ammach	Bahrain	The Utilization of Solar Electricity from the Vertical Installed Solar PV Panels on the Energy Storage Tank at Sitra for Water Cycle Production
12	Sami Ismael Marhoon	Bahrain	تقييم مستوى الإدارة المستدامة للمياه الجوفية في مملكة البحرين باستخدام إطار البنك الدولي
13	Sarah Thamer Al-Dawood	Iraq	Impact of the Institutional Framework on Water Resources Management: The Case of Iraq, 1990-2020
14	Sharifa Abdullah Al-Shehhi	Oman	Evaluating the Potential of Greywater Reuse in the Sultanate of Oman, Case study Musandam Governorate
15	Sufyan Mohammed Bouday	Saudi Arabia	وضع خطة إدارة بيئية لاستخدام المياه المعالجة ثلاثياً في الزراعة في منطقة الأحساء بالمملكة العربية السعودية
16	Yasir Said AL-Saadi	Oman	Assessment of the Sustainability of Water Management System in the Sultanate of Oman: A Case Study of Al-Batha Basin
17	Yasmin Chukri Malla	Syria	إدارة الأحواض الجزئية في الساحل السوري، حوض نهر الغمقة بين مقترحي إنشاء سد رئيس أو مجموعة سدات حصاد مائي

Integrated modeling and future water scenarios of the Ham watershed in UAE using WEAP

Aisha Abdulla Al-Yamahi Email: aishah.alyammahi@moei.gov.ae Supervised by **Prof. Waleed Al-Zubari**	

Fujairah City is located in the outlet of Wadi Ham that overly dependent on groundwater to satisfy the demands for various uses. Groundwater resources are being used to meet the demands for various uses including domestic sector. Over time, the rate of groundwater consumption has outpaced its natural recharge, resulting in its severe depletion and subsequently groundwater quality deterioration due to saltwater intrusion. This research attempt to develop a mathematical dynamic model that integrates all water resources and uses in Wadi Ham watershed and simulate their interaction, investigate future demands, and provide alternative management solutions to preserve groundwater. Wadi Ham's case study is considered as a representative for the UAE eastern watersheds. The descriptive analytical approach was used to assess the current water conditions and identify its main problems and challenges, and then to define appropriate management actions that can enhance the sustainability of the water sector in serving the Wadi Ham future development needs by integrating all water uses and water resources and simulating their interaction. The model is based on data collected in 2020 from various water-related agencies in the emirates of Fujairah (water resources sector, desalinated water sector, wastewater treatment sector). These data and information were analyzed and processed in an appropriate manner, which is compatible with the mathematical simulation program (WEAP). The results indicate that the current conditions for managing water resources in the Wadi Ham is unsustainable due to the focus on the supply side management approach. Two plausible strategic management alternatives are suggested and simulated: increasing the collection and treatment rates of wastewater and reusing treated wastewater in agriculture to replace groundwater. The results indicated that future generated treated wastewater, if utilized effectively in agriculture, could help in reducing groundwater deficit. It is recommended that a priority and focus should be given to the wastewater sector in terms of treatment through increasing wastewater collection and utilization in the agricultural sector, which will not only help in reducing groundwater deficit, but will also minimize a wide range of problems, including pollution and adopting to drought conditions.

Keywords: Groundwater depletion, Saltwater Intrusion, Dynamic model, wastewater treatment.

Evaluating Pricing Policy and Tariff of the Municipal Water Supply in the Kingdom of Bahrain

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Prof. Waleed Al-Zubari
Prof. Ahmed El-Kholei

Bahrain is among the most water scarce countries and its groundwater resources are deteriorated. To meet escalating water requirements for its rapidly growing population and escalating urbanization, it relies on desalination. Water desalination is relatively an expensive process, energy-intensive, and is associated with many negative environmental externalities. Therefore, it is essential to use this water in a rational and optimum manner to minimize its costs through employing all possible water conservation policies. One of the effective policy instruments is pricing, and a well-designed domestic water tariff can be a powerful tool to achieve that goal. This research focuses on analyzing the water tariff of the subsidized domestic households sector, which forms the majority of the total water users. The research summarizes and presents water pricing theory, objectives, design criteria, and historical development of water tariffs in the Kingdom of Bahrain. It also addresses the issue of water pricing from a human rights perspective and the best practice on designing a water tariff to comply with it. Then, the domestic water tariff is evaluated by considering four main criteria: a) Revenue Sufficiency; b) Economic Efficiency; c) Environmental Sustainability; and d) Social Concerns. The main research findings reveal that Bahrain faces a challenge in terms of Revenue Sufficiency since the subsidized domestic households form around 70% of the total users, combined with the rapidly increasing population, which results in a significant financial burden. Furthermore, in terms of Economic Efficiency, the current tariff system is relatively low-priced compared to the Per Capita GDP and also in comparison to other GCC and Arab countries; hence, it needs to be modified to be more effective in discouraging wasteful use of water. Two alternatives to the current water tariff system are presented which are more effective in achieving cost recovery, limiting wasteful use of water, more environmentally sustainable, and socially acceptable. The first alternative is to modify the current three-block water tariff system by minimizing the block sizes and adding a fourth block that imposes the total marginal cost. The second proposed alternative is a Unified Priced Tariff with Rebate (UPR), which charges a uniform rate and deducts a flexible subsidy amount based on the household size. This study recommends that the subsidy amount can be adjusted according to the ideal per capita consumption based on Bahrain socio-economic and cultural conditions, the cost recovery level of each tariff structure, the optimum balance between cost recovery, costumer ability to pay, and conservation encouragement, and that a more thorough in-depth comparison of the proposed tariff systems to be conducted in order to select the best option.

Keywords: Revenue Sufficiency, Cost Recovery, Human Right in Water, Tariff Subsidy, Water Conservation, Block Tariff, Unified Priced Tariff with Rebate (UPR).

Sludge Management in Bahrain: A Preliminary Investigation on the Potential Uses and Safe Disposal

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Dr. Sumaya Yousef

Although the Bahrain's government is adopting the sustainability and zero waste approach, the increasing improvement of Waste Water Treatment Plants (WWTPs), owing to urbanization, is resulting in production of higher amounts of sewage sludge (SS) that is becoming a serious environmental problem. Assessing the current disposal mechanisms and investigating the opportunities of beneficial use of SS is considered vital for any Integrated Water Resources Management program. In this study, the national and international standards were studied and a general overview of using SS internationally for beneficial uses was addressed from previous studies. A field experiment was conducted in pots where SS is mixed with soil in the ratios of 0, 1, 2.5 and 5.0% by weight in a completely randomized manner with 3 replications. The used SS was produced from Tubli Water Pollution Control Centre (TWPCC). The experiment was conducted in a greenhouse during the harshest summer month of July 2021 using the common purslane vegetable as a test crop. The goal was to assess the contents of heavy metals in purslane leaves in addition to general observations on development of seedlings. The SS produced from TWPCC is class A, and in most of the tested parameters, is within exceptional quality (EQ) according to the EPA part 503. The results indicated that there was no correlation between heavy metals concentration in the plant and the SS ratios applied. The study suggested that, considering the short duration and the limitation of the timing of experiment, further detailed and continuous long-term experiment on different types of crops and vegetables should be undertaken to fully understand the potential and limitations of using Bahrain's Municipal SS for agricultural production. Other methods of disposals must also be tested instead of the current landfilling due to the severe area limitation at Askar's landfill.

Keywords: Sewage, Fertilizer, Sludge disposal, Sludge treatment, Sludge uses, Sustainable management.

Identifying and Mapping Areas Susceptible to Flood and Flooding Risk using Flash Flood Potential Index – FFPI, Khartoum, Sudan

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Supervised by
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Flash floods are catastrophic natural disasters. Flash flood potential index (FFPI) is used to study and analyze the impacts of heavy rain on different areas. This study investigates the relationship between the heavy-rain overflow factor and the physical and spatial characteristics of the Khartoum state area. The spatial analysis utilizes remote sensing data on the digital elevation model (DEM), slope, soil texture type, land use land cover (LULC), and vegetation cover in the GIS environment. The FFPI index is computed using raster data, which is used to split the study area into cells (30X30 meters), then evaluated, categorized, and calculated using GIS technology. The physical and empirical relationships between the criteria were used to create an index to enable decision-makers and urban planners in cities exposed to flash floods to identify the foremost natural and human factors for the increased level of flash flood risks in the capital of Sudan Khartoum. Each criterion (Index) was classified from 1 to 10 by identifying their levels based on the Flash Flood Potential Index (FFPI) model. The Final FFPI map of the Khartoum area was divided into five threatened classes based on their susceptibility to high floods, (v. high, high, medium, low and v. low). The v. high susceptible area class is about 3590.82 km2, the high-class area is mound to about 9869.64 km2, the medium is 7917.24 km2, the low and v. low is mound to about 190.57 km2 and 573.73 km2. The study indicated that the impact rate in the state of Khartoum amounted to 13460.46 square km, which is equivalent to 61% of the area of the state, the high affected areas equal 9869.64 km2 , Which represents 45% of the state area , wile the very high affected areas equal 3590.82 km2 , which presents 16% of the state area , and the localities of East Nile, Umm Bedda, and Khartoum North were the most affected, the results showed that the level of damage in the state was divided into very high, high, medium, low, and very low. The study recommended the need to develop a database for flood damage and the need to develop an early warning system for floods with the integration of the response and preparedness system for floods. The index map explains the environmental and natural factors that affect Khartoum's flash flood phenomena. In addition, the index map explained the factors that cause the catastrophic effects of flash floods. Many artificial wrong practices must be paid attention to, and physical and geographical investigations must be conducted before developing urban areas, in addition to the need for urban planners to be aware of the risks of destructive construction within the natural paths of temporary watercourses. Therefore, the spatial distribution of FFPI values provides a good starting point for flood risk management and the possibility of implementing prevention and protection measures in Khartoum state.

Keywords: Digital Elevation Model (DEM), Geographical Information System (GIS), Classification, Land use-land cover, soil types.

Maximizing Product Water Recovery of Ras Abu Jarjur RO Desalination Plant: Technical, Economic and Environmental Viabilities

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The kingdom of Bahrain like other Arabian Gulf states suffers from severe shortage of freshwater resources. The country therefore relies mainly on water desalination to cope with its increasing municipal water demand. One of the desalination plants in Bahrain is the Ras Abu Jarjur RO Plant. The plant is fed from highly brackish groundwater with TDS of 13,000 ppm known as Umm Er Radhuma aquifer. The water in this aquifer is non-renewable and had suffered over the past years a sharp and continuous level declination. This study aims to sustain the use of this vital water resource and explore the technical, economic and environmental viabilities of using the reject water from the RO process to increase the plant water production. Two methodologies were used: computer simulation using Toray DS2 software followed by 8 months pilot plant testing. Taking advantages of the new generation of spiral wound RO membranes, two approaches were investigated: direct recovery increase and reject re-desalination using a second pass. The results reveal that the water recovery rate at Ras Abu Jarjur plant could be safely increased from 70 to 78% while remaining reject water could be re-desalinated at recovery of 39.5%. Adopting both approaches will increase the plant capacity by 25% and will add 4 MIGPD of product water totaling plant production to 20 MIGPD. Economically, a CAPEX saving of approximately BD 7.6 million could be achieved as no expansion will be needed in plant intake and pretreatment. Likewise, the OPEX, driven by reduction of specific energy consumption, was remarkably reduced from BD 0.25 to BD 0.172/m^3. It was marginally increased to BD 0.180/m^3 with the increase of recovery rate. From the environmental perspective, the results confirmed that using reject water to increase the plant production have no additional impact on the marine environment. The study recommends changing the RO membranes to energy efficient type and adopt increasing the recovery rate to 78% in the main plant. It also recommends carrying out pilot testing for reject water re-desalination to confirm its viability and implement the same once approved.

Keywords: Reject Water, Specific Energy Consumption, Concentration Factor, CAPEX, OPEX.

Managing Treated Wastewater Reuse in All Sectors (Agricultural, Industrial, and Municipal) in Saudi Arabia: Setting the Priorities

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This research discusses a long-standing issue with water resource management in the Kingdom of Saudi Arabia (KSA) as the population grows and water demand increases. Due to the increasing urbanization in the KSA, the government has intensively invested in desalination plants and sewage treatment plants (STP) to meet the high demand. The National Transformation Program (NTP) aims at reducing reliance on nonrenewable groundwater resources and to achieving 70% treated wastewater effluent (TSE) reuse by 2030, which has driven the Government of Saudi Arabia to consider reusing TSE in irrigation, power generating, manufacturing, street cleaning, and urban reforestation to avoid aquifers depletion and increase the return on investment in STP. However, it is challenging to manage the proportion of water sources that maximize environmental protection and returns on investment. Previous studies related to TSE reuse and sewage treatment revealed that merging multi-criteria analysis and geographical information system data is significantly accurate along with other parameters (Zagonari & Rossi, 2020). Other studies found that country's social and economic factors impact wastewater management efforts (Vincent et al., 2017). This study focuses on determining how KSA can overcome the high demand on TSE, as an alternative water resource, by applying a multi-criteria decision-making procedure (MCDM) to define the priority. This study analyzed the abovementioned sectors in terms of usage types by applying Analytical Hierarchy Process (AHP) based on the pairwise comparison. The research found that agriculture is the best alternative. The research concludes that, although several risks associate with treated wastewater, balancing its environmental and social effects alongside economic aspects can ease acceptance of the available alternatives. The study recommends that future studies use lower level of criteria and involve more stakeholders. A cost-benefit analysis is a must for more accurate and comprehensive details on water scarcity, uses, and return on investment.

Keywords: Analytical Hierarchy Process, Multi-criteria Decision-Making, TSE reuse priority, Water Resources Management.

Treating and Utilizing Second Generation of Wastewater from Sulaibiya Wastewater Treatment & Reclamation Plant (SWWT&RP)

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Low salinity water and brackish groundwater are valuable "drought-proof" resources that are plentiful in much of Kuwait. The Sulaibiya Wastewater and Reclamation Plant (SWWT&RP) is the largest reverse osmosis (RO) wastewater plant in the world, where its final product of advanced treated wastewater is currently limited to agricultural and landscaping irrigations. Considering reuse of the relatively low salinity rejected wastewater (Brine), which result from the quaternary advanced RO treatment, as source of water in Kuwait Oil Company (KOC) will reduce consumption of the expensive desalinated water and the depleted groundwater. However, this brine product is currently dumped in Kuwaiti seashore after primary treatment, and this has negative impacts on Kuwait marine life. Moreover, the KOC future water demand is expected to exceed 21 Million Imperial Gallon Per Day (excluding North Kuwait & drilling demand) taking into account that the Abdaliyah aquifer is the only productive field of low salinity water, which KOC has relied on since 1945 for industrial and other applications in the South East, West Kuwait and Ahmadi residence area. Therefore, exploring, evaluating and utilizing the available and sustainable low salinity water sources (tertiary and Quaternary treated wastewater, desalination of KOC effluent water, KOC wastewater and any other available source of low salinity water) could help KOC in resolving the water shortage problem. If these sources are used for non-potable purposes such as low salinity water injection, de-salters wash water, Enhanced Oil Recovery low salinity demand, drilling mud demand, firefighting systems and landscape irrigation, they will free up substantial amounts of Abdaliyah aquifer and other precious brackish water supplies that are currently dedicated to these uses and will eventually secure KOC future industrial water demand. Moreover, brackish water in South East Kuwait has been deteriorated by Hydrogen Sulfide (H_2S), making it unsuitable for industrial application, and in North Kuwait the brackish water has also been deteriorated by high salinity water intrusion. The KOC realized that exploring other sources of low salinity water will be a wise decision, as part of its efforts to protect natural resources and secure its future low salinity water demands, and accordingly experimental trails to treat the RO reject stream Brine from SWWT&RP is being conducted. The objective of this study is to assess if this relatively low salinity rejected wastewater is suitable for KOC industrial applications by using the following treatment techniques: softening, multimedia filtration, RO, evaporation and deaeration. Samples and analysis were taken to measure different chemical and microbiological parameters of the treated effluent, such as (Total hardness, Silica, Total Dissolved Solids, Sulfate, Iron, Dissolved Oxygen and Total Suspended Solids). Results indicated that the reject stream is free of sulfates, carbonates, iron, bacteria, corrosive salts and oxygen, which means this water will not produce surface or sub-surface scaling if used in KOC installations, and due to absence of bacterial content, there will be no growth pf Sulfate Reducing Bacteria (SRB). Therefore, this reject water can be used as a sustainable water source for the KOC industrial applications. Treating of RO reject stream (Brine) not only would overcome KOC future industrial low salinity water demands, but it would also protect public health and the environment by preventing discharging this waste into surface water. It is recommended to apply this study on a full-scale implementation, as this would save significant amounts of water for industrial uses.

Keywords: Wastewater, reclamation plant, low salinity, water, brackish water, reverse osmosis, water treatment, water reuse.

Management of Produced Water in the GCC Countries– A Review of Best Practices (Technical, Economics, and Environmental Perspectives)

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Produced water (PW) naturally exists in most oil and gas reservoirs and is by far the largest byproduct in the oil and gas industry. Its volumes and composition vary significantly by locations and over the lifetime of the reservoir development. Globally, hundreds of millions of barrels of contaminated water are produced with crude oil and gas. In the Middle East, about 40 million barrels of brine water is produced every day. Most of the oil and gas fields in the region have not reached advanced maturity and produced water percentages are still considered lower than in other regions. However, as the fields mature, increase in produced water production is unavoidable. With 60% of the world proven reserves present in the GCC region, the region will continue to be the main oil and gas producer in the future. This will be coupled with high local growth in population and development increasing local demands. These factors will accelerate the growth in production rates of oil and gas which is expected to significantly increase the volumes of produced water in the future. Management of produced water is one of the main challenges facing oil and gas industry. Produced water causes problems in the reservoir management phase, separation and handling phase and the disposal phase. It is contaminated with hydrocarbons, heavy metals and other chemicals, which makes it unfavorable resource. Most of the operators elects to use produced water as a mean to maintain reservoir pressure by returning it to the producing formations. However, with the expected increase in produced water volumes, produced water is expected to cause a sharp increase in operating costs. Effective management of produced water will help in controlling the increase in relevant costs. This research conducted a review of relevant published papers with a focus on the GCC region and performed a gap analysis to compare existing practices in the GCC with the international best practices. The research evaluated the decision-making process related to each strategy of common produced water management system. The main outcome of this research is that in GCC there are no shortage of technology utilization in the implementation of PW first and second strategies. PW is not widely considered for reuse since PW ratios are relatively low and most of the PW is recycled through injection for reservoir pressure maintenance with exception of Oman where PW ration is significantly higher. However, it was noticed that there is a limited integration in the implementation of the PW strategies. This research indicates that each of the three strategies are strongly interlinked with the other two strategies. For example, PW reduce strategy is typically implemented with limited attention given to its impact on surface facilities and the rest of the network. Likewise, PW quality is typically determined primarily based on receiving formation characteristics with limited attention given to total treatment and injection lifecycle costs and water treatment system costs. This research proposes to add a fourth strategy, Reassess, to enhance decision-making process toward total PW cost rather than individual strategy cost. Total PW cost can be reduced through the reassessment strategy.

Keywords: Water Treatment, Water Control, Water Costs, Water Reuse, Water Technologies.

Exploring the Potential of Adopting Smart Water Quality Monitoring in Municipal Water Sector in the Kingdom of Bahrain

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Safe water is becoming a scarce resource, due to the combined effects of increased population, pollution, and climate change and variability. Water quality monitoring is thus paramount, especially for drinking water. Traditionally used laboratory-based testing approaches are manual, costly, time consuming, and lack real-time feedback. Recently developed systems utilizing Information-and-Communication Technology (ICT) and Internet-of-Things (IoT) are deploying variety of solutions for smart water quality monitoring, as a steppingstone towards having a smart water grid. To ensure the safe supply of drinking water, the quality needs to be monitored online in real time. The consequence of inadequate monitoring can result in substantial health risks, economic, and reputational costs. Therefore, this research aims to identify the main water quality parameters within the safe range of drinking water, review the current water quality monitoring system, explore the technologies deployed as use cases and others that have been adopted in a number of countries (Singapore and the USA (Ohio State)). The research is conducted based on literature review and interviews with representatives from Bahrain's water utility to be able to customize an approach that is suitable for the municipal water distribution network in Bahrain. The main research findings are that smart water quality monitoring SWQM depends on a set of system components such as: sensing devices, sampling locations, communication solutions, data transmission characteristics, deployed topology, data processing, analysis approaches, data management, and energy consumption. Consequently, several preconditions must be met to achieve a solution that covers the distribution network, such as setting SWQM goals, performance objectives, current system functional review, robust design with broad scalability. It is recommended to investigate SWQM in more depth, perform pilot local studies, explore more case studies from countries with similar environment, and perform cost estimates as well as return on investment. Furthermore, comprehensive research shall be undertaken to establish guidelines that determine sampling locations, and to select the most suitable technology based on the existing and planned water distribution network.

Keywords: SWQM; Water Parameters, Distribution Network, ICT solutions, Communication Technologies, Data Transmission, Data Collection, Data Management, Drinking water.

Mapping Flash Flash Potential using GIS and the Flash Flood Potential Index (FFPI) in Ras AlKhaima, UAE

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Flash flood is one of the massive natural disasters around the world. Flash flood potential index (FFPI) is used to determine the impact of storm rain in different locations based on hydrological response to the watersheds. The objectives of this study are to find the critical flooding areas in Sha'am Basin by analyzing geospatial factors to find the final map of FFPI. The methodology depends on using four geospatial variables in Sha'am Basin, such as terrain slope in Degree, land use, land cover, and Soil type by using GIS tools, and spatial analysis utilizes to extract, reclassify, and generate the raster dataset cells (DEM 30X30 meters) to end up with flash flood potential index (FFPI). All dataset maps are classified into five classes, Class 1 is a lesser response and potential for flash floods, and class 5 is a more significant response and potential for flash floods. After all data sets were reclassified, the raster calculator in Map Algebras was used to calculate the average reclassified dataset raster to go next for effectiveness weight (slope 55%, soil 10%, and LuLc 35%) to get FFPI. The results show that the FFPI values will increase when the effectiveness weight of slope and land use is increasing and affects in FFPI equation result more than soil weight. The Final FFPI map of the Sha'am Basin area was divided into four threatened classes based on their susceptibility to high floods (V. High, High, Moderate, low). Both indexed values 4 and 5, high and very high susceptible area classes with 7.3 km2 and 8 km2, respectively, are covered more than 70% of all Sha'am Basin. The moderate and low areas are 10.4 km2 and 0.006 km2, respectively, covering 30% of Sha'am Basin area. In conclusion, seventy percent (70 %) of the Sha'am Basin area occurs under a very high flash flood zone. Therefore, FFPI can be helpfully used in UAE to show the future critical flash flood risk zones.

Keywords: Flash flood, FFPI, Risk zone, Basin, Shaam, Geographic Information System.

The Utilization of Solar Electricity from Vertically Installed Solar PV Panels on the Energy Storage Tank at Sitra for Water Cycle Production

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Bahrain's main source of fresh water is desalination of seawater. The main challenge of desalination is that it is energy-intensive in addition to its negative environmental externalities. Using a sustainable energy source, such as solar energy, for operating desalination plant, with high recovery ratio, will minimize fossil fuel consumption and therefore CO_2 emissions (i.e., zero emission). The objective of this project is to study the feasibility of using solar electricity to power a small-scale reverse osmosis (RO) plant, i.e. integrating solar energy in water production to decouple fossil fuel from desalination as an important component in managing the water-energy nexus. The project concluded that the vertically installed PV's on the facade of the storage tank (called herein as PV Elevated Storage Reservoir, PVESR) has the potential to produce 83 m^3/day (21,926 US gallon/day) and annually 30,277 m^3 (7,998,337 US gallon) with an annual solar electricity of about 196,800 kWh as per system simulation. Furthermore, it is found that if 80 % of the roof space of the storage tank is used to install PV panels installed at a tilt angle of 20°, then the annual energy will increase to about 357,108 kWh and the water production would reach about 150.5 m^3/day (about 44% increases). The vertically installed PVs system is expected to operate effectively, on average 4 hours, due to the unavailability of batteries for electricity storage. The capital cost of the plant is estimated to be nearly BD 100,000, with a unit cost of produced desalinated water at about BD 0.165 /m^3. The PVESR system will offset about 81 tonnes of CO_2 annually.

Keywords: Vertical PV installation, Solar water desalination, Solar power, Reverse Osmosis, Bahrain.

تقييم مستوى الإدارة المستدامة للمياه الجوفية في مملكة البحرين باستخدام إطار البنك الدولي

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تعد الإدارة المتكاملة للمياه إحدى أفضل الأساليب للوصول إلى الاستدامة المائية. وبالرغم من تحقيق مملكة البحرين العديد من الإنجازات في تحقيق مبادرات وبرامج أهداف الأمم المتحدة للتنمية المستدامة 2030، حيث حققت درجات عالية جدا في مجال توفير خدمات مياه الشرب والصرف الصحي، إلا إنها حققت درجات متدنية نسبياً في مجال تنفيذ الإدارة المتكاملة لموارد المياه (39.7 من 100). يركز هذا البحث على المياه الجوفية في المملكة ويهدف إلى تقييم مستوى الإدارة المستدامة للمياه الجوفية باستخدام إطار البنك الدولي لتشخيص وتقدير مدى كفاءة التدابير المتبعة حالياً لإدارة المياه الجوفية وتحديد الثغرات ومواطن النقص فيها، وتقديم التوصيات اللازمة للوصول للإدارة المتكاملة للمياه الجوفية. ولقد بينت نتائج التقييم أن إدارة المياه الجوفية في مملكة البحرين منخفضة المستوى ولا تتناسب مع مرحلة الإجهاد الحالية التي تمر بالخزان الجوفي، حيث يتم تطبيق الأدوات الإدارية وكأن المياه الجوفية في مرحلتها الأساسية أو تتعرض لإجهاد أولي بينما هي في مرحلة تنمية غير مستقرة بسبب ضعف إدراك المؤسسة على اتخاذ الإجراءات التنظيمية الفعالة من وضع آليات للموازنة والتحصيص، والعمل على إنفاذ وتحديث التشريعات، والرقابة المسؤولة. نوصي بتعزيز مواطن القصور والعمل على الإصلاحات المؤسسية من توظيف وتنمية قدرات الكوادر لتتولى وضع برامج وخطط شاملة لإدارة مستدامة للمورد الجوفي، والعمل على إصدار إطار قانوني شامل لإدارة المياه الجوفية، وأن يتم تحصيص المورد دون الإخلال بالموازنة المائية أو تخطي كمية السحب الآمن للمياه، واستخدام الأدوات الاقتصادية والقيود على الاستهلاك طبقاً لكل مراحل من مستويات التنمية الموضحة في إطار البنك الدولي.

الكلمات الدالة: مياه جوفية، الأدوات الفنية، الإجراءات التنظيمية، الوسائل المؤسسية، مراحل تنمية المياه الجوفية.

Impacts of the institutional Framework on Water Resources Management: The Case of Iraq, 1990-2020

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The Republic of Iraq is located in the Middle East. It shares borders with Saudi Arabia, Kuwait, Jordan, Syria, Turkey, and Iran. In the past few decades, the Middle East has experienced water scarcity crisis primarily due to increasing water demands on one hand and shortage of water sources availability and adverse climatic conditions on the other. The unstable political situation in the region has also propagated the problem; Iraq is amongst those countries that have suffered in the last three decades from many political events and wars that have affected its stability. Iraq has two primary surface water sources represented by the Tigris and Euphrates rivers. Both rivers originate from outside Iraq's borders, mainly from the Taurus Mountains on the southern side of the republic of Turkey. In the twenties and thirties of the twentieth century, Turkey discussed the possibility of damming both rivers to use water mainly for power generation and agricultural activities. It built some dams from time to time with the signing of treaties that preserve Iraq's right to the waters of the two rivers. However, Turkey has built 31 dams in the past three decades making the rivers in Iraq under the inevitable danger of drought. Besides the fifteen dams built on the Karun River - one of the important tributaries of the Shatt al-Arab by Iran, which causes a significant negative impact on the water situation in the southern part of the Tigris River. This study aims to assess the institutional role of the availability and water management in the republic of Iraq. The dataset comprises key climatic metrics and amounts of surface water from 1990 to 2020; then the dataset was projected on key political events in Iraq's recent history to establish an association between surface water availability and the role water institution plays. Multiple linear regression as a primary statistical test was applied to assess the relationship and its significance. Results suggest that invading Iraq in 2003 and the emergence of ISIS in 2014 were the events most negatively associated with a decline in surface water flow (P-value: <0.001) and (P-value: <0.001), respectively. Other factors, such as the Invasion of Kuwait and the Oil for Food program, were slightly or not statistically significant. The results imply a statistically significant role of the institution/government in providing a sustained water supply to the Republic of Iraq. The Ministry of Water Resources should be well regulated and efficiently structured to develop appropriate strategic plans on water resources to meet the future demand.

Keywords: Water sustainability, Climate change, Surface water, Groundwater, Deductive approach.

Evaluating the Potential of Greywater Reuse in the Sultanate of Oman, Case study Musandam Governorate

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Greywater recycling is an important management alternative to reduce consumption and cost of limited drinking water resources in arid regions such as Oman. Greywater recycling can help replace precious drinking water in low-quality applications such as industry, irrigation, toilet flushing and washing; this in turn will reduce the consumption of fresh water. Aside from generating wastewater, greywater recycling can be beneficial in increasing national water reserves, as well as ensuring increased water supply for irrigation, leading to increased agricultural productivity and sustainability of the agricultural sector in areas affected by high salinity groundwater. Urban, economic and commercial development in the Governorate of Musandam have led to increased demand for water and excessive consumption of drinking water, which resulted in high levels of salinity in groundwater as well as an expansion in desalination plants. This study assessed the possibility of reusing greywater in Musandam Governorate, as a case study for the Sultanate of Oman, to be an alternative user of fresh water in industry, agriculture and domestic consumption. This is made by estimating the quantities of greywater generated in the governorate and examining its physical, chemical and bacteriological properties. The results indicated that all quality parameters of greywater generated in the governorate are within the Omani regulations and standards for wastewater reuse and discharge, except for turbidity and bacteria content. Ablution greywaters are found to be of high quality water for all parameter after treatment and disinfection. It is concluded that greywater generated from different sources in the governorate can be reused for agricultural or domestic purposes such as washing and cleaning (except drinking) after removal of turbidity and disinfection of water using simple techniques. It is recommended to review and update the regulations and laws related to the reuse of greywater and to intensify efforts and studies at the level of the Sultanate of reusing greywater.

Keywords: Household, Tourism, Chemical, Bacteriological, Treatment system.

وضع خطة إدارة بيئية لاستخدام المياه المعالجة ثلاثياً في الزراعة في منطقة الأحساء بالمملكة العربية السعودية

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لقد أصبح نقص المياه المخصصة للزراعة مشكلة مزمنة للدول ذات الندرة المائية، مثل المملكة العربية السعودية. ولذلك، فإن استخدام المياه المعالجة في الأغراض الزراعية سيمكنها من تحقيق جزء من الأمن الغذائي محلياً، والتخلص البيئي الآمن من المياه المعالجة، وتخفيف الضغط على مصادر المياه غير المتجددة المستخدمة في الزراعة. ولقد بادرت المملكة في العمل على زيادة استخدام المياه المعالجة ثلاثياً في الزراعة من خلال نقلها من مناطق إنتاجها الحضرية إلى المناطق الزراعية. إلا أن هذه العملية يصاحبها العديد من المشاكل التشغيلية المتعلقة بجودة المياه أثناء نقلها وتخزينها. هدفت هذه الدراسة إلى تقييم تجربة أحد مشاريع نقل المياه المعالجة بين مدينتي الخبر والأحساء، ومن ثم تطبيق خطه بيئية لضمان جودة عمليه النقل والتخزين لتلك المياه. وتم اتباع منهجية التحليل الفني لطريقة عمل النظام وتبع ذلك عمل الاختبارات الحقلية لتحديد المواقع التي تتدهور بها جودة المياه ومن ثم تطبيق الإجراءات التحسينية عليها وتقييم النتائج. ومن خلال مراقبة عمل المشروع اتضح أن المياه يتم استلامها من المصدر سليمة ومطابقة للشروط التنظيمية، ولكن تتدهور جودتها عند الوصول للمصب. وتم تطبيق إجراءات تحسينية تتمثل في استخدام تقنيتين مختلفتين: الأولى هي تركيب منظومة التجريع بفقاعات الهواء النانونية، والثانية تركيب منظومة التجريع بالكلورين في موقعين مختلفين ومتطابقين في التصميم والفلسفة التشغيلية ومن ثم المقارنة بينها. ولقد أظهرت النتائج أن التقنية الأولى الخاصة باستخدام الفقاعات النانوية لم تحقق جميع الاشتراطات التنظيمية، بينما كان خيار استخدام الكلورين ناجح ومستوفي للشروط، وأجدى مالياً من التخلص من المياه غير المطابقة للمواصفات. خلص البحث إلى أن استخدام الكلورين هو الخيار الأسلم بيئياً لضمان توصيل المياه من المصدر حتى تصل المستهلك النهائي، ولكن يوصى بالقيام بدراسات معمقة حول حدود الكميات القصوى لتجريع الكلورين بالشبكة. كما يوصى بتطوير نموذج محاكاة تشغيلي لنقل وتخزين وتوزيع المياه المعالجة يهدف إلى المحافظة على مستويات الجودة في الحدود المسموح بها.

الكلمات الدالة: الري؛ نقل المياه المعالجة؛ منظومة التجريع؛ الفقاعات النانونية؛ الكلورين؛ تحسين جودة المياه.

Assessment of the Sustainability of Water Management System in the Sultanate of Oman: A Case Study of Al-Batha Basin

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The natural resources sector in the Sultanate of Oman is one of the sectors that faces many challenges due to the various comprehensive development requirements. There is an imbalance between supply and demand, and thus the Sultanate of Oman is working on building many desalination plants to cover the water deficit and building many dams on the valleys. Wastewater treatment also contributes little to meeting the water deficit. However, the approach that the Sultanate of Oman is currently working on has not helped in reducing the water deficit, which is estimated at 316 Mm^3. Seawater desalination is considered very expensive for the government and has environmental impacts over time. This study aims to evaluate the water resources management system in the Sultanate of Oman by using one of the water basins, which is the Al-Batha basin as a case study, and through this basin, the most important challenges facing the management of water resources in this basin were identified and then the possible solutions and future scenarios that can contribute to reducing the water deficit in the Al-Batha basin, which is estimated at about 54.6 Mm^3, were suggested. The WEAP program was used to build a dynamic mathematical model that simulates the water management system in the Al-Batha basin during the period from 2020-2040, i.e., the period of implementation of the Oman 2040 vision. The results showed that if 1) the leakage in the network is reduced by 10%; 2) the wastewater collection rate is increased, and 3) the irrigation efficiency is raised to 70%, this would have a significant impact in reducing the amount of water to a large extent in 2040. The total municipal water demands are calculated at 294 Mm^3 compared to about 317 Mm^3, according to the reference scenario in 2020. Wastewater collected quantity was 270,779 m^3 in 2020 and will reach about 318,744 m^3 in 2040, compared to the reference scenario where the amount is about 316,866 m^3, an increase of 1,878 m^3. In the agricultural sector, the amount of irrigation used can be reduced from 236.6 Mm^3 in the reference scenario to 118.3 Mm^3 by the year 2040; if irrigation efficiency measures are implemented. This study recommended the necessity of reducing leakages in the network, increasing the collection of wastewater, and raising the efficiency of irrigation to sustainably manage the water resources in Oman.

Keywords: WEAP, Integrated Management of Water Resources, Aflaj.

إدارة الأحواض الجزئية في الساحل السوري، حوض نهر الغمقة بين مقترحي إنشاء سد رئيس أو مجموعة سدات حصاد مائي

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نُفِّذَ البحث لتقييم منظومة منشآت البنى التحتية (السدود والسدات) اللازمة لإدارة الموارد المائية في حوض نهر الغمقة، أحد الأحواض الفرعية المشكلة للمنظومة الهيدرولوجية في الساحل السوري ويقع في وسط الجزء الجنوبي منه ضمن محافظة طرطوس. يهدف البحث لتقييم الحوض بين خيارين مقترحين؛ الأول هو إنشاء سد رئيس، والثاني مجموعة سدات صغيرة تعتمد على مبدأ الحصاد المائي لتأمين الاحتياجات المائية مكانياً للتجمعات السكانية وأنشطتها، واختيار البديل الأمثل بشكل متكامل بمقارنة مختلفة الأبعاد المؤثرة في اتخاذ القرار. اعتمد البحث المنهج الوصفي التحليلي والمنهج التطبيقي وفق آلية التحليل الهرمي ((Analytic Hierarchical Process (AHP) المستخدمة في عملية اتخاذ القرار متعدد المعايير (multi-criteria decision making) لدراسة تأثيرات منظومات البنى التحتية لتخزين المياه السطحية وإدارة الجريانات والتحكم بها، وذلك من خلال تقدير علاقتها المتبادلة مع التأثيرات البيئية، والاجتماعية، والاقتصادية، والهندسية، والسياسية (علاقة المجتمع المحلي الشريك مع مؤسسات إدارة الموارد). أبرزت نتائج التقييم عبر استبيان عينة موجهة تُمثل الشركاء جميعاً (صانعي قرار ومخططين وطنيين وأبناء المنطقة)، احتلال قضايا البيئة بنسبة 36.8% يليها الاعتبارات المجتمعية 21.2% التي تمثل آراء المجتمع المحلي ومن ثم الاعتبارات الاقتصادية 18.3% وأخيرا المعايير الهندسية والسياسية بنسب 13.1% و10.7% على التوالي، وقد أكّدَت نتائج تحليل المخرجات أفضلية التوجه نحو السدات الصغرى بنسبة 79.6% مقارنة بإنشاء سد واحد كبير. يوصى باتباع منهجية AHP في تحديد الخيارات وفق ظروف محددة (على مستوى الحوض الواحد)، ولاتخاذ القرارات المتعلقة في إدارة الموارد المائية بالتشارك الفعّال مع المجتمع المحلي.

الكلمات الدالة: تحليل هرمي متعدد المعايير، منظومة بنى تحتية، إدارة الموارد المائية، التشاركية الفعّالة، حوض الغمقة.

Ninth Batch: 2023-2024

Ninth Batch Students

No.	Name	Country	Project Title
1	Ahmed Al-Qattan	Bahrain	Characterization and Potential Reuse/Recycle of Wastewater in the Poultry Sector in Bahrain, Case Study: Delmon Poultry Company
2	Ahmed Al-Shamsi	UAE	Brine Water in UAE: Overview on Analysis, Assessment, and Possibility of Reuse
3	Ahmed Fouda	Egypt	Collecting and Assessing the Main Criteria for Flash Flood Impacts on the Road Network of Kidd Valley, Sinai, Egypt
4	Ali AlNasheri	KSA	قياس القبول المجتمعي لإعادة استخدام المياه المعالجة في مدينة القنفذة بالمملكة العربية السعودية
5	Anwar AlSheraimi	KSA	تقييم مستوى حوكمة المياه الجوفية غير المتجددة في المملكة العربية السعودية
6	Bader AlShehri	KSA	تقدير القيمة الاقتصادية للسدود في المملكة العربية السعودية. منطقة الدراسة: سد وادي بيش
7	Fatima AlAsbool	Bahrain	Effectiveness and Economical Comparison of Air Water Harvesting Techniques in Bahrain
8	Magdi Ahmad	Yemen	اختيار أفضل موقع لمحطة معالجة صرف صحي لمدينة البريقة في محافظة عدن
9	Osama Tabash	Palestine	Integrated Municipal Water Planning and Management of KhanYounis Governorate, Gaza Strip, Palestine, using Dynamic Modeling (WEAP)
10	Rabeea Badaam	Yemen	تحليل تأثير التغيرات المطرية على مساحات الأراضي الزراعية، دراسة حالة: وادي حجر في محافظة حضرموت، اليمن
11	Raed Al-Harbi	KSA	التوزيع الأمثل للمحطات المطرية بمنطقة مكة المكرمة باستخدام نظم المعلومات الجغرافية (GIS)
12	Raed Ghazal	Jordan	Assessment of Groundwater Resources in Northern Jordan: Implementing Integrated Water Resource Management for Sustainable Water Use
13	Saleh Elsenuusi	Libya	A Comprehensive Assessment of Drinking Tap Water vs Bottled Water in the City of Benghazi, Libya. Case study: Salmani Neighborhood
14	Sanaa AlAleiwi	Syria	تحديد أنسب المواقع لحصاد مياه الأمطار في حوض نهر الغمقة الساحلي باستخدام التحليل متعدد المعايير والنمذجة في نظم المعلومات الجغرافية
15	Zakareya Bucheery	Bahrain	تحديد مؤشرات الأداء الرئيسية لقطاع المياه البلدية في مملكة البحرين

Characterization and Potential Reuse/Recycle of Wastewater in the Poultry Sector in Bahrain, Case Study: Delmon Poultry Company

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The poultry industry consumes relatively large amounts of potable drinking water that is used for different chickens' and cleaning processes, of which large amounts of the consumed water is produced as wastewater. Currently, in Bahrain this wastewater is directly disposed without reuse. Under the scarcity conditions in Bahrain, which is expected to increase in the future due to population growth and climate change, wastewater reuse becomes an important option for adaptation. The selected case study in this research was Delmon Poultry Company, which has a significant issue in saving the water especially that the chicken slaughter sector needs a huge amount of water for a variety of processes, including chicken's sanitization, machines and tools disinfection. In this research a characterization of the generated wastewater produced by the company is made and the potential for its reuse as a regeneration project based on a nature-based solution are explored, to reduce the cost of the wastewater treatment and contribute to saving the environment. The study results indicated that BOD, COD, and TSS, were high and above Bahrain's reuse standards, but E. coli was within the accepted level (<1 CFU/100ml), maybe because of the detergents they are using. Nevertheless, results of the literature review showed that the constructed wetlands, using reed bed or other plants, resulted in removal of parameters, such as COD, BOD, TDS, TKN, and nutrients up to 85%-99%. In conclusion, constructed wetlands technology can be a promising and environmentally sound solution for treating wastewater and reducing pollution, and can also be a valuable addition for wastewater reuse schemes.

Keywords: Wastewater characterization, Wastewater reuse, Regeneration project, Natural Based Solutions, Reed Bed.

Brine Water in UAE: Overview on Analysis, Assessment, and Possibility of Reuse

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The arid climate and rapid urbanization in the UAE have exacerbated water scarcity, making efficient management of water resources a critical priority. Brine water, a byproduct of various industrial processes and desalination, presents both challenges and opportunities. This research delves into the composition and characteristics of brine water, assessing its environmental impact and exploring viable options for its safe and beneficial reuse. The analysis encompasses the salinity levels, contaminants, and potential for technological treatment. The assessment evaluates the environmental repercussions, emphasizing soil and aquatic health. Additionally, the study investigates various methods and approaches for reusing brine water, considering both technical feasibility and economic viability. Addressing these aspects is imperative for sustainable water management, aligning with the UAE's goals of achieving a circular economy and mitigating water scarcity. The findings and recommendations herein provide valuable insights for policymakers and stakeholders to enhance brine water management and promote sustainable reuse practices in the UAE.

Keywords: Desalination, Climate Change, RO, MSF, Water reuse, Environment, Water governance.

Collecting and Assessing the Main Criteria for Flash Flood Impacts on the Road Network of Kidd Valley, Sinai, Egypt

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Similar to most desert regions, the governorate of South Sinai in Egypt faces threats caused by regular flashfloods occurring in the valleys where human activity and urbanization are concentrated. Wadi Kidd is considered a unique example of such a situation, as several torrents that differ in size, magnitude, and duration of their flow were characterized by their irregularity, random occurrence, temporal and spatial occurrence, and even random characteristics of their discharge. The flow of these torrents has led to the destruction of large sections of the vital and main road that connects the cities of Sharm el-Sheikh and Dahab with the rest of the lands in Egypt. It also destroyed many forms of urbanization and development that extend along the interior of the central valley on both sides of the road or at the mouths of the tributaries and the meeting points of the network's streams, which cause significant economic losses. In addition, flashing torrents represent a waste of water resources in an arid area that needs every drop of water for drinking, agriculture, grazing, and other activities. Therefore, such circumstances impose the necessity of examining how to identify and manage this issue, using the latest scientific research methods to determine the characteristics and behavior of torrents and to suggest appropriate ways for protection from their dangers, and how to utilize their waters optimally. To address the problem of flash flooding and plan to mitigate their impacts, a literature review and data collection and characterization were conducted in preparation of an in-depth future study. The literature review showed that different techniques and approaches can be used for studying flash floods. Several data were used to characterize the current situation, such as: land use, precipitation, road network, geology of the area and Kidd Valley DEM. The results can be used to build a hydraulic model for Wadi Kidd that will reduce the risk of flash floods on the Sharm El Sheikh-Dahab Road and facilitate water harvesting, as a starting point towards this goal.

Keywords: Dahab, Sharm-ElSheik, Flash Flooding, Torrents, Risks, Tourism.

قياس القبول المجتمعي لإعادة استخدام المياه المعالجة في مدينة القنفذة بالمملكة العربية السعودية

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يهدف البحث إلى الكشف عن مدى القبول المجتمعي لإعادة استخدام المياه المعالجة في المملكة العربية السعودية، من خلال الكشف عن الاتجاهات الثقافية والاجتماعية التي تؤثر في ذلك، والتعرف على المخاوف المحتملة المرتبطة بإعادة استخدام المياه المعالجة. تم بناء البحث وفق المنهج الوصفي بأسلوب المسح المجتمعي، بالاعتماد على الاستبيان كأداة له والتي وزعت على عينة عشوائية قوامها (384) ممن يعيشون في مدينة القنفذة بمنطقة مكة المكرمة والقرى المجاورة لها على صيغة رابط إلكتروني. تبين من نتائج البحث وجود فروق ذات دلالة إحصائية بين آراء العينة تجاه القبول المجتمعي للمياه المعالجة، حيث بينت النتائج وجود مخاوف كبيرة لدى العينة في استخدام المياه المعالجة نابعة من المشاكل الصحية والناتجة عن الاستخدام. كما بينت النتائج عدم ممانعة العينة في استخدام المياه المعالجة في ري المسطحات الخضراء، واشجار النخيل وفي القطاع الصناعي للتبريد وفي التعدين، وعلى ضوء هذه النتائج يجب استغلال المياه المعالجة في المجالات الزراعية والصناعية والحضرية، وخاصة زراعة المسطحات الخضراء، والأشجار الكبيرة ذات الساق، مع وجود ضرورة لتوعية وإرشاد المجتمع بأهمية الاستفادة من المياه المعالجة وذلك من خلال تسخير العديد من وسائل الإعلام في التوعية المجتمعية بما يتعلق بفوائد استغلال المياه المعالجة.

الكلمات الدالة: معالجة مياه الصرف الصحي، مكة المكرمة، إعادة تدوير مياه الصرف الصحي، الموقف العام، توعية المجتمع.

تقييم مستوى حوكمة المياه الجوفية غير المتجددة في المملكة العربية السعودية

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تشكل إدارة المياه الجوفية "غير المتجددة" واستدامتها تحدياً كبيراً لقطاع المياه في المملكة العربية السعودية. وقد بذلت المملكة الكثير من الجهود واتخذت العديد من التدابير الفنية والاستراتيجية والمؤسسية لمواجهة هذه التحديات. ويأتي هذا البحث ليساهم في العمل ضمن رؤية قطاع المياه المتمثلة في "قطاع مياه مستدام ينمي الموارد المائية ويحافظ عليها، ويصون البيئة، ويوفر إمداداً آمناً وخدمات عالية الجودة، وكفاءة تسهم في التنمية الاقتصادية والاجتماعية" من خلال الاستفادة من أفضل الممارسات العالمية لإدارة المياه الجوفية غير المتجددة ومفاهيم استدامتها. هدفت هذه الدراسة الى تقييم مستوى الإدارة المستدامة للموارد المائية الجوفية غير المتجددة وتحديد الثغرات والتحديات الإدارية المرتبطة بها. وقد تم التواصل مع عدد من المسؤولين في وكالة المياه بوزارة البيئة والمياه والزراعة، كونها المسؤول الأول عن إدارة وتخطيط وتنظيم المياه الجوفية غير المتجددة، وتم الاطلاع على الدراسات العلمية التي قامت بها الوزارة بالتعاقد مع كبرى الشركات الاستشارية العالمية، والاطلاع على محتويات الاستراتيجية الوطنية للمياه وأنظمة المياه، والممارسات القائمة حالياً والمستقبلية المخطط لها، وكذلك جمع البيانات الخاصة بالمياه الجوفية غير المتجددة والاطلاع على المراجع العلمية المتعلقة بأفضل الممارسات لإدارة هذه المياه. وقد تم استخدام قائمة تدقيق البنك الدولي للعوامل والتدابير المطلوبة لتحقيق الإدارة المستدامة للمياه الجوفية غير المتجددة، والتي تتضمن توصيف النظام الجوفي، تقييم استراتيجية إدارة الموارد، والتدابير المؤسسية، وتم تحديد الثغرات الرئيسية فيها. وتوصلت الدراسة الى تحديد السياسات المطلوبة لرفع مستوى الاستدامة، والخروج بعدد من التوصيات لتكون عملاً يُبنى عليه في تحقيق إدارة شاملة للوصول إلى استدامة المياه الجوفية في المملكة العربية السعودية.

الكلمات الدالة: استدامة المياه الجوفية، الموارد المائية غير المتجددة، السياسات المائية، أفضل الممارسات، قائمة تدقيق البنك الدولي في إدارة المياه الجوفية.

تقدير القيمة الاقتصادية للسدود بالمملكة العربية السعودية. منطقة الدراسة: سد وادي بيش

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يمثل تقدير القيمة الاقتصادية لمياه السدود في المملكة العربية السعودية تحديًا استراتيجيًا مهمًا، نظرًا للظروف الجغرافية والمناخية الخاصة بها، والتي تجعل من تلك الموارد محورية للتنمية المستدامة وضمان الأمن المائي. هدفت الدراسة إلى تحليل تأثير مياه السدود على القيمة الاقتصادية في البلاد، وتحديداً سد وادي بيش كأحد السدود الرئيسية في منطقة جازان، وذلك من خلال استخدام منهجية شاملة تتضمن المسح الأدبي والبيانات المتاحة. حاولت الدراسة تقدير القيمة الاقتصادية للمياه كمورد اقتصادي يسهم في تعزيز كفاءة استخدامها وتشجيع الترشيد في الاستهلاك والاستثمار في البنية التحتية المائية. وقد تم التركيز على تحليل الآثار الاقتصادية، الإيجابية والسلبية، لإنشاء السدود على القطاعات المختلفة باستخدام دراسة الحالة، بما في ذلك الزراعة والصناعة والسياحة وإنتاج الطاقة. وبناءً على هذا التحليل، قدمت الدراسة مجموعة من التوصيات، من بينها ضرورة تقييم التأثيرات البيئية والاجتماعية لبناء السدود قبل إنشائها، وتحسين إدارة السدود لضمان الاستفادة القصوى من فوائدها. كما تشدد الدراسة على أهمية دعم القطاع الخاص في مجال بناء السدود والاستثمار فيها، بالإضافة إلى تعزيز فرص التنمية الاقتصادية والبيئية في المناطق المحيطة بالسدود. بشكل عام، تقدم الدراسة إطارًا شاملاً لفهم قيمة مياه السدود في المملكة العربية السعودية وتوجيهات لسياسات واستراتيجيات مستقبلية تساهم في تحقيق الاستدامة المائية والتنمية الشاملة في البلاد.

الكلمات الدالة: موارد المياه السطحية، الأمن المائي، إدارة السدود، قيمة المياه، تكلفة المياه، منطقة جازان.

Effectiveness and Economical Comparison of Air Water Harvesting Techniques in Bahrain

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The feasibility of water harvesting from air is investigated as a potential source to lower municipal water demands in Bahrain. This is made by comparing a number of active (i.e., requires energy as opposed to the passive) water harvesting techniques, with the current water municipal water supply source of desalination from an economic perspective. The study investigated three active techniques. Two of these were based on previous studies: air conditioner byproduct and dehumidifier, while the third techniq ue was the thermoelectric cooling or water harvesting generators, which was not studied in Bahrain before. The comparison results indicated that modern water harvesting generators showed higher potential to be used as a sustainable source of water using solar power generators and can help introducing rooftop greenhouses to the systems. It is recommended that this technique to be further investigated using a pilot study in Bahrain.

Keywords: Active water harvesting; A/C condensate; Dehumidifier; Thermoelectric cooling; Solar energy.

اختيار أفضل موقع لمحطة معالجة مياه الصرف الصحي لمدينة البريقة في محافظة عدن

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يهدف هذا البحث الى إيجاد أفضل موقع لعمل محطة معالجة للصرف الصحي في منطقة البريقة في محافظة عدن، حيث أدى التوسع العمراني غير المخطط والنمو السكاني المتزايد خلال السنوات الأخيرة في عدن إلى حدوث أزمة مائية كبيرة تعيشها المنطقة في كل يوم. وقد صاحب ذلك زيادة في الطلب على المياه، مما أضاف أعباء على شبكة الصرف الصحي للمدينة. ومن أكثر المناطق تأثراً بهذه المشكلة مدينة البريقة، التي توسعت بشكل سريع جداً، بسبب ظروف الحرب ونزوح السكان، والتي تعتبر المدينة الوحيدة في عدن التي لا توجد فيها محطة معالجة لمياه الصرف الصحي الناتجة من حوالي 70% من المستهلكين، حيث يتم تجميع هذه المياه، التي تقدر حالياً بأربعة ملايين متر مكعب سنوياً، على محطات رفع ومحطة ضخ رئيسية وتصب بعد ذلك مباشرة الى البحر بدون معالجة. وقد أدى ذلك الى زيادة التلوث وانتشار بعض الحشرات والأمراض وتأثر قطاع السياحة. وقد تم التركيز في هذا البحث على مراجعة مجموعة من المواصفات والمعايير الأساسية من الدراسات السابقة، والتي قامت بها المؤسسات الدولية العاملة في المنطقة. وبسبب الطبيعة الجبلية لمنطقة الدراسة (البريقة) ترتكز هذه المعايير على استخدامات الأراضي والغطاء الأرضي، وطبيعة السطح وجيولوجيا المنطقة وانحدارها، بالإضافة إلى الكثافة السكانية للمنطقة ومواقع التجمعات السكانية وشبكات التصريف. وقد تم اختيار موقع أولي لعمل محطة معالجة مياه الصرف الصحي من أجل الحد من هذه الكارثة البيئية وإعادة استخدام المياه والاستفادة منها بعد معالجتها.

الكلمات الدالة: التلوث البيئي، شبكات الصرف الصحي، محطة معالجة، تحليل معايير السطح، اليمن.

Integrated Municipal Water Planning and Management of KhanYounis Governorate, Gaza Strip, Palestine, using Dynamic Modeling (WEAP)

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Water resources in Palestine face substantial challenges in meeting various sectors demands. Traditional approaches of increased groundwater extraction, desalination, water purchases from "Israel", and limited wastewater and storm water reuse have failed to significantly reduce the water deficit and create long-term sustainability. This study aims to improve water resource system planning and management in the Gaza Strip, using Khan Yunis Governorate as a case study. By employing a dynamic mathematical model built with the WEAP program, the research proposes a number of interventions to enhance system efficiency and sustainability, aligning with the goals of the Palestinian Water Authority's strategy. Besides the "business-as-usual" scenario that evaluates the current water sector's performance, the proposed interventions, were: **1)** Increasing per capita water consumption to meet the WHO recommended value (150 liters/person/day), **2)** Reducing network leakage to 10%, **3)** Raising wastewater collection and treatment rates to 80% of the network, **4)** Boosting agricultural irrigation efficiency to 60% by 2042. These interventions had the potential to significantly expand the per capita water share and reduce the associated costs. The research recommended that developing a comprehensive water sector simulation model, that includes all administrative, social, economic, and hydrogeological aspects, along with future scenarios, is fundamental to optimize long-term water resource sustainability in the Gaza Strip's coastal basin. Unfortunately, due to the current war conditions in Gaza City, significant negative impacts have occurred on the water sector as a whole, and we pray for this to end soon.

Keywords: Integrated Water Resource Management (IWRM), Regeneration, Water resources, Water scarcity, WEAP model.

تحليل تأثير التغيرات المطرية على مساحات الأراضي الزراعية. دراسة حالة: وادي حجر في محافظة حضرموت، اليمن

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تعد المياه السطحية الجارية من أهم موارد المياه في الجزء الجنوبي والشرقي من اليمن، وتتدفق كأودية جارية أو منابع مائية طوال العام بسبب السيول الموسمية والأمطار، وخصوصاً في المناطق المرتفعة، مثل مناطق كنينة ووادي يون، بينما تتوافر المياه الجوفية بكميات محددوة. ويمتاز وادي حجر بأنه الوادي الوحيد الذي تجري فيه المياه المتدفقة بشكل مستمر على مدار العام، ولكن بمعدلات تدفقية متباينة تبعاً لسقوط الأمطار، وعلى الرغم من أن كميات مياه الأمطار المتساقطة ليست غزيرة؛ إلا أنها تضاف إلى المياه المخزنة في الوادي مسبقاً، وتعمل على تدفق المياه بشكل دائم، بسبب انحدار أرض الوادي من أعلى الجبال إلى مصباتها في البحر، وانخفاض كمية تسرب المياه إلى الخزانات الجوفية. وتستخدم المياه في هذا الوادي بشكل رئيسي لأغراض الشرب وللقطاع الزراعي، حيث يعتمد السكان على نسبة تزيد عن 85% من الإنتاج المحلي الزراعي. ولكن يعتبر تذبذب التساقط المطري خلال العشر سنوات الماضية أحد الأسباب الرئيسة التي شدت انتباه متخذي القرار في القطاع المائي للتركيز على هذا الوادي. فقد برزت العديد من التحديات في إدارة الموارد المائية فيه، الذي قد يهدد الأمن المائي لدرجة تصل إلى الجفاف في بعض المناطق. ويفتقر القائمون على إدارة وادي حجر إلى البيانات والمعلومات الأساسية من محطات الرصد المناخية والمطرية التي تساعد في عملية الإدارة المستدامة لمياه الوادي. ويركز هذا البحث على تحليل أسباب انخفاض كميات المياه المتدفقة في الوادي، من خلال جمع وتحليل البيانات المناخية وتوقعات التغيرات المطرية ودرجات الحرارة، لفترات زمنية طويلة، وكذلك التغيرات في مساحات الأراضي المزروعة، وتأثيرها على نشاط القطاع الزراعي. وقد أظهرت الدراسة انخفاض كبير في مساحة الأراضي المزروعة في وادي حجر بنسبة تصل إلى 74% خلال الأربعين سنة الماضية، كما توقعت الدراسة انخفاض في معدلات التساقط المطري في المستقبل، وبالتالي انخفاض إنتاجية العديد من المحاصيل الزراعية، مما يؤثر سلباً على دخل المزارعين، وكذلك على الاقتصاد الوطني لليمن.

الكلمات الدالة: مصادر المياه السطحية، تدفق الأودية، تذبذب التساقط المطري، القطاع الزراعي، تغير المناخ.

التوزيع الامثل للمحطات المطرية بمنطقة مكة المكرمة باستخدام نظم المعلومات الجغرافية (GIS)

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تعتبر المحطات المطرية مؤشرات رئيسية في العديد من التخصصات لأنها تتنبأ بتوافر المياه للاستخدامات البشرية واستخدامات النظام البيئي. وبناءً على مخرجات النماذج المناخية والتوقعات المحتملة، من المتوقع أن تزداد الحالات المطرية المتطرفة في منطقة مكة المكرمة في المملكة العربية السعودية. ركزت هذه الدراسة على دراسة تلك الحالات المتطرفة بتحديد كثافة الأمطار في منطقة الدراسة وربط تضاريسها وجيولوجيتها المائية والمناخية، لإيجاد العدد الأمثل للمحطات المطرية وإعادة توزيع مواقعها. تم اعتماد طريقتين لهذه الدراسة: أولاً: تقييم عدد وتوزيع المحطات حسب معايير منظمة الارصاد الدولية (WMO)، وتقييم مستوى عدم الدقة بين المحطات القائمة من حيث العدد والتوزيع من خلال نموذج رياضي بين المسافة وعدم الدقة في البيانات. ثانياً: تم استخدام أدوات التحليل المكاني وأدوات التحويل في نظام (ArcGIS 10.8)، حيث تعتمد منهجية البحث على التحليل المكاني بأسلوب منهج التحليل الوصفي من خلال تطبيق المحلل المكاني (Spatial Analyst)، والتحقق من معدلات عدم التوافق بين المحطات المجاورة والمسافة التي بينهم. واتضح من التحاليل الأولية للطريقة الأولى بأن معدلات الخطأ مع المسافة ليست واضحة في هذه المرحلة بسبب وجود مساحات كبيرة بمنطقة الدراسة وقلة البيانات، مما يستدعي اجراء المزيد من التحاليل لتأكيد التغير بإدراج عدة عوامل من أجل تصنيف المحطات واستنباط معادلة خطية تقيس معدل الخطأ مع المسافة. لذا تم استخدام الطريقة الثانية بجمع البيانات التي يمكن الاستفادة منها، ودمجها بنظم المعلومات الجغرافية، باستخدام أدوات التحليل المكاني وأدوات التحويل في نظام (ArcGIS)، وتم تحديد أفضل المواقع لاضافة محطات جديدة لدعم الشبكة الهيدرولوجية لمنطقة مكة المكرمة.

الكلمات الدالة: المملكة العربية السعودية، الحالات المطرية المتطرفة، تغير المناخ، البيانات الهيدرولوجية، رصد الأمطار.

Assessment of Groundwater Resources in Northern Jordan: Implementing Integrated Water Resource Management for Sustainable Water Use

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The water situation in Northern Jordan presents a critical challenge, demanding urgent attention and strategic intervention. Efforts are underway to identify sustainable water resources, with a focus on desalination and treated wastewater reuse. Advanced data collection and analysis techniques are being employed to evaluate water scarcity issues in the region, exacerbated by the excessive groundwater extraction of 171.85 MCM. In order to reverse the situation and alleviate the water stress in Northern Jordan, it is important to consider all resources and users, i.e., the supply-side engineering and demand-side management, and to plan and manage the water sector in an integrated approach. On the supply side, initiatives such as the reuse of 18.8 MCM of wastewater in areas like Irbid, Wadi Arab, and Shalala WWTP to replace groundwater, brackish water desalination, and managed aquifer recharge are the most promising options that will contribute to addressing water scarcity. On the demand side, implementing water conservation measures, especially increasing irrigation efficiency, is probably the most effective way to balance groundwater use. Moreover, on the governance side, raising users' awareness and curbing illegal groundwater abstraction will help protect remaining groundwater resources from depletion. All these management options represent essential components of a strategic intervention to ensure the long-term sustainability of water resources in Northern Jordan and ensure its service to the socio-economic development of the region.

Keywords: Groundwater analysis, Holistic water management, Water sustainability practices, Resource conservation, Jordanian aquifers, Water resource planning, Sustainable water strategies.

A Comprehensive Assessment of Drinking Tap Water vs Bottled Water in the City of Benghazi, Libya. Case Study: Salmani Neighborhood

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The availability of drinking water sources is a reflection of the water quality in any particular region, country, or city. Given the importance of this topic, the problem of the study lies in evaluating the quality of the available water types (Man-Made River Project, local desalination plants, and big desalination plants) in Benghazi, the second largest city in Libya in terms of area and population. This study aims to conduct a comprehensive survey and assess the quality of drinking water in Salmani Neighborhood in accordance with the Libyan specifications and the World Health Organization, to provide a database for the public and decision makers, and a reference for future studies. A total of 35 samples were gathered during the winter of 2023–2024 from the following sources: 15 samples from the Man-made River Project (tap water), and 20 bottled water samples from local selling points. The samples were collected in sterile bottles and placed in a refrigerated container, then transferred to the laboratory for chemical and microbiological analysis within 24 hours, and the results were compared to the Libyan Standard No. (82) for the year 2013 and the World Health Organization (WHO) Drinking Water Standards (No. 1409-01 of 1993). The findings showed that, according to both WHO and Libyan standards, the water samples from the mainline and distribution network lines of the Man-Made River project had the best water quality. The results of the bottled water samples were in compliance with the Libyan and WHO standards, but their quality varied in the chemical parameters, where the best bottled water quality were from Al-Aseel Factory, and the Eastern Salmani District area had the best water quality from the local water selling points.

Keywords: Man-Made River Project, Water resources, Water quality, National standards, WHO standards.

تحديد أنسب المو اقع لحصاد مياه الأمطارفي حوض نهر الغمقة الساحلي باستخدام التحليل متعدد المعايير والنمذجة في نظم المعلومات الجغر افية

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يعتبر حوض الغمقة، الذي يقع في الجزء الجنوبي من الساحل السوري، من المناطق التي تتميز بمعدل هطول مطري عالي يصل إلى 1000ملم/سنة. ويعتمد سكان هذا الساحل على مياه الأمطار اعتماداً كلياً في الشرب والزراعة والاستخدامات المنزلية، وخاصة سكان المناطق المرتفعة، ولكنهم يعانون من نقص حاد في المياه في فصل الصيف بسبب عدم توفر وسائل لحصاد المياه المتدفقة لتجميعها والاستفادة منها صيفاً. لذا تهدف هذه الدراسة إلى اختيار أنسب المواقع لحصاد مياه الأمطار في حوض الغمقة الساحلي باستخدام التحليل متعدد المعايير لتحليل ومعالجة البيانات المكانية الجغرافية المطلوبة لبناء السدات (السدود الصغيرة الحجم) في منطقة الدراسة. استخدمت النمذجة المكانية من خلال توظيف تقنيات نظم المعلومات الجغرافية لاختيار مواقع الحصاد المائي. وقد شملت المعايير لتوصيف سطح الأرض: طبوغرافية المنطقة والتي تم بناءها من نموذج الارتفاع الرقمي (SRTM DEM, Resolution 30m) ومخطط الانحدار والمعايير الهيدرولوجية باستخدام أدوات مرفق التحليلي (Arc Hydro tool) من برنامج نظم المعلومات الجغرافية (ArcGIS). تم تحديد اتجاه الجريان وشبكة ورتب المجاري المائية ومخطط توزع الهطول المطري ومعايير استخدامات الأراضي والغطاء النباتي. استخدمت جميع هذه المعايير لبناء نموذج متعدد المعايير لتحديد أفضل المواقع لبناء السدات المطلوبة، وصنفت الخرائط وفقاً للمعايير السابقة، وباستخدام عملية المعالجة (weighted overlay) ومن خلال بناء خريطة الملاءمة (Suitability map) تم اختيار ثلاث مواقع لإنشاء سدات تصلح لإقامة السدات المطلوبة لتجميع مياه الأمطار: الموقع الأول بمساحة 4 كم^2 والموقع الثاني بمساحة 1 كم^2 والموقع الثالث بمساحة 1 كم^2، حيث كانت المساحات المتوفرة في منطقة الدراسة هي المحدد النهائي لاختيار الموقع. وتقع هذه المواقع الثلاث على أراضي متوسطة الارتفاع مقارنة بمنطقة الدراسة، وضمن شبكة أودية كثيفة. ومن أهم توصيات الدراسة، إجراء تقييم مفصل للمواقع النهائية مع الأخذ بعين الاعتبار معايير التربة والمعايير البيئية والاجتماعية والاقتصادية، وإجراء زيارات ميدانية للمواقع المختارة للتحقق من ملاءمتها.

الكلمات الدالة: الساحل السوري، السدات، أنظمة حصاد المياه، النمذجة المكانية، المطابقة الوزنية.

تحديد مؤشرات الأداء الرئيسية لقطاع المياه البلدية في مملكة البحرين

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يُعد قطاع المياه البلدية في مملكة البحرين أحد القطاعات الحيوية التي تهدف إلى توفير خدمات المياه النقية والصحية للسكان. وتعتبر هيئة الكهرباء والماء في مملكة البحرين المزود الحصري للمياه البلدية للمواطنين والمقيمين، حيث تقوم على إيصال خدمة المياه لجميع المنتفعين من خلال تقديم طلب تزود بالخدمة. وتقوم الهيئة على تشغيل شبكة المياه وصيانتها والحفاظ على كفاءة وجودة المياه التي تصل إلى المنازل والمنشئات، إضافة إلى إصدار الفواتير الشهرية لاستهلاك المشتركين. لذلك، لابد من استخدام نظام المقارنة المرجعية لقياس كفاءة وجودة المياه البلدية وعملية تشغيل وصيانة شبكة المياه، إضافة إلى تقييم الخدمات المقدمة للمشتركين والمتعلقة بقطاع المياه البلدية، وذلك لمعرفة أداء مملكة البحرين في هذا المجال والخدمات المتعلقة به والعمل على ما يجب تحسينه والمحافظة على إبقائه في مستوى جيد. وتكمن مشكلة البحث في عدم وجود نظام شامل لتقييم جودة خدمة المياه البلدية، يتضمن تقييم رضا العملاء عن الخدمات التي توفرها الهيئة، ليتم الاستفادة منه لتقييم الجهود المبذولة لتوفير المياه البلدية. هدف هذا البحث إلى المساهمة في مراجعة أولويات الخطة الاستراتيجية لهيئة الكهرباء والماء المتعلقة بقطاع المياه البلدية من أجل تحديد جوانب القوة أو الضعف في كل عملية، لتركيز الاهتمام على الجانب الذي يجب تحسينه وذلك من خلال حصر المؤشرات المطلوبة لقياس جودة خدمة إمداد المياه البلدية، وإدخال مؤشرات أداء جديدة لهيئة الكهرباء والماء، تساعد على قياس وتطوير الخدمات الخاصة بالمياه البلدية. ولتجميع البيانات في هذا البحث والتوصل إلى النتائج، فقد تم تجميع المؤشرات ذات العلاقة بخدمات المياه البلدية من الدراسات السابقة ومقارنتها بالمؤشرات التي يتم استخدامها وحسابها في هيئة الكهرباء والماء حالياً. وبالتالي، فقد تم الحصول على 40 مؤشر ذو علاقة مباشرة مع عمل هيئة الكهرباء والماء في مجال تزويد المواطنين والمقيمين بالمياه البلدية. وبعد ذلك، تم تصنيف الـ 40 مؤشر من حيث استخدامه من عدمه في الهيئة وتوافر البيانات اللازمة لقياسه. بعد ذلك، تم طرح توصيات لهيئة الكهرباء والماء للمؤشرات التي تتواجد البيانات المطلوبة لقياسها، وتوظيف هذه المؤشرات في متابعة وتطوير الخدمات الخاصة بقطاع المياه البلدية مع مقترح لاحتساب وجمع البيانات اللازمة لقياس هذه المؤشرات التي لا توجد لها بيانات، ومن ثم إدخالها ضمن المؤشرات الخاصة بقطاع المياه البلدية. وتوصي الدراسة بضرورة تركيز قطاع المياه البلدية في البحرين على الابتكار والتطوير المستمر عن طريق تبني التكنولوجيا الحديثة والحلول الذكية لتعزيز الكفاءة وتحسين جودة الخدمات لتعكس هذه الجهود استدامة قطاع المياه. ويوصى لتطوير هذا العمل باحتساب جميع المؤشرات التي تتوفر بياناتها ومقارنتها بأفضل الممارسات في العالم بمجال المياه البلدية وخدماتها. وبالتالي، معرفة جودة وكفاءة خدمات المياه البلدية في مملكة البحرين وتحديد أوجه القصور وبدأ العمل على خطة للتحسين.

الكلمات الدالة: كفاءة وجودة المياه في مملكة البحرين؛ جودة خدمة المياه البلدية؛ الخدمات الخاصة بقطاع المياه البلدية؛ هيئة الكهرباء والماء؛ توزيع المياه.

Tenth Batch: 2024-2025

Tenth Batch Students

No.	Name	Country	Project Title
1	Abdalmoiz Suliman	Sudan	Developing a Water Safety Plan for Kassala City, Sudan: A Stepwise Implementation Strategy
2	Abdalrahman AlEnezi	Kuwait	Performance Efficiency Assessment of Sulaibiya Wastewater Treatment Plant in the State of Kuwait (2017–2024): A Descriptive and Analytical Study
3	Abdulrahman Bakr	KSA	Developing SIO KPIs for Treated Wastewater Reuse
4	Abeer Soulieman	Syria	التقييم البيئي المتكامل لمياه حوض نهر الأبرش في محافظة طرطوس، سوريا
5	Ahmad Bali	Jordan	Using Water Audit Techniques to Mitigate GHG Emissions through Efficient Residential and Institutional Water Use: Evidence from Amman, Jordan
6	Ahmed Sharha	Yemen	تقييم استخدام الطاقة المتجددة في ضخ المياه الجوفية لمناطق النزوح: دراسة حالة في منطقة أسلم في اليمن
7	Ahmed AlQurashi	KSA	تحليل الخصائص الزراعية لموقع مقترح غرب المدينة المنورة لزراعة النخيل باستخدام المياه المعالجة
8	Ahmed Habib	Bahrain	Energy Consumption in the Municipal Water Supply Sector in the Kingdom of Bahrain
9	Alaa Ali	Egypt	Economic Assessment of Constructed Wetlands Technology (CWT) for Circular Wastewater Management in the Bahariya Oasis, Egypt
10	Amina AlBloshi	Bahrain	Assessing the Potential and Barriers for Reusing Treated Sewage Effluent (TSE) in Firefighting in the Kingdom of Bahrain
11	Bader Abdulrahman	Bahrain	Assessment of Water Demands Using Dynamic Modelling Approach. Case Study: Salman City, Kingdom of Bahrain
12	Hajar Budhahi	Bahrain	Assessing the Environmental and Economic Impacts of Water-Saving Fixtures under the Gulf Technical Regulation: A Pilot Case Study of Madinat Salman, Bahrain
13	Karam Al-Aoor	Palestine	Emergency Integrated Planning of Water Sector in Gaza Using the WEAP model
14	Mohamed AlJanahi	Bahrain	Diagnosis of the Groundwater Management System and Framework Development for Operations and Management for SCE and MUN, Bahrain
15	Mohammed AlRiyami	Oman	Assessing the Effectiveness of Nama Water's Strategies for Reducing Non-Revenue Water in Nizwa, Dakhliya Governorate, Oman
16	Sara AlShamlan	Bahrain	Towards Sustainable Brine Management in Bahrain: Exploring Feasible Solutions for Environmental Mitigation
17	Yahya AlShahrani	KSA	استدامة ري المناطق الزراعية بالمملكة العربية السعودية: دراسة حالة منطقة سد العقيق بالباحة ومصادر المياه لسد العقيق
18	Yaser AlDakheel	Bahrain	Synergies and Harmonization between the National Water Strategy and the UNESCO IHP-IX, and Insights for the Upcoming Update of the NWS
19	Yasmin Hooh	Palestine	Assessment of Drinking Water Quality in the West Bank, Palestine, Using the CCME Water Quality Index (WQI)

Developing a Water Safety Plan for Kassala City, Sudan: A Stepwise Implementation Strategy

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Sudan's drinking water supply system lacks a Water Safety Plan (WSP) and relies on reactive crisis response. This situation poses significant risks to public health, economic development, and environmental sustainability. The study aims at contributing to the implementation of water safety planning in Sudan, by following the methodology of WHO guidelines for WSP. Moreover, the study also described the water supply system, attempted in detail to identify hazards and hazardous events at the catchment/source, treatment, storage/distribution/ collection, and point of use, as well as an improvement plan to be conducted after establishing the plan and its operation. This study has developed a plan for the development of a WSP in Sudan, to ensure the provision of safe and reliable water supplies, thereby protecting public health, enhancing the water supply resilience, and promoting sustainable water resource management. This study recommends the water-related authorities to adopt and utilize its findings to implement a WSP across all the states of Sudan, and to establish a National WSP task force to oversee its planning, monitoring, and enforcement.

Keywords: Risk assessment, proactive response, public health, WHO guidelines, water security.

Performance Efficiency Assessment of Sulaibiya Wastewater Treatment Plant in the State of Kuwait (2017–2024): A Descriptive and Analytical Study

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This study evaluates the performance efficiency of the Sulaibiya Wastewater Treatment Plant (WWTP) in Kuwait from 2017 to 2024, framing its role within the framework of Integrated Water Resources Management (IWRM) and Kuwait Vision 2035. As the world's largest advanced quaternary treatment facility using Reverse Osmosis, Sulaibiya plays a fundamental role in the National water security by reclaiming nearly 60% of Kuwait's wastewater. This research adopts a descriptive–analytical approach, based on operational data from three key sources: the Ministry of Public Works, the Environment Public Authority, and the Utilities Development Company. Findings showed significant improvements in recovery efficiency, from 72% in 2017 to 86% in 2024, yielding over 1.28 billion m^3 of high-quality treated wastewater (TWW), that consistently met and exceeded WHO, FAO, and KEPA standards. The 2019 capacity expansion proved its success in avoiding overload, yet by 2024 the plant was again operating at near-full capacity, emphasizing the need for further infrastructure investments. Despite these successes, some challenges remain, such as the lost opportunity of 42% of unused TWW, and the continued discharge of brine by-products (~14% of inflows) into the Gulf. The analysis highlights that the main constraints to maximizing reuse are institutional and legislative barriers rather than technical limitations, with fragmented responsibilities limiting policy integration and low public acceptance. Comparisons with global (Singapore, California) and regional (Qatar, Oman) best practices, emphasize the importance of unified governance and reuse targets enforcement. The study recommends expanding sanitation networks, developing innovative brine management strategies, strengthening inter-agency coordination, and public awareness campaigns to raise reuse rates toward 80–100%, thereby enhancing water security and supporting Kuwait's sustainability agenda.

Keywords: Quaternary treatment, treated wastewater reuse, operational efficiency, brine management, environmental sustainability, Kuwait Vision 2035.

Developing SIO KPIs for Treated Wastewater Reuse

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This study focuses on developing a standardized framework of Key Performance Indicators (KPIs) for treated wastewater reuse within the Saudi Irrigation Organization (SIO), aligning with the International Water Association (IWA) standards and Integrated Water Resources Management (IWRM) principles. Recognizing the growing importance of treated wastewater as a sustainable resource under Saudi Vision 2030, the study identifies and classifies 24 KPIs across three categories: Operational (12), focusing on efficiency, maintenance, and performance; Quality of Service (6), emphasizing customer experience, reliability, and responsiveness; and Economic & Financial (6), targeting cost recovery, and financial resilience. The methodology encompassed indicator selection, field validation, pilot application, and dashboard development to visualize performance and identify improvement areas. The results indicate strong operational and customer responsiveness performance, but also highlight weaknesses in energy efficiency, cost recovery, and infrastructure renewal. The study concludes that while SIO has a solid operational and service foundation, the proposed KPI system shows that there is an improvement opportunity towards achieving financial sustainability.

Keywords: IWA Standards, IWRM principles, cost recovery, financial sustainability, Saudi Vision 2030.

التقييم البيئي المتكامل لمياه حوض نهر الأبرش في محافظة طرطوس، سوريا

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تقدّم هذه الدراسة تقييماً بيئياً متكاملاً لحوض نهر الأبرش في محافظة طرطوس، مع التركيز على الموارد المائية السطحية والجوفية ودورها في دعم الاستقرار البيئي والاجتماعي والاقتصادي. تم اعتماد إطار الدوافع–الضغوط–الحالة–الآثار–الاستجابات (DPSIR) كمنهجية تحليلية لربط أنشطة المجتمع بالحالة البيئية، مدعومًا بمجموعة من المؤشرات والمعايير المرجعية العالمية (WHO, CCME, FAO, EEA). ومن خلال هذا النهج، أُنشئ مؤشر جودة المياه (WQI) ومؤشر صحة المياه (WHI) لتشخيص الوضع البيئي بصورة كمية، مع الاستعانة بمؤشرات بديلة (Proxy Indicators). أظهرت نتائج التحليل أن المياه في حوض الأبرش تعاني من تلوث جرثومي وكيميائي ملحوظ، لا سيما عند وارد النهر إلى بحيرة سد الأبرش، حيث سُجّلت قيم مرتفعة للقولونيات البرازية FC (≈100/7000 مل) مقارنة بانخفاضها داخل البحيرة (≈100/10 مل). كما تراوحت قيم COD بين (2.7–13.6 ملغ/ل)، في حين بلغت تراكيز الأمونيا (0.13–0.53 ملغ/ل) والنترات (0.6–4.1 ملغ/ل)، بمستويات تتوافق إجمالاً مع حدود الاستخدام الزراعي، لكنها تُظهر قابلية للتصاعد في مواسم الذروة، خصوصًا خلال فترة عمل معاصر الزيتون. تؤكد هذه المعطيات أن مياه الصرف الصحي ومياه الجفت (Olive Mill Wastewater) تمثل المصدرين الأساسيين للتلوث. وإلى جانب ذلك، تكشف تحاليل صور الأقمار الصناعية عن تدهور في الغطاء النباتي بانخفاض NDVI في سنوات متتالية بعد 2015 وزيادة مخاطر الانجراف، خصوصًا في المناطق الشمالية الشرقية من الحوض، ما يعزز انتقال الرسوبيات والملوثات إلى المجاري المائية. يبين تطبيق إطار DPSIR أن الدوافع تشمل النمو السكاني والتوسع الزراعي، بينما تتمثل الضغوط في صرف صحي غير معالج، ومياه جفت الزيتون، والنفايات الصلبة، وتغيّرات استخدام الأراضي. أما الحالة فتتجلّى في تدهور نوعية المياه وتذبذب كميتها، مما يؤدي إلى آثار بيئية وصحية خطيرة تشمل مخاطر الأمراض المنقولة بالماء، ارتفاع تكاليف المعالجة، وتراجع خدمات النظام البيئي. وفي المقابل، تقترح الدراسة استجابات عاجلة مثل تحسين شبكات ومحطات الصرف الصحي، وإدارة متكاملة لمياه الجفت عبر الجمع والمعالجة وإعادة الاستخدام، وإنشاء أحزمة نباتية ومصدات للتعرية، إضافة إلى إجراءات هيكلية على المدى المتوسط مثل إغلاق المكبات العشوائية وتطوير إدارة النفايات الصلبة.

الكلمات الدالة: إدارة الموارد المائية، الدوافع–الضغوط–الحالة–الآثار–الاستجابات، مؤشر جودة المياه، تدهور نوعية المياه.

Using Water Audit Techniques to Mitigate GHG Emissions through Efficient Residential and Institutional Water Use: Evidence from Amman, Jordan

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Jordan is ranked as the world's most water-poor country, with less than 61 m³ of renewable freshwater per person per year, far below the global absolute scarcity threshold of 500 m³. The water sector is highly energy-intensive, consuming approximately 14.9% of national electricity. Furthermore, over-abstraction of aquifers and high non-revenue water rates (46.2%) exacerbate this crisis. Addressing inefficiencies in municipal water use has therefore become a national priority, embedded in the Water Sector Strategy 2023–2040 and the National Adaptation Plan 2022. This study evaluates household water audits as a tool to enhance the efficiency of resources (water and energy) and support the mitigation of GHG Emissions through Efficient Residential and Institutional Water Use, aiming to achieve sustainable management. Flow rates of household fixtures in a representative residential unit located in the Al-Rashid suburb of Amman, Jordan, were measured before and after the installation of water-saving devices, in accordance with Jordanian Code standards. For this single household case study, annual savings reached 164 m³ of water and 3,187 kWh of energy, equivalent to 1.5–1.7 tCO_2e of avoided emissions. These household-level results were later scaled to the institutional case and national context to demonstrate the broader applicability of water auditing for mitigation planning. Financial analysis demonstrated that retrofitting reduced annual household bills by 328 JOD under current tariff structures, with potential savings exceeding 580 JOD, if billed under unified meter configurations. At the institutional scale, the Al-Hussein Park audit (2023) confirmed the scalability of such measures, with combined water and energy savings valued at over 43,000 JOD/year. A comparison-only district-scale scenario for Al-Jami'ah (214,560 households) indicates city-relevant savings (35.19 MCM/yr, i.e., 571.13 GWh/yr, i.e., 306.7/268.5 $ktCO_2e/yr$ using grid EF 0.537/0.4702 kg CO_2/kWh), illustrating scalability without altering measured results. The findings highlight the co-benefits of water–energy–carbon–finance integration through household and institutional retrofitting, framed within the IWRM and Water–Energy–Food–Ecosystem (WEFE) nexus approaches. Scaling such audits could contribute to Jordan's NDC mitigation targets, while creating pathways for integration into voluntary carbon markets. Recommended actions include institutionalizing standardized household/institutional water audits, aligning tariff structures with efficiency outcomes, and integrating audit outputs into MWI/MoEnv monitoring frameworks.

Keywords: IWRM, WEFE nexus, Water–Energy–Carbon–Finance co-benefit, Household efficiency, Residential water use, Water demand.

تقييم استخدام الطاقة المتجددة في ضخ المياه الجوفية لمناطق النزوح: دراسة حالة في منطقة أسلم في اليمن

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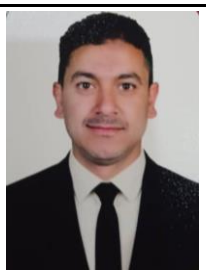

تُصنف اليمن ضمن أكثر دول العالم معاناة من شح المياه بسبب عوامل طبيعية مثل الجفاف، ونقص الأمطار، والتصحر، وأسباب بشرية مثل سوء إدارة واستخدام للمياه، الحفر العشوائي للآبار الجوفية، وتدمير البنية التحتية نتيجة الحروب. تنعكس هذه الأزمة إنسانياً على السكان، حيث يضطر الأهالي إلى شراء صهاريج المياه بتكاليف مرتفعة، أو جلبها يدوياً من مناطق بعيدة، مما يشكل عبئاً ومشقة كبيرة، خاصة على الأطفال والنساء، ويؤثر سلباً على صحتهم وحياتهم اليومية. في ظل هذه الأزمة الإنسانية ولا سيما في المناطق الريفية والنائية التي تشهد تزايداً في أعداد النازحين، أصبحت الحاجة إلى إيجاد حلول مستدامة لتوفير المياه الآمنة من أولويات التدخلات الطارئة والإنمائية. يهدف هذا البحث إلى دراسة مدى جدوى استخدام الطاقة الشمسية في ضخ المياه الجوفية لتلبية احتياجات المجتمعات المحلية والنازحة، في قرية العميرية في منطقة أسلم شمال صنعاء في دولة اليمن، التي تشهد كثافة في النزوح الداخلي، مع التركيز على تطبيق أنظمة التحكم عن بُعد لتحسين الكفاءة التشغيلية وتقليل الهدر. وقد تم استخدام المنهج الوصفي التحليلي، وتم جمع بيانات كمية ونوعية حول الموقع المناسب للمشروع المقترح ومكوناته الأساسية (وحدة الضخ الشمسي، وأنظمة المراقبة الذكية)، إضافة إلى تحديد التكلفة التقديرية. أظهرت النتائج أن تكلفة التنفيذ الأولية للمشروع مرتفعة، إلا أنه سيساهم على المدى الطويل بانخفاض كبير في نفقات التكاليف التشغيلية من خلال الاستغناء عن المشتقات النفطية. وتوصي الدراسة بتبني حلول الطاقة المتجددة (الشمسية) باعتبارها صديقة للبيئة، سهلة الصيانة، وحلاً فعالاً من حيث الاستدامة، حيث تضمن إمداداً مستقراً للمياه، وتقلل من الاعتماد على الوقود التقليدي الذي يعاني من نقص حاد. كما ستسهم أنظمة التحكم عن بُعد من تحسين كفاءة التشغيل، واكتشاف الأعطال، و تقليل فقدان المياه.

الكلمات الدالة: إدارة الموارد المائية، الأمن المائي، الطاقة الشمسية، النازحين، شح المياه، استدامة المياه.

تحليل الخصائص الزراعية لموقع مقترح غرب المدينة المنورة لزراعة النخيل باستخدام المياه المعالجة

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تُعد زراعة النخيل من الزراعات الاستراتيجية في منطقة المدينة المنورة نظراً لأهميتها الدينية والاقتصادية. تهدف هذه الدراسة إلى تقييم مدى ملاءمة موقع مقترح غرب المدينة المنورة لزراعة النخيل باستخدام مياه معالجة من مصادر محلية. تمت هذه الدراسة من خلال تحليل الخصائص الفيزيائية والكيميائية للتربة والمياه وفق معايير علمية معتمدة. اعتمدت المنهجية على بيانات تقارير جيوتقنية رسمية صادرة من المؤسسة العامة للري، بالإضافة إلى مراجعة الأدبيات العلمية ذات الصلة، وتم بناء نموذج رياضي باستخدام أسلوب الانحدار الخطي المتعدد لقياس تأثير مجموعة من المتغيرات البيئية على مؤشر نجاح الزراعة. شملت هذه المتغيرات ملوحة المياه، نسبة الصوديوم، درجة الحموضة، نوع التربة، نسبة المادة العضوية، عدد ساعات السطوع الشمسي، والرطوبة النسبية. أظهرت نتائج التحليل أن معظم الخصائص المدروسة تقع ضمن النطاق المقبول نسبيا لزراعة النخيل، مع الحاجة إلى بعض التعديلات الزراعية لتحسين كفاءة التربة وجودة المياه. توصي الدراسة بتنفيذ تجربة زراعة ميدانية محدودة، ومتابعة دورية للخصائص البيئية، واستخدام النموذج الرياضي كأداة تقييم قبل التوسع في المشروع. كما تسهم هذه الدراسة في دعم جهود المملكة نحو استدامة الموارد المائية والتوسع في الزراعة النوعية في البيئات الصحراوية.

الكلمات الدالة: المملكة العربية السعودية، جودة المياه، الزراعة النوعية، نموذج الانحدار الخطي المتعدد، استدامة المياه .

Energy Consumption in the Municipal Water Supply Sector in the Kingdom of Bahrain

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The link between water and energy, known as the Water–Energy Nexus, has become a critical concern globally and particularly in the Gulf Cooperation Council (GCC) countries. Most GCC states, including the Kingdom of Bahrain, rely heavily on fossil fuels to produce drinking water through desalination, as the region lacks natural freshwater resources, i.e., there are no rivers, lakes, or substantial groundwater reserves capable of meeting water demand. This study adopts a bottom-up analytical approach to quantify energy consumption across the three main stages of Bahrain's municipal water supply system: water production, transmission, and distribution. The results reveal that desalination is the dominant energy consumer, accounting for approximately 83% of total sectoral energy use, followed by transmission (17%) and distribution (0.003%). Projections for 2025 indicate that the water production stage alone will require about 1,816 GWh of electricity, resulting in an estimated 0.82 million tons of CO_2 emissions. The analysis further shows that Bahrain's average energy intensity for desalination (≈5 kWh/m³) remains significantly higher than global best practices (2.5–3.5 kWh/m³). This inefficiency is primarily attributed to the continued reliance on thermal desalination technologies (Multi-Stage Flash (MSF) and Multi-Effect Distillation (MED)), which together account for more than half of total production energy consumption. In comparison, the transmission stage consumes approximately 1 kWh/m³, which is 30–50% higher than international benchmarks (typically 0.5–0.7 kWh/m³ in optimized gravity-assisted systems). This indicates a substantial opportunity to improve transmission efficiency through network optimization, pressure management, and pump performance upgrades. The distribution stage, by contrast, shows minimal energy intensity at 0.002 kWh/m³, aligning with global norms. To enhance efficiency and sustainability, the study recommends retrofitting existing desalination plants with advanced Energy Recovery Devices (ERDs), institutionalizing energy management within water sector operations, optimizing transmission systems to reduce pumping requirements through greater utilization of gravity flow, and strategically redistributing production facilities toward the Northern regions of Bahrain to minimize transmission energy losses. Implementing these measures would substantially improve energy performance, reduce carbon emissions, and strengthen the resilience and sustainability of Bahrain's water sector.

Keywords: Water–Energy Nexus, thermal desalination, carbon emissions, water production-transmission-distribution, operational measures, water sustainability.

Economic Assessment of Constructed Wetlands Technology (CWT) for Circular Wastewater Management in the Bahariya Oasis, Egypt

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Water scarcity and the growing challenge of wastewater management present critical issues in arid regions such as Egypt's Bahariya Oasis. This study provides an economic assessment of Constructed Wetlands Technology (CWT) as a circular solution for wastewater treatment and resource recovery. A cost–benefit analysis (CBA) was conducted using an 8 percent real discount rate over 6, 10, and 15-year horizons. The evaluation is framed within the Water–Energy–Food–Ecosystem (WEFE) Nexus, highlighting the multiple dimensions of CWT contributions. Water reuse reduces dependence on non-renewable groundwater abstraction. Solar photovoltaic systems replace fossil-based energy inputs and ensure sustainable operation. Afforestation supported by treated wastewater generates timber and biomass, contributing to rural livelihoods and food–energy security. In addition, ecosystem services are enhanced through carbon sequestration, biodiversity support, and soil fertility improvements. The quantified benefit streams include water reuse (170,854 EGP per year), verified emission reductions, timber and biomass thinning (100,000 EGP per year from year four onward), nutrient substitution, and service fees. Results show negative net present values and benefit–cost ratios below unity under baseline assumptions. However, sensitivity analysis indicates that project viability improves substantially under higher water valuation, increased carbon credit prices, and partial capital expenditure subsidies. The findings suggest that while CWT may not be financially viable in isolation, its integrated contributions across the WEFE pillars justify policy support and blended financing to realize long-term sustainability in desert oases.

Keywords: WEFE Nexus, Wastewater Reuse, Nature-Based Solutions, Cost–Benefit Analysis, Carbon Sequestration, Blended Finance.

Assessing the Potential and Barriers for Reusing Treated Sewage Effluent (TSE) in Firefighting in the Kingdom of Bahrain: Technical and Social Dimensions

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The Kingdom of Bahrain faces severe freshwater scarcity and relies heavily on desalination, with about 45–65% of its Treated Sewage Effluent (TSE) currently utilized in the agricultural sector. To improve water sustainability, Bahrain can expand the reuse of TSE to other applications, such as firefighting. This study aims to evaluate the possibility of using TSE as an alternative water source for firefighting in Bahrain. The methodology includes: 1) assessing TSE water quality by collecting data on the physical, chemical, and microbiological parameters of TSE and comparing it with the generally accepted firefighting water standards, 2) evaluating the suitability of the existing TSE infrastructure, and 3) assessing social acceptance through a short survey to have a first feeling about the public perceptions regarding the reuse of TSE for firefighting. The results show that most parameters meet the standards for firefighting; except chloride concentration that was moderately high, presenting a moderate risk of corrosion to metallic firefighting equipment, highlighting the need for corrosion-resistant materials. Additionally, the existing pressure in the TSE network (1.4 bar) meets the minimum pressure required for firefighting, but the TSE distribution network is geographically limited, making a fully TSE firefighting system impractical. Therefore, a dual-supply system is recommended, using TSE as a supplementary source in areas where the sanitation network can reach. Moreover, the survey results indicate strong public support, with nearly 70% of respondents willing to use TSE instead of desalinated water for firefighting, reflecting a positive social foundation for implementing this initiative. In conclusion, TSE reuse is technically and socially viable for firefighting, however, challenges related to corrosion risk and the limited network coverage should be addressed by clear National firefighting regulations, network expansion, and the initiation of pilot projects.

Keywords: Water scarcity, non-conventional water resource, water quality, sanitation network, social acceptance, water sustainability.

Assessment of Water Demands Using Dynamic Modelling Approach. Case Study: Salman City, Kingdom of Bahrain

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This paper presents a comprehensive case study on the assessment of municipal water demand in Salman City, a developing urban area in the Kingdom of Bahrain. As a small island nation with scarce natural water resources, Bahrain faces mounting pressure on its water supply systems due to exponential population growth, urban expansion, and climate-induced stress. Salman City, situated on reclaimed land and primarily composed of government-distributed housing units, reflects these national water management challenges in a concentrated urban setting. Using a dynamic modelling approach, the study employs the Water Evaluation and Planning (WEAP) system to simulate and forecast water demand and supply scenarios from 2020 to 2030. The methodology integrates key elements of Integrated Water Resources Management (IWRM), focusing on improving efficiency, maximizing resource reuse, and ensuring sustainable service delivery. Data inputs were collected from various governmental bodies including the Electricity & Water Authority (EWA) and the Ministry of Works Sanitary Affairs, covering available and estimated household data, desalinated water supply, wastewater flows, irrigation demands, and non-revenue water (NRW). The analysis reveals a consistent increase in municipal water demand driven by new housing distributions and rising consumption rates, with desalinated water serving as the dominant source. Despite the presence of a fully functional sewage treatment plant (STP) in Salman City, the study identifies a significant shortfall in treated sewage effluent (TSE) reuse for irrigation or non-potable purposes, with a large portion being discharged into the sea. Additionally, water losses due to NRW, averaging 16.09%, present a substantial inefficiency in the system. This research contributes a replicable model for other cities in the Kingdom of Bahrain for sustainable water resource planning and management in arid regions, offering practical insights for policymakers, urban planners, and water utility sectors.

Keywords: WEAP, simulation, forecasting, NRW, water resource planning and management.

Assessing the Environmental and Economic Impacts of Water-Saving Fixtures under the Gulf Technical Regulation: A Pilot Case Study of Madinat Salman, Bahrain

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The Kingdom of Bahrain is a clear example as a nation with limited freshwater resources. In response to these pressures, steps have been taken by the government to ensure water availability by initiating a reliable desalination network, considering desalinated water as the main non-conventional resource to meet municipal sector needs. The study aims to examine the environmental and economic impacts of adopting water-saving fixtures under the Gulf Technical Regulation for Water-Consumption Conservation Products (MC-230503-01) in Madinat Salman as a pilot case, with a focus on domestic water use to estimate potential savings in water and energy, reductions in carbon emissions, and financial implications for both households and the government. The findings show that retrofitting households with GSO-compliant fixtures has a potential of reducing indoor water demand by 18–36%, equivalent to 0.55–1.11 million m^3 annually. These reductions translate into avoided desalination energy of 7–15 GWh/year, natural gas savings of 0.7–1.4 million m^3/year, and a decrease of 4,200–8,400 tCO_2eq emissions, along with 1.3–2.5 million m^3/year less brine discharge to the marine environment. At the national scale, scaling up such measures would provide meaningful contributions to Bahrain's net-zero 2060 target while alleviating financial burdens from subsidies, estimated at 414,000–833,000 BD/year in avoided costs. These results highlight the importance of adopting efficiency regulations, behavioral assessments, and subsidy reforms to ensure sustainable water management and strengthen Bahrain's resilience under the National Water Strategy 2030. By upscaling the assessment beyond Salman City to the national level and including the potential savings from wastewater treatment, Bahrain could significantly reduce water demand and lower the financial burden on the government.

Keywords: Water demand, efficiency regulations, GSO, Net-Zero target, Bahrain's National Water Strategy.

Emergency Integrated Planning of Water Sector in Gaza Using the WEAP model

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Before the October 2023 war, Gaza's water sector was already in crisis due to chronic shortages, seawater intrusion, nitrate pollution, over-reliance on groundwater, and underperforming WWTPs. The war severely worsened these conditions, erasing two decades of progress. By October 2024, about 85% of water and wastewater facilities were destroyed or damaged, domestic water supply had dropped to 10 l/c/d (far below Sphere Standards), all WWTPs had stopped operating, and only 5% of agricultural land remained cultivated. In response, the Palestinian Water Authority (PWA) developed the Gaza Recovery and Restoration Plan (GRRP) to rehabilitate and expand water and sanitation infrastructure. While the GRRP emphasizes flexible and sustainable recovery, it lacks an adaptive decision-support framework to ensure integrated and long-term sector resilience. This study applied the WEAP model to evaluate the Gaza Recovery and Reconstruction Plan (GRRP) by validating its objectives, assessing the sector's sustainability, and optimizing the plan's performance, with a particular focus on domestic water supply. An evaluation-focused approach was adopted, representing Gaza as a single catchment with four supply sources, two demand sites, a wastewater node, and three return links. Two scenarios were tested for 2024–2034: the GRRP scenario, which evaluated proposed interventions to measure unmet demand and the sector's sustainability, and the Optimal Scenario, which coupled WEAP with Python via the WEAP API to minimize unmet demand by optimizing supply inflows under defined constraints. The results showed that while the plan rapidly achieves Sphere Standards in 2025 (15 l/c/d) and restores pre-war supply levels by 2029 (86 l/c/d), unmet demand persists in most years due to slow rehabilitation during 2027–2028 and limited supply capacity. Optimization with Python reduced total unmet demand from 32.1 MCM to 21 MCM, yet structural constraints prevented fully closing the supply-demand gap. Agricultural recovery relies heavily on groundwater because wastewater treatment and reuse remain insufficient, leading to continued marine pollution risks. In particular, significant quantities of domestic sewage and treated wastewater, peaking to 20.6 MCM during 2031-2033 and to 23.9 MCM in 2029 respectively, are projected to be disposed directly into sea. The study concludes that although the GRRP provides a strong foundation for the water sector's recovery, adaptive strategies and integrated planning are essential for long-term resilience. Recommendations include expanding WWTPs and reuse schemes, securing sustainable energy for critical facilities, promoting efficient irrigation, refining WEAP with higher-resolution data, improving model validation, coupling it with hydrogeological models to better represent surface–groundwater dynamics, and institutionalizing the WEAP within the PWA as an adaptive monitoring and planning tool.

Keywords: Gaza Water Crisis, Domestic Water Supply, Gaza Recovery and Reconstruction Plan (GRRP), Water and Sanitation Infrastructure Destruction, Palestine.

Diagnosis of the Groundwater Management System and Framework Development for Operations and Management for SCE and MUN, Bahrain

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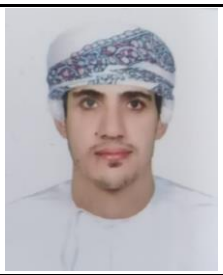
Groundwater, a vital yet overexploited resource in Bahrain, faces growing challenges due to increasing demand, over-abstraction, and emerging regulatory requirements. This study conducts a diagnostic assessment of Bahrain's groundwater management system and develops a framework to strengthen operations and governance for the Supreme Council for Environment (SCE) and the Ministry of Municipalities (MUN). Using a mixed-methods approach that includes data analysis, stakeholder engagement, and gap assessment, the study identifies key institutional, regulatory, and technical weaknesses in existing groundwater monitoring and management practices. Based on these findings, a structured framework is proposed encompassing improved monitoring systems, sustainable abstraction mechanisms, technological integration, and governance reforms. The research provides actionable recommendations aligned with Bahrain's National Water Strategy and international best practices, offering a roadmap for sustainable groundwater management and long-term water security.

Keywords: Water security, gap assessment, regulatory requirements, sustainable abstraction, water governance.

Assessing the Effectiveness of Nama Water's Strategies for Reducing Non-Revenue Water in Nizwa, Dakhliya Governorate, Oman

Mohammed AlRiyami Email: mohammed.riyami@owwsc.nama.om Supervised by **Prof. Waleed Al-Zubari**	

Physical losses of water are one of the major challenges faced by water utilities, which they aim to minimize in the most cost-effective way. This research presents the World's best practices for reducing water loss in the water supply networks. It also describes how water flows and is shared via the water distribution system. In addition, the research shows the activities, steps, plans, and actions implemented by Nama in Nizwa, Dakhliya Governorate, to lower the water losses. Nama has made significant investments in improving its water system and monitoring its performance. Additionally, it has trained its staff by establishing a special team to detect the leaks, and a support team that regularly checks and examines the system. The results show that Nama's efforts to reduce physical water losses were successful. Despite the rapid increase in both the number of users and the amount of water supplied, all the important indicators had improved. The study concludes that using several programs and actions together is essential in reducing water losses, since they support and enforce each other. For further improvement, it is advised that Nama continues investing in the water distribution system, especially in setting up District Metered Areas (DMAs) and training its staff. Moreover, the recording and documentation of non-revenue water (NRW) data must be also improved.

Keywords: Leak Detection, DMA (District Metered Area), Water Balance, Nama.

Towards Sustainable Brine Management in Bahrain: Exploring Feasible Solutions for Environmental Mitigation

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The increasing reliance on desalination to address water scarcity in Bahrain has led to the generation of significant quantities of brine, a byproduct with detrimental environmental impacts. Brine discharge into the marine environment alters salinity, raises water temperatures, and introduces toxic chemicals, all of which disrupt local ecosystems and threaten biodiversity. This study explores the need for sustainable brine management solutions in Bahrain, examines the feasibility of various strategies aimed at mitigating the environmental consequences of brine disposal, and evaluates lessons from the GCC countries. Solutions such as controlled dilution, zero liquid discharge (ZLD) technology, deep-well injection, brine reuse, and the integration of advanced membrane technologies are discussed. Additionally, the study addresses economic implications and policy considerations for implementing sustainable practices. It concludes that a multi-faceted approach combining technological innovation, economic investment, and strong regulatory frameworks is crucial to ensuring the sustainability of Bahrain's water resources and marine environment. This research focuses on the management of brine water discharged from desalination plants in the Kingdom of Bahrain, intending to provide practical mitigation solutions tailored to the local environmental and operational context. A descriptive-analytical methodology was applied, combined with a field case study of five sites. The results revealed elevated levels of temperature and residual chlorine, alongside a limited application of advanced mitigation techniques. Based on data analysis and stakeholder consultations, a concise guideline has been proposed, outlining mitigation measures and regulatory requirements for future desalination projects. This study identifies practical strategies to mitigate the environmental impacts of brine discharge from Bahrain's desalination sector, tailored to each plant's operational and geographic context. Measures include brine blending with treated effluent or cooling water, multiport diffusers for offshore plants, and rotating discharge sites in shallow areas. Long-term options such as constructed wetlands and advanced technologies, like Zero Liquid Discharge (ZLD) and salt recovery, were assessed though limited by cost. Operational improvements, such as RO optimization at the RAJ plant, offer immediate potential to reduce brine volumes.

Keywords: Desalination, Marine Environmental Protection, Innovative Technologies, Water Sustainability.

استدامة ري المناطق الزراعية بالمملكة العربية السعودية: دراسة حالة منطقة سد العقيق بالباحة ومصادر المياه لسد العقيق

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تهدف هذه الدراسة إلى تطبيق مفهوم الإدارة المتكاملة للموارد المائية لتحقيق استدامة ري المناطق الزراعية في منطقة سد العقيق بالباحة، جنوب غرب المملكة العربية السعودية. اعتمدت الدراسة على جمع بيانات شاملة حول البيانات المناخية كالأمطار والبخر-نتح، وبيانات التربة وكفاءة نظم الري لتقدير الاحتياجات المائية للمحاصيل الزراعية (8 محاصيل) وكذلك حساب المقنن المائي لها. وكذلك تم جمع البيانات الطبوغرافية والهيدروجيولوجية، إضافة الى البيانات التصميمية للسد، لتقدير الموثوقية، التي تعتمد على حساب الجريان السطحي للسد، الحجم المخزّن، البخر والرشح، و قواعد التشغيل (مراقبة منسوب التخزين)، لتحديد كميات السحب الآمنة من السد. تم اختبار 10 سيناريوهات لمعدلات السحب من أجل تحديد أعلى معدل سحب يحقق موثوقية لا تقل عن 80% (المعيار المقبول عالمياً)، وقد أظهرت النتائج أن كمية السحب الآمن من بحيرة السد يجب أن لا تتعدى 13,495 م^3/اليوم لموثوقية أكبر من 80%. كما أكدت الدراسة على أن أعلى هطول مطري كان في شهر أبريل، الأمر الذي يتطلب تعظيم الفائدة بتبني تقانات حصاد المياه. وأشارت كذلك إلى أن نظام الري بالتنقيط يحقق أعلى كفاءة في استخدام المياه لأكبر مساحة زراعية (تصل إلى نحو 84 هكتار). خلصت الدراسة إلى أن النهج العلمي القائم على تحليل الموثوقية يوفر أدق التقديرات لاستغلال السدود، وبأن التوازن بين الموثوقية العالية والكمية المسحوبة والمساحة المزروعة هو الوصفة المثلى لضمان استدامة المورد المائي وتحقيق التنمية الزراعية المستدامة.

الكلمات الدالة: كفاءة الري، الهطول المطري، حصاد المياه، تحليل الموثوقية، الزراعة المستدامة، الإدارة المتكاملة للموارد المائية.

Synergies and Harmonization between the National Water Strategy and the UNESCO IHP-IX, and Insights for the Upcoming Update of the NWS

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This study explores the strategic alignment between Bahrain's National Water Strategy (NWS) and UNESCO's Intergovernmental Hydrological Programme Phase IX (IHP-IX), using Singapore's advanced water governance model as a benchmark. It begins by contextualizing Bahrain's acute water scarcity, institutional fragmentation, and climate vulnerabilities, then examines Singapore's integrated water sourcing, technological innovation, and sustainability frameworks. A targeted expert survey provided qualitative insights into the NWS's operational impact, sectoral challenges, and international alignment. Respondents highlighted strengths such as digital transformation and strategic clarity, while identifying critical areas for improvement—including stakeholder engagement, private sector inclusion, treated wastewater reuse, and the adoption of emerging technologies. The study emphasizes the need to integrate artificial intelligence (AI), Internet of Things (IoT), and machine learning into water monitoring and management systems, promote nature-based solutions for climate resilience, and institutionalize citizen science to enhance public participation and data collection. These recommendations inform the upcoming NWS update, aiming to position Bahrain as a regional leader in inclusive, innovative, and science-based water governance.

Keywords: Water governance, Singapore's water model, IWRM, sustainability framework, Digital transformation, Kingdom of Bahrain.

Assessment of Drinking Water Quality in the West Bank, Palestine, using the CCME - Water Quality Index (WQI)

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In Palestine, the Service Providers (SPs) are responsible for delivering water and wastewater services. However, they face ongoing challenges, including unreliable supply, inadequate infrastructure, and repeated damage to water distribution systems caused by the Israeli occupation. As the regulatory body overseeing the sector, the Water Sector Regulatory Council (WSRC) relies on a limited set of key performance indicators (KPIs) to monitor the water quality. To unify and standardize data, the Council developed a Water Quality Index (WQI) consistent with the international practices, marking its first attempt to implement such a tool. The WQI was used to evaluate drinking water quality for the SPs, considering both spatial variations across West Bank governorates and temporal variations during the summer season. The study targeted nine governorates, focusing on the SPs with functioning water quality monitoring systems. Monthly water samples were collected by the SPs at 104 sites, resulting in 2,049 tests conducted between May and July 2025. Seven parameters have been tested, including turbidity, pH, TDS, NO_3, FRC, TC, and FC, with results compiled by the WSRC. The Canadian Council of the Ministers of the Environment WQI (CCME WQI) was adopted to classify water quality grades during the study. Findings highlighted the overall patterns and the key concerns, notably non-compliance with FRC and nitrate standards. Despite these issues, the SPs maintained water quality ranging from fair to excellent throughout the study period. According to the overall CCME WQI, the SPs of Nablus, Jericho, Hebron, and Salfit municipalities achieved an excellent score (100). Jerusalem Water Undertaking (JWU), Water Supply & Sewerage Authority Bethlehem (WSSA), Jenin municipality, and Tulkarm municipality were rated good at grades 92, 92, 83, and 82, respectively. However, Qalqilya municipality recorded the lowest result with a score of 77, indicating fair quality. Results also showed minimal temporal fluctuations but noticeable spatial disparities among governorates. Despite limitations, such as the short duration of evaluation, restricted sampling sites, and constrained parameters, the study offers an initial assessment of water quality in the main pipelines within the drinking water distribution networks of the SPs. It further emphasizes the value of water quality indices as practical monitoring tools capable of providing reliable results for analysis and communication with decision-makers.

Keywords: Service Providers, drinking water distribution network (DWDN), temporal variations, spatial variations, water quality indices.

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