



**Scholarship Program Funded by Middle East Desalination Research Center (MEDRC)**

**Technical Affairs Directorate**

**Research and Development Department**

**Funded by:**



MEDRC program was under the title “Scholarship Program- Palestinian Water Authority, (2012 in progress), the program funded by Middle East Desalination Research Center (MEDRC). The main juristic justification for MEDRC is to focus on priority research, training and communication needs. As a result, each year, the Center will reevaluate its overall program, to continually enrich its activities and maintain close proximity to the changing needs of the desalination technologies. Each year a revised Program Framework and Profile (PFP) will be presented to the Research Advisory Council (RAC) for their review and their input for the technical agenda of the upcoming year. The MEDRC-PWA CoE Scholarship Program offers students in Gaza and the West Bank the opportunity to study at local universities in the fields of water management, desalination and reuse. The aim of the program is to allow students to gain skills and expertise to make a long term contribution to the further development in water management, desalination and water reuse activities in Gaza and the West Bank. MEDRC has developed a MEDRC-Palestinian Water Authority (PWA) scholarship program for Palestinian students to obtain M.Sc degrees at universities in the Palestinian territories: Gaza and the West Bank. The study focus should be engineering related to the fields of desalination, environment and water reuse. MEDRC program funded 207 students through Palestinian Water Authority in the period 2011-2018.

MEDRC is directed to focus on priority research, training and communication needs, in order to achieve the objectives defined by its Establishment Agreement. As a result, each year, the Center will reevaluate its overall program, to continually enrich its activities and maintain close proximity to the changing needs of the desalination technologies. Each year a revised Program Framework and Profile (PFP) will be presented to the Research Advisory Council (RAC) for their review and their input for the technical agenda of the upcoming year.

**Objectives of MEDRC:**

1. Decrease the cost of desalination.
2. Develop productive partnerships and cooperation.
3. Develop sustainable desalination technologies.
4. Improve communications in the desalination community.
5. Develop human resources for application of desalination and foster international cooperation in research activities, particularly among regional experts.
6. Utilize limited regional and international research resources .
7. Maximize technology transfer

# Purification of Groundwater from Heavy Toxic Metals using Suspended Polydentate Supported Ligands

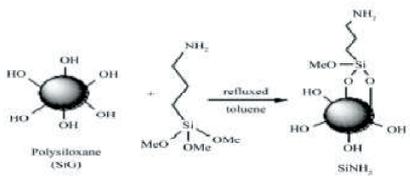
Bayan Khalaf<sup>1</sup>, Shehdeh Jodeh<sup>1</sup>, Ismail Warad<sup>1</sup>  
<sup>1</sup>An-Najah National University

## 1. Research Background:

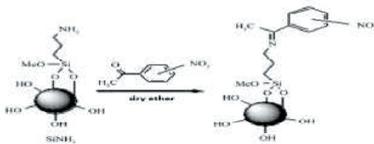
The increasing levels of heavy metals in the water resources and environment represent a serious threat to human health, living resources and ecological systems. This study aims to prepare several vehicles chelation polydentate supported ligands in order to be susceptible to imply conjunction with the highly toxic heavy metal ions in the water including Lead, Nickel and Cadmium ions, as the process of interaction between ligands and heavy metals depends on the circumstances surrounding conditions which are treated in this research. Metal ion uptake through complexation can be affected by hydrophilic-hydrophobic balance, the nature of chelate ligands and the extent of cross-linking of macromolecular supports. Ligand function also dictates reactivity, complexation ability and efficiency of polymer supported ligands in the present case expected to be good solution for such problem. This research involves the synthesis of new polysiloxane surfaces modified with ortho-, meta-, or para-nitrophenyl moieties. The resulting adsorbents have been characterized by SEM, IR, UV, <sup>13</sup>C solid state NMR, BET surface area, B.J.H. pore sizes and TGA. These porous materials showed a very good thermal and chemical stability and hence they can be used as perfect adsorbents to uptake Cd(II), Pb(II) and Ni(II) from groundwater taking from Burjinn village in Palestine.

## 2. Methodology:

### 2.1. Preparation of Silica-Immobilized Propylamine (SiNH<sub>2</sub>)



### 2.2. Synthesis of Nitrophenyl-Substituted Silicas: (Si-o-NO<sub>2</sub>), (Si-m-NO<sub>2</sub>) and (Si-p-NO<sub>2</sub>)

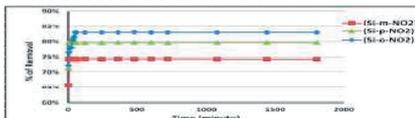


**2.3. Batch experiments:** In order to investigate the adsorption efficiency for each adsorption process. The effect of solution conditions on each adsorption process were studied. These conditions involve the effect of contact time, pH value, temperature, adsorbent dose and the initial concentration of adsorbate.

## 3. Results:

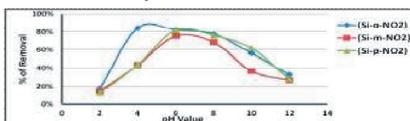
### 3.1. Adsorption of Cadmium

#### 3.1.1. Effect of Contact Time



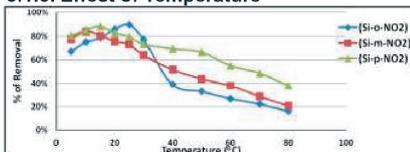
As shown here, the highest percent of Cd(II) removal was 82.98% for (Si-o-NO<sub>2</sub>) after 50 minutes of shaking.

#### 3.1.2. Effect of pH Value



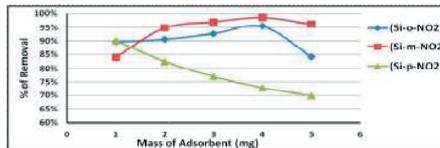
From the plot, (Si-o-NO<sub>2</sub>) adsorbent has the maximum percent of Cd(II) removal that is 84.57% compared with that for (Si-p-NO<sub>2</sub>) that equals 81.72% and (Si-m-NO<sub>2</sub>) that equals 75.39%.

#### 3.1.3. Effect of Temperature



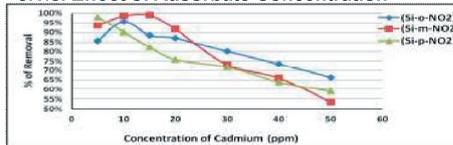
The percents of removal at each optimum temperature for the three adsorbents are 89.56% for (Si-o-NO<sub>2</sub>), 83.95% for (Si-m-NO<sub>2</sub>) and 87.94% for (Si-p-NO<sub>2</sub>).

#### 3.1.4. Effect of Adsorbent Dose



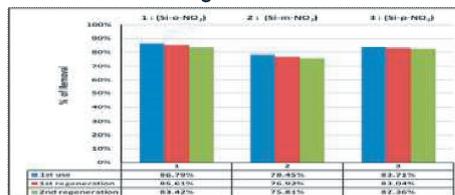
As shown above, the maximum percent of Cd(II) removal was 98.61% using 4 mg of (Si-m-NO<sub>2</sub>).

#### 3.1.5. Effect of Adsorbate Concentration



The maximum percent of Cd(II) removal was 98.99% for (Si-m-NO<sub>2</sub>) by using 15 ppm as concentration of Cadmium solution.

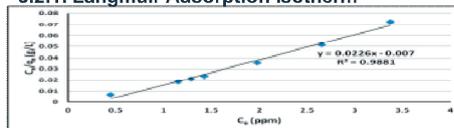
#### 3.1.6. Adsorbent Regeneration



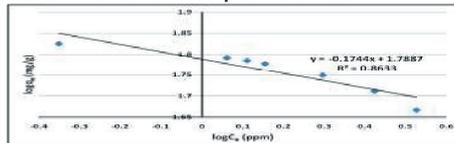
From the plot, the difference between the percents of Cd(II) removal after the first and second regeneration of each modified polymer is very low. This is strong evidence that the three synthesized adsorbents can be recycled, and hence be used for several times.

### 3.2. Adsorption of Cd(II) on (Si-o-NO<sub>2</sub>): Adsorption Kinetics and Thermodynamics

#### 3.2.1. Langmuir Adsorption Isotherm

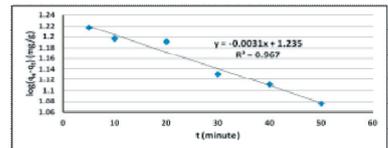


#### 3.2.2. Freundlich Adsorption Isotherm

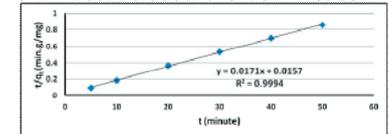


According to the values of R<sup>2</sup>, adsorption of Cd(II) on (Si-o-NO<sub>2</sub>) followed Langmuir adsorption isotherm such that, R<sup>2</sup> for Langmuir plot equals 0.9881 while R<sup>2</sup> for Freundlich plot is 0.8633.

#### 3.2.3. Pseudo First-Order Kinetics

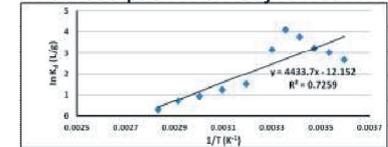


#### 3.2.4. Pseudo Second-Order Kinetics



According to R<sup>2</sup> values, This adsorption process followed Pseudo Second Order Kinetics with R<sup>2</sup> of 0.9994.

#### 3.2.5. Adsorption Thermodynamics



Adsorbent	Adsorption of Cd(II) Adsorption Thermodynamics	
	ΔH (kJ)	ΔS (J/K)
Si-o-NO <sub>2</sub>	36.861	-101.032
Si-m-NO <sub>2</sub>	32.148	-85.052
Si-p-NO <sub>2</sub>	24.065	-54.221

The graph shows that adsorption of Cd(II) on (Si-o-NO<sub>2</sub>) is endothermic process and non spontaneous.

**Summary:** The characterization of (Si-o-NO<sub>2</sub>), (Si-m-NO<sub>2</sub>) and (Si-p-NO<sub>2</sub>) showed that these polymers have very good thermal and chemical stabilities, and hence they can be used as perfect adsorbents to uptake Cd(II), Pb(II) and Ni(II) from groundwater. The maximum extent of adsorption was for (Si-p-NO<sub>2</sub>) polymer in the presence of lead ions. This adsorption needed only 1 minute of shaking to have 99.95% as percent of Pb(II) removal. For cadmium and nickel ions, the maximum percent of removal was 98.99% in the presence of (Si-m-NO<sub>2</sub>) adsorbent. In addition, the results showed that all of these adsorption processes followed Langmuir isotherm and the mechanism of all of these reactions followed pseudo second-order kinetic model.

The thermodynamic parameters proved that all the adsorption processes are endothermic (ΔH > 0) and non spontaneous (ΔS < 0). The synthesized polymers were also regenerated, and the percentage removal before and after adsorbent recovery is determined.



# The Assessment of Private Sector Participation through different Contracting Models on the Sustainability of Desalination Plants

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**Research Background:** Seawater desalination plants offer an abundant alternative resource to meet the growing need of water. But this technology is very costly ,needs huge resources to be implemented and requires proper understanding (good experience) ,for designing , planning and operating to make the system more sustainable and to produce fresh water . So governments such as Palestine which don't have the sufficient affordability to implement such large and risky projects as desalination plants , look for Public-Private Participation (PPP) expression which means getting the private sector involved in construction and operation of desalination plants through different contracting models.

**Methodology:** The adopted approach for selecting the optimal PPP contract was based on extensive literature review to abstract the most well-known PPP contracts that fit the Palestinian reality and several meetings with experts who have a good background about the desalination process, PPP contracts, sustainability ...etc., to finding the beneficial tool to collect the data. Structured interview designed to collect the data where it conducted with different sectors that related to water sector or concerned on investment in this sector ,and based on five indicators of sustainability ; financial, institutional, technical, socioeconomic, and environmental to classify each of the PPP contracts .Through the analysis process of the data collected using SPSS program, three points will be assessed; first, the importance rate for sustainability of each of five indicators (financial, institutional, social, and environmental viabilities) for desalination plant in Palestine. Second, sustainability of each of the five indicators that effect on deciding the structural framework of PPP contracts. Third, the different contracting models.

### Area of study (Gaza Strip):

Gaza strip is a region located in Palestine country. It's extended along the southwestern portion of the Palestinian coastal plains , that borders; Egypt on the southwest for 11 kilometers and Israel on the east and north along a 51 km. It has an area about of 360 km<sup>2</sup>, the length is about 45 km on the western Mediterranean coast and the width varies from 7 km to 12 km (Gaza Municipality, 2014). Besides, it consists of five governorates ;North, Gaza, Middle, Khanyunis, and Rafah. With the population of 1.8 million , where Gaza strip considered one of the most densely populated regions in the world (over 4,500 people per km<sup>2</sup>) (Union for the Mediterranean Secretariat, 2011; Gaza Municipality, 2014 ; PCBS (2014)



Map 1: Gaza Strip , Palestine

### Results:

Four steps evaluated to select the optimal PPP contract for Gaza strip Desalination plant :

1. The importance rate for the each types of sustainability using weighted average method found as shown in figure 1. 82% of the respondents evaluate the financial viability as the highest priority when selecting the PPP contract for the desalination plant. This might be explained by the high expected cost for the desalination plants .The second priority was given to the institutional viability with 76%. This is related to the importance of having a clear institutional framework to organize the PPP projects and to ensure that such projects are profitable for the private sector. Due to the political situation in Palestine. However, technical, socio-economic and environment viabilities are classified in the third ,fourth and fifth priorities with 72%, 62% and 59% respectively.
2. Evaluation of the sustainability of each of five indicators ( Financial , Institutional, Socio-economic and environmental) against the different type of PPP contracts . See figure 2 , shows the financial viability against PPP contracts , where the Greenfield contract got the highest score that has the affordability to covered the project costs than other contracts.
3. Evaluation of PPP types (Traditional contract, Service and Management contract, Lease contract, Joint venture contract, Green field contract (concession contract) and divestiture contract )based on sustainability indicators. See figure 3 , shows Traditional contract against sustainability indicators .
4. Finally, Overall evaluation of the different contracting model .See figure 4 , where the Green field contract (concession contract) got the highest weighted average among the other contracts .

**Summary :** At the end , determining the optimal contract for desalination plant in Palestine and the extent to which the private sector might be involved either in establishing, operating and/or preserving the sustainability of the desalination plan. This was enabled by collecting data through using interviews structures that targeted with a sample of organizations in the field of water sector in West Bank and Gaza Strip. The selection process for the optimal PPP contract was based on five indicators: financial, institutional, technical, socio-economic, and environmental viabilities. After analyzing the data using the software SPSS, the concession contract (Green field contract ) found that the most optimal choice (best) for the respondents with a 3.3/5 weighted average .that means this contract has the elasticity and the specificities to handle with the possible political, economic and social challenges that might face the desalination project in Palestine especially in Gaza strip

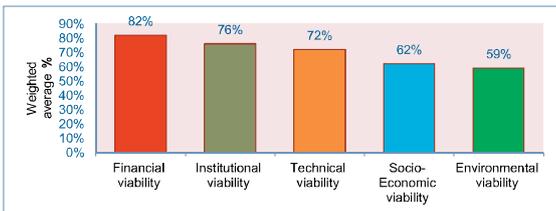


Fig. 1: The importance of each type of sustainability using weighting average

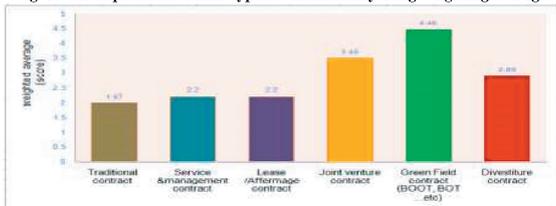


Fig. 2: Assessment of Financial Capacity to Afford the Capital Cost of Desalination

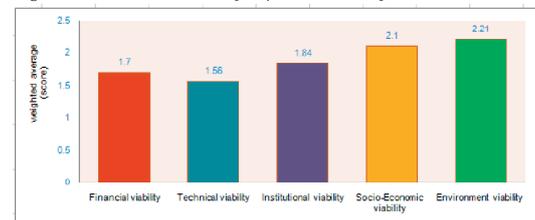


Fig. 3: Evaluation process for Traditional contract against sustainability indicators

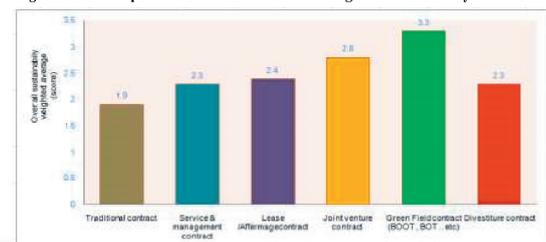


Fig. 4: Overall evaluation of the different contracting model



# Assessment of Reverse Osmosis Process for Brackish Water Desalination in the Jordan Valley

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- Research Background:** Cost studies have done a remarkable work in investigation and optimization of hybrid renewable energy for BWRO desalination systems. This study aims to analyze the feasibility of both BWRO stand-alone system powered by PV cells and hybrid RE unit located in Az Zubeidat village, by first assessing the water resources with the corresponding demand, then assessing the renewable energy sources available in order to decide optimal renewable energy sources suitable for desalination using RO technique, finally developing a reliable cost analysis approach for desalination system.

**Methodology:** (i) **Data Collection:** Data will be obtained from:

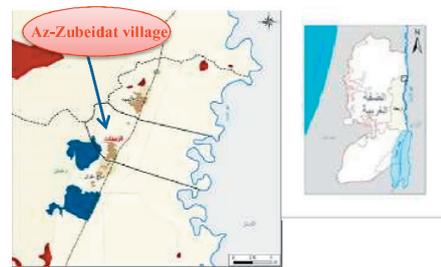
1) Geographical Information System (GIS) database 2) Water supply and demand data. 3) Data from Az Zubeidat desalination plant

(ii) **Economic Analysis:**

In this research, the BWRO system was analyzed economically using HOMER Pro<sup>®</sup> which is a microgrid software developed by the U.S National Renewable Energy Laboratory (NREL).

**Area of study (Az-Zubeidat Desalination plant):**

Al-Zubeidat village is one located about 35.4 km to the north of Jericho city. The village is about 275 meters above sea level (see Map 1: Az-Zubeidat village, Jericho, West Bank) The annual solar radiation is 5.37 kWh/m<sup>2</sup>. The village has a desalination unit which was constructed; the RO unit was implemented by both Al-Najah National University and the local contractor (General Environment Services - GES) with the Palestinian Water Authority (PWA) as supervisor and Middle East Desalination Research Center MEDRC as a donor.



Map 1: Az-Zubeidat village, Jericho, West Bank

## Optimal System Type

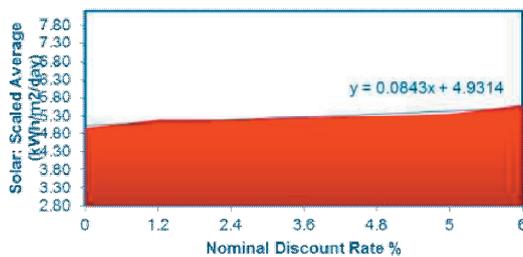


Fig. 1: Graphical results of the sensitivity analysis of the PV system with and without batteries.

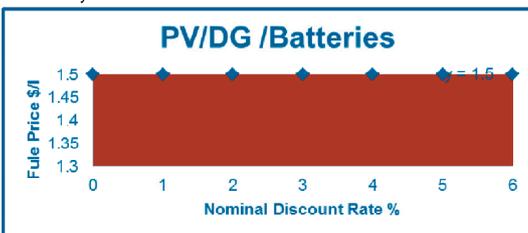


Fig. 2: Graphical results of sensitivity analysis between Diesel fuel price and solar radiation value for optimal Hybrid system.

Pollutant	CO <sub>2</sub>	CO	Hydrocarbon	Particulate Matter	SO <sub>2</sub>	NO <sub>x</sub>
Percentage decrease %	68.3	68.2	68.3	67.1	67	68.2

Table.1: Reduction percentage of the yearly GHG production when using PV/Battery/DG instead of using DG only.

## Results:

- Three separate scenarios were adapted, the first one is the current unit with PV/Battery system, as result showed whenever the solar scaled average is below approximately 5 kWh/m<sup>2</sup>/day it is more economic to use the PV system alone and the PV/battery system is used otherwise (see Figure1: Graphical results of the sensitivity analysis of the PV system with and without batteries). The maximum solar scaled average (8.19 kWh/m<sup>2</sup>/day) has the least COE (0.0234 \$/kWh) of all three solar radiation values, but the system should include the batteries to overcome the stability problems, and the minimum solar scaled average (2.28 kWh/m<sup>2</sup>/day) has the highest COE (0.0618 \$/kWh) of all three solar radiation values. Meanwhile; all of them do not work properly without batteries.
- The second scenario was powering the system with diesel generator alone. Analysis showed that a 10kW generator with 1\$/W capital price, 0.7 replacement and 1, 67 \$/hr O&M, the optimal system when the interest rate was minimum 0%, the price of diesel was minimum 1.3\$/l and COE of 1.25 US\$/kWh which is relatively high with large GHG emissions.
- The third scenario was to operate the system for twice the time as it is using hybrid system consist of PV/Battery/DG with different sensitivity variables (see Figure2: Graphical results of sensitivity analysis between Diesel fuel price and solar radiation value for optimal Hybrid system) which gave an optimal configuration with the least COE of US\$0.424/kWh when the fuel price is minimum (1.3\$/l) and the solar scaled average is maximum (8.91 kWh/m<sup>2</sup>/day), for both 6 and zero IR percent, the best configuration comprises of 10 Kw diesel generator, a 27.2 Kw of PV modules and 24 batteries of 1.75 kWh capacities, and the system has 70% renewable energy fraction, the system Net Present Cost equals US\$ 99455 with yearly carbon dioxide production of 3501 Kg/yr.
- As the IR increases, the COE increases.
- As Diesel price increases, the COE increases.
- PV/Battery/DG solution gives an average of 68% GHG reduction (see Table.1: Reduction percentage of the yearly GHG production when using PV/Battery/DG instead of using DG only.)

## Summary

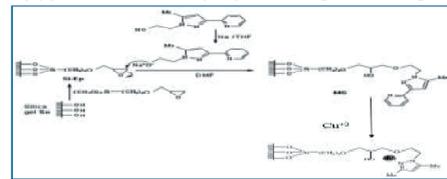
Three different scenarios were analyzed economically and environmentally using HOMER Pro, the third scenario was to operate the system for twice the time as it is using hybrid system consist of Photovoltaic/Battery/diesel generator (PV/Battery/DG) with different sensitivity variables which gave an optimal configuration with the least COE of \$0.424/kWh when the fuel price is minimum (1.3\$/L) and the solar scaled average is maximum (8.91 kWh/m<sup>2</sup>/day), for both 6 and zero Interest Rate (IR), the best configuration comprises of 10 kW diesel generator, a 27.2 kW of PV modules and 24 batteries of 1.75 kWh capacities, and the system has 70% renewable energy fraction with a 68% GHG reduction.

# Synthesis And Characterization Of Novel Porous SiO<sub>2</sub> Material Functionalized With C,c Pyridylpyrazole Acceptor For Sulphate Removal From Waste Water

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- Research Background.** Sulphate is a common constituent of many natural waters and wastewaters, and is sometimes present in high concentrations. Industrial wastewaters are responsible for most anthropogenic emissions. Certain industrial effluents may contain several thousands of milligrams per litre while domestic sewage contains typically less than 500 mg l<sup>-1</sup>. The damage caused by sulphate emissions is not direct, since sulphate is a non-toxic compound. However, high sulphate concentrations can unbalance the natural sulphur cycle. This research involves the synthesis of pure modified porous polysiloxane SiO<sub>2</sub>. The surface modification (MS) was characterized by elemental analysis, infrared spectra, and SEM. This porous material exhibits good chemical and thermal stability determined by Thermogravimetry curves and hence they can be used as perfect adsorbents to uptake sulfate from water.

**Methodology:** synthesis of the new modified silica gel (Si-RO-PzPyr) which will be used in this research can be summarized by reacting the activated silica gel with 3-glycidoxypropyltrimethoxysilane to form the epoxy-silica that acts as a precursor for further immobilization of the molecule containing the donor atom. The second stage involved the condensation of the C,C pyridylpyrazole salt with epoxy silica to give the target material MS as shown in the [figure 1](#)



figer1- synthesis of the new modified silica gel (Si-RO-PzPyr)

- Preparing stock solution of 1000 mg/L was prepared and Different concentration was prepared by dilution. Linear calibration curve between absorbance and concentration was constructed
- Studying the effects of several factors on the complexation process such as; the effect of temperature, pH, contact time, dose and the effect of sulfate conc as shown in the following [figures\(2-5\)](#)

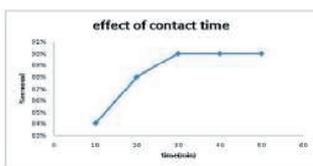


Figure2-effect of contact time

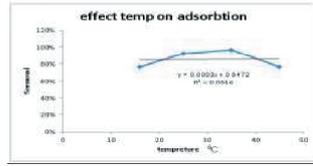


figure 3-effect temperature on adsorption

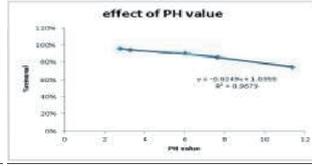


figure4- effect of PH value

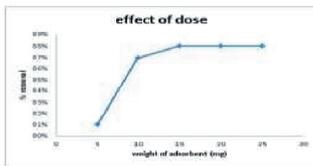


Figure 5-effect of dose

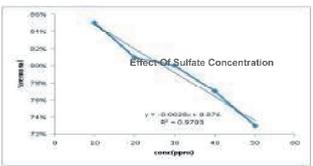


figure 6-effect of sulfate concentration

- The best equilibrium isotherm model for the adsorption process was investigated according to the value of the correlation coefficient of Langmuir and Freundlich and Temkin isotherm adsorption model as shown in the [figures\(7-9\)](#)

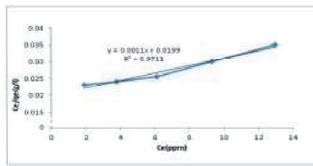


figure7-langmuir Adsorption Isotherm

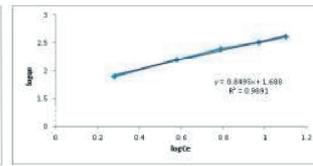


figure8-Freundlich Adsorption Isotherm

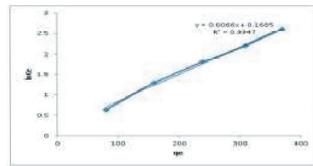


Figure9-Temkin Adsorption Isotherm

- Also the kinetic of adsorption were investigated using pseudo first-order and pseudo second-order kinetics model as shown in the [figures\(10-11\)](#). In addition, Van't Hoff plot for adsorption in order to determine the values of enthalpy change and entropy change, and hence determining if the adsorption process is spontaneous or not, and if it is exothermic or endothermic one in [figure\(12\)](#)

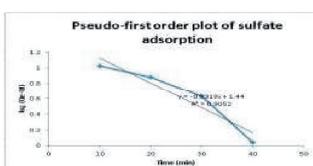


Figure10-: Pseudo-first order plot of sulfate adsorption

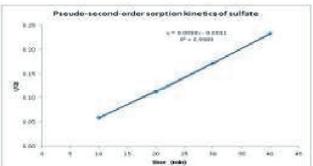


Figure11-Pseudo second order adsorption kinetics of sulfate

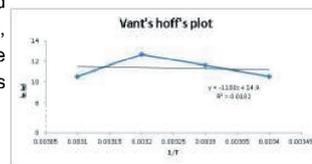


Figure12-Van't Hoff plot

## Results:

1-(Si-RO-PzPyr) was able to remove sulfate within the first 30 minutes with high removal efficiency at pH around 2, 30°C Temperature, 0.015g weigh of dose and initial concentration 10 mg/L

2-Adsorption of sulfate by (Si-RO-PzPyr) was explained well by Temkin model. adsorption model has the highest value of regression(0.994) and thus the best fit.

3-The adsorption reaction mechanism conformed with pseudo second-order kinetic adsorption model with correlation coefficient of about one.

4-The thermodynamic parameter of adsorption sulfate on (Si-RO-PzPyr) is endothermic ( $\Delta H > 0$ ) and spontaneous ( $\Delta S > 0$ ).

**Summary:** In this study, it is found that the new modified polysiloxane polymer has very good thermal and chemical stabilities, and so it can be used as a good adsorbent to grab sulfate from wastewater.



# The Effect of *Bacillus Megaterium* on Barley Tolerance to Salinity

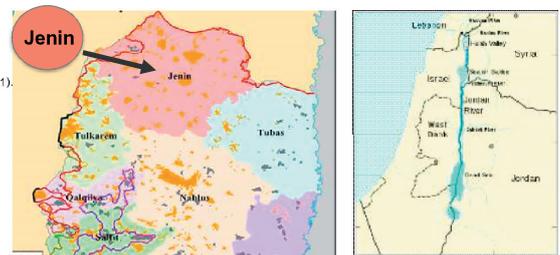
Jardaneh H,  
An-Najah National University

**Research Background:** Salinity is abiotic stresses and one of the most important environmental parameters that affect on Barley growth and more harmful to crop plants. In Palestine the Jordan Valley is a fertile productive region, described as the food basket of Palestine. Groundwater originating from the Quaternary Aquifer System forms the main water resource in the Jordan Valley. The quality of this groundwater is threatened mainly by the high chloride concentration. The use of Plant Growth Promoting Rhizobacteria (PGPR) such as *Bacillus Megaterium* is a promising strategy to alleviate salt stress in horticultural crops and to maintain an acceptable level of productivity under higher salt concentrations (Fig. 1).

**Methodology:** (i) Plantation of three barley cultivars: Reehan, ICARDA 5 and Nabawi. Sum of 5 seeds per pot was used under greenhouse conditions. Salinity treatments: (ii) Irrigation with five salinity levels 0, 50, 100, 150 and 200 mM of NaCl after three weeks of seed germination (iii) Bacterial inoculation by irrigation of the soil with 1.5 ml/plant of *Bacillus Megaterium*. The experiment consists of two parts, one part with bacteria inoculation and the other part without bacterial inoculation. (iv) The response of plants to the treatments monitored for the following parameters; vegetative growth at maturity, including plant height, number of tillers, leaf area, leaf number, peduncle length, awn softness, total dry weight per plant, total fresh weight per plant and chlorophyll contents (V) Evaluation the mineral composition of shoot and roots:  $K^+$ ,  $Ca^{+2}$ ,  $Na^+$ ,  $Cl^-$ , N, and P.

## Area of study:

At National Agriculture Research Center (NARC) in Jenin area- West Bank in Palestine (Map1). The study conducted under greenhouse condition in order to evaluate the efficiency of *Bacillus Megaterium* on reducing the effect of salinity on Barley (Map 1).



Map 1: Jenin, West Bank, Palestine



Fig. 1: Barley with Bacterial inoculation



Fig. 2: Barley without Bacterial inoculation

## Results:

1. *Bacillus Megaterium* enhanced the ability of plants to tolerate salinity stress and significantly reduces the effect of salinity on chlorophyll content in three landrace.
2. Texture influenced with salinity level as *Bacillus Megaterium* inoculation increased the level roughness of awns.
3. Reehan landrace was not affected by bacteria inoculation for leaf length, leaf number and width.
4. In Icarda 5 and Nabawi Landraces at 100-150 mM Bacterial inoculation reduced the impact of salinity on leaf length, width and number, root weight, shoot weight and plant height which are growth parameters
5. The Sodium accumulation levels decrease in shoot and root of plant which inoculated with bacteria..
6. Low Sodium accumulation in plant inoculated with Bacteria was observed at 200 mM NaCl especially in the shoot and root of Icarda 5 and Nabawi.
7. Bacterial inoculation reduces the accumulation of Chloride in shoot and root of Reehan and Nabawi.
8. Plant Growth Promoting Rhizobacteria increased the accumulation of Phosphorus and N in Reehan, Icarda5 and Nabawi at moderate to high salinity.
9. Bacterial inoculation have positive effect on the accumulation of Potassium in barley root at high level of salinity
10. Bacterial inoculation reduces the accumulation of Phosphorus in shoot at low and high salinity level however at salinity level 100mM the response was opposite.

**Summary:** In Palestine, Soil and water salinity is one of the most important environmental parameters that impact on the growth of barley and more harmful to crop plants. Although barley (*Hordeum vulgare L.*) is regarded as salt tolerant among crop plants, its growth and plant development is severely affected by ionic and osmotic stresses in salt-affected soils water (Fig.2). *Bacillus Megaterium* stimulate plant growth under saline conditions and improve nutrient uptake.



# Synthesis of 1-(Pyrrol-2-yl) imine modified silica as a new sorbent for the removal of hexavalent chromium from water

S. Jodeh1\*, G. Hanbali1, I. Warad1, H. Lgaz2, D. Jodeh3, S. Radi4, S. Tighadouini4

**Research Back Ground :** The water pollution of the most intractable problems faced by the countries of the world, without exception. Heavy metals can be defined as any metal or metalloids have density more than  $4 \text{ g/cm}^3$ . One of the most important and toxic heavy metals in wastewater is chromium. Chromium (VI) is released from different industrial operations. The traditional separation and preconcentration methods for metal ions are liquid-liquid extraction, coprecipitation, and ion exchange. Chemically modified Polysiloxane is one of the most successful adsorbents, because this inorganic polymer support does not swell or shrink like the organic polymeric resin.

The aim of this study is to remove Cr (VI) from wastewater, using this prepared material as an adsorbent for the solid-phase extraction. The adsorption behaviors of the adsorbent with Cr (VI) has been studied. Adsorption isotherms, adsorption kinetic and thermodynamics has been studied by varying the following three parameters: initial concentration of Cr (VI) solution, volume of the Cr (VI) solution, and adsorbent dose on the uptake of Cr (VI) from the solution.

## Methodology:

### A- Synthesis of adsorbent 1-(pyrrol-2-yl)imine-Substituted Silica (SiNPr) .

To prepare the (SiNPr), a mixture of pyrrol-2-carbaldehyde (1.5 g) and 3-aminopropylsilica (SiNH<sub>2</sub>) (2.5 g) in 50 mL of dry diethyl ether was mixed and stirred for 24 h. At room temperature, the solid residue was filtered, acetonitrile, methanol and dichloromethane was used in Soxhlet extraction of the product for 10 h. The desired solid product was dried completely over more 24 h. The synthesis step is shown in Figure .1

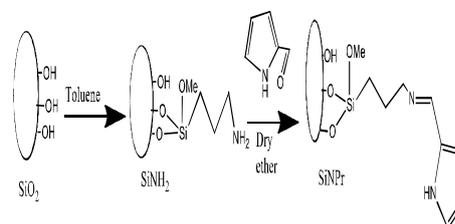


Figure 1: The synthesis step of (Si-NPr)

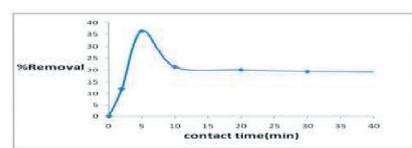


Fig. 2: Effect of Contact Time

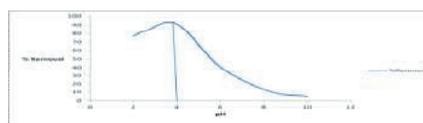


Figure 3: Effect of PH

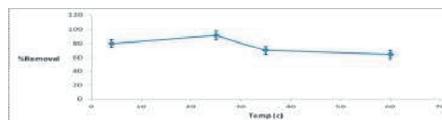


Figure 4: Effect of Temperature

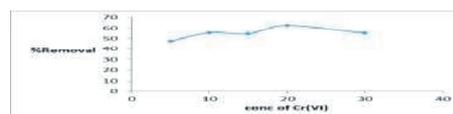


Figure 5: Effect of Adsorbate Concentration

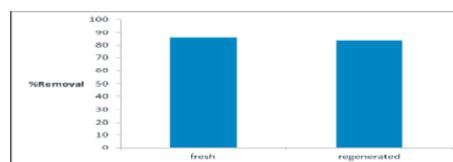


Figure 6: Percentage of Cr (VI) removal by recovered adsorbent

## Result:

### A- Batch Experiments:

1- **Contact time effect on Cr (VI) adsorption :** During the first 5 min, rapid adsorption of Cr (VI) was detected (Figure 2)

2- **pH effect on Cr (VI) adsorption :-** At low pH such as 2 to 4 there was increase of the adsorption capacity for Cr (VI). When pH is further enhanced, a sharp decrease in uptake capacity of adsorption was noticed. (Figure. 3).

3- **Temperature effect on Cr (VI) adsorption :-** increasing the temperature above the room temperature (25°C) has effect on decreasing the adsorption capacity of modified surface. (Figure4)

4- **Cr (VI) concentrations effects :** the percent removal of Cr (VI) increases with increasing initial concentration of Cr (VI) until 20ppm. Above 20 mg/L initial concentration of Cr (VI), the percentage removal of Cr (VI) ion reduced. (Figure 5).

### B- Recovery of Cr(VI) and reusability of Si-NPr

Figure 6 showed that regenerated adsorbent have good adsorption capability and excellent stability. Results confirmed the possibility of use of adsorbent again without reducing the efficiency of adsorption

### Conclusion:

- Over 86% removal efficiency of Cr(VI) was achieved after 5 min. at solution pH around 4, 25°C temperature, 0.01 g weight of dose and initial concentration of 20 mg/L of 15mL Cr(VI) solution.
- It was found that adsorption of Cr(VI) using (Si-NPr) is explained well by Langmuir, Freundlich isotherm models, but adsorption of Cr(VI) onto (Si-NPr) fits most with Freundlich model.
- Si-NPr matrix removed Cr (VI) from wastewater and it was recyclable for a promising degree .

### Acknowledgment:

I would like to acknowledgment to all my doctors, my parents and my friends and PWA For funding the master work



# Life Cycle Assessment of RO Water Desalination System Powered by Different Electricity Generation Alternatives

Sbaih I<sup>1</sup>, Bearat H<sup>1</sup>, Alsayed M<sup>1</sup>,  
<sup>1</sup>An-Najah National University

**Research Background:** As a need for a new water resource that meets the water consumption, RO desalination technology seems to be a suitable alternative as explained above. Therefore, it is important to evaluate the RO system, considering the environmental and economic effects of the system. Since the process energy requirement is high, the evaluation will be for RO system based on three different sources of energy which are PV, electricity generated from coal and electricity generated from natural gas, through a scientific methodology, figure 1 shows the LCA system boundaries of RO-PV system. In this study, the alternatives are environmentally-compared using the life cycle assessment (LCA) tool. This study will contribute to solve the shortage of fresh water in AL-Murashahat area by using Al-Fashkha springs water source.

**Methodology:** This work will be done by life cycle assessment (LCA) methodology; in general by four steps. (i) goal and scope definition, are designed to obtain the required specifications for the LCA study. (ii) inventory analysis, which includes collecting all data of the unit processes within a product system and relates them to the functional unit of the study. (iii) impact assessment phase aims at making the results from the inventory analysis (IA) more understandable and more manageable in relation to human health, the availability of resources, and the natural environment. (iv) the interpretation phase, which aims to evaluate the results from the inventory analysis or impact assessment and compare them with the goal of the study defined in the first phase

## Area of study (Al- Fashkha springs):

The case study for this project will be Al- Fashkha springs where the desalination plant will be; the beneficiary of permeate water will be Al-Murashahat area. Al- Fashkha springs are located on the northwestern shore of the Dead Sea at the foot of the escarpment cliff, and is 6.5 kilometers long and about 3 kilometers south of Qumran Wadi. The springs, which are 10 springs, emerge at 390 meters below sea level as shown in map 1.



Map 1: Location map of the study area

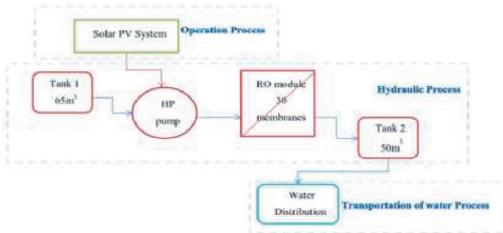


Fig. 1: LCA system boundaries of RO-PV system

## Results:

1. For all systems, it was found that the water distribution process contributes most to the overall environmental impact followed by the operation process, as shown in figure 2 for RO-PV system, that because of using delivery water trucks (5 trucks per day for 20 years).
2. If the water distribution process is eliminated from the systems, the operation process will be the main contributor of the life cycle assessment for the three systems. Across all impact categories the RO-PV system has the least environmental impact. However the RO-coal electricity system has the largest environmental impact, this is due to the large amount of energy consumption and the used source of the energy (i.e. coal power station), as shown in figure 3.
3. The three systems recorded high results in marine aquatic eco-toxicity indicator. The RO-PV system seems the most friendly to the ozone layer. The highest impacts of human toxicity come from the RO-coal electricity system.
4. In conclusion the total cost of 1m<sup>3</sup> water produced by RO-PV System calculated to be 1.8 \$/m<sup>3</sup>, however the total cost of 1m<sup>3</sup> water produced by RO-electricity systems calculated to be 1.27 \$/m<sup>3</sup> (coal or natural gas). The cost of water produced by RO-electricity systems (coal or natural gas) is lower than the cost of RO-PV system, this is due to the high cost of PV batteries in RO-PV system. Furthermore, the cost of water distribution between Al-Fashkha springs to Al-Murashahat area by delivery trucks for 1m<sup>3</sup> calculated to be 7.14 \$/m<sup>3</sup>, which is constant for the three systems.

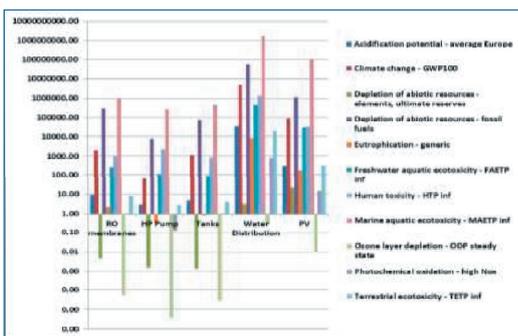


Fig. 2: The impacts of all processes together for RO-PV system

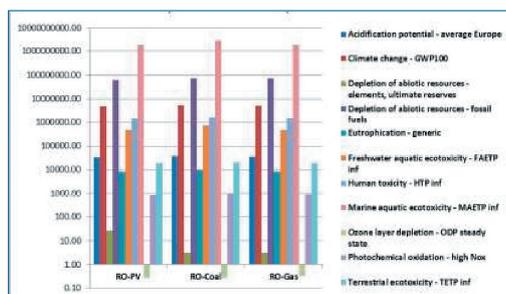


Fig. 3: Comparison between the impacts of all processes in the three systems

**Summary:** In this study a life cycle analysis was performed on three RO desalination systems. The first system is RO system operated by PV (RO-PV system). The second system is RO system operated by electricity generated from coal (RO-coal electricity system). The third system is RO system operated by electricity generated from natural gas (RO-natural gas electricity system). The open LCA software, Ecoinvent database was used, and the CML baseline LCIA method was chosen for the evaluation of systems impact on its 10 categories for functional unit of 50 m<sup>3</sup>/day.

Across all impact categories the RO-PV system has the least environmental impact, however the RO-coal electricity system has the largest environmental impact.



# Impact of Using Desalinated Brackish Water on Chemical and Physical Characteristics of Heavy Saline Soil

Ghnameh I<sup>1</sup>, Mahmoud N<sup>2</sup>  
Ministry Of Agriculture<sup>1</sup>, BIRZEIT University<sup>2</sup>

**Research Background:** The impact of using desalinated water on soil properties still under investigation in the world despite of desalination water process is used since 50 years ago, the majority of the researches were conducted to study the economic visibility of using desalinated water as alternative of water resources over the world in different locations and conditions. In addition few researches focusing on impact of using desalinated water on soil fertility status on the sandy soils which is consider light soils to study the deficiency of nutrients on plants irrigated with desalinated water. The impact of using desalinated water for irrigation is not investigated before under the local conditions in Jordan rift valley with saline clay loam soils.

**Methodology:** The applied research was carried out at one of the effected lands of saline farms in Marj Na'a'ja village, where the desalination unit provided by MoA is located. Four types of water, based on TDS content were considered, namely: T1 Desalinated water with TDS of 200 ppm. T2 blended water with a final TDS of 750 ppm. T3 blended water with a final TDS of 1600 ppm. T4 Raw brackish water with TDS of 4500 ppm. Soil sampling were conducted two times at four depths of 0-15, 15-30, 30-45, and 45-60 cm, before the crop season and after the crop season to measure the soil chemical properties, in the experiment, plant tomato. Plant spacing 80 cm, drip irrigation system was used with emitter spacing of 80 cm and raw spacing of 1.2 m. amples at each depth with 10 cm distance between sequent in the X-Y direction.

**Area of study:** The research was conducted in Marj Na'a'ja village which is located to the Northern part of the Jordan Valley (32° 10' 56.74 N, 35° 10' 28.33 E) and about 40 km north to Jericho, and lays 270 m below sea level as shown in Figure . According to the soil analysis and land observation the soil is classified as saline soil with high content of sodium as a result of using low quality water with high TDS reaches 4500 ppm. The cropping pattern in the study region is mainly vegetables and some date palm and field crops. The total cultivated lands equal 111.3 hectare in which 93% of it is cultivated by vegetables and palm trees (MoA, 2010).



Map 1: Marj Naaja village , Jericho, West Bank

## Conclusions:

1. Irrigating heavy saline soils with desalinated water increases the Sodium Adsorption Ratio (SAR). SAR was clearly increased especially in first 15 cm even worse than brackish water, SAR value was increased from 8.17 to 10.21 in the surface soil layer (15 cm) whereas SAR was slightly decreased in the in T2 (750 ppm), T3 (1600 ppm) which was irrigated with blinding ratio and T4 which was irrigated with raw brackish water with TDS 4500 ppm comparing with blank (Fig1).
2. Irrigating heavy saline soils with desalinated water increases water movement horizontally and decreases water movement vertically as compared with brackish water (fig 2 and 3).
3. Irrigating heavy saline soils with desalinated water negatively affected the soil structure in the surface layer (15 cm), even worse than brackish water, as soil structure was changed from granular and sub angular with medium size and moderate to strong grad, when irrigated with saline soil, to granular and crump with medium size and moderate grade.
3. The optimum blinding ration found to achieve the avoiding of soil degradation properties as a result of using desalinated water on heavy saline soil properties is that with total dissolved salts of the irrigation water 1600 ppm.

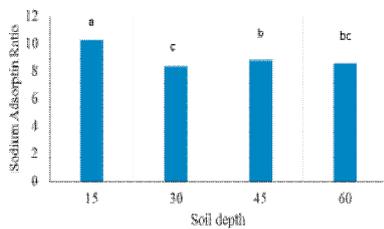


Fig. 1: Soil SAR for all depths in T1 (200 ppm)

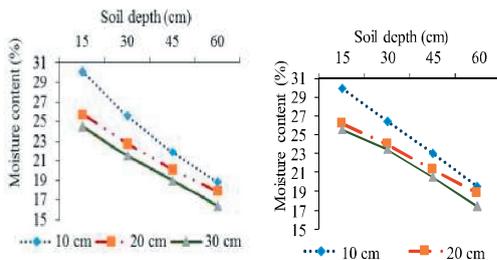


Fig. 2 Soil moisture content for T1 (200 ppm) and T4 (4500 ppm) / stage one

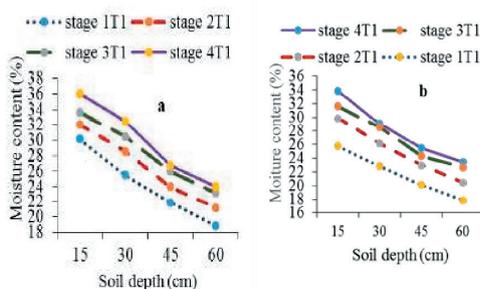


Fig. 3 Soil moisture content for T1 (200 ppm) at the different stages and depths for a: 10 cm horizontal space; b: 20 cm horizontal space

## Recommendations:

Continuous and comprehensive researches should be continued in the same conditions to overcome any expected negative results on soil properties and plant nutrition.

Calcium and Magnesium sources should be added or injected with irrigation system or direct to the soil.

Improving soil physical properties and soil management practises to increase leaching process of the sodium and salinity out of the root zone.

Direct supervision form the soil and irrigation experts to follow the farmers whom using desalinated water for irrigation in their farms.

Blinding desalinated with brackish water to increase mainly calcium and magnesium content considered as is low cost strategy.



# Palestinian Water Regulation to Promote Good Governance, Case Study in Jerusalem Water Undertaking

Marwan "Mohammad Said" Abd-Alrahman Bdair, Dr. Abd Alrahman Al Tamimi.  
Al-Quds University

**Research Background:** The research aims to identify the role of the regulatory functions of the Palestinian water sector in promoting of good governance, taking the case study Jerusalem Water Undertaking. Through which it will recognize the reality of the application of the Palestinian water sector regulation and its role in promoting good governance, also study the relationship between the regulation of the water sector tools and their role in promoting good governance in Palestine will be studied.

**Methodology:** The research used the descriptive approach, analytical, qualitative study of mixed-style, future studies i.e. Delphi studies style, focusing on the impact of the independent variables on the dependent. The study offers a detailed description of the procedures followed by the researcher in the implementation of the research, how the information was collected and documents from sources and interviews.

**Area of study:** Jerusalem Water Undertaking is located in the Ramallah and Al-Bireh Governorate (Map 1). The service area extends over an area of 600 km<sup>2</sup>, which currently includes the cities of Ramallah and Al-Bireh, 10 other cities and municipalities, more than 43 villages, 5 refugee camps and the northern part of Jerusalem. The number of subscriptions is approximately 61,000, serving a population of approximately 370,000, and for the remaining sites in the governorate, receives water through West Bank Water Department (Jerusalem Water Authority website, 2016).



Map 1: Jerusalem Water Undertaking, West Bank

**Results:** the study found (table 1) that there is a positive role for regulatory functions and their tools of the Palestinian water sector in the promotion of good governance. The results show that the theme of "The role Palestinian water sector regulatory function in promoting good governance" and the most important item from this discussion is the "new water law", followed by the second theme "The role of handling complaints of citizens in the promoting of good governance", followed by the theme of "The role of water tariff, technical and financial indicators, finally, "The role of community participation of regulatory function in the promoting of good water governance". The results have been applied on the case study which is Jerusalem Water undertaking; where it was found that there was similarity of the results in terms of the role of the water sector regulation in the promotion of good governance.

Table 1: identify the role of the Palestinian water sector regulation functions in promoting good governance arranged the themes and their most important element,

Number theme	Elements of the regulation function to promote good governance	Rate of Hvaluation
1	The role of the regulatory function of the water sector in Palestine in promoting good governance	4.28
element	The new Water Law has added value to the regulation of the Palestinian water sector to promote good governance	4.47
2	The role of regulating the handling of citizens' complaints to promoting good governance	4.25
element	addressing citizen complaints is supportive of raising the satisfaction of the recipients of the service lead to the promotion of good governance	4.53
3	The role of monitoring technical performance indicators in the promotion of good governance	4.19
element	Monitoring technical performance indicators promotes efficiency and sustainability of water system for water service providers that promote good governance	4.53
4	The role of water tariffs in promoting good governance	4.17
element	efficiency in economic pricing of higher consumption levels to promote water conservation here is a role to play in achieving sustainability of the water sector by achieving economic	4.42
5	The role of monitoring financial performance indicators in promoting good governance	4.07
element	Enhancing financial sustainability that sustains the services provided promotes good governance	4.47
6	The role of community participation in the organizational function in promoting good governance	3.88
element	The community participation of the organizational function must be institutionalized	4.32

**Conclusions:** there is a gap in the current Palestinian legal framework of water sector regulation, and that the legal modifications contain in the new Water Law No. (14) Year 2014 on water, it was of utmost importance in the role of the water sector regulation in the promotion of good governance, through the separation of mandates and tasks within the new restructuring of water sector. There is a role for regulation tools, from handling of complaints, monitoring technical and financial performance indicators, role of water tariffs, and role of community participation in the regulatory function of promoting good water governance.

**Recommendations:** The study performs several recommendations including, bridging the gap of the legal framework in water sector regulations, through the issuance of some legal decree by law, accelerate the establishment of National Water Corporation and Regional Water Utilities, and the Palestinian government to solve the problem of indebtedness of government institutions and camps. The water service providers have to do some actions to achieve the goals of regulation tools, including separation of water complaints center, re-adjust water tariff through economic pricing levels for high consumption, and improving technical performance indicators, most importantly of which is to reduce the non\_revenue water and overall performance.



# Impact of Using Desalinated Brackish Water on Chemical and Physical Characteristics of Heavy Saline Soil

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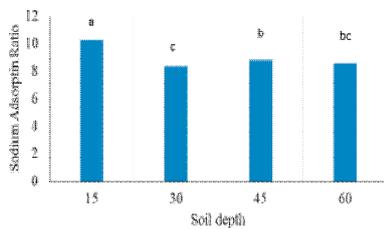


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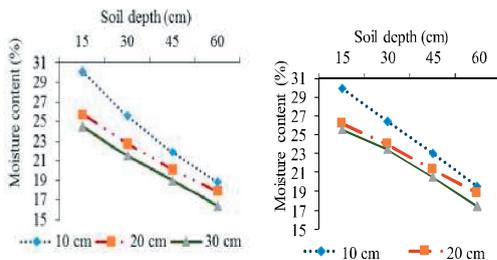


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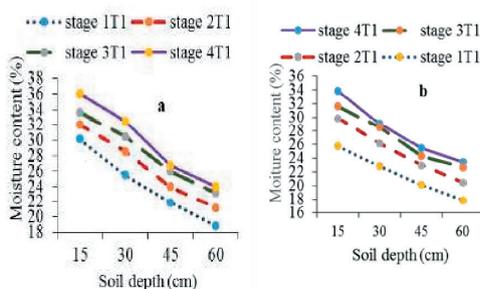


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# Prediction of Pipes Break in Water Distribution System Using Data Mining Tools “Case Study Nablus Municipality”

Saleh M

Arab American University- Jenin

**Research Background:** The water loss from water distribution networks is one of the most serious problems leading to water shortage in Palestine. Some studies showed that the rates of water loss resulting from it are higher than 30%, while other studies argued that in some Palestinian areas this percentage reaches up to 50%. Pipe breakage is one of the main causes of water loss from water distribution networks. Municipalities in all governorates in the West Bank seek to solve this problem by trying to detect and repair broken pipes in the shortest time possible. researchers presented different techniques that can be applied to improve the entire water management value chain, from data collection to analysis and interpretation. Solutions presented include regression models, data mining algorithms, stochastic processes and genetic programming techniques.

**Methodology:** (i) understanding the nature of water distribution system and its parts and components.8 (ii) Collection of the information related to main pipes and its maintenance. (iii) The data preprocessing, normalization and selection the variable as a prelude to modeling. (iv) three different classification algorithms are used to build seven prediction models for breaking pipes and to classify the pipes according to their breaking possibility into two classes that is Yes or No. (v)The performance evaluation of these models to find the bset and reliable model in the anticipation of pipes' breaks from these models.

## Area of study (The water distribution network of Nablus city):

Nablus is a city in the northern West Bank, Located between Mount Ebal and Mount Gerizim. it is one of the largest Palestinian cities. The area of it is 28.6 km<sup>2</sup>. The center of this city is about 550 meters above sea level. The annual rainfall is about 660.1 mm while the humidity is about 61% their.



Map 1: Nablus City, West Bank

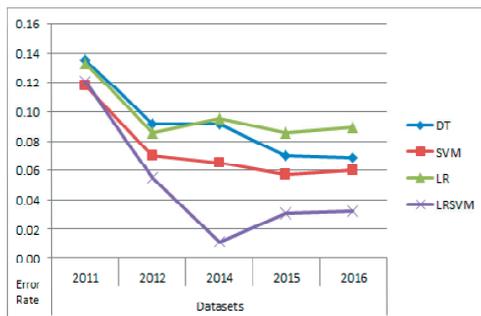


Fig. 1: Error Rate for Models.

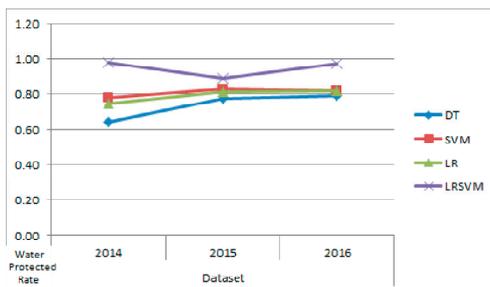


Fig. 2: Water Protected Rate from Loss Water for Models.

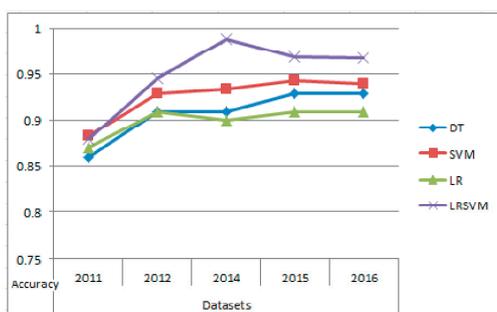


Fig. 3: Accuracy for Models.

## Results:

1. Building a new integrated database for pipes in water distribution networks in Nablus, which contains all the data related to all pipelines in the network as well as maintenance data.
2. Building seven binary classification models to predict the break of the pipes based, on the Decision Tree, Logistic Regression and the Support Vector Machine algorithms.
3. When comparing the performance of research models, it was found that the LRSVM model is the most reliable model in the anticipation of pipes' breaks because it gave the best values for most of the calculated performance measures as its error rate varied between 0.01 and 0.12 as shown in Figure 1, and it may be able to save up to 0.97 water from the amount of water lost from the network as shown in Figure 2, with an accuracy rate that may reach 0.99 as shown in Figure 3.
4. This research presented an integrated database for the water distribution network in Nablus.
5. The research models presented the variables that affect the broken pipes, which are Pressure Zone values, type of network and pipe age, material and diameter.

**Summary:** The water distribution network in Nablus contains from 4810 main pipes, approximately 26% of the water supplied in the network is lost. The pipe breakage is one of the main causes of water loss from water distribution networks.

this research seek to reduce water loss that resulting from broken pipes by solving the problem of broken pipes before it occurs by built a prediction model that combining the Logistic Regression and Support Vector Machine techniques, which is called LRSVM model, which is can be able to save up to 0.97 water from the amount of water lost from the network, with an accuracy rate that may reach 0.99.



# Functionalized C,N-bipyrazole receptor grafted onto silica surface for As adsorption and its antibacterial activity.

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**Introduction :** Attention in the world is growing with respect to the idea of accumulation of heavy metals in the environment. These metals are considered as a threat to both human health and environment, especially when their tolerant levels are exceeded. Arsenic (As) is naturally present at high levels in the groundwater of a number of countries. Arsenic is highly toxic in its inorganic form. Contaminated water used for drinking, food preparation and irrigation of food crops poses the greatest threat to public health from arsenic. Long-term exposure to arsenic from drinking-water and food can cause cancer and skin lesions(1). As heavy metal pollution has become one of the most serious environmental problems today. The treatment of heavy metals is of special concern due to their recalcitrance and persistence in the environment so many methods of treatment of heavy metals were extensively studied. These technologies include chemical precipitation, filtration, ion-exchange, flocculation and adsorption, in this research adsorption on new chemical adsorbent (C,N-bipyrazole with a 3-glycidoxypyrpoyl-trimethoxylane silylant agent) onto a silica surface in short(SG2P) was used.

**Methodology:** This study used polluted water made in laboratory by adding As<sub>2</sub>O<sub>3</sub> (arsenic oxide: 197.841 g/mol) was used to prepare 1000ppm arsenic solution, many parameters were checked on adsorption process( PH, temperature, concentration, time contact and adsorbent dosage).

Micro-broth dilution method was used to determine antibacterial activity and minimum inhibitory concentrations (MIC) of SG2P against two bacterial reference strains.

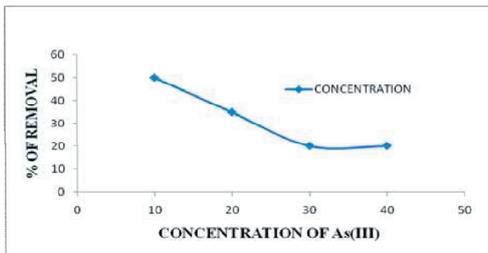


Fig. 3: effect of concentration on As(III) adsorption process.

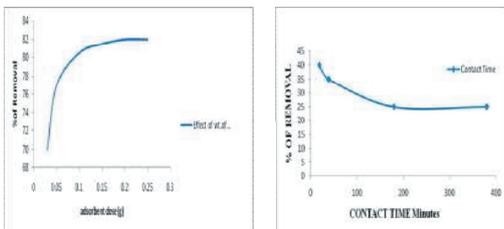


Fig. 4: effect of adsorbent dosage and time contact on As(III) adsorption.



Fig.5: Bacterial growth inhibition in broth micro dilution tray.

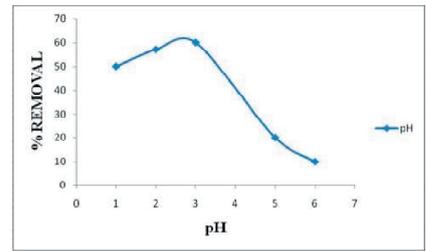


Fig. 1: PH effect on As(III) adsorption P

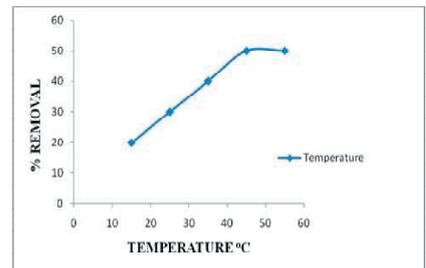


Fig. 2: effect of temperature on As(III) adsorption process.

## Results:

Studying parameters showed different percentage on adsorption as it increases as PH, temperature to a certain line as in figure (1,2,4).

And it showed decreased level in adsorption as concentrations increase as in figure(3), where the optimal time was recorded around 20 minutes.

Adsorption of As(III) by SG2P reached 50% in special recorded parameters, which is a proof of effective adsorption process using silica-compound confirming research hypothesis.

In biology part in checking antibacterial activity of SG2P, as the minimum inhibition concentration of SG2P was 1.5625 mg/ml which meant that SG2P possessed antibacterial activity against examined bacteria.

**conclusion:** The adsorption of As(III) onto SG2P was successfully tested for removing As(III) from the aqueous solution, SG2P is considered as a good alternative in removal of heavy metals from contaminated solution, it is a promising method for waste management and environmental treatment.

Studied adsorption parameters as pH, initial concentration of metal ion, temperature and contact time have an effect on the removal of As(III) by SG2P. The optimal percent removal of As(III) ions by SG2P was 50%. The suitable conditions for adsorption at pH 5.0, initial concentration of 10 µg/L, temperature (35° C - 40° C) and contact time (20 minutes) and SG2P has a low antibacterial activity against both Staphylococcus aureus, Escherichia coli.



# Modeling of Solar Still Enhanced with Evacuated Tube Collectors for Brine Volume Reduction from Reverse Osmosis Plants

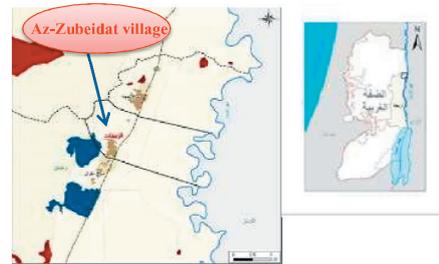
Abu-Safa A<sup>1</sup>, Hamad A<sup>1</sup>  
<sup>1</sup>An-Najah National University

**Research Background:** Brine discharge is the is generally up to 40% and 90% of the intake flow rate for Desalination membrane and thermal based technologies, contains a high percentage of salts and dissolved minerals (TDS>35000 mg/L). World is trying to minimize the effluent volume from desalination plants by many technologies: Technologies for reducing and eliminating brine disposal: Salt recovery technologies, Brine adaptation for industrial uses and Metal recovery technologies.

**Methodology:** (i) Identification of solar stills and evacuated tubes collectors as thermal desalination configurations and a brief literature review about these systems. (ii) Derivation of a mathematical and computational model for the hybrid system. (iii) Evaluation of the important design and operating variables and parameters which controlling the efficiency of the system. (iv) Based on the results of the previous steps, the decision will be taken if solar still – evacuated tubes system is effective for brine volume reduction or not.

## Area of study (Al-Zubeidat RO Desalination plant in Al-Zubeidat village ):

Al-Zubeidat village is one of Jericho governorate villages, located about 35.4 km to the north of Jericho city, it is bordered by the Jordan River to the east, Marj Na'ja village to the north, Tubas city to the west and Marj al-Ghazal village to the south. This village is about 275 meters above sea level. The annual rainfall is about 192 mm and the average temperature is 23 degrees Celsius while the humidity is about 48% their. This village has a RO Desalination Plant with bout (10 m<sup>3</sup>/day) as a production rate.



Map 1: Az-Zubeidat village , Jericho, West Bank

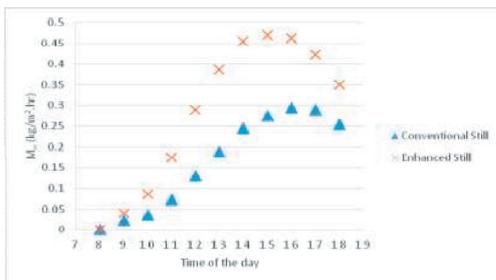


Fig. 1: Productivity of conventional and enhanced (hybrid) stills as a function of time.

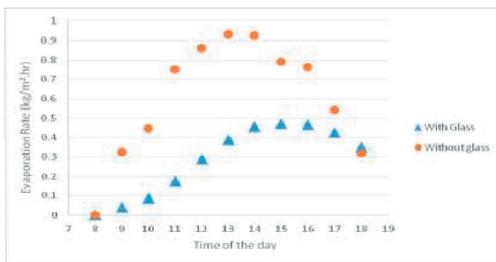


Fig. 2: Rate of evaporation from the enhanced still with and without the glass cover.

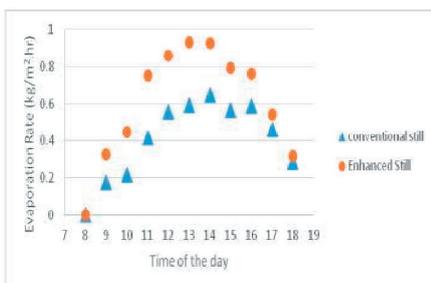


Fig. 3: Rate of evaporation of conventional and enhanced stills without the glass cover considering variable parameters.

## Results:

1. The proposed study indicates a method to increase the productivity of solar still effectively.
2. The water temperature increases when additional heat energy was added from evacuated tube collectors, which in turn increased the productivity of the solar still.
3. The still output is a strong function of temperature difference between the water in the basin and the glass cover, as the difference increases the output increases.
4. At wind speed =1 m/s the total output water was 3.14 (kg/m<sup>2</sup>) and at wind speed = 3 m/s it was 4 (kg/m<sup>2</sup>) and it was 4.39 (kg/m<sup>2</sup>) at wind speed = 5 m/s which means that the increasing in wind speed will lead to a higher productivity due to the higher temperature difference occurred. A cooling of the outer side of the glass by outer fan in order to increase the air movement on the surface of the glass will increase the productivity.
5. When the depth in the basin was 3 cm the output water was 4.3 (kg/m<sup>2</sup>), it decreased to 3.13 (kg/m<sup>2</sup>) as the water depth increases to 5 cm, and when the water depth was set to be 10 cm the output from the still decreased to 1.7 (kg/m<sup>2</sup>), it is clear that the water depth has an inverse effect on the productivity. Lower water depth still produces more water.
6. Removing the glass cover increases the evaporation rate from the still to 6.7 (kg/m<sup>2</sup>) with about 100% increasing ratio from the still with the glass cover.
7. Using enhanced still for producing drinking water for individual use in Az-Zubeidat village would be effective.

**Summary:** Az-Zubeidat desalination RO station has a daily production rate of a bout (10 m<sup>3</sup>/day) , the input is about (12.1m<sup>3</sup>/day) producing (2.1 m<sup>3</sup>/day) as a brine stream. For suggested hybrid system the (2.1 m<sup>3</sup>/day) retentate could be used as a feed .If 40 houses were included in the project, each house would have 2 m<sup>2</sup> of this hybrid system with glass cover and 1m<sup>2</sup> without glass cover, the optimum depth in this case is 2.65 cm for first 2 m<sup>2</sup>. The first 2 m<sup>2</sup> will produce 8.2 L/day for indusial use, the rest 44.8L brine then moved to the second 1 m<sup>2</sup> for free evaporation, the system will evaporate about 6.7 L/day. The total volume reduction in this case would be 28%.



# Using Thiophene Supported on SiO<sub>2</sub> for Removal Cr(VI) from Water

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**Research Background:** The main problem that affects our environment is pollution, because this processes making land, water, air and other parts of our environment unsafe and unsuitable to life. The exposure to heavy metals ions through ingestion or uptake of drinking water and foods can lead to its accumulation in animal's body and plants, as the human body exposure to high concentrations. Chromium (VI) is one of toxic, danger heavy metals, Chromium (VI) effects are to be a strong oxidizing agent, posing a high risk to humans and animals due to its carcinogenic and mutagenic properties, Objectives of this work is using Thiophene Supported on SiO<sub>2</sub> for Removal Cr(VI) from water, at the optimal conditions.

**Methodology:** (i) Synthesis, characterization of 3-Glycidoxypropyl-functionalized silica (MSiTh). (ii) Preparation of Chromium(VI) Solution. (iii) Determination the optimal conditions of pH, temperature, amount of adsorbent, concentration, and contact time for (MSiTh) to adsorb Cr (VI) efficiently.

## Area of study :

The study was made in the lab, The study project is aimed at all wastewater treatment plants in Palestine for the disposal of heavy metals resulting from the factories

Such as the public water purification plant in Deir Sharaf and the wastewater treatment plant in Jenin and in the city of Ramallah and the purification plants that will be built in the future in cooperation with the Palestinian Water Authority.

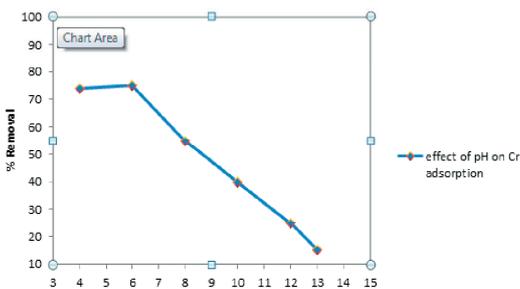


Figure 1. pH effect on Cr(VI) adsorption (C<sub>0</sub>=10ppm, T=25°C, adsorbent dose = 0.04g)

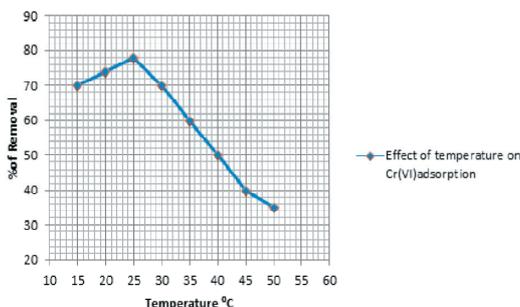


Figure2: The effect of temperature on Cr(VI) adsorption (C<sub>0</sub>=10ppm, time = 60min, adsorbent dose = 0.04 gm, solution volume = 50ml)

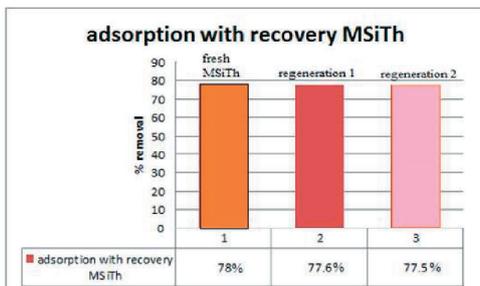


Figure 3: Percentage of Cr(VI) removal by the regenerated adsorbent compared with a fresh one at (Temp = 25°C, pH= 6, adsorbent dose= 0.04 g, sol. Volume = 10 mL, contact time = 30 min)

## Results:

1. The adsorption of Cr(VI) onto MSiTh was successfully for removing Cr(VI) from the aqueous solution .
2. The results shows that MSiTh compound was able to remove Cr(VI) within 20 min at pH around 6 (figure1), temperature 25°C (figure2), with adsorbent dose =0.04g in 10ml Cr(VI) solution and the initial concentration 10ppm, the removal efficiency of Cr(VI) was 78% (figure2), also this efficiency was achieved at 24 hour with the same conditions.
3. The adsorption isotherm of Cr(VI) onto MSiTh was studied and the values of Langmuir maximum adsorption capacity Q<sub>m</sub>=10.672mg/g, and RL =0.2375, indicate that the adsorption of Cr(VI) onto MSiTh is favorable . Also Freundlich model parameters value 1/n and n, showing that the adsorption of Cr(VI) onto MSiTh is favorable.
4. MSiTh silica gel compound has been used and has high efficiency to remove Cr(VI) from water, this efficiency is lower than other adsorbents that were used in other researches for removal of Cr(VI) at high pH, but it can be more effective at lower pH near water pH at 25°C.
5. The small positive value of  $\Delta S$  indicates there are some structural changes take place on the adsorbent and entropy increases through the adsorption.
6. MSiTh compound has been able to remove Cr(VI)several times with high efficiency (figure3).

**Summary:** The adsorption experiments were applied for a range of pH (2-13), temperature, adsorbent dosage, initial concentration, and contact time. The results revealed that the percentage removal of Cr(VI) decreased with the increase of Cr(VI) concentration, pH and temperature, while the percentage removal increase with increase contact time and adsorbent dose. The removal efficiency for Cr(VI) adsorption was more than 75% after 24 hour this achieved at pH around 6, and temperature 25°C, using 0.04g weight of dose, at initial concentration 10 ppm for 10 mL Cr(VI) solution. The adsorption of Cr(VI) onto MSiTh was optimized under acidic conditions (pH< 7) at room temperature.



## Abstract

Sanitary landfill is the most common way to eliminate solid urban wastes, Al-Menya is Palestinian sanitary landfill located in south West Bank. The most disadvantages of Al-Menya sanitary land fill is leachate production as results of solid waste compacted. Leachate is a complex liquid that contains many contaminants and excessive concentrations of biodegradable and non biodegradable products including organic matter, phenols, ammonia nitrogen, phosphate, heavy metals, and sulfide. If not properly treated and safely disposed, landfill leachate could be an impending source of surface and ground water contamination as it may percolate throughout soils and sub soils, causing adverse impacts to receiving waters.

Al-Menya landfill leachate is classified as young leachate according to BOD, COD and solids analysis. The BOD/COD ratio shows indicated the possibility of biological treatment. The heavy metals concentrations were variation in leachate samples because there different solid waste types as metal electroplating, as stabilizers or pigments in plastics, batteries and alloys as a result of no complete waste separation stage. The concentration of Cr and Ni is the highest concentration with higher than 5 ppm where as the Ag and Pb below the detection limit.

The primary treatment and biological treatment using SBR shows 88%, 95%, 100% and 96% removal for COD, TSS, Ammonia nitrogen and phosphate. The final stage of treatment included the advanced membrane technology (UF and RO). The treatment of SBR effluent using UF unit shows highly efficient of UF unit for TSS, Nitrate, and phosphate, Al, Zn, removal with (100%), (98%), (95%), (100%), (82%), respectively. The heavy metals were partial removal, the Al was complete removal where as Cr concentration shows no different concentration. An efficient removal ranging between 97-100% were observed for COD, Ammonia-Nitrogen, TSS, Al, K and Na using RO unit whereas Cr and Cd still have high concentration.

Key words: Sanitary Landfill, Leachate, Biological Treatment, Physical Treatment, Sequence Batch Reactor, solid waste management.

## Results and Discussion

Al-Menya leachate samples were taken during the years 2014 and 2015.

The number of leachate samples were 6 taken directly from the pool influent without consider the seasonal parameter. 3 - samples were taken for triplication.



Leachate Sample      Effluent from SBR      RO Effluent      UF Effluent

Table 5. The average physical and chemical characteristics of influent and effluent leachate samples after completed biological treatment using SBR cycle. The total time ( 8 hrs ) , filling time: 1hr , reaction time: 3hrs, settling time: 2hrs, decantation time: 1hr, and idle time: 1hr. Under HRT: 1.5 day and temperature: 25°C.

Characteristic	Influent	Effluent (Bio)	removal %
COD (ppm)	11000 ± 400	1330 ± 0.0	(88%)
TSS (mg/l)	2500 ± 5	124 ± 0.5	(95%)
Ammonia-Nitrogen (mg/l): NH <sub>3</sub> <sup>+</sup> -N/NH <sub>4</sub> <sup>+</sup> /NH <sub>3</sub>	0.48 / 0.62 / 0.58 ± 0.1	0.0	(100%)
Nitrate: (mg/l) NO <sub>3</sub> <sup>-</sup> /N/NO <sub>2</sub> <sup>-</sup>	19.57 / 4.4 ± 0.0	13.00 / 3.0 ± 0.0	(34% / 32%)
Phosphate (mg/l)	8.00 ± 0.0	0.289 ± 0.0	(96%)
Na (mg/l)	5700 ± 0.1	730 ± 0.0	(87%)
K (mg/l)	1000 ± 0.0	659 ± 0.0	(34%)

## Results and Discussion

Table 7. Physical treatment effluent and percentage removal using Ultrafiltration

Characteristic	Influent	Effluent (UF)	Removal %
COD (ppm)	11000	975	91%
TSS (mg/l)	2500	0.0	100%
Ammonia-Nitrogen (mg/l): NH <sub>3</sub> <sup>+</sup> -N/NH <sub>4</sub> <sup>+</sup> /NH <sub>3</sub>	0.48 / 0.62 / 0.58	0.0	100%
Nitrate: (mg/l) NO <sub>3</sub> <sup>-</sup> -N/NO <sub>2</sub> <sup>-</sup>	19.57 / 4.4	0.3 / 0.1	98% / 98%
Phosphate (mg/l)	8.00	0.422	95%
Na (mg/l)	5700	338.68	94%
K (mg/l)	1000	377	62%
Al (mg/l)	3.86	0.531	100%
Cd (mg/l)	3.66	3.64	0.55%
Zn (mg/l)	3.37	0.622	82%
Ag	***	***	***
Cr	5.22	5.07	3%
Cu	0.643	0.393	39%
Ni	5.15	5.23	***
Pb	***	***	***

Table 8. Physical treatment effluent and percentage removal using Reverse Osmosis

Characteristic	Influent	Effluent (RO)	removal %
COD (ppm)	11000	345	97%
TSS (mg/l)	2500	0.0	100%
Ammonia-Nitrogen (mg/l): NH <sub>3</sub> <sup>+</sup> -N/NH <sub>4</sub> <sup>+</sup> /NH <sub>3</sub>	0.48 / 0.62 / 0.58	0.0	100%
Nitrate: (mg/l) NO <sub>3</sub> <sup>-</sup> -N/NO <sub>2</sub> <sup>-</sup>	19.57 / 4.4	5 / 1.1	74% / 75%
Phosphate (mg/l)	8.00	0.400	95%
Sodium (mg/l)	5700	136	98%
K (mg/l)	1000	9.47	99%
Al (mg/l)	3.86	0.00	100%
Zn (mg/l)	3.37	1.09	68%
Ag	***	***	***
Al	3.86	***	***
Cd	3.66	3.63	0.8%
Cr	5.22	4.88	7%
Cu	0.643	0.669	***
Ni	5.15	4.93	4%
Pb	***	***	***

## Acknowledgment:

A.A and M.Q. thanks Palestinian Water Authority for there support to start this study, represented by The Middle East Desalination Research Center (MEDRC). Also, thanks Al- Menya sanitary landfill Administration for helping in leachate sampling and information.

# Growth enhancement and alleviation of deleterious effects induced by salt stress in Faba Bean (*Vicia Faba*) by PGPB

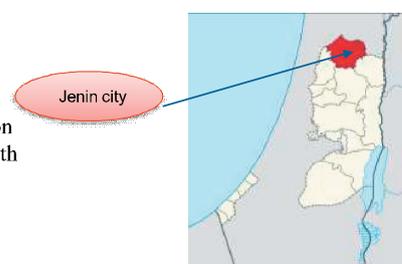
Ali F. A Shaikh Ibrahim  
An-Najah National University

**Research Background:** Salinity has been a threat to agriculture in some parts of the world for over 3000 years; in recent times, the threat has grown (Tim Flowers, 2006). Legumes have long been recognized as sensitive or moderately tolerant to salinity (Subbarao and Johansen, 1993). The reductions in growth from high salinity are the consequences of both osmotic stress including a water defect and the effects of excess Na<sup>+</sup> and Cl<sup>-</sup> ions on critical biochemical processes (Munns and Tester, 2008). Interaction of PGPB with several crops in saline conditions reduced the extent of poor growth and thus helps plants survive and improve performance in adverse conditions (Dimkpa et al. 2009). The inoculation of PGPB under osmotic stress conditions have beneficial effect are not only as a biomass growth increasing, but also as an improvement in water status (Nadeem et al. 2007; Kohler et al. 2009). The inoculation with *B. megaterium* also had a significant effect on reducing the salt injury which estimated by quantifying the percentage of necrotic leaf area with inoculated plants compared with non-inoculated (Adriana M et al., 2010).

**Methodology:** Intact seeds, homogeneous and identical in size and color, and free from wrinkles, were chosen. Grown in mix of sand and clay 1:1. The experiment design were 2\*5\*3 factorial including irrigation with four different salinity levels and one with fresh tab water (0, 2, 4, 6 and 8 ds/m NaCl), one inoculation treatments (inoculated with *B. megaterium*) with 3 replicates for each treatment for each Faba Bean variety in lines, with each line comprising of all treatments. Growth parameters, yield components, chlorophyll content and nutrient content (Na, Ca, N, P, K, Cl) and soil analysis.

## Area of study and plant material (Jenin in the north of West Bank, Palestine):

The experiments were carried out in a greenhouse (in order to control irrigation without rainfall), at Jenin in the north of West Bank (Palestine) using (*Vicia Faba* L.) plant. Two varieties were used (Qertase and local); the Qertase have bigger seeds size, more surface area of leaves, more production of seed number and weight than local variety, the seeds were obtained from the local market and both are of the types grown in Palestine.



Picture 1: Jenin, West Bank

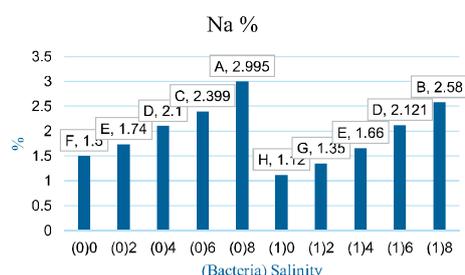


Figure 1. Effect of the interaction between salinity and *B. megaterium* on Sodium content of Faba Bean. 0: without *B. megaterium* 1: with *B. megaterium*, Salinity: (control, 2, 4, 6, 8) ds/m

## Results:

- *B. megaterium* has significant effect in alleviating salinity stress on growth parameters (plant height increased 9%, number of leaves increased 10 %, fresh weight of shoot increased 21%, and fresh weight of roots 36%).
- *B. megaterium* increase bean production significantly even under high level of salinity (seeds number 21% and pods number 29%).
- The inoculation with *B. megaterium* significantly increased flowers number (27 %) and reduced the period required for flowering (from 66 days to 55 days), good indicator for early yield.
- The accumulation of Na and Cl in plant tissue significantly reduced.
- The bacteria improved plant absorption ratio for K, P, N and Ca was higher in plant inoculated with bacteria under high salinity level compared to non inoculated plants.
- Bacteria have a positive effect in reducing soil salinity (15 %).

## Soil Analysis

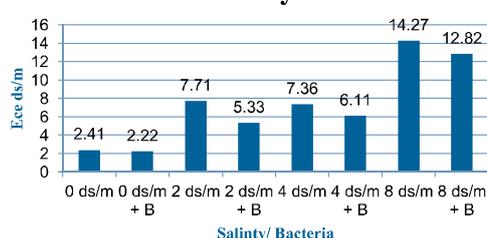


Fig. 2: Rate of evaporation of conventional and enhanced stills without the glass cover considering variable parameters.

**Summary:** Application of *B. megaterium* mitigates the effect of sodium chloride stress and improved the growth and yield in the present study. The inoculation with remarkably *B. megaterium* increased plant height, number of leaves, number of flowers, plant biomass, early flowering, improved chlorophyll content, root system and in contrast, alleviated sodium chloride accumulation in leaves, increased the absorption of K, Ca, P. Inoculated plants with *B. megaterium* displayed stronger ability to tolerate salt stress than non-inoculated plants. The study revealed that the soil salinity could be reduced by using *B. megaterium* with plants.



# Removal of Methylene Blue from Industrial Wastewater in Palestine Using Polysiloxane Surface Modified with Bipyrazolic Tripodal Receptor

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<sup>1</sup>An-Najah National University

**Research Background:** Different pollutants from industries leach every day to soil and ground waters without treatment. This will lead to different health problems to both human beings and animals. Pollution caused by agents such as heavy metals and dyes are amongst the list which rendered the environment unwholesome and posed serious health concern to the populace. Industrial effluents are one of the major causes of environmental pollution because effluents discharged from dyeing industries are highly colored with a large amount of suspended organic solid. Untreated disposal of this colored water into the receiving water body either causes damage to aquatic life or to human beings by mutagenic and carcinogenic effect. The major problem here is to detect the concentration of one of the pollutants like methylene blue and try to remove it by adsorption.

**Methodology:** (i) synthesis of 3-aminopropylsilica (Si-NH<sub>2</sub>) (ii) synthesis of Synthesis of N,N-bipyrazole-substituted silica (Si-NPz<sub>2</sub>). (iii) This work is focused on the synthesis, characterization and applications of a new N,N-bis (3,5-Dimethylpyrazol-1-yl methyl)-3-aminopropyl Polysiloxane (Si-C<sub>3</sub>H<sub>6</sub>NPz<sub>2</sub>) by the chemical modification of the pre-prepared functionalized silica gel for quantitative extraction and elimination of methylene blue (MB) from industrial wastewater. This new product (Si-C<sub>3</sub>H<sub>6</sub>NPz<sub>2</sub>) can be synthesized by mixing and stirring for 7 days of the pre-prepared functionalized silica gel with an excess of 3,5-Dimethylpyrazole-1-methanol under mild conditions ( room temperature and atmospheric pressure) using anhydrous acetonitrile as a solvent. (iv) (FT-IR) was used to confirm that the Dimethylpyrazole units have been immobilized onto the surface of the modified silica gel. (v) (SEM) technique was used to examine the Modified Polysiloxane surface. (vi) The thermal stability of polysiloxane derivatives (Si-C<sub>3</sub>H<sub>6</sub>NH<sub>2</sub>), and (Si-C<sub>3</sub>H<sub>6</sub>NPz<sub>2</sub>) were determined by thermogravimetric analysis. (vii) The adsorption experiments of MB dye were conducted for a wide range of pH, adsorbent dosage, temperature, initial concentration and contact time. (viii) The Freundlich, Langmuir and Temkin models are employed to analysis adsorption occurred in the experiment data of adsorption isotherms

## Methylene Blue ( 3,7-bis(Dimethylamino)-phenothiazin-5-ium chloride ):

Methylene Blue is a heterocyclic aromatic compound with molecular formula C<sub>16</sub>H<sub>18</sub>ClN<sub>3</sub>S. Methylene blue (MB) is a cationic thiazine dye that is deep blue in the oxidized state while it is colorless in its reduced form leucomethylene blue. MB and leucomethylene blue exist as a redox couple in equilibrium and together form a reversible oxidation-reduction system or electron donor-acceptor couple as shown in Figure 2.

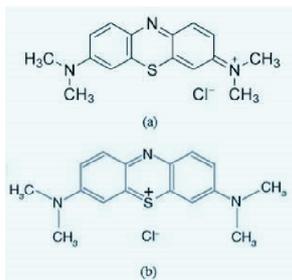


Figure 2: Molecular structure scheme of the methylene blue.

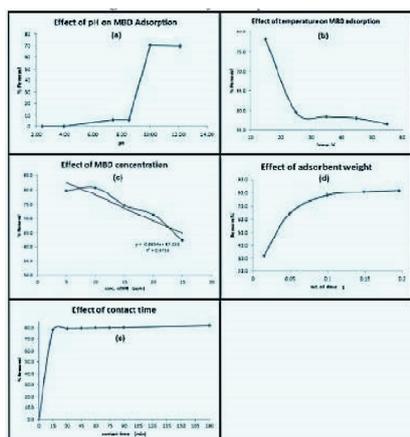


Fig. 3: The percentage removal of Methylene blue dye under different conditions. The adsorption experiments were conducted for a wide range of (a) pH (b) temperature (c) MB dye concentration (d) adsorbent weight and (e) contact time.

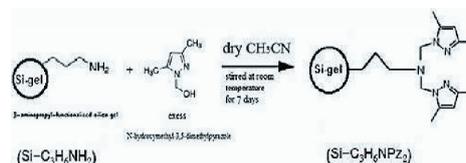


Figure 1: The synthesis route of modified polysiloxane

## Results:

- SEM images of the Modified Polysiloxane surface show rough and porous nature, indicating that the materials present good characteristics to be employed as an adsorbent.
- FT-IR analysis confirms that the dimethylpyrazole units have been immobilized onto the surface of the modified silica gel.
- Thermogravimetric analysis (TGA) reflects the thermal stability of this new product.
- The increase of MB dye uptake as the pH value is increased. At low pH, the retention of MB dye by the (Si-C<sub>3</sub>H<sub>6</sub>NPz<sub>2</sub>) is not significant since the ligand is entirely in its protonated form.
- Increasing the temperature above the room temperature has slightly influence on decreasing the adsorption capacity of the new modified surface. The maximum adsorption (78%) was achieved at 15°C. This indicates that the adsorption of MB dye on (Si-C<sub>3</sub>H<sub>6</sub>NPz<sub>2</sub>) follows exothermic process.
- The uptake of MB dye was rapid at lower concentration (5-10 mg/L) and as concentration increase the amount of MB dye adsorbed was decreased. That is because, at lower concentration, the ratio of the initial number of MB dye molecules to the available surface area is low and the available sites are high but at high concentrations of dye, the available sites are fewer.
- Removal efficiency was increased sharply with increasing amount of adsorbent up to 0.1 g. Then removal efficiencies were not changed significantly with increasing amount of adsorbent.
- MB dye showed a fast rate of adsorption during the first 15 min, and then the rate of adsorption becomes almost insignificant after that due to consuming of the adsorbing sites.
- The sorption data fitted into Langmuir, Freundlich, and Temkin out of which Temkin adsorption model was found to have the highest regression value and hence the best fit. This isotherm contains a factor that taking into the account of adsorbent-adsorbate interactions which indicates the presence this interaction.
- The value of  $\Delta H$  was higher than those corresponding to physical adsorption. This would suggest that the adsorption process is chemical in nature. The small positive value of  $\Delta S^\circ$  suggests that some structural changes occur on the adsorbent and the randomness at the solid/liquid interface in the adsorption system increases during the adsorption process.
- The results show that the pseudo second order kinetic model fits perfectly the experimental data with linear regression coefficients 0.9999. A pseudo second order suggests that this adsorption depends on the adsorbate as well as the adsorbent and involves chemisorption process in addition to physisorption.
- The comparison of the uptake capacity of the recycled adsorbent showed an excellent adsorption ability and has a good stability and can be reused many times without decreasing its extraction percentage.

**Summary:** The product (Si-C<sub>3</sub>H<sub>6</sub>NPz<sub>2</sub>) was successfully prepared. The FTIR results confirmed that the Dimethylpyrazole units have been immobilized onto the surface of the modified silica gel. SEM images indicated that the Modified Polysiloxane surface presents good characteristics to be employed as an adsorbent. MB sorption using (Si-C<sub>3</sub>H<sub>6</sub>NPz<sub>2</sub>) can be described using pseudo second order and Temkin isotherm model. Based on the results, the (Si-C<sub>3</sub>H<sub>6</sub>NPz<sub>2</sub>) is able to remove MB rapidly within 15 min with high removal efficiency. Over 82% removal efficiency of Methylene blue dye was achieved after 180 min. at solution pH around 10, 20°C temperature, 0.25 g weight of dose and initial concentration of 15 mg/L of 50mL MB dye solution.

# Transport of nutrients and organic carbon by wastewater discharge in Al-Qilt catchments transboundary region / Jordan Valley, West Bank

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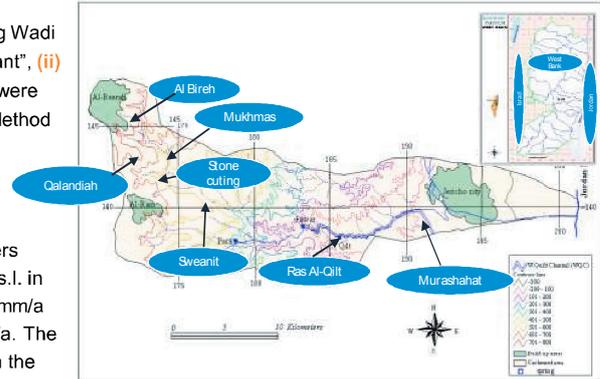
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**Research background:** Wastewater delivered to and transported by surface water run off will affect the groundwater quality (springs and wells) that are used for domestic and agricultural purposes in the studied area. Domestic wastewater and urban runoff will enrich beyond other substance the sediments with nutrients and organics carbon and increase the loads that can be transported.

**Methodology:** Surface water of batched sample from seven sampling points along Wadi Al-Qilt classified as: (i) effluents from treated wastewater "Al-Bireh treatment plant", (ii) untreated wastewater (iii) Wadis wastewater (iv) Water from springs. Samples were taken in June, 2008 and analyzed according to Water and Wastewater Standard Method (APHA, 2000) and (UFZ, Magdeburg, Germany) according to the Deutsche Einheitsverfahren zur Wasser-, Abwasser- und Schlammuntersuchung.

## Area of study (Al-Qilt):

Al-Qilt's catchment in the West Bank at the western side of the Jordan Valley covers about 173 km<sup>2</sup> and is characterized by a steep relief with elevations from 800 m a.s.l. in the western part to -250 m b.s.l. in the eastern part. The rainfall estimated by 600 mm/a in the West and 150 mm/a in the East, average rainfall over catchment is 400 mm/a. The long term observations of flow for Wadi Al-Qilt ranges from 3.0 to 12.0 MCM/a with the continues base flow for the Ras Al-Qilt spring of around 300 L/s.



Map 1: Al-Qilt catchments, major city, topographical elevation, community, regional location, springs and sampling point

## Results:

- The relation between TOC, DOC and nitrate is shown in (Fig. 3) and (Fig. 1). High TOC and DOC from Al-Bireh effluents plants and stonecut are the reason for biological activities in which bacteria consume the nitrate in dinitrification process (Fig. 1) and decrease it. At lower TOC and DOC in combination in wadi Mukhmas, the nitrate concentration is increased.
- As it is shown in Fig. 1 the limit for Palestinian guideline for artificial recharge to the groundwater of treated wastewater (PS) "Ref PSI 2003-742" (for NO<sub>3</sub>, 15 mg/L and 10 mg/L for NH<sub>4</sub>) is exceeded after the emission of untreated waste water (sampling points 2, 3, 4). As a consequence of the self cleaning process between stonecut and Ras Al-Qilt the concentration of Ammonia decreases significantly as well as the nitrate concentration.
- PO<sub>4</sub> (Fig. 2) is the main phosphorous component with concentration between 10 and 20 mg/L (partial exceed of the limit for PS for PO<sub>4</sub> with 15 mg/L). Much lower concentration at the "Spring" indicates self purification processes like adsorption.

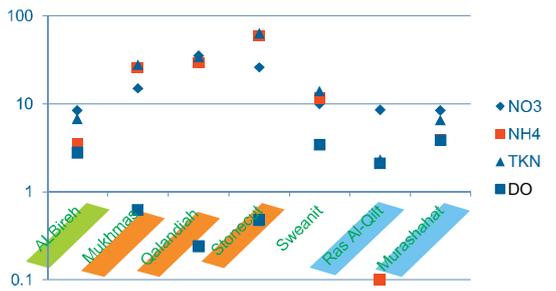


Fig. 1: Nitrogen balance variations in Wadi Al-Qilt. Units in mg/L.

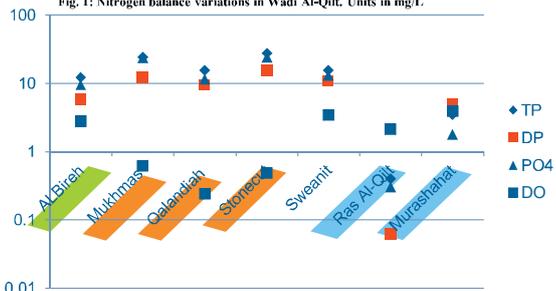


Fig. 2: Phosphorus variations in Wadi Al-Qilt. Units in mg/L.

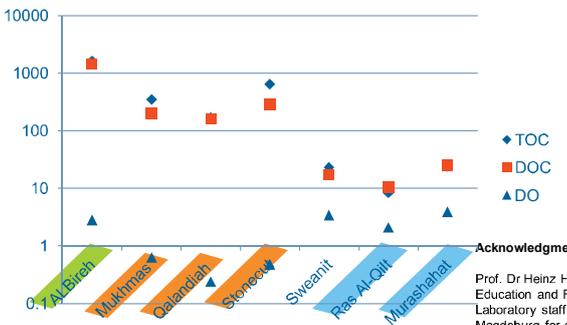


Fig. 3: Organic carbon variations in Wadi Al-Qilt. Units in mg/L.



**Summary:** Until now the self cleaning procedure of the wadi works good enough in the Karstic region to guaranty at the "spring" Ras Al-Qilt a good water quality according to PS in relation to the nitrate and phosphate. Nevertheless it can not be excluded that the water quality in Ras Al-Qilt decreases if untreated waste water continuously enter the catchment up stream.

## Acknowledgments:

Prof. Dr Heinz Hötzi from SMART project supported by Federal Ministry of Education and Research (BMBF), University of Karlsruhe. Laboratory staff at Helmholtz Centre for Environmental Research (UFZ) in Magdeburg for analysis and cooperation. Eng. Ayman Jarrar, Yousef Awayes, Waleed Abu Muhsen, PWA / Hydrological departments (Othman Sheha and Sami Daraghmah). Dr. Abd Al-Rahman Tamimi from Palestinian Hydrological Group (PHG), Palestine. SIDA, Rambolla Natura AB, SIWI and Jordan University

# Removal of chromium from tannery wastewater using nanoparticles

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- **Research Background:** Global demand for water continues to increase while freshwater source s are becoming scarce. Industry is the main consumers of fresh water and hence scientific advances in fields of nanotechnology are merging as a cost-effective technology for cleaning up industrial wastewater
- . Here in Palestine, the tanning of skins is one of the important industry that relies heavy on fresh water for the tanning process. Hence, significant amount of wastewater is generated, which is typically discharged back to the environment without any proper treatment.

**Methodology:** (i) Study will be conducting a literature review to get updated on the advanced application of nanotechnology and look into the current treatment technology that typically employed for tannery wastewater treatment. (ii) Statistical data on the current tannery effluent in Palestine will be collected to gain an idea about technology scaling up. (iii) Synthesis of nanoparticles from locally sourced materials (iron oxide, rust) will be employed. (iv) Test the prepared nanoparticles on the cleaning up wastewater effluent. After that, optimum method that can be both cost-effective and efficient will be adopted

## Area of study (tannery stations in Al-Fahes village)

The area of study is West bank in general and Al-Fahes village, located to the south of Hebron city (map.1). This area was chose especially because of the increasing population growth, the shortage of water supplies and has a many tannery wastewater stations. In tanning industry, the chromium concentration in terms of total chromium in the exhaust chromium liquor, with a volume of 4% to 6% of the total wastewater volume discharged from the tanning process, ranges from 1,500- 5,000 mg/L.



Map 1: Al-Fahes village, Hebron, west bank

Table(1): The effect of different types of absorbent on removal on chromium from wastewater

Type of Abs	CE	Removal %
AC	0.116	58
Sand	0.134	67
Nps+PEI	0.126	63
Sand(SE F)	0.194	97

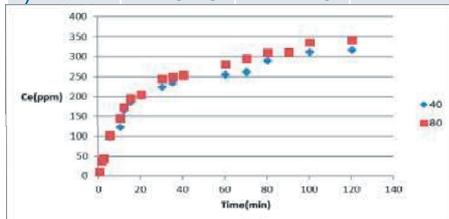


Fig.1: effect of time on the removal with different concentration of initial chromium solution

## Result:

The removal percentage and the adsorption capacity of chromium from the tannery wastewater was increased by

- Using sand embedding with iron oxide nanoparticles as absorbent(table1)
- Using pH range from 8 to 9.5
- Chromium concentration range from 40 to 200 ppm
- Time of reaction between adsorbent and wastewater approximately 2hr (. 1)

**Summary:** In this study, polyethylenimine-functionalized iron oxide nanoparticles were embedded into silicon dioxide (sand), a commonly used filter aid, at <5 wt% to remove a dissolved chromium (Cr) from wastewater in batch and continuous flow column experiments. An array of characterization techniques, such as SEM was carried out for the sand embedded nanoparticles. The adsorption performance of the fixed-bed column was tested for sand, before and after embedding it with iron oxide nanoparticles, to determine the breakthrough curves under different operational conditions (e.g., inlet concentration of Cr, inlet flow rate, and bed height).



سلطة المياه الفلسطينية  
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# Growth enhancement and alleviation of deleterious effects induced by salt stress in Faba Bean (*Vicia Faba*) by PGPB

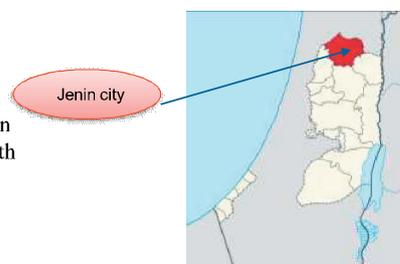
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**Research Background:** Salinity has been a threat to agriculture in some parts of the world for over 3000 years; in recent times, the threat has grown (Tim Flowers, 2006). Legumes have long been recognized as sensitive or moderately tolerant to salinity (Subbarao and Johansen, 1993). The reductions in growth from high salinity are the consequences of both osmotic stress including a water defect and the effects of excess Na<sup>+</sup> and Cl<sup>-</sup> ions on critical biochemical processes (Munns and Tester, 2008). Interaction of PGPB with several crops in saline conditions reduced the extent of poor growth and thus helps plants survive and improve performance in adverse conditions (Dimkpa et al. 2009). The inoculation of PGPB under osmotic stress conditions have beneficial effect are not only as a biomass growth increasing, but also as an improvement in water status (Nadeem et al. 2007; Kohler et al. 2009). The inoculation with *B. megaterium* also had a significant effect on reducing the salt injury which estimated by quantifying the percentage of necrotic leaf area with inoculated plants compared with non-inoculated (Adriana M et al., 2010).

**Methodology:** Intact seeds, homogeneous and identical in size and color, and free from wrinkles, were chosen. Grown in mix of sand and clay 1:1. The experiment design were 2\*5\*3 factorial including irrigation with four different salinity levels and one with fresh tap water (0, 2, 4, 6 and 8 ds/m NaCl), one inoculation treatments (inoculated with *B. megaterium*) with 3 replicates for each treatment for each Faba Bean variety in lines, with each line comprising of all treatments. Growth parameters, yield components, chlorophyll content and nutrient content (Na, Ca, N, P, K, Cl) and soil analysis.

## Area of study and plant material (Jenin in the north of West Bank, Palestine):

The experiments were carried out in a greenhouse (in order to control irrigation without rainfall), at Jenin in the north of West Bank (Palestine) using (*Vicia Faba* L.) plant. Two varieties were used (Qertase and local); the Qertase have bigger seeds size, more surface area of leaves, more production of seed number and weight than local variety, the seeds were obtained from the local market and both are of the types grown in Palestine.



Picture 1: Jenin, West Bank

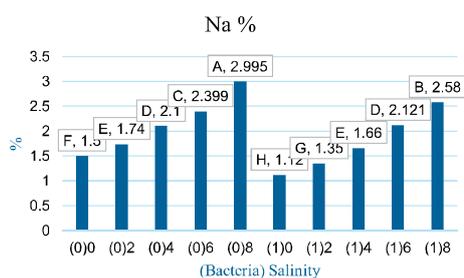


Figure 1. Effect of the interaction between salinity and *B. megaterium* on Sodium content of Faba Bean. 0: without *B. megaterium* 1: with *B. megaterium*, Salinity: (control, 2, 4, 6, 8) ds/m

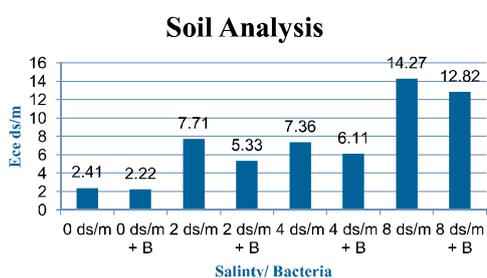


Fig. 2: Rate of evaporation of conventional and enhanced stills without the glass cover considering variable parameters.

## Results:

- *B. megaterium* has significant effect in alleviating salinity stress on growth parameters (plant height increased 9%, number of leaves increased 10 %, fresh weight of shoot increased 21%, and fresh weight of roots 36%).
- *B. megaterium* increase bean production significantly even under high level of salinity (seeds number 21% and pods number 29%).
- The inoculation with *B. megaterium* significantly increased flowers number (27 %) and reduced the period required for flowering (from 66 days to 55 days), good indicator for early yield.
- The accumulation of Na and Cl in plant tissue significantly reduced.
- The bacteria improved plant absorption ratio for K, P, N and Ca was higher in plant inoculated with bacteria under high salinity level compared to non inoculated plants.
- Bacteria have a positive effect in reducing soil salinity (15 %).

**Summary:** Application of *B. megaterium* mitigates the effect of sodium chloride stress and improved the growth and yield in the present study. The inoculation with remarkably *B. megaterium* increased plant height, number of leaves, number of flowers, plant biomass, early flowering, improved chlorophyll content, root system and in contrast, alleviated sodium chloride accumulation in leaves, increased the absorption of K, Ca, P. Inoculated plants with *B. megaterium* displayed stronger ability to tolerate salt stress than non-inoculated plants. The study revealed that the soil salinity could be reduced by using *B. megaterium* with plants.



# Phytoremediation for Treatment of Brackish Water from Groundwater Wells

Hamed R<sup>1</sup>

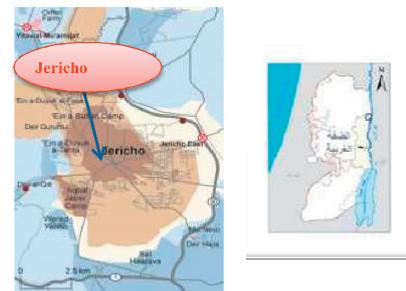
<sup>1</sup>An-Najah National University

**Research Background:** Phytoremediation is one of the methods that can be used to remediate water and land salt using plants. Brackish water contains significant concentrations of dissolved salts ions such as Na<sup>+</sup>, Cl<sup>-</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup>, K<sup>+</sup>, SO<sub>4</sub><sup>2-</sup>, and CO<sub>3</sub><sup>2-</sup> and the range of TDS is 1500 – 10000 mg/L. In West Bank/ Jericho the amount of brackish water produced from groundwater wells are in the range of 12-18 million m<sup>3</sup>. In this research, Phytoremediation was applied as a method to treat the brackish water by using two tolerant plants species (**Barely and Malt**) plants. These plants were germinated with Plant Growth Promoting Rhizobacteria (PGPRs) strains *Pseudomonas putida* UW3 and *Pseudomonas putida* UW4.

**Methodology:** (i) Study the effect of (PGPR) on plants in terms of biomass production and photosynthetic activity under salt stress. (ii) Study the effect of PGPR on plants cells integrity: salt ions entry damage cell membrane, and increase its permeability will be studied. (iii) Study the effect of antioxidant hydrogen peroxide on seed germination rate under brackish water.

## Area of study (Jericho Groundwater wells):

The **Jericho Governorate** is one of 16 Governorates of Palestine. It is located along the eastern areas of the West Bank, along the northern Dead Sea and southern Jordan River valley bordering Jordan. Rising salinity levels is one of the significant signs of water-quality degradation in groundwater. The alluvial Pleistocene wells in the Jericho area, Palestine show high salinity and a high susceptibility to contamination. Future exploitation and management of the water resources under these conditions will require an in-depth understanding of the sources and mechanisms of contamination.



Map 1: Jericho, West Bank

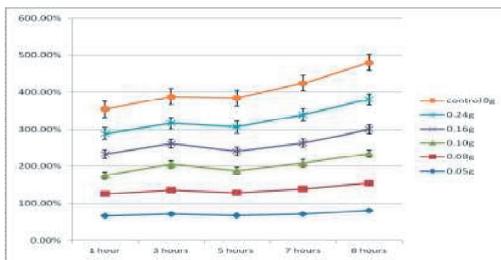


Fig. 1: Absorbance of bacteria grown in saline (0 g, 0.05g, 0.08g, 0.10g, 0.16g, and 0.24g NaCl)/20 ml tryptic soy broth (TSB) medium at 600 nm at each time.

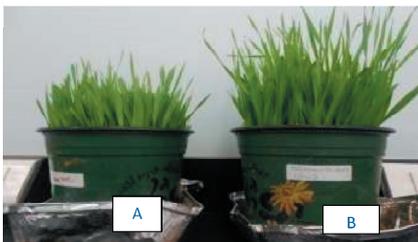


Fig. 2: Control Barley Plant irrigated with fresh water (A), Barley Plant with UW3+UW4 irrigated with 6000 mg/L (Right)

Trials	Fresh water	6000 mg/L of brackish water	10000 mg/L of brackish water
Control Barely plant	100%	8.98 %	150.08%
Barely plant treated with UW3	237.31%	249.40%	156.11%
Barely plant treated with UW4	156.11%	237.31%	288.83%
Barely plant treated with UW3+UW4	128.12%	267.67%	288.56%
Barely plant treated with UW3 + H <sub>2</sub> O <sub>2</sub>	116.88%	237.31 %	249.40 %

Fig. 3: Biomass production (Sig in Red)

## Results:

- Measurement of PGPR growth under saline NaCl solutions: Different concentrations of NaCl – TSB solution were prepared, to test performance of PGPR salt tolerance on two plant species. **Figure 1** show % of control – Absorbance for UW3 at  $\lambda = 600$  nm in NaCl - (TSB) solution (0 g, 0.05g, 0.08g, 0.10g, 0.16g, and 0.24g). it showed UW3 germination were increased under saline condition at different time interval, until it reached maximum levels and it became constant without any incensement after 8 hours. This increase indicated that salinity tolerant performances of PGPRs were increased [Shan, 2009], Moreover increased in growth had been shown for TSB medias containing (0.08g, 0.10g, 0.24g) to be as (74.55%, 78.31%, 79.68 %) respectively at 8 hours incubation, surprisingly, the least measurement of bacterial growth was obtained for 0.16g salts contained media (66.88%), and may be this related to some performance of germination of bacteria in the tube.
- Figure 2** : Picture where (A) represent trial of control Barley plant irrigated with fresh water, (B) trials of treatment of Barley plant with UW3+UW4 irrigated with 6000mg/L. it showed leaves of Barley Plants that treated with PGPR as taller –thicker, and green darker color compared to untreated ones. Besides that, their roots were longer compared to untreated plants. Thus, PGPR affected photosynthetic activity even under irrigation with salt solution. For control trials without PGPR irrigated with two different concentration of brackish water; the colors of their leaves were visibly pale green. Some leaves turned to yellow and shorter -smaller. Some followed by premature necrosis. Even they reached their growth cycle end before crop coefficient. Beside it is shown in biomass production in **Figure 3**.
- NaCl accumulation in plant tissue for total dry mass ranged from 36.3-8357.5 mg, and for Ratio of Cl/Na 0.6-1.01 for experimental results compared to theoretical atomic weight equal 1.5.

## Summary:

Specifically, trials treated with PGPRs had showed significant improvements in salt accumulation for the plants (Barley and Malt) that used in these experiments, indicated that these two plants successfully can be used in phytoremediation process in combination of the PGPRs (*Pseudomonas putida* UW3 and/or UW4), with an advantage of Barley over Malt Plant. Results had showed that these PGPRs increase the cell membrane stability as demonstrated by less electrolyte leakage from plant cells relative to plants that were not treated with PGPR. Results from pulse amplitude modulated fluorometry (PAM) studies indicated that these plants which treated with PGPR had increased photosynthesis rate thus prevented salinity damage to photosystems compared to those untreated ones. Biomass measurements showed a significant mass increase for those plants treated with PGPRs compared with those control (untreated); which biomass production could enhance phytoremediation efficiency, as well as be used as forage food for animals.



# Improvement of large scale wastewater treatment plant using Epuvalisation technique and micelle clay complex column

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**Research Background:** The agriculture sector is the largest consumer for water supplies and the utilization of treated wastewater. Reuse of treated wastewater in irrigated agriculture would provide additional water supplies and it would reduce environmental pollution caused by untreated/poorly treated wastewater. One of the problems on Wastewater Treatment Plant is over loading which increase the fouling and coagulate the membranes which means short life time and more money is needed. In this research we are investigating the efficiency of Epuvalisation system using Rosemary and Geranium Plants and Micelle clay complex column in wastewater treatment.

**Methodology:** 1. **Epuvalisation Technique** as a biological wastewater recycling system based on hydroponic cropping techniques using Rosemary and Geranium Plants to treat Secondary Treated Wastewater.

2. **Adsorption using Micelle Clay Complex Column** (Octadecyltrimethylammonium-Bromide). The secondary treated effluent was pumped to the Hollow Fiber ultra filtration unit, then to micelle clay complex column. The MCXC permeate was collected in a tank and used to feed the Ultra-Filtration Spiral Wound.

## Area of study (Al-Quds University Wastewater Treatment Plant):

Al-Quds University Wastewater Treatment Plant (AUWWTP) at Al-Quds University (Palestine), (AUWWTP) located to the southern east of Al-Quds University Campus, (AUWWTP) is a pilot wastewater treatment plant that consist of four treatment stages: Preliminary, primary, secondary and tertiary. It collects a mixture of black (from toilets), gray (from showers and sinks), and storm (rain) water, as well as waste water (from certain laboratories), which hosts approximately 13,000 students and staff members in the day time.

**Table1:**Physical and chemical quality of hydroponic recycled water after 10 days of Epuvalisation treatment, FW compared to TWW during the same period using Geranium Plants.

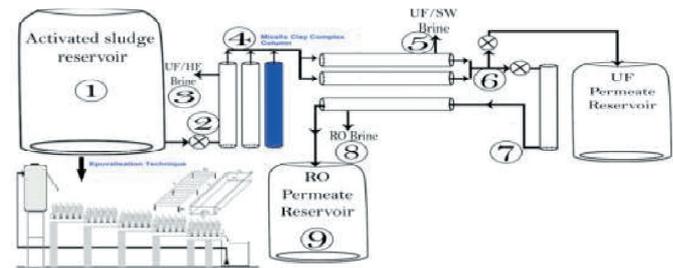
Cycle 5	FW		Percentage Removal (%)	TWW		Percentage Removal (%)
	Influent	Effluent		Influent	Effluent	
pH	7.4 ± 0.9	8.4 ± 0.1		7.3 ± 0.8	6.9 ± 0.0	
EC (µS/cm <sup>2</sup> )	1257 ± 115	650 ± 0	48	2106 ± 11.5	1003 ± 6	52
TDS (mg.L <sup>-1</sup> )	627 ± 6	320 ± 0	49	1053 ± 6	500 ± 0	53
SS (mg.L <sup>-1</sup> )	2.4 ± 3	2 ± 0	17	81 ± 36	4 ± 0	95
TUR (NTU)	7 ± 10	5.5 ± 3.5	21	117 ± 57	7 ± 0	94
COD (mg.L <sup>-1</sup> )	188 ± 16	63 ± 21	67	282 ± 4	167 ± 4	41
BOD (mg.L <sup>-1</sup> )	43 ± 10	33 ± 1	23	71 ± 21	55 ± 3	23
Mg <sup>2+</sup> (mg.L <sup>-1</sup> )	13.5 ± 0.6	3 ± 0.4	78	19 ± 5	14 ± 3	26
Ca <sup>2+</sup> (mg.L <sup>-1</sup> )	124 ± 1	72 ± 13	42	151 ± 0	99 ± 0	34
K <sup>+</sup> (mg.L <sup>-1</sup> )	38 ± 43	10 ± 0	74	43 ± 26	14 ± 2	59
Na <sup>+</sup> (mg.L <sup>-1</sup> )	70 ± 4	28 ± 2	60	138 ± 3	129 ± 12	7
PO <sub>4</sub> <sup>3-</sup> (mg.L <sup>-1</sup> )	39 ± 0	0 ± 0	100	61 ± 2	7 ± 0.5	89
Cl <sup>-</sup> (mg.L <sup>-1</sup> )	62 ± 26	39 ± 6	37	89 ± 88	36 ± 26	60
TN as NH <sub>4</sub> <sup>+</sup> and NO <sub>3</sub> <sup>-</sup> (mg.L <sup>-1</sup> )	4.4 ± 0	0 ± 0	100	24 ± 0	0.4 ± 0.3	98

**Table2:** Variation of physical, chemical and biological characteristics of influent of effluent of micelle clay complex column.

Volume l.	pH	EC µS/cm	TDS mg/l	TSS mg/l	Turbidity FAU	COD mg/l	BOD mg/l
0	7.2 ± 0.2	1630 ± 10	810 ± 10	88	44 ± 5	240 ± 30	125 ± 25
20	7.9 ± 0.2	1400 ± 5	700 ± 10	0	0	195 ± 25	92 ± 10
50	7.6 ± 0.2	1300 ± 5	650 ± 10	0	0	173 ± 10	84 ± 10
100	7.5 ± 0.2	1260 ± 5	630 ± 5	0	0	153 ± 10	74 ± 10
200	7.4 ± 0.2	1250 ± 5	620 ± 5	0	0	135 ± 5	62 ± 5
400	7.4 ± 0.2	1200 ± 5	590 ± 5	0	6 ± 0.1	22 ± 5	15 ± 5
800	7.3 ± 0.2	1180 ± 5	590 ± 2	0	3 ± 0.1	13 ± 2	10 ± 2
15800	7.6 ± 0.1	1280 ± 2	640 ± 5	55 ± 0.5	79 ± 0.5	500 ± 5	255 ± 5
15900	7.5 ± 0.1	1220 ± 2	610 ± 5	17 ± 0.5	20 ± 0.5	358 ± 5	189 ± 20
16220	7.0 ± 0.1	1430 ± 2	670 ± 5	62 ± 0.5	91 ± 0.5	450 ± 5	231 ± 15
16700	7.0 ± 0.1	1320 ± 2	670 ± 5	8 ± 0.5	2 ± 0.5	413 ± 5	213 ± 5

**Table3:** Water Quality of Micelle clay complex column influent and effluent of UF-SW.

Test	Average Sample		Average Sample	
	Effluent of MCX column	Effluent of UF-SW	Influent of MCX column	Effluent of UF-SW
pH	7.6 ± 0.06	7.6 ± 0.06	7.4 ± 0.06	7.6 ± 0.06
EC (µS/cm)	1160 ± 6	1160 ± 6	1140 ± 6	1130 ± 6
TDS (ppm)	580 ± 6	580 ± 6	570 ± 6	560 ± 6
Turbidity (FAU)	0 ± 0.06	3 ± 0	0 ± 0	0 ± 0
COD (ppm)	32 ± 2.4	53 ± 9.2	48 ± 7	68 ± 26
SS (ppm)	0 ± 0	0 ± 0	0 ± 0	0 ± 0



**Fig. 1:** Al-Quds University Wastewater Treatment Plant with the insertion of Epuvalisation system and Micelle Clay Complex Column, Al-Quds University.

## Results:

The results of water quality analysis of both TWW and FW using the Rosemary and Geranium plants show a remarkable decrease of BOD, COD, EC, TDS, SS, K<sup>+</sup>, TN, Cl<sup>-</sup> and PO<sub>4</sub><sup>3-</sup>. **Table1** showed the Physical and chemical quality of hydroponic recycled water after 10 days of Epuvalisation treatment using Geranium Plants.

Plant growth parameters (plant height, fresh and dry weight, number of branches and flowers number) of Rosemary and Geranium showed no significant difference between irrigation with both media. The results of plant analysis of roots, leaves, stems and flowers showed that there is no effect for irrigation with the secondary wastewater in plant tissues.

The results have shown that the Epuvalisation system is a promising technique for wastewater treatment using the Rosemary and the Geranium plants.

**Table2** show a percentage removal of COD ranged from 53 to 95% and the column becomes saturated after 15800 liter, due to low variation difference between influent and effluent of COD values. The percentage removal was 20%, which could be refer to the high accumulation of organic matter on the MCXC.

**Table3** show no difference between influent and effluent of UF-SW. The results suggested that micelle clay complex can decrease the fouling as a results of organic matter removal, so we can use the effluent of MCX directly for RO membrane without passing through UF-SW due to the water quality analysis for both effluents of MCXC effluent and UF-SW effluent which mean we can use MCXC instead of UF-SW.

## Summary:

Rosemary and Geranium plants showed a good efficiency in term of purification, their ability in purifying the treated wastewater proved from the results of chemical analysis of treated wastewater during the cycles.

The results of MCXC shows efficient removal of COD during the operation time. The removal efficiency of organic matter varied between 53 to 95%.

Integrating micelle-clay complex after the UF-HF enhanced the water quality and decreased the fouling rate of the UF-SW membrane in the subsequent ultra-filtration unit. The results support/encourage the insertion of micelle clay complex column as pre-treatment stage before UF-SW and RO Al-Quds University WWTP and UF-SW could be replaced by MCXC.



MEDRC



# Pretreatment and Chemical Cleaning Effects on Fouling Reduction in a Pilot UF Membrane Bioreactor Treating Wastewater from Birzeit University Campus

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<sup>1</sup>Birzeit University

## Research Background:

Current strategies and scientific research concentrate on interaction mechanisms between foulants and clean membrane surface as well as foulants and fouled membrane. The present study based on collecting and evaluating technical data on the factors behind UF membrane fouling. The major object for this study is to evaluate and reviewing the current studies about reducing fouling, and finding the effects of wastewater, and chemical treatment of UF membrane Pilot. Pre-treated wastewater can ensure the long-term stability of MBR facility by altering the size of the volunt and reducing the nutrients available for microbial growth. To reduce biofouling and retrieve the membrane flow of the MPR facility, chemical cleaning of membranes is critical. Thus, the interaction techniques between the chemical factor and the foulant layer formed on the membrane surface and potential problems in the chemical cleaning operation will also be examined.

## Methodology:

- I. Data collection, literature review and description of current system.
  - II. Sampling and lab analysis of influent, liquid waste streamshock loads and reclaimed water; sludge filterability tests and biomass characteristics
  - III. Install micro strainer and/or mesh and chemical precipitation using local raw materials [charcoal, iron and stone cutting liquor] and predict the impacts on pollution loads reduction, then identify possible impacts on bioreactor design of the MBR and flux rate.
  - IV. Data analysis and research results discussion.
- Preparation and reproduction of the thesis.

## Area of study (MBR pilot system at Birzeit University ):

The recently installed MBR pilot system installed at Birzeit University will be used for this research study. The technical description of the flat sheet membrane bioreactor will be detailed in a second stage. The MBR system includes a pre-anaerobic stage followed by the main biological reactor, each has a working volume of about 1000 liters. Currently the MBR system is designed to treat about 1 m3 per day, which is feed by a dry pump installed at the balancing tank of the centralized sewage works serving BZU campus. The raw wastewater receives no effective pretreatment stage except a bar screen. The system has a chlorinating unit for the reclaimed water disinfection.

## Research question and identified problems:

- 1) What are the causes behind possible fouling and reduction in flux performance of the flat sheet membrane installed in the MBR pilot?
- 2) What practical methods to apply for fouling reduction, considering high strength wastewater characteristics and possible pretreatment technologies?
- 3) What are energy savings achievable by avoidance of frequent cleaning?

## Summary:

Ultrafiltration (UF) membranes are widely used in membrane bioreactor (MBR) facilities for wastewater treatment to cope with stringent effluent quality standards and protect public health and receiving environment. However, membrane fouling forms an essential problem in the process of its application and current research efforts focus on this issue. Current operational strategies to reduce UF membranes fouling in MBR facilities depend on deep scientific and engineering understanding of the interaction mechanisms between foulants and clean membrane surface as well as foulants and fouled membrane. The current study starts with compiling and evaluation of technical data form published studies pertaining to major factors behind UF membrane fouling. This research study aims at reviewing the recent studies about causes and mitigation measures of UF fouling and exploring the impacts of wastewater pretreatment and chemical treatment of UF membrane Pilot at Birzeit University. We argue that pretreated wastewater can ensure long life stability of the MBR facility through change in foulant size distribution and reduce in nutrients available for microbial growth. To reduce biofouling and recover the membrane flux of MBR facility, chemical cleaning of UF membranes is crucial. Hence, the interaction mechanisms between the chemical agent and foulant cake formed on the membrane surface and possible problems in chemical cleaning process will be also examined. Finally, future direction in research and development in the field of MBR fouling will be identified and the potential impacts on the annual operational costs of MBR facility will be estimated.



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# Enhanced Phytoremediation Of Olive Mill Wastewater "Zibar" Using Plant Growth Promoting Rhizobacteria (PGPR) With Barley and Clover

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**Research Background.** Olive mill wastewater (OMWW) has negative environmental impact. Utilization of OMWW in irrigation is difficult due to the toxic effect. Different phytoremediation methods were used to improve the use of OMWW in irrigation.

**Methodology:** 1-PGPRs were implemented to investigate their efficiency of improving the phytoremediation technique for plants irrigated with olive mill waste water.2- Two strains of PGPR (UW3, *Pseudomonas putida*(A). UW4, *Pseudomonas putida*(C) with unassigned one (B)) were used with Barley (*Hordeum vulgare* L.) and clover plants (*Trifolium* sp.).3- All trials were carried in a designed green house in faculty of agriculture at AnNajah national university in Tulkarem for 30 days.4- Plants irrigated with different concentration of OMWW (0%, 10%, 25%, and 50%).5- Seeds of both barley and clover irrigated by different concentration of olive mill waste water, showed significant differences in germination among the concentration levels of OMWW.

## Area of study (greenhouse in An- Najah National university in Tulkarem city):

The Tulkarm governorate : is an directorial region and one of 16 Governorates of Palestine situated in the northwestern West Bank. The governorate's land area is 268 square kilometers. According to the Palestinian Dominant Bureau of Statistics, the governorate had a population of 172,800 inhabitants. The muhfaza or district capital is the city of Tulkarm.



Map 1:Tulkarem, West Bank

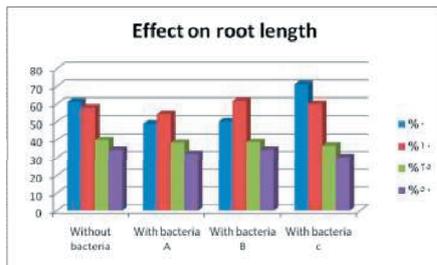


Fig. 1:Effect of bacteria and OMWW concentration(%) on root length of barley plant.

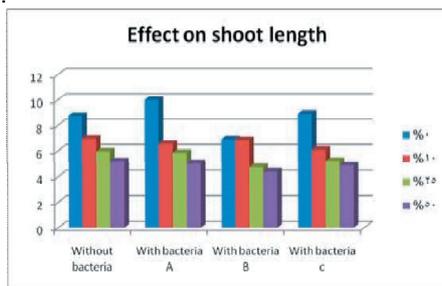


Fig. 2:Effect of bacteria and OMWW concentration on shoot length of clover plant.

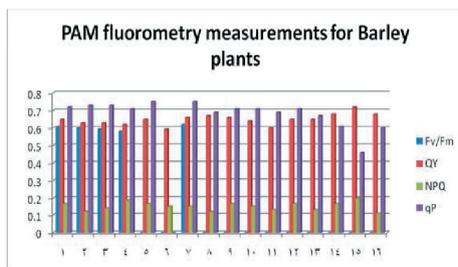


Fig. 3:PAM fluorometry measurements for Barley plants.

**Results:**It was notable that the OMWW has negative impact on seed germination of both plants. Neither barley nor clover plants treated with PGPRs had significant improvement in biomass compared with those irrigated with fresh water. Root length was decreased significantly with the increase of OMWW levels (57.8 and 58.5cm respectively). The OMWW application significantly reduced the shoot length. OMWW at 50% reduced the stem length (15.5 cm). A similar trend was observed with other measures (both fresh and dry weight of the plant). OMWW application was highly reduced both weights of stems and roots of both plant species. For clover plants, root length, shoot length, wet weight ( $P=0.0057-0.0001$ ), were reduced, however, total dry weight, dry weight of roots, and dry weight of shoots ( $p < .05$ ). The higher root length was observed with the control and 10% OMWW (25.22 and 23.98 cm, respectively). Regarding shoot, shoot length was reduced, the lowest shoot length was observed (4.879) at 50% zibar application. Wet weight of clover was differs significantly among the different concentration of OMWW and different type of bacteria used. Pulse Amplitude Modulation (PAM) fluorometry showed no improvement in photosynthesis. Barley plants their values of  $F_v/F_m$  were ranged from (0.55 -0.68), which mean that plant is under stress, and its photosynthesis not proceed as it should be, and NPQ values ranged (0.11-0.17). The same was for clover plants treated with PGPR (UW3), irrigated with fresh water, 10% concentration of OMWW, values of  $F_v/F_m$  are closed to 0.8 and NPQ are decreased to .07. Other Trails of clover plants values of  $F_v/F_m$  were ranged from (0.62 -0.70), and NPQ values ranged (0.04-0.16).Which mean that plant is under stress, and its photosynthesis not proceed as it should.

**Conclusion::** Specifically, trials treated with PGPRs has shown no significant improvements in the plant growth for the plants (Barley and clover) that used in these experiments, indicated that these two plants cannot be used in this type of phytoremediation process in combination of the PGPRs (*Pseudomonas putida* UW3 and/or UW4).Results from pulse amplitude modulated fluorometry (PAM) studies indicated that these plants which treated with PGPR have no effect on the rate of photosynthesis. Biomass measurements showed no significant effect on mass for those plants treated with PGPRs compared with those control (untreated); so there is no phytoremediation efficiency. Concentration of OMWW less than 10% more suitable for this type of phytoremediation





# Techno-economic Evaluation of BWRO Systems for Brackish Water Desalination in the Jordan Valley

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## Abstract

Due to the brackish water nature of ground and limited access to fresh water resources, few Brackish Water Reverse Osmosis (BWRO) desalination plants were constructed in the Jordan Valley. The aim of this study is to evaluate the techno-economic feasibility of these water treatment facilities, with focus on factors affecting the unit cost of desalinated water and coupling solar photovoltaic (PV) to BWRO desalination unit.

The analysis results revealed that the unit product cost (UPC) of Marj Na'aja BWRO unit is \$0.245 /m<sup>3</sup> and is capable of producing water in the range of \$0.21-\$6.54 /m<sup>3</sup>, depending on the plant size, power source and cost. The cost breakdown results of Marj Na'aja unit showed that energy, material, labor, and capital costs account for 64%, 4%, 20% and 12% of the total costs, respectively.

## Research Questions and Objectives

### Research Questions

What are the key considerations in BWRO desalination projects in the Jordan Valley to define the best practices to be applied to reduce the cost of desalination?  
 What are the effects of applying various sources of power (electricity and solar energy) in RO desalination plants on the unit cost of desalinated water?  
 What are the factors that affect the unit cost of desalinated water in the Jordan Valley?

### Research Objectives

This research aims to highlight the applicability of RO desalination systems to overcome the water issues in the Jordan Valley. Consequently, this research is intended to evaluate cost and performance of various sources of power (electricity and solar energy) in order to enable an effective comparison of different alternatives. Moreover, this research intends to study the effect of different parameter (e.g. feed salinity, electricity cost, interest rate, etc.) on the unit cost of desalinated water.

## Methods

As a first step, the research highlights the current water and energy issues in the Jordan Valley. Field data was collected by a comprehensive survey, as a form of personal interviews with RO plants operator. In the evaluation process, local data and assumptions from previous literature were used. The cost data include site-specific feed intake, pretreatment, post-treatment, site development and concentrate treatment costs, RO replacement, water transport costs, etc.

In order to perform the cost comparison, the Desalination Economic Evaluation Program (DEEP) was used. DEEP was used to evaluate the performance and the cost of various water and power co-generation configurations. The results were used to hold a comparison of a large number of design options and scenarios on a consistent basis with common assumptions.

In this study, three scenarios were analyzed economically. The first case was analyzed by taking the present situation in Marj Na'aja BWRO unit as the base case. The second scenario was to analyze the option of coupling solar energy to the BWRO unit in Marj Na'aja. And the third scenario was the small scale Al-Zubiedat BWRO unit- powered by PV. Besides, sensitivity analyses were carried out by changing several important parameters that could potentially have a major influence on the UPC. Those parameters are plant water capacity, electricity cost, interest rate, plant availability, feed water salinity, and feed water temperature. These analyses will be carried out to permit deep understanding of possible trends in the cost of desalinated water as the mentioned factors change. The common approach is to choose a base case scenario of input values and to change one factor, while holding all other input variables constant.

## Results

### Case 1: Marj Na'aja BWRO unit powered by a conventional energy sources- present situation

The UPC is found to be 0.245\$/m<sup>3</sup>, this value is lower than the value given by Abu-Alhaja, 2015, which is \$ 0.346 /m<sup>3</sup>. However, the calculated UPC value is in agreement with the value estimated by Karagiannis and Soldatos, 2008, with UPC value ranged between \$0.26-\$1.33/m<sup>3</sup> for brackish water desalination, Miller, 2003; and Selhi, 2007 also have found that the UPC ranges between \$0.10/m<sup>3</sup> - \$1.00/m<sup>3</sup>. Whereas, the UPC of Marj Na'aja BWRO is lower than the cost trends for BWRO desalination units provided by Jaber and Ahmed, 2004. They reported that for BWRO units with capacity range between 20-1200 m<sup>3</sup>/d, the cost may vary from \$0.78- \$1.23/m<sup>3</sup>. This shows the variation in the reported UPC values in literature. The estimated UPC is less than the water selling price in The Jordan Valley which is around \$0.41 /m<sup>3</sup>, this indicate that applying RO technology for brackish water desalination is a feasible option.

It is also noticed, that Marj Na'aja BWRO exhibits a low capital costs, (12 % of the total cost). This is contributed to the lower operating pressures required for the low salinity feed, therefore, equipment costs are low. The highest percentage in the cost breakdown is energy cost (64%). If the cost of electricity decreases, from \$ 0.15 /kWh to \$ 0.1/kWh, the UPC will be decreased potentially by 23 %. However, it has been reported, that the power cost of typical brackish water RO represents only 11% of the total cost, and the largest costs are fixed costs at 54% (Miller, 2003).

### Case 2: Marj Na'aja BWRO unit powered by the solar PV cells

The resulted installation cost of the PV system found to be \$230,651.8. Under case 2, the capital cost percentage increased up to 76% of the total cost compared to 12% of case 1. The UPC of the desalinated water by Marj Na'aja unit coupled with PV cells became \$0.423/m<sup>3</sup>. This UPC found to be relatively high when compared to the first case despite the reduction in energy costs. Yet again this is attributed to the high equipment and installation costs of the PV cells.

## Sensitivity Analysis

### Effect of purchased electricity cost on UPC

The effect of the cost of purchased electricity consumed by pumps and other components in the BWRO on UPC was studied. The results obtained from the analysis were presented in Figure 11. The analysis shows that increasing the electricity price from \$0.08 up to \$0.10 per kWh will increase the UPC by about 13%.

### Effect of water capacity on UPC

The sensitivity of UPC to the specific capacity of water plant was established and represented in Figure 12. The trend shows the decrease on UPC as the water capacity of the plant increases. It was found that UPC decreased by 6 % when the plant capacity increased from 1320 m<sup>3</sup> to 2000 m<sup>3</sup>.

Moreover, the effect of smaller plant capacities on UPC is major represented by the steep slope of the curve at the start. For example, if the plant capacity is increased from 100 m<sup>3</sup>/d up to 200 m<sup>3</sup>/d the decrease on UPC is about 38 %.

## Conclusions

- Energy is certainly the most significant item and has a significant effect on UPC for electricity powered BWRO desalination unit, where, energy represents 64% of the total cost in Marj Na'aja unit powered by electricity.
- The cost of the small scale BWRO desalination units is higher than the larger ones. The estimated UPC found to be between \$0.514-\$6.54 /m<sup>3</sup> for desalination plant with capacity ranges between 10- 200 m<sup>3</sup>, while for capacity ranges between 300-5000, the estimated UPC was between \$0.409-\$0.21/m<sup>3</sup>.
- Sensitivity analysis results indicate that for high capacity BWRO units, the economy of scale is only a few percent of the UPC. This effect is higher for lower size plants. Moreover, increasing interest rate will increase UPC. While increasing plant availability or feed water temperature will reduce UPC.

## Future Directions

- Focused research on optimizing the PV cells to use the solar energy should be a significant boost to the BWRO powered by those cells.
- The suggested key considerations should be translated into action plans.
- The option of combining power plant for energy generation to a large-scale desalination plants should be investigated.

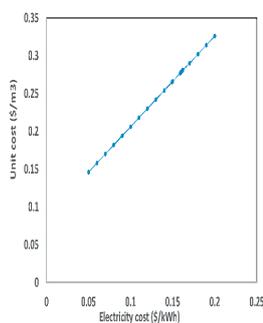


Figure 1: Effect of purchased electricity cost on UPC

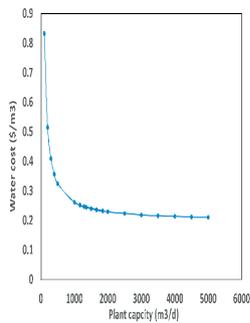


Figure 2: Effect of the water capacity of the units on UPC

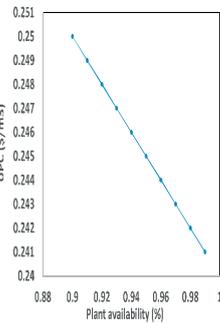


Figure 3: Effect of the plant availability on UPC

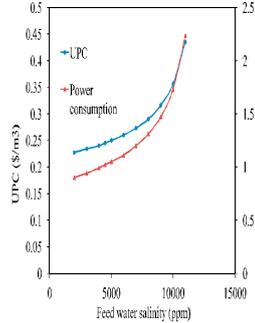


Figure 4: Effect of the water salinity of the units on UPC

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- Institute of Environmental and Water Studies, Birzeit University.

# Efficiency of Magnetic CoFe<sub>2</sub>O<sub>4</sub> Supported on Graphene for Removal of Cyanide from Wastewater

S. Jodeh<sup>1</sup>, A. Zubaida<sup>1</sup>

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**Research Background:** Different pollutants from industries leach every day to soil and ground waters without treatment. This will lead to different health problems to both human beings and animals. Cyanide is a very toxic compound that is released into the environment through the effluents of industrial activities such as metal plating, electronics, photography, coal coking, plastics, chemical fertilizer and mining. Cyanide is included in the priority list of hazardous substances and has adverse health effects on people as well as other living organisms. Exposure to small amounts of cyanide can be deadly irrespective of the route of exposure

**Methodology:** (i) Synthesis of CoFe<sub>2</sub>O<sub>4</sub> Nanoparticles (ii) Synthesis of GO-CoFe<sub>2</sub>O<sub>4</sub> Nanohybrids (iii) This work is focused on the synthesis, characterization and applications of a Modified Magnetic- CoFe<sub>2</sub>O<sub>4</sub> Graphene oxide Nanohybrids (MGONH). This product of (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) can be synthesized by mixing of Iron(III) Chloride Hexahydrate and Cobalt(II) Chloride solution of colloidal graphene oxide and stirred for 30 minutes. The interaction was continued for the same duration for five minutes and then cooled to the temperature of the room which was 25°C. The particles of nanohybrid were separated with a magnetic and cleaned with extra acetone and water. The precipitates were dried at room temperature for a day. (v) (SEM) technique was used to examine the Modified Magnetic- CoFe<sub>2</sub>O<sub>4</sub> Graphene oxide. (vi) The thermal stability of Magnetic- CoFe<sub>2</sub>O<sub>4</sub> Graphene oxide are determined by thermogravimetric analysis. (vii) The adsorption experiments of CN were conducted for a wide range of pH, adsorbent dosage, temperature, initial concentration and contact time. (viii) The Freundlich and Langmuir models are employed to analysis adsorption occurred in the experiment data of adsorption isotherms

## Molecular structure scheme of the cyanide):

Cyanide is present as anion form CN<sup>-</sup> in some compounds such as Potassium Cyanide and Sodium Cyanide, which are toxic compounds, with IUPAC name Cyanide Because of the Cyanide anion of high nucleophilicity, cyano groups are introduced into organic molecules by displacement of a halide group.



Figure 1: Molecular structure scheme of the Cyanide.

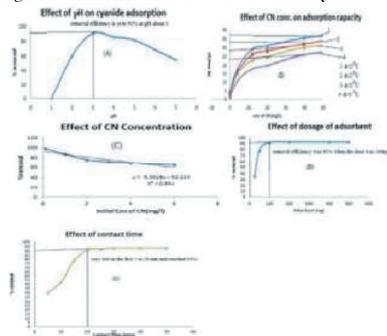


Fig. 2: The percentage removal of Cyanide under different conditions. The adsorption experiments were conducted for a wide range of (A) pH (B) temperature (C) CN concentration (D) adsorbent weight and (E) contact time.

## Results:

- SEM images of the Modified (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) show rough and porous nature, indicating that the materials present good characteristics to be employed as an adsorbent.
- FT-IR analysis confirms that provide information on the redistribution of cations between eight surfaces and tetrahedral locations of the inverse spinel structure in GO.
- Thermogravimetric analysis (TGA) reflects the thermal stability of (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) product.
- Cyanide adsorption gradually increases with the increasing of pH and the removal efficiency is over 91% at pH about 3. The results show that as the pH increases up to 3, the adsorption of Cyanide will be less favorable. It is due to the electrostatic repulsion between the adsorptive anion and the surface of the GO.
- that the adsorption process is more suitable at 15 oC temperature. This is mainly due to low surface activity suggesting that the absorption between CN<sup>-</sup>ion and GO is a thermal reaction. With increasing temperature, attractive forces between the surface of graphene oxide and CN<sup>-</sup> are weakened and then sorption decreases.
- that uptake of CN was rapid at lower concentration (0.11.5 mg/L) and as concentration increase the amount of CN adsorbed was decreased. At lower concentration, the ratio of the initial number of CN molecules to the available surface area is low and the available sites are high, but at high concentrations of CN, the available sites are fewer.

- Removal efficiency was increased sharply with increasing amount of adsorbent up to 100 mg. Then removal efficiencies were not changed significantly with increasing amount of adsorbent.
- The adsorption of CN on (MGONH) samples were very fast in the first 5 to 20 min and reached 91%.The adsorption rate becomes almost insignificant after that, because of use of the adsorption sites.
- The adsorption data fitted into Langmuir and Freundlich out of which Langmuir adsorption model was found to have the highest regression value and hence the best fit. This isotherm contains a factor that taking into the account of adsorbent-adsorbate interactions which indicates the presence this interaction.
- AS<sup>o</sup> value is positive indicating that entropy increases on the surface / solid solution through the absorption process, And The negative AH<sup>o</sup> denotes that this adsorption is an exothermic process, It is clear from the table that all values the Gibbs free energies (AG<sup>o</sup>) were negative and this shows the spontaneous nature of the adsorption process to different temp.
- The results show that the pseudo second order kinetic model fits perfectly the experimental data with linear regression coefficients 0.9999.
- The comparison of the uptake capacity of the recycled adsorbent showed an excellent adsorption ability and has a good stability and can be reused many times with little decreasing its extraction percentage.

**Summary:** The product (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) was successfully prepared. The FTIR results confirmed that the GO have been immobilized onto the surface of the modified M- CoFe<sub>2</sub>O<sub>4</sub>. SEM images indicated that the Modified M- CoFe<sub>2</sub>O<sub>4</sub> surface presents good characteristics to be employed as an adsorbent. CN adsorption using (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) can be described using pseudo second order and Langmuir isotherm model. Based on the results, the (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) is able to remove CN rapidly within 20 min with high removal efficiency. Over 91 % removal efficiency of Cyanide was achieved after 60 min. at solution pH around 3, 15°C temperature, 0.25 g weight of dose and initial concentration of 15 mg/L of 50mL



# Study the Effect of Reeds Tissues on the Adsorption of Heavy Metals and Bacteria from Sewage Water

Salman M<sup>1</sup>, Abu Obiad A<sup>1</sup>, Alkowni R<sup>1</sup>

## Introduction:

Environmental pollution is the greatest challenge facing human today. Water pollution is one of these greatest challenges, the removal of pollutants from water and soil has been long researched in the fields of environmental science and engineering in order to find ways of eliminating this serious problem in both, the developed and developing world .

Water contamination may include organic contaminants such as pathogenic bacteria and inorganic contaminants such as heavy metals.

Heavy metals are among the contaminants in the environment. Almost all human activities have produced heavy metals as the side effect beside the natural activities. Transportation of these contaminants from contaminated areas into non-contaminated areas by dust or leachates through the soil and spreading of heavy metals containing sewage sludge are examples of this pollution. **Figure** : Phragmites from purification plans in Sarra towards contamination of the ecosystems

Figure : Phragmites from purification plans in Sarra



Figure : Phragmites from Wdi Al Bata



**Methodology:** in this study *Phragmites australis* plant was collected from Wadi Al Bathan field. Plants were removed from the soil and washed, and the roots were separated from the stems and leaves. The other samples of phragmites were collected from the sewage wastewater treatment plant from Sarra. Washed, and the roots, stems, and leaves, were separated. All samples were oven dried at 37°C for one week. Then the leaves, root and stem of both plant samples were crushed separately.

This was followed by two parts of the experiment: The potential of *Phragmites australis* plant which collected from Wadi Al Bathan to remove (Fe<sup>3+</sup>, Cd<sup>2+</sup>, Cu<sup>2+</sup>, Ni<sup>2+</sup>, and Pb<sup>2+</sup>) from aqueous solution was studied and compared with other plant of Phragmites which was taken from sewage purification plant in Sarra. The antibacterial activity for the *Phragmites australis* was tested in the biological part.

## Results:

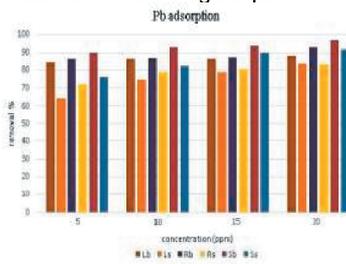


Figure : Effect of initial lead metal ion concentration on the %removal by both phragmites

The results show an efficient capability of *Phragmites Australis* and the other type phragmites which from Sarra in removing all metals were studied in this work. The removal of metals by both plants increases by increasing the amount of biomass.

The biomass was able to remove metal ions rapidly within 15-30 min. with high removal efficiency at pH around 7, 25°C temperature and initial concentration of 20 mg/L of metal ions. Around 97.3% removal efficiency of Pb<sup>2+</sup> was achieved within the first 30 min. at the optimum condition. As can be seen from results the *Phragmites australis* (common reed) is more efficient, as it almost completely removed lead from the shoot sample.

Investigation the sorption behaviour under competitive conditions when several metallic species are present in the presence of all metal ions the percent removal of the metal ions was in the order of Pb<sup>2+</sup>>Cu<sup>2+</sup>>Fe<sup>3+</sup>>Ni<sup>2+</sup>>Cd<sup>2+</sup>.

Negative values of ΔG at different temperatures point that adsorption is spontaneous at these temperatures. The negative ΔH° denotes that this adsorption is an exothermic process. ΔH° value is lower than 40 KJ/mol which suggests that the nature of adsorption is a physical process.

The results of the uptake of Pb (II) by reed shoot fit well with the Langmuir adsorption isotherm more than Freundlich adsorption isotherm, and Pseudo second-order kinetic model fit better than pseudo first order model.

The results of all samples of antibacterial activity test reveal that is negative. This indicates that the plant extracts have no antibacterial effect on the Gram-negative and Gram-positive bacteria

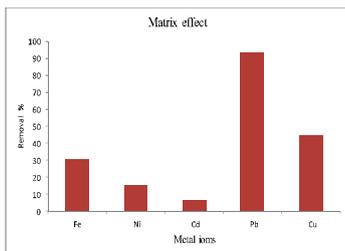
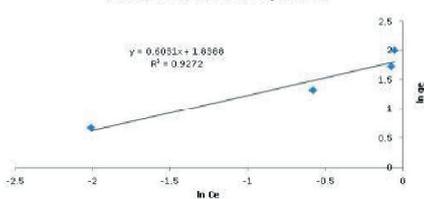


Figure : Effect of metal ions on the percent removal of each other by shoot samples, (Pb<sup>2+</sup>>Cu<sup>2+</sup>>Fe<sup>3+</sup>>Ni<sup>2+</sup>>Cd<sup>2+</sup>)

### Freundlich model equation



## Summary

Findings in this thesis show that *Phragmites australis* plants from Wadi Al- Bathan can absorb metals more than other phragmites which imports from other country; hence it is recommended to utilize them for pollution removal from water

## Acknowledgment:

I would like to acknowledgment the Middle East Desalination Research Center (MEDRC) who funded the master work through the Palestinian Water Authority



# Performance Test and Techno-Economic Evaluation of a PV Powered Reverse Osmosis Brackish Water Desalination System in (BWDS) West Bank

By Samer Farid, Supervisor Prof.Dr. Marwan Mahmoud  
An-Najah National University

## Research Objectives

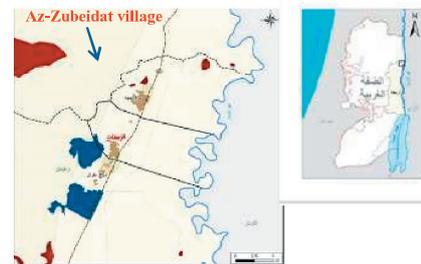
1. Provide the inhabitants of Az-Zubeidat village with potable drink water from the available BW by using solar energy.
2. Study and design (BW) reverse osmosis (RO) desalination systems powered by solar electric energy.
3. Determining the performance of BWRO desalination systems powered by solar electric energy under Palestinian weather and environmental conditions as well as determining the productivity of such systems during the different year seasons.
4. Testing the performance of the solar PV system powering the RO desalination system and investigating the optimal design of such systems according to salinity and daily solar radiation intensity.
5. Determination of the economic feasibility of using solar electric systems for desalination of BW in rural Palestinian villages lacking for electricity and potable water.
6. Identify the effects of BW desalination on the environment, health and social conditions in the potential sites of the West Bank.

**Methodology:** This research discusses the energy required, the techno-economic issues, and environmental analysis of the first BWRO desalination system operated by solar electric power (PV) in West Bank- Palestine. This system is built in Az-Zubeidat village–Jordan valley to demonstrate the applicability of solar energy in water desalination and to provide the inhabitants with the desalinated drink water.

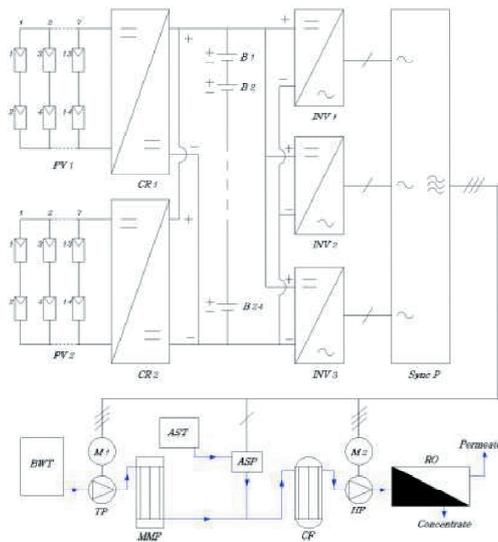
## Area of study (Az-Zubeidat RO Desalination plant in Az-Zubeidat village ):

Az-Zubeidat village is one of Jericho governorate villages, located about 35.4 km to the north of Jericho city. it is bordered by the Jordan River to the east, Marj Na'ja village to the north, Tubas city to the west and Marj al-Ghazal village to the south. This village is about 275 meters above sea level. The annual rainfall is about 192 mm and the average temperature is 23 degrees Celsius while the humidity is about 48% their (Map 1).

This village has a RO Desalination Plant with bout (10 m<sup>3</sup>/day) as a production rate.



Map 1: Az-Zubeidat village , Jericho, West Bank



Schematic diagram for Az-Zubeidat project.

## Results:

1. A considerable volume of brackish water with an appropriate TDS value allowing to use it for RO desalination membranes is available in West Bank.
2. Since the RO desalination systems are considered to consume the lowest amount of energy, RO systems are very appropriate to be operated by solar electric power systems represented in PV.
3. Palestine enjoys a high solar energy potential amounting in average to 5.4 kWh/m<sup>2</sup>-day, therefore it is appropriate to exploit this energy in brackish water desalination using RO membranes.
4. This study has shown that 1m<sup>3</sup> of permeate water produced from brackish water with a TDS 2681mg/L, requires 2.3 kWh which is represented at  $G_{av}=5.4$  kWh/m<sup>2</sup>-day approximately in 450 W<sub>p</sub> PV cells.
5. The economic analysis has shown that the cost of 1m<sup>3</sup> of permeate water produced from brackish water with a TDS 2681mg/L is 3.17\$ with battery, and 2.33\$ without battery.
6. Battery bank represent 23% from capital cost of Az-Zubeidat project and 26.5% from all project cost during the total life time (20 years).
7. For remote area having only such brackish water as Az-Zubeidat village who depends only on potable water delivery trucks to secure its needs of drinking water, the annual saving would be 17740\$ when using RO brackish water desalination system powered by PV, for a daily capacity of drink water amounting to 10m<sup>3</sup>/day.
8. Environmental analysis shows that Az-Zubaidat system preserves the environment of production 4195 kg of CO<sub>2</sub> per year.
9. Az-Zubaidat project produce brine solution contains about 11274 kg/year.

**Summary:** Az-Zubeidat system produces 10 m<sup>3</sup>of potable water per day, from Brackish Water(BW) with TDS of 2680 mg/L using RO technology powered by solar PV generator of 5.2 kW<sub>p</sub>.

Energy analysis shows that 1 m<sup>3</sup>of produced potable water needs 2.3 kWh of electrical energy, which corresponds to 450 W<sub>p</sub> PV modules.

Economic analysis shows that the cost of 1 m<sup>3</sup>of potable water produced by this system is 3.17\$ when using battery bank and 2.33\$ without using battery. This result is very reasonable compared with 5.07\$/m<sup>3</sup>as cost of potable water delivered by trucks. The annual savings by using such system amount to 17740\$.

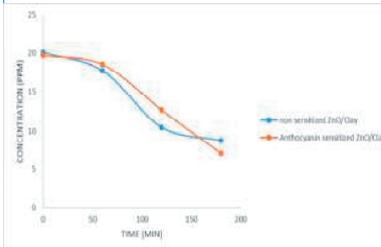
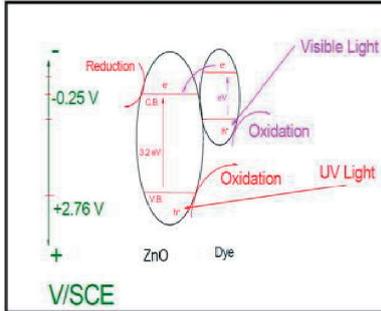
Investigations on varying the recovery has shown that higher recovery results in higher power requirement of the high pressure pump and thereby higher energy consumption of the system, it increases also the TDS of permeate which results in higher probability of membrane scaling.

Environmental analysis shows that using such a small system preserves the environment of production 4195 kg of CO<sub>2</sub> per year.



## Abstract

This work describes the adsorption and photocatalytic degradation of aqueous 2-chlorophenol (2CP) contaminant using nano sized ZnO semiconductor photocatalyst. The ZnO particles are trapped into solid natural clay particles, producing a new highly active and easy to recover ZnO catalyst system. The degradation was performed under direct sun light. This research investigates the effect of sensitization on the photocatalytic efficiency. The prepared ZnO and prepared ZnO/natural clay systems were characterized by several methods, such as FT-IR, UV-Visible, Photoluminescence, SEM and XRD which confirmed the ZnO formation in the composite catalyst. High Performance liquid chromatography was used to study the 2-chlorophenol adsorption and degradation. The results showed that the 2CP photo-degradation on the sensitized ZnO/clay occurred with highest activity (~64% + 0.01) loss of 2CP compared with ZnO/Clay composite catalyst (~56% + 0.01) loss of 2CP under direct sun light under natural conditions. Effects of different reaction parameters onto photo degradation reaction of 2CP by natural clay/ZnO catalyst have also been studied. The ability of catalyst recovery and reuse in photo-catalytic reactions was also studied, the recovered catalyst showed loss efficiency (~41%) of 2CP. Attempts were made to regenerate efficiency of recovered catalyst by adding new dye molecules. When calculating relative catalytic efficiency, in terms of turnover number, all recovered and regenerated catalysts maintained original efficiency of fresh samples.



Catalyst sample	% removal of 2-Chlorophenol	T.N (10 <sup>-3</sup> )	T.F (10 <sup>-3</sup> )
Fresh catalyst	64	2	0.01
Recovered catalyst	41	1.5	0.0125
Re-dying recover catalyst	50	1.87	0.015

## Results & Discussion

### -Comparison between Sensitized ZnO/Clay catalyst and non-sensitized ZnO/Clay photo catalysts

ZnO semiconductor has wide band gap (3.2 eV). Therefore, it can oxidize organic pollutants to simple non-toxic molecules. However, ZnO demands UV regions of solar light, which limits its degradation activity to only 4% of fallen sunlight. Using alternative smaller band gap semiconductor is unfavorable due to its instability. In this work, Anthocyanin dye was used to improve ZnO catalyst properties. Anthocyanin has a medium band gap of 2.3eV and absorbs visible regions of fallen sun light. This leads to electron-hole generation in the dye molecule. The electrons move from dye LUMO to ZnO conduction band, lead to generation of oxygen radical which reacts with hydrogen to produce hydroxyl radicals that oxidize the pollutant. Thus dye-sensitized composite ZnO/Clay catalyst uses both UV (by ZnO) and visible (by dye) regions together. This increases its photocatalytic degradation activity.

This explain the increase in photo-degradation of 2CP pollutant when Anthocyanin/ZnO/Clay catalyst was used, indicates that anthocyanin-sensitization improved activity of the supported catalyst by ~ 10%.

### -Recovery of the ZnO/Clay catalyst and sensitized ZnO/Clay catalyst

- The ability of catalyst recovery and reuse in photocatalytic reactions is an important characteristic. This can contribute significantly to lowering the cost of water treatment processes, and prevents further water contamination.
- After the end of the photo-degradation reaction, the treated mixture was filtered, and catalysts were collected and reused for fresh reactions, following the same procedures. In another experiment the filtered sensitized composite catalyst was re-dyed in attempt to restore its efficiency as photo-catalyst under direct sun light.
- The recovered composite catalyst used showed good but decreased efficiency (~41%) loss of 2CP. Re-dying the used catalyst was found to restore its efficiency to (~50%) loss of 2CP in each run. The lowering in contaminant removal by recovered catalyst is due to loss of catalyst while recovery.
- Asper catalyst efficiency, in terms of T.N and T.F, the catalyst did not lose its efficiency on recovery and reuse,

# Desalination Processes for Drinking Water in Palestine: Optimization Using Decision Support System

Khader A<sup>1</sup>, Snober Sh<sup>1</sup>

<sup>1</sup>An-Najah National University

**Research background:** Palestine is going through a grave water shortage due to the Israeli domination of the water resources as per Oslo II Accords. Israel's water consumption average is 350 liter per capita per day, compared to 76 liter per capita per day for the Palestinians, so desalination is one of the solutions for the water shortage problem. There are many types of desalination processes so its essential to find the optimal one for both brackish and sea water for drinking purposes, using solar energy to be friend to the environment.

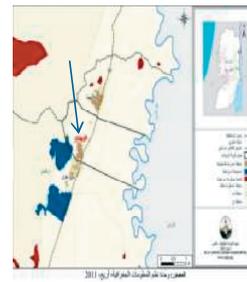
## Methodology:

- The 1<sup>st</sup> case study for brackish water in Zbaidat village the Data were collected from literature review for Reverse Osmosis and Nano Filtration, then they were both designed using Reverse Osmosis System Analysis Software. The results were used in Multi Criteria Decision Analysis to find the optimal desalination technique.
- The 2<sup>nd</sup> case study for seawater in Gaza Strip the data were collected from literature review for Reverse Osmosis, Multi Stage Flash and Multiple Effect Distillation .MCDA was used to find the optimal desalination technique. The optimal technique was designed using ROSA software

## Area of study:

1- Zbaidat is a village which lies 35km north of Jericho City and bordered by the Jordan River to the east, Marj Na'ja village to the north, Tubas city to the west, and Marj al Ghazal village to the south (Map 1).

2- Gaza Strip lies on the eastern coast of the Mediterranean Sea. More than 90% of the population of the Gaza Strip depends on desalinated water for drinking purposes. About 90% of the groundwater is unacceptable for drinking as a result of contamination by nitrate and chloride (Map 1).



Zbaidat Village



Gaza Strip

Map 1: Location of the two case studies.

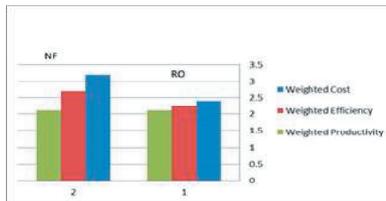


Fig. 1: Optimal Desalination Technology for Zbaidat Village.

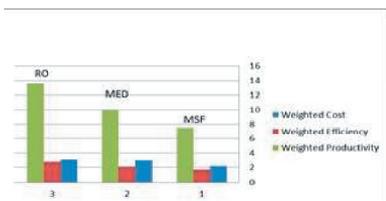


Fig. 2: Optimal Desalination Technology for Gaza Strip.

## Results:

1. Many countries suffer from water shortage, especially Palestine due to the occupation that controls the water resources.
2. As the Nano filtration desalination structures are considered to consume the lower quantity of energy than Reverse Osmosis systems in desalinating Brackish Water, it is very suitable to be activated by solar electric power methods represented in Photovoltaic, since Palestine enjoys a high solar energy potential. And NF is more efficient as in Fig(1) in this case Study.
3. The Reverse Osmosis is the optimal technique for Seawater desalination in Gaza Strip, since it needs the lowest amount of energy than thermal techniques(MSF, MED), but the energy there is not sustainable so the PV used in this study, also RO is the most productive technology, cheap and efficient as in Fig (2).
4. The permeate quality of both brackish and sea water conforms to the World Health Organization and Palestinian Water Authority standards of drinking water.

**Summary:** Palestine suffers from water shortage problem, there is a good potential for addressing the water shortage problem in rural and remote areas through sustainable saline water desalination technologies. In Palestine two types of water can be desalinated, brackish and sea water that differs in the total dissolved solids content, and this is reflected on the final cost of the desalination. So the optimal technology was found, depending on productivity, efficiency and cost, and the quality achieves the standards of the WHO and PWA for drinking purpose and the least cost for the consumer also achieved. NF was the optimal for the brackish water, and the RO for seawater.

## Acknowledgments:

Brendan Smith from MEDRC Water Research project supported by The Middle East Desalination Research Center, Muscat, Sultanate of Oman

Dr. Subhi Samhan, PWA, Palestine.  
Dr. Abdelhaleem Khader, Palestine, Nablus, An Najah National University



# Efficiency of Magnetic CoFe<sub>2</sub>O<sub>4</sub> Supported on Graphene for Removal of Cyanide from Wastewater

S. Jodeh<sup>1</sup>, A. Zubaida<sup>1</sup>

<sup>1</sup>An-Najah National University

**Research Background:** Different pollutants from industries leach every day to soil and ground waters without treatment. This will lead to different health problems to both human beings and animals. Cyanide is a very toxic compound that is released into the environment through the effluents of industrial activities such as metal plating, electronics, photography, coal coking, plastics, chemical fertilizer and mining. Cyanide is included in the priority list of hazardous substances and has adverse health effects on people as well as other living organisms. Exposure to small amounts of cyanide can be deadly irrespective of the route of exposure

**Methodology:** (i) Synthesis of CoFe<sub>2</sub>O<sub>4</sub> Nanoparticles (ii) Synthesis of GO-CoFe<sub>2</sub>O<sub>4</sub> Nanohybrids (iii) This work is focused on the synthesis, characterization and applications of a Modified Magnetic- CoFe<sub>2</sub>O<sub>4</sub> Graphene oxide Nanohybrids (MGONH). This product of (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) can be synthesized by mixing of Iron(III) Chloride Hexahydrate and Cobalt(II) Chloride solution of colloidal graphene oxide and stirred for 30 minutes. The interaction was continued for the same duration for five minutes and then cooled to the temperature of the room which was 25°C. The particles of nanohybrid were separated with a magnetic and cleaned with extra acetone and water. The precipitates were dried at room temperature for a day. (v) (SEM) technique was used to examine the Modified Magnetic- CoFe<sub>2</sub>O<sub>4</sub> Graphene oxide. (vi) The thermal stability of Magnetic- CoFe<sub>2</sub>O<sub>4</sub> Graphene oxide are determined by thermogravimetric analysis. (vii) The adsorption experiments of CN were conducted for a wide range of pH, adsorbent dosage, temperature, initial concentration and contact time. (viii) The Freundlich and Langmuir models are employed to analysis adsorption occurred in the experiment data of adsorption isotherms

## Molecular structure scheme of the cyanide):

Cyanide is present as anion form CN<sup>-</sup> in some compounds such as Potassium Cyanide and Sodium Cyanide, which are toxic compounds, with IUPAC name Cyanide Because of the Cyanide anion of high nucleophilicity, cyano groups are introduced into organic molecules by displacement of a halide group.



Figure 1: Molecular structure scheme of the Cyanide.

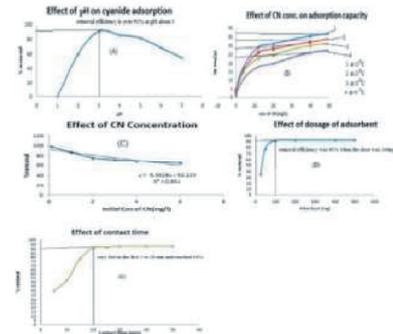


Fig. 2: The percentage removal of Cyanide under different conditions. The adsorption experiments were conducted for a wide range of (A) pH (B) temperature (C) CN concentration (D) adsorbent weight and (E) contact time.

## Results:

- SEM images of the Modified (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) show rough and porous nature, indicating that the materials present good characteristics to be employed as an adsorbent.
- FT-IR analysis confirms that provide information on the redistribution of cations between eight surfaces and tetrahedral locations of the inverse spinel structure in GO.
- Thermogravimetric analysis (TGA) reflects the thermal stability of (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) product.
- Cyanide adsorption gradually increases with the increasing of pH and the removal efficiency is over 91% at pH about 3. The results show that as the pH increases up to 3, the adsorption of Cyanide will be less favorable. It is due to the electrostatic repulsion between the adsorptive anion and the surface of the GO.
- that the adsorption process is more suitable at 15 °C temperature. This is mainly due to low surface activity suggesting that the absorption between CN<sup>-</sup>ion and GO is a thermal reaction. With increasing temperature, attractive forces between the surface of graphene oxide and CN<sup>-</sup> are weakened and then sorption decreases.
- that uptake of CN was rapid at lower concentration (0.11.5 mg/L) and as concentration increase the amount of CN adsorbed was decreased. At lower concentration, the ratio of the initial number of CN molecules to the available surface area is low and the available sites are high, but at high concentrations of CN, the available sites are fewer.

- Removal efficiency was increased sharply with increasing amount of adsorbent up to 100 mg. Then removal efficiencies were not changed significantly with increasing amount of adsorbent.
- The adsorption of CN on (MGONH) samples were very fast in the first 5 to 20 min and reached 91%.The adsorption rate becomes almost insignificant after that, because of use of the adsorption sites.
- The adsorption data fitted into Langmuir and Freundlich out of which Langmuir adsorption model was found to have the highest regression value and hence the best fit. This isotherm contains a factor that taking into the account of adsorbent-adsorbate interactions which indicates the presence this interaction.
- AS<sup>0</sup> value is positive indicating that entropy increases on the surface / solid solution through the absorption process, And The negative AH<sup>0</sup> denotes that this adsorption is an exothermic process, It is clear from the table that all values the Gibbs free energies (AG<sup>0</sup>) were negative and this shows the spontaneous nature of the adsorption process to different temp.
- The results show that the pseudo second order kinetic model fits perfectly the experimental data with linear regression coefficients 0.9999.
- The comparison of the uptake capacity of the recycled adsorbent showed an excellent adsorption ability and has a good stability and can be reused many times with little decreasing its extraction percentage.

**Summary:** The product (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) was successfully prepared. The FTIR results confirmed that the GO have been immobilized onto the surface of the modified M- CoFe<sub>2</sub>O<sub>4</sub>. SEM images indicated that the Modified M- CoFe<sub>2</sub>O<sub>4</sub> surface presents good characteristics to be employed as an adsorbent. CN adsorption using (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) can be described using pseudo second order and Langmuir isotherm model. Based on the results, the (M- CoFe<sub>2</sub>O<sub>4</sub>/ GO) is able to remove CN rapidly within 20 min with high removal efficiency. Over 91 % removal efficiency of Cyanide was achieved after 60 min. at solution pH around 3, 15°C temperature, 0.25 g weight of dose and initial concentration of 15 mg/L of 50mL



# Generating Fresh Water from Highly Concentrated Salty Water Using Thermochemical Cycles

Bearat H<sup>1</sup>O idahIE-dbA,<sup>1</sup>  
<sup>1</sup>An-Najah National University

**Research Background:** By using desalination plants, large amounts of potable water will be produced but also large amounts of highly concentrated salty water will be created. So there is an urgent need to find a suitable way to solve this problem, or reduce its effect. Actually, until now there is no efficient way of management of brine. Moreover, while the cost of RO produced water has continued to drop in the past decades, brine disposal can simply double the cost of constructing and operating of reverse osmosis facility.

**Methodology:** 2.6lCaC) edirohlc muiclac era hcihw ,stlas detardyh tnereffid ruof fo selpmas fo stnuoma cificeps gniraperP (i)H<sub>2</sub>O), sodium sulfate (Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O), magnesium chloride (MgCl<sub>2</sub>.6H<sub>2</sub>O), and Alum (Potassium aluminum sulfate KAl(SO<sub>2</sub>.12(4H<sub>2</sub>O) (ii) Complete drying of all samples was done using an oven at 120° C (iii) A special chamber (closed glass box) was made, to do the hydration experiments in it(iv) Every sample was tested in the steam box to do the hydration reaction, and the oven for many cycles.

## Area of study (Al-Zubeidat RO Desalination plant in Al-Zubeidat village):

The objective of this thesis is to find a management solution for the brine water that is produced from reverse osmosis plant in Az- Zubeidat village. The project takes this plant as a case study because it is the largest and most famous desalination plant in West Bank. Az-Zubeidat village is located at an altitude of 275m below sea level with a mean annual rainfall of 192mm. The average annual temperature in this 10 area is egareva eht dna ,C°23 .48% yletamixorppa si ytidimuh launna



Map 1: Az-Zubeidat village, Jericho, West Bank

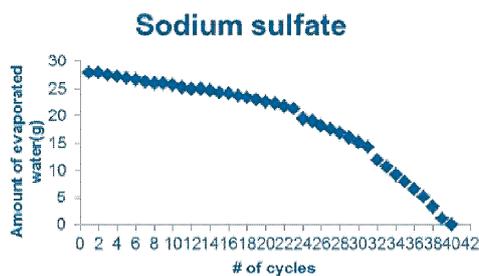


Figure (1): Number of cycles performed on Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O<sub>2</sub> and amount of released water for each cycle

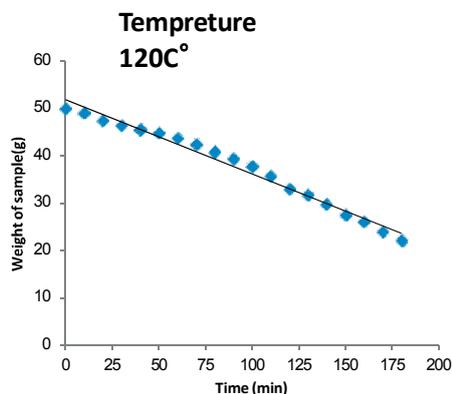


Figure (2) fo noitardyheD : (2g Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O at 120° C

## Results:

- When the cycles were done at ° 120 C MgCl<sub>2</sub> and Alum (KAl(SO<sub>2</sub>H<sub>2</sub>(4O) served for three cycles and then failed, also the cycles of CaCl<sub>2</sub> were 9 cycles. On the other hand, Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O took 39 cycles before.
- Special attention was given to sodium sulfate, that's because the required cycles for it were much more than other
- Dehydration of sodium sulfate was done at 120° C, but also at three other temperatures ° 150 C, ° 170 C, and 200° C) in order to know the relationship between temperature and the required time for complete dehydration rate of
- At ° 120 C; the required time for 50g of Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O to be 22.1g (completely free of water) was 180 min. Moreover, the rate of dehydration at ° 120 C was 5-10\*9.00M/s.
- At 150° C; the required time for totally drying of 50g of Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O was 90 min. additionally, the rate of dehydration at ° 150 C was found to be 5-10\*12.00M/s.
- At 170° C, the time for complete dehydration of 50g Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O decreased to 30 min. And the rate of reaction at 170° C was 4-10\*2.25M/s.
- At 200° C the drying time of the same sample (50g Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O) was only 20 min. The dehydration rate at 200° C was 3-10\*1.50M/s.
- For dehydration of Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O; as the temperature increase, the dehydration time decrease. On the other hand, the rate of reaction increases with increasing the temperature.
- The activation energy of the hydration reaction was 54176.46 J/mol.
- The activation energy of the hydration reaction was found to be 31875.9 J/mol.

**Summary:** from the results it is clear that the sodium sulfate can generate large amount of fresh water, that is because a sample of sodium sulfate decahydrate contains about 56% water, and it can produce all this amount of fresh water by dehydration. Accordingly, a sequential cycle can be done for sodium sulfate, each cycle consists from two steps; dehydration and then hydration. In the first step, when a sample of Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O is heated at ° 200 C for example, it will lose about 56% of its weight in the form of water vapor. So this vapor can be cooled by brine water, and so we get fresh water. The second step is hydration of Na<sub>2</sub>SO<sub>4</sub>.10H<sub>2</sub>O.



## Membrane based treatment technologies: Feasibility of Desalinated Brackish Water and Effluent Reclamation for Agricultural Use in Jericho area

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*Sa'ed*

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### Background

- Rising salinity levels in Jericho area is one of the significant signs of water-quality degradation in groundwater.
- Natural salinity in the alluvial Pleistocene wells in the Jordan Valley area
- Anthropogenic influences due to increment of nitrate, bromide and sulphate, through agricultural chemical effluents or sewer pollution from adjacent septic tanks which are mainly constructed in top gravel in the Samara layer
- Lack of sanitation services, limited access to freshwater sources, salinized soil and seasonal rainfall caused food insecurity and poverty in Jericho district
- Proper management and application of innovative water and wastewater treatment systems using membrane based treatment technologies to enhance water independence, food security and economical development in Jericho district is NOT well known yet.

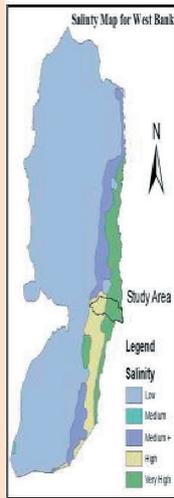


Figure 1: Salinity map to Palestine (PWA)

### Research Questions

- Will the beneficiaries accept desalinated water as alternative water source for domestic, industrial and agricultural consumption ?
- What should be the quality guidance for blending waters added post-desalination for stabilization?

### Research Objectives

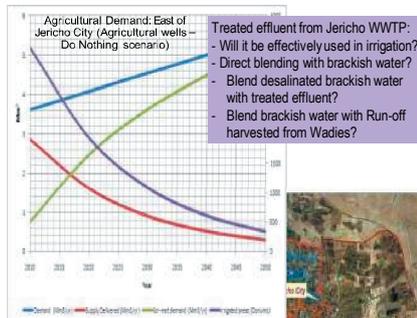
- Evaluating brackish water and reclaimed effluent quantities in the study area and evaluating the feasibility of membrane based treatment technology and other alternatives for brackish water desalination in the Jordan Valley.
- Assessing farmers' perception for using desalinated water and reclaimed influent in agriculture.
- Evaluating new alternatives to reduce water withdrawals from the country's overdrawn natural storage bodies of potable water (the two main aquifers) to avoid their further degradation by saline water intrusion (some of it irreversibly) and, eventually, raising their levels to hydrological safe values.
- Reviewing of international standards and guidelines for water quality parameters suitable for irrigation and acceptable by farmers

### Results

- The research highlighted the current agricultural water issues in the Jordan Valley, and tried to explore new feasible alternatives for brackish water desalination in order to utilize abundant brackish water in the Jordan Valley.
- To lower the cost, RO was combined with other alternatives such as utilizing the grid off solar PV, blending the brackish water with treated effluent or flood water harvested from Wade's run-off.
- It has been proved that blending brackish water with treated effluent is a feasible alternative by considering the fact that JWWTTP will generate 3.5MCM/Y when operated at ultimate capacity and this alternative can be optimized to include other areas in the Jordan when additional 15 MCM/Y conveyed to the Jordan valley from other cities.
- The research recommended RO-PV as replication of published studies recommendations and the results of RO projects in Palestine. RO-PV is recommended for its market availability and economic feasibility of energy cost. Coupling RO to the off-grid solar PV lowered the cost to an average \$ 0.083(USD)/CM for the Zbeid desalination unit compared to \$ 0.346 USD/CM for Marj Na'ajeh RO unit supplied through the Electricity grid network. The average cost of desalinated water would still be cheaper if brackish water treatment combined with other alternatives such as blending with treated effluent or harvested run off.
- The research recommended that further studies is still needed on blending and reuse.

### Research Problem

- Rising salinity levels in Jericho area is one of the significant signs of water-quality degradation in groundwater.
- Natural salinity in the alluvial Pleistocene wells in the Jordan Valley area
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Direct use of brackish water in agriculture lead to

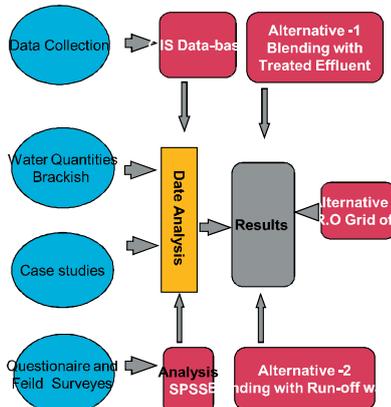
- low agricultural productivity
- Soil degradation/salinity
- Desertification, abandoning agricultural fields
- Poverty and food insecurity



### Conclusion

- Integrated scheme combining desalination of brackish water with effluent reuse and Flood Run would be one of the most suitable solutions to improve the water resources in the Jordan Valley and bridge the gap between supply and demand.
- Water scarcity in many countries has brought about significant progress in the use of non-conventional resources (desalination and effluent reuse).
- Problem of brine disposal resulted from desalination process which depends on the degree of salinity of the raw water.
- Jordan and Israel experience has demonstrated that even desalination cost is still expensive but it can be considered as feasible alternative and can be incorporated in overall production costs (even for private initiatives)
- Cost of desalination of brackish water can be competitive but can't be assumed by all the end-users, even the agricultural industry.

### Methodology



### Recommendations

- The cost of desalinated water and treated effluent is still high to be handled by the farmers; this implies investigating new alternatives to support farmers and empowers their affordability.
- The desalination technology needs a comprehensive management system, to organize the desalination plants distribution based on brackish water availability, areas' needs and capacity.
- Monitoring program for the desalinated plants should be developed for evaluating the product and distributed water.
- To avoid the negative environmental impact, the disposal of brine should be considered and EIA should be performed.
- Awareness campaign targeting the consumers to increase their awareness about the drinking water recommendations and healthy water quality.
- Palestine is in a great need for capacity building in the field of water desalination technology.
- Desalination of inland brackish water raises problems even not well solved due to the brine discharges or brine disposal, and it's necessary to research more about this important topic.
- Further researches on feasibility of desalination and effluent reuse will be needed in order to improve the efficiency and minimize the cost.

## Abstract

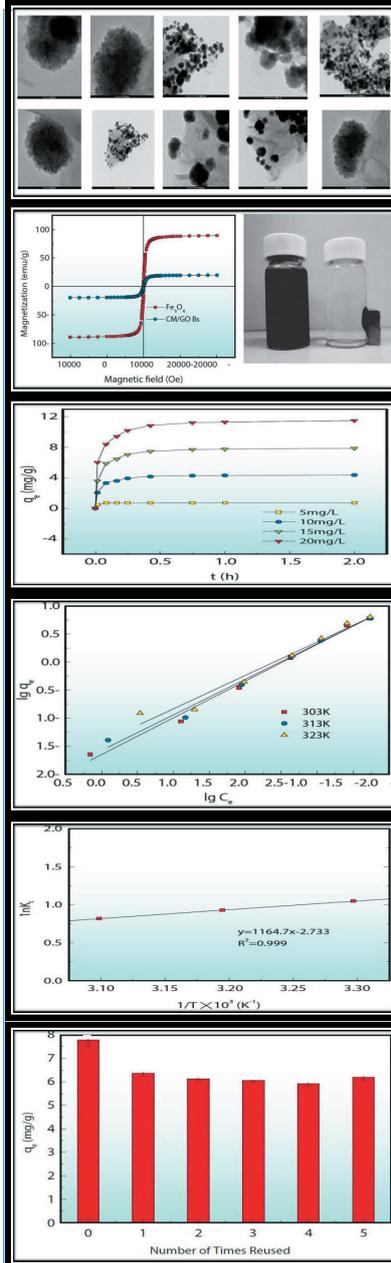
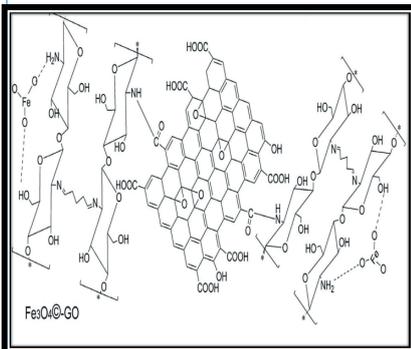
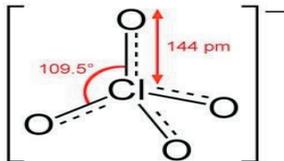
One of an emerging trace contaminants is perchlorate that has been detected in surface water, ground water, soil and food globally. Cross linked Magnetic Chitosan / Graphene Oxide Beads (CM/GO Bs) were synthesized and tested to remove perchlorate anions from waste water.

The complex was characterized by transmission electron microscopy, Fourier Transformation Infrared spectroscopy and vibrating sample magnetometry.

The effect of pH, contact time, co-existing anions and temperature on adsorption was investigated. Particles could be recovered easily by external magnetic field because they were super-paramagnetic.

The CM/GO Bs complex could adsorb perchlorate in a wide range of pH from 4 to 10 . Co-existing anions may inhibit the adsorption of perchlorate on CM/GO Bs.

Kinetic data were well fitted to the pseudo-second-order model. The enthalpy and negative gibbs standard free energy show that the adsorption process was exothermic and spontaneous . the exhausted adsorbent can be regenerated well by 0.1% NaCl solution.



## Results & Discussion

The CM/GO Bs complex could adsorb perchlorate efficiently at a wider range of pH than raw chitosan which was from 4 to 10. Co-existing anions, especially  $SO_4^{2-}$ , will affect the perchlorate adsorption onto CM/GO Bs. The adsorption data fitted the pseudo-second-order model. In addition, Langmuir and Freundlich isotherms followed the equilibrium data well. The enthalpy and Gibbs standard free energy showed that the adsorption process was exothermic and spontaneous

Perchlorate adsorption on CM/GO Bs was a complex chemical and physical adsorption

The exhausted adsorbent could be regenerated efficiently using NaCl eluent.

T(K)	Q <sub>0</sub> mg/g	B L/mg	R <sup>2</sup>
303	28.153	0.068	0.913
313	28.352	0.062	0.897
323	26.455	0.061	0.910

### Langmuir Adsorption Isotherm

C <sub>0</sub> mg/L	K <sub>1</sub> h <sup>-1</sup>	R <sup>2</sup>	K <sub>2</sub> g/mgh	R <sup>2</sup>
5	0.991	0.635	269.550	0.999
10	0.446	0.607	12.919	0.999
15	0.448	0.641	8.017	0.999
20	0.392	0.693	3.780	0.999

### Adsorption Kinetics

T (K)	K <sub>s</sub>	G <sub>s</sub> (kJ/mol)	H <sub>s</sub> (kJ/mol)	S <sub>s</sub> (J/mol K)
303	2.852	-2.583	-9.773	-22.811
313	2.739	-2.455	-9.773	-22.811
323	2.764	-2.231	-9.773	-22.811

### Adsorption Thermodynamics