PROPOSALS FOR GOOD GOVERNANCE OF WATER RESOURCES IN MEDITERRANEAN SEA BASIN - RESPONSE OF THE SCIENTIFIC WORLD

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KEYWORDS: Agriculture, Mediterranean Sea, virtual water, water footprint, water scarcity

Abstract
Water resources in Mediterranean Sea Basin are under strain from rapid urbanization and industrialization. The situation is made worse by water-related disasters, climate change and poor governance. Countries especially in the southern-rim are experiencing the urban scenario of water stress. Traditional systems to share water are increasingly unable to cope with growing demand and competition between users. In this study, the water resources management in Mediterranean Sea Basin is evaluated using water footprint methodology and proposals for sustainable management are introduced. In addition, through bibliometric analysis the responses of the scientific world to water related problems in the selected Med Sea Basin countries are introduced.

1 Introduction

Water is a necessary component for all major socioeconomic sectors, contributing to each in different ways. Agriculture requires large quantities of water for irrigation as well good quality water for various production processes. Energy requires water for powering turbines (hydroelectricity), cooling power plants (thermal and nuclear electricity) and growing biofuels. Access to safe water supplies and basic sanitation are necessary for maintaining public health, and water is needed to support healthy ecosystems, which in turn provide critical environmental goods and services. The benefits from each of these sectors are provided through water [1].

There is enough water on Earth for all, even in areas where temporary shortages may exist. According to the study "Water governance in OECD countries" managing water for all is not only a question of resources availability and money, but equally a matter of good governance [2]. Water is essentially a local issue and involves numerous stakeholders at basin, municipal, regional, national and international levels. In the absence of effective public governance to manage interdependencies across policy areas and between levels of government, policymakers inevitably face obstacles to effectively designing and implementing water reforms.

Agriculture is the largest water demanding sector in the Mediterranean Sea Basin countries. According to Rockström [3], roughly 1,300 m^3/cap/year is needed to produce the food for a balanced diet. This equates to 5,400 km^3/year of water used globally to produce crops. It is estimated that water scarcity threshold is approximately 1,500 m^3/capita/year. Below this threshold, a country's demand for cereal import increases exponentially with decreasing water resources [4]. The water footprint (WF) of an agricultural product is defined as the total volume of freshwater that is used to produce the product [5]. This WF consists of three components: green, blue and grey WF. The blue WF refers to the volume of surface and groundwater consumed as a result of the production of a good; the green WF refers to the rainwater consumed; grey WF is the volume of freshwater that is required to assimilate the load of pollutants [5]. From an ecological point of view, it is usually preferable, if demands of the agricultural production are supplied by green water rather than blue one, as blue water is taken from surface or groundwater and, therefore, is no longer available in the natural water cycle.

For the majority of the countries located in the eastern-southern parts of Med Sea Basin, physical water scarcity is the main handicap. This situation is enhanced through low levels of agricultural productivity expressed in yield values. Water resources used for the irrigation are supplied from blue water resources, which are under serious threat of climate change. In order to maintain food security for the future, sustainable usage of limited water resources is unavoidable.

Water footprint methodology will be used to evaluate the sustainability of the agricultural production based on the water resource used. In addition, within the scope of this study the focus is given to the response of the scientific community of the selected countries to water related problems, evaluated using bibliometric analysis.

2 Mediterranean Sea Basin

The Mediterranean region considered in this study includes 25 countries or territories bordering the Mediterranean Sea (Figure 1). Three sub-regions were identified in order to make comparisons easier [6].

- the North or greater Europe: Portugal, Spain, France and Monaco, Italy, Malta, Bosnia-Herzegovina, Croatia, Slovenia, F.R. of Yugoslavia, Albania, Greece;
- the East: Turkey, Cyprus, Syria, Lebanon, Israel, Palestinian territories of Gaza, and the West Bank, Jordan;
- the South: Egypt, Libya, Tunisia, Algeria, Morocco.

Figure 1: Mediterranean Sea Basin

The countries of the Mediterranean basin cover 8,759 million km^2 and presently hold 427 million people. It is forecasted that the population of the northern Med Sea countries will reach to 196 million in 2025 whereas the population of the southern and eastern Med Sea countries will be 327 million within this period. The population living in the coastal regions of the basin will reach to 174 million by 2025 [7].

In the Mediterranean basin countries, fresh water is becoming scarcer and more unequally distributed. In numerous Mediterranean countries, water use is approaching the limit level of available resources. In 2000, 130 million people in the Mediterranean region were living in water stressed countries (less than 1,000 m^3/inhabitant/year) and 45 million people were living in water scarce countries (less than 500 m^3/inhabitant/year). 30 million people in the region do not have access to clean water, notably in the southern countries and the eastern region, and 27 million people do not have access to basic sanitation. According to estimates, the number of people living in the areas with water shortages will increase to 63 million by 2025 [8].

Climate change, the growing demand for water in agriculture and urban development, as well as the expanding tourism industry (300 million international tourist arrivals) have further aggravated the water stress in the region. Agriculture is the main water-consuming sector and accounts for 64% of total water demand: 45 % in the North and 82% in the South and East and is the main focus point of this study [9]. In Table 1, the basic data regarding the population, growth rate, gross domestic production (GDP), agricultural production and its share on GDP of the Med Sea countries are presented [10-14].

Table 1: Population and agricultural production [15]

Country	Population 2014	Population growth rate (%) 2000-2014	GDP per capita (USD) 2014	Total agricultural production (t/year) 2009	Agriculture, value added (% of GDP) 2014
Northern-rim					
Albania	2,893,654	-0.48	4,569	2,069,948	22.92
Croatia	4,238,389	-0.29	13,481	5,994,524	4.33
France	66,495,940	0.63	42,697	135,811,809	1.73
Greece	10,892,413	0.08	21,674	18,362,436	3.72
Italy	60,789,140	0.44	35,365	61,348,335	2.16
Slovenia	2,061,980	0.26	29,719	1,022,219	2.42
Spain	46,480,882	1.01	24,021	60,053,251	2.52

Southern-rim					
Algeria	38,934,334	1.57	5,484	16,273,341	11.09
Egypt	89,579,670	1.93	3,366	81,152,215	11.09
Israel	8,215,700	1.96	37,583	3,993,714	2.20
Jordan	7,416,083	3.05	4,831	2,235,666	3.78
Morocco	33,921,203	1.13	3,187	25,066,968	13.00
Tunisia	10,996,600	1.01	4,329	7,904,442	9.68
Turkey	77,523,788	1.46	10,304	104,746,734	8.01

Egypt and Morocco are the two leading countries, by which agricultural production plays a significant role in the overall GDP of the countries, followed by Turkey and Tunisia. Although equal important, the agricultural production has a lesser degree of importance for the other basin countries. Highest amount of production is realized in Turkey followed by Egypt, Italy and Spain.

Agricultural water demand differs in the basin. Whereas in all of the selected Eastern-Southern Med Sea countries the agriculture is the biggest consumer, industry and municipal demands plays also an important role in the Northern Med Sea countries as shown in Figure 2.

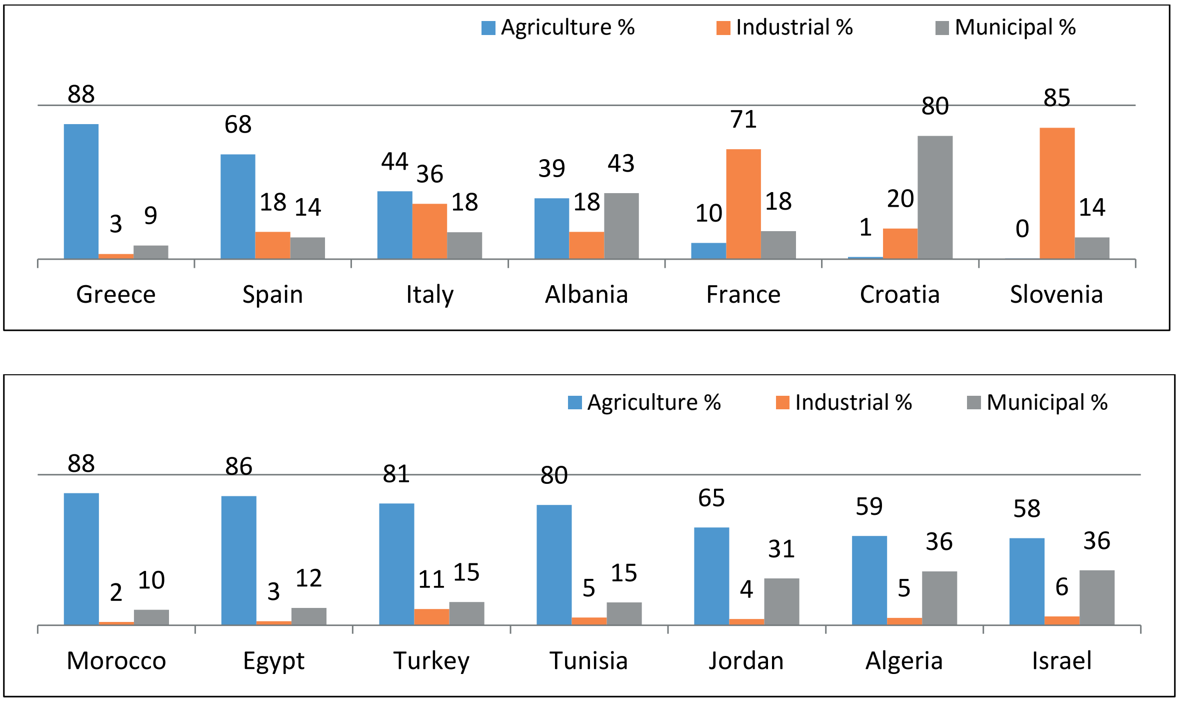

Figure 2: Sectoral water demand in Med Sea Basin Countries

Based on statistical data gathered from FAO data bases the ten most produced agricultural goods in the selected countries are calculated [15]. The water demand for these productions in terms of blue and green water shows that Egypt and Israel are the two countries, by which significant amount of irrigation water (70% and 35%, respectively) is supplied by blue water resources (Fig. 3).

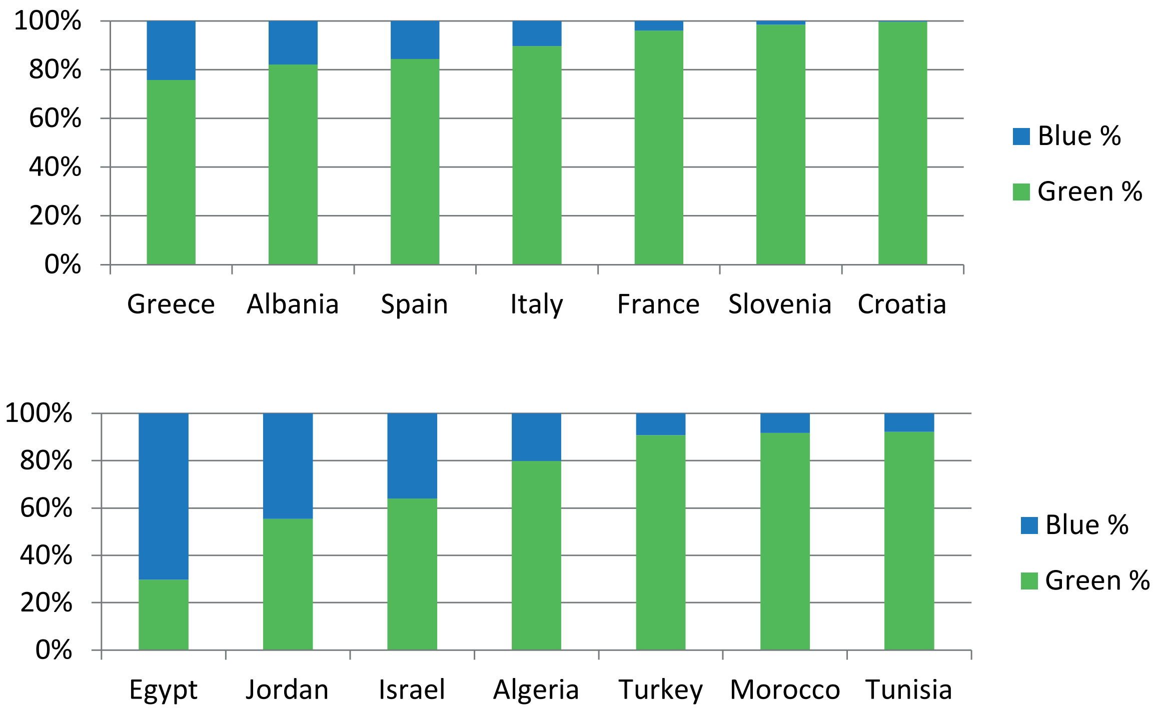

Figure 3: Water footprint of the ten most produced agricultural goods

3 Academic studies related to "water" in Med Sea Basin countries

In this study, a bibliometric analysis is conducted for the evaluation of the contribution of the scientific world of the selected countries to the water related problems of their respective countries. According to Pritchard (1969), bibliometric analysis is the application of mathematical and statistical methods to books and other media of communication. The bibliometric methods have been used commonly in many disciplines of science and engineering to study the scientific production and research trends [16-20]. Quantitative analysis and statistics were used to analyze distribution patterns of publications in a given topic, field, institute or country [21]. The Science Citation Index Expanded (SCI-Expanded) database from the Web of Science, the Thomson Reuters, was the most important and frequently used database for the bibliometric research to get a review of scientific accomplishment in many studying fields [22, 23]. Conventional bibliometric methods often evaluate the research trends by publication outputs of countries, research institutes, journals, research fields' analysis [24-25] as well as by citation analysis [26, 27].

The results of the survey with usage of 14 keywords conducted during the time period 1970-2016 are shown in Table 2. It is interesting that in countries, in which water scarcity and water stress is a common problem, the number of scientific publications are significantly behind the countries with almost no water problems. This methodology does not display the contribution of the scientific world comprehensively, as English is the only language of the publications covered and the contributions in country languages are not considered. On the other hand, the authors are the opinion that the publication numbers can reflect the trend of scientific research in the countries.

Table 2: Academic publications on water related topics 1970 - 2016

Keyword	WORLD total	Germany	Egypt	Jordan	Morocco	Tunisia	Turkey	Spain	France	Italy	Greece
Water resources	28,330	1,429	238	154	111	120	565	1,023	956	992	478
Water potential	10,777	510	49	7	40	86	103	983	711	554	126
Water management	17,711	1,182	100	65	43	67	192	773	700	683	283
Water scarcity	3,470	269	45	48	21	45	61	314	131	159	58
Water stress	21,583	1,081	219	24	95	169	393	1,766	1,302	1,083	191
Water quality	66,277	2,206	324	111	94	150	1,048	1,664	1,937	1,455	658
Water treatment	45,245	2,193	335	88	102	220	800	2,361	1,950	1,166	513
Wastewater	89,232	3,281	970	281	334	634	2,685	5,094	2,869	2,674	1,431
Wastewater treatment	36,398	1,636	283	113	89	193	827	2,248	1,428	1,239	612
Irrigation	75,138	2,895	813	302	336	472	2,009	4,180	2,272	2,671	1,053
Desalination	13,446	483	397	137	59	207	136	715	376	362	227
Climate change	145,769	1,2728	241	91	153	185	838	5,917	7,947	5,416	1,080
Food security	13,179	733	58	26	29	28	80	210	453	714	25
Water security	1,029	57	9	5	2	2	4	18	27	24	7

It is interesting that Germany will be affected from climate change relatively lighter than countries such as Egypt, Jordan and Turkey, but far more publications are conducted in Germany. Spain is another leading country in water related publications in the Med Sea Region.

4 Conclusions

Especially the eastern-southern Med Sea basin countries will be faced with serious problems in supplying the agricultural water demanded. In this study, using the WF methodology it is shown that in the eastern- southern rim countries of the Med Sea blue water is an important source for irrigation. In scope of the sustainable demand management it would be more favourable to meet the agricultural water demand with green water resources.

There are two alternatives: either to increase the amount of exploitable water or to decrease the agricultural WF. In the first case, it can be easily predicted that this alternative is coupled with increased costs and can lead to unforeseen environmental damages such as salt water intrusion etc. In mid-long term, the latter one is the more sustainable alternative, namely decreasing the agricultural WF while increasing the yields followed by replacing the water consuming plants with water saving ones and externalizing the water demand. The findings of this study indicate that WF methodology can help the decision makers for better allocation of scarce water resources in the Mediterranean Sea Basin countries.

An important outcome of this study is the fact that the contribution of the scientific world in the Eastern-Southern Med Sea Countries is significantly behind the water related problems which the countries have to face with.

5 Acknowledgements

The authors want to thank DAAD and the Exceed-Swindon Project that enabled the participation at this workshop.

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PASTURE LAND IN A DESERT AREA AT AL-KARAK PROVINCE/ JORDAN

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Keywords: Desert plants, Fodder, Pasture land, Jordan

Abstract

Evaluation of irrigation with treated wastewater at the initial stage of germination on biomass production for five desert plant species (*Strolled halimus, Achillea, Salsola vermiculite, Medical sativa* and *Sednaniasesban*) was done in a semiarid area at Karak, Jordan. Revegetation was done by using two methods; seeding and out planting nursery grown seeding and different irrigation schedule. The investigated season was a wet year with 309 mm of rain which was much higher than average long term amount of 227 mm. Therefore, the results of this work are applicable to wet years only. The biomass yield varied with plant species and irrigation program. The biomass for sites irrigated once every week ranged from 1.000 g/m^2, 1,050 g/m^2, 150 g/m^2 and 50 g/m^2 for sites without irrigation to 4,500 g/m^2, 2600 g/ m^2, 1,200 g/m^2 and 1,200 g/ m^2. In general, biomass increased with increasing frequency of irrigation. For out planting, the biomass at the end of the experiment was 325 g, 1,200 g, 1,500g, 1,250 g per each plant for *Achillea, Artemisia annua, Salsola vermiculit,e* and *gataf,* respectively. Irrigation at the initial stage of seeds germination increased the biomass production rather than using plantation

1 Introduction

Water scarcity in Jordan seriously affects the social and economic development of the country. Water availability per capita ranks among the lowest in the world and all renewable water resources of suitable quality are fully exploited. With an area of around 89,000 km^2 more than 90% are deserts with less than 100 mm rainfall. The deserts in Jordan are used mainly for livestock production which is raised mainly on natural grazing plains. The arid zone in Jordan covers about 560,000 ha east of a line from Mafraq in the north to Ma'an in the south, excluding the semi-humid and semi-arid zones. It includes most of the villages where settled owners keep their flocks during winter. In summary, most of the country's land is under the threat of aridity and desertification and hence the need for development programs to secure income and food production while sustaining land resources is crucial.

In Jordan, availability of desert plants plays an important role in the economy of nomad people. Whenever desert plants are available, their incomes of local people increase. Otherwise they ought to buy it from local market. Many studies were done to utilize desert areas for fodder production using the available wastewater produced from different sources. Rimawi et al. 2008 found that the wastewater produced from phosphate industries in Jordan can be utilized to produce wheat and barley in desert areas with rainfall less than 100 mm/year and their product was higher than using fresh water under the same conditions [1].

Jiries et al. 2009 used the slightly treated wastewater at Al-Lajjon disposal site to produce fodder. Four plant species (*Tamarix sativa, Medicago sativa, Pennisetum glaucum,* and *Atriple xhallimus*) were planted in the wastewater treatment plant site and they found that *Purpureum glaucum* showed the highest production as it was estimated to be 28.3 ton/ha and it was safe in terms of its pollutants content [2].

Revegetation in desert areas can be done by using two methods; seeding and out planting nursery grown seeding. On the one hand, the advantage of seeding is considered to be capable to cover a great area compared to planting in a nursery. However, planting in nursery decreases the uncertainty of germination in the field due to better care of the plant conditions than in the field [3]. The effectiveness can differ between these techniques and some species perform well with only one technique or the other [4]. One study concluded that seeding was more effective than planting in a moist study area [5], while three other studies, in moist and semiarid areas, concluded that out planting was far more effective [6-8]. Other studies in moist and semiarid areas concluded that out planting was far more effective.

There are many factors that promote germination of the seeds and enhance survival of out plants such as irrigation type [8]; methods of providing water such as direct application of water or gel materials that slowly release water [9]. The water quality used for irrigation also plays a role as treated wastewater is loaded with higher concentrations of nutrients than fresh water.

The aim of this work was to increase the quantity of these plants through using the available resources of treated wastewater in planting fodder only at the initial stage. Besides introducing new species, this might show better tolerance to the desert condition and the climate change impact in the region.

2 Experimental

Site Selection

For the site selection, several requirements were allocated for selection process of the experimental site that were:

- It must be arid or semi-arid with a rain fall less than 250 mm/year,
- Existence of some desert plants to be sure those plants can grow.

Based on the above criteria, the experimental site was constructed at Al-Ghweir area in Karak province about 30 km west of the main Qatrana – Al-Karak national road (Figure 1) at an elevation of 1,150 m above sea level, with a topography characterized by low to moderate relief with a very slight slope towards the east, drainage is ephemeral, wadies flow only in winter.

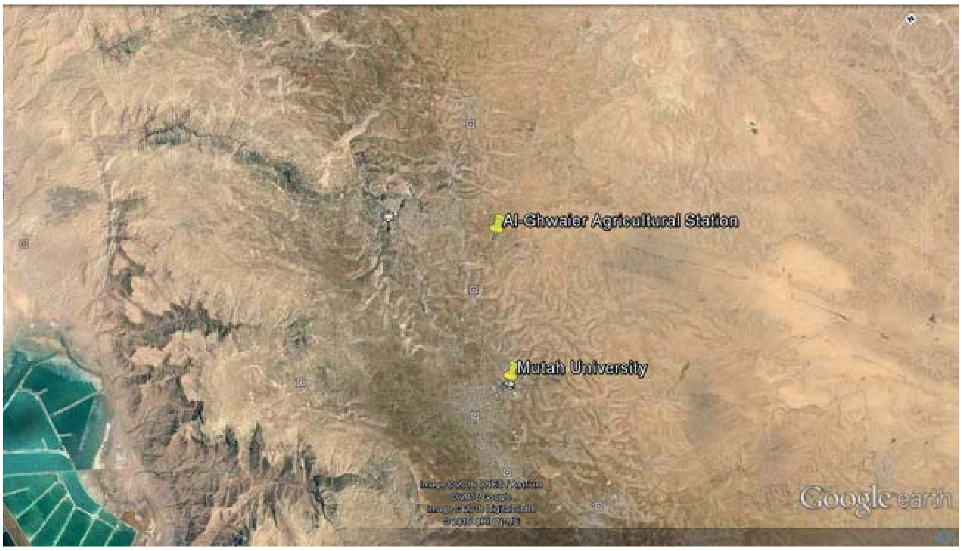

Figure 1: Location Map

Study area

The investigated site is a semi-arid area located in Karak province at the border of desert, which locates to the east of the investigation site.

The dominant climate of the study area is semi-arid to arid with a rainfall between 103 and 309 mm/year and an average value of 227 mm/year, receiving no precipitation between June and September. Majority of precipitation falls during January, February and March. Summers are hot and dry, high evaporation rates; sparse vegetation of cereal crops are grown in thicker soil areas. The long term average temperatures over the past ten years at the investigation site showed that the coldest month of the year was January with a mean value of 8.1 °C, and the hottest month was August with a mean value of 25 °C.

Site preparation

Pilot study was initiated on June 2015 by establishing two experimental fields. The first field was done for seeding, where sixty blocks were constructed for plantation of five different types of plants. Each plot was 4 m^2 (2 m x 2 m) by leveling the plot area and confined by 20 cm deep soil panel. Seeds of plant species used for this experiment were *Artemisia annua, Salsola vermiculite, Strolled haalimus, Sesbania sesban,* and *Medical sativa*.

The second experimental field was designed for out planting experiments. Four desert plant species were planted at the site after being germinated in an incubator for one year before being transferred to the site.

Irrigation

Treated wastewater from Mutah University wastewater treatment plant was used for irrigation. The tank was connected to both sites through an irrigation system. The amount of irrigation water was controlled at each time of irrigation to register the amount of irrigation water entering each plot.

For each of the five plant species, four irrigation treatments were applied for each plant species. The irrigation schedule for each plant species was irrigation once every week, irrigation once every two weeks, irrigation once every three weeks and without irrigation as control to reflect the natural conditions of the area for nine weeks only whereas after that it left for the natural conditions. The amount of irrigation water applied to each of the seed plot was 20 L/m^2 per irrigation and 30 L/m^2 per irrigation for out planting plots. The high amount of irrigation was to overcome soil dryness under the arid conditions.

For out planting experiments, the density of plantation was one plant per each square meter, while the seeds were spread at a rate of 3 g/m^2 in the plot.

Seeding Experiments

The seeding experiment started by the end of summer season 2015 by spreading the seeds from five plant species (*Salsola vermiculite, Strolled halimus, Achillea, Sesbania sesban, Medical sativa*) at a rate of 3 g/m^2. The seedlings were brought from Ministry of Agriculture plantation facility at Mafraq.

Out planting Experiments

Plants were grown for a year in 4 L (15 cm diameter and 20 cm height) plastic pots filled with 2:1 soil : organic potting soil in local greenhouses. Plants were one year old when out planted by the end of summer season 2015.

3 Results and Discussion

Soil

Soil texture of the investigated site was silty clay loam. The high percentages of clay and silt enhance the soil to retain higher moisture content due to high suction value of these fine particles which was clear in its high moisture content. The soil chemistry was investigated in all plot areas in order to have a better idea about nutrients added from treated wastewater and consumed by different plant species as the water used for irrigation was treated wastewater.

As the treated wastewater was used for irrigation, it is assumed that the important nutrients (N, P and K) must increase with successive irrigation. However, a decrease of K concentration was observed with increasing irrigation, although the irrigation water was rich in K content. This can be due to leaching of K ion from top soil to underlying soil profile.

Although the concentration of P was high in irrigation water, its concentration in soil was similar to that of K as highest concentration was found in sites without irrigation, and it was decreasing with increasing frequency of irrigation as the lowest value for all types of crops was at sites irrigated once every week.

Irrigation water quality

The used water for irrigating in the investigation fields was produced without tertiary treatment in order to retain the nutrients existing in the used wastewater. Statistical summary of the major ionic composition of used wastewater for irrigation is given in table 1. The results showed that all used wastewater was saline as the electrical conductivity ranged from 3,546 µS/cm to 3,970 µS/cm with an average value of 3,789 µS/cm.

The major cause of salinity is due halite which is used at household activities that the Na and Cl ions account for more than 50% of total salinity. The PO_4 was found to be relatively high ranging from 96 to 170 ppm with an average value of 133 ppm enhancing plant growth. For NH_4 the concentration is high ranging from 250 to 460 ppm with an average value of 321 ppm and the time was not sufficient to convert it to nitrates. However, the added NH_4 would improve soil nutrients content through irrigation.

Table 1: Ionic composition of the treated wastewater used for irrigation in the investigation site

Parameter	Min	Max	Average	Parameter	Min	Max	Average
Temp (^oC)	22.4	28.4	25.5	**NH_4^+(ppm)**	250	460	321
pH	6.52	8.92	7.9	**Cl^- (ppm)**	807	1,167	1,011
EC (µS/cm)	3,546	3,970	3,789	**F^- (ppm)**	ND	1.5	0.6
Na^+ (ppm)	493	1,093	729	**NO_3^-(ppm)**	ND	253	73
K^+ (ppm)	80	110	92	**SO_4^{-2}(ppm)**	105	182	153
Ca^{2+} (ppm)	65	99	82	**PO_4^3(ppm)**	96	170	133
Mg^{2+}(ppm)	61	82	71	**HCO_3(ppm)**	1,128	1,220	1,165

Soil Water Content

The soil water content was found to vary with time and frequency of irrigation. The most important factors that influenced the water content in the soil were the frequency of irrigation, amount of rainfall, and seasonal effects.

For the rainfall factor, the water content in soil was high after precipitation for all fields, decreasing from its field capacity of 34% descending gradually until reaching to less than 19% for fields irrigated once every week, around 12% for fields irrigated once every two weeks, and around 6% for fields irrigated once every three weeks. These values were variable with the seasons as it was lower during hot dry summer months and higher during cold winter months.

The investigated season (2015-2016) was a wet year as the total precipitation fallen on the site was 36% higher than the annual rate where 309 mm of rain fallen on the site during the running period of the experiment. Most of the rain was fallen during January 2016 as 43% of the rainfall was recorded during this month. Therefore, the result of this work can be applicable to wet years only and not for every year, and it is expected to have higher seeds growth due to higher water content of the soil.

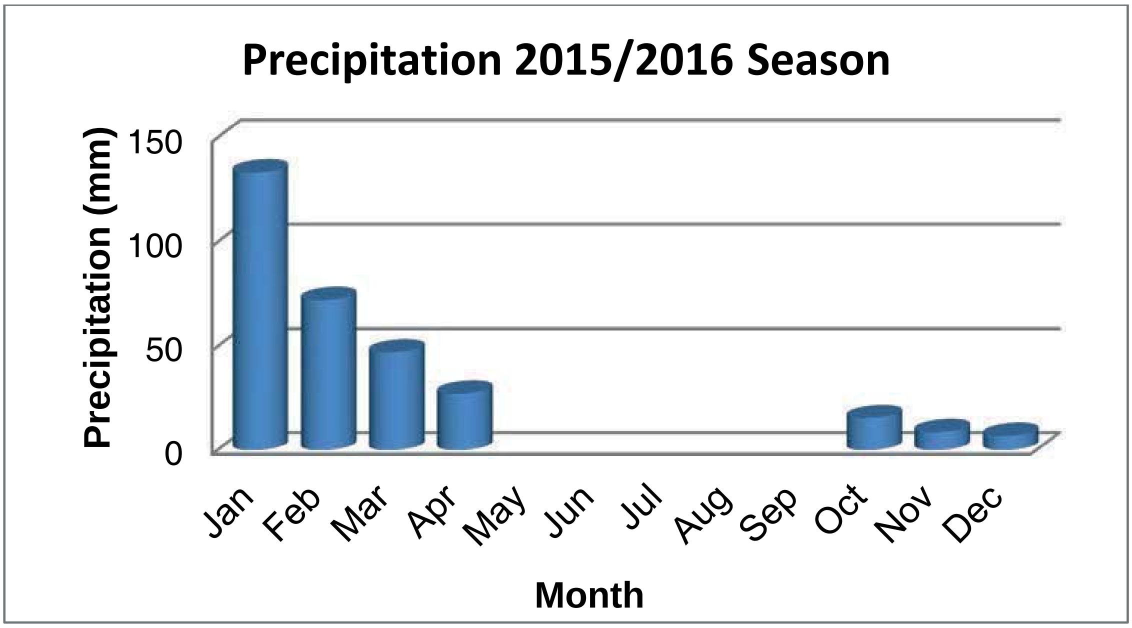

Figure 2: Accumulative monthly amount of precipitation fallen on the investigation site during the investigation period of the experiment.

Biomass

The results of the biomass collected from each treatment plots at the end of the experimental period of one year for the five plant species (*Salsola vermiculite, Strolled halimus, Achillea, Sesbania sesban* and *Medicago sativa*) *from seeding experiments* are given in table 2.

The results indicates that for all plant species there was an increase in biomass quantities with increasing amount of irrigation frequency.

The biomass yield was different for each plant species. Under natural conditions of no irrigation the yield was 1100g/m^2, 1050 g/$m^{2,}$ 1000 g/m^2 150 g/$m^2$and 50 g/m^2 increasing *with increasing frequency as it reached 3100* g/m^2, *2500* g/m^2, 1200 g/m^2, 1200 g/m^2 and 4500 g/m^2 at irrigation frequency once every week for *Salsola vermiculite, Strolled halimus, Medical sativa, Achillea, and Sesbania sesban, respectively.*

Table 2: Biomass collected from seeding plots at the end of the experimental period for different irrigation schedules

Frequency of Irrigation	*Salsola vermiculite*	*Strolled halimus*	*Achillea*	*Sesbania sesban*	*Medical sativa*
One week	3,100	2,600	1,200	1,200	4,500
Two weeks	2,300	2,500	1,000	650	3,200
Three weeks	1,900	2,000	700	100	2,600
No irrigation	1,100	1,050	150	50	1,000

Parallel to the seeding experiments, plantation with similar plant species was done in a nursery for one year and then transferred to the site. Plants were treated the same way irrigation schedule as the seeding plots The biomass for each plant is shown in table 3 at the end of the experimental period of one year; it was 325 g, 1,200 g, 1,500 g, and 1,250 g per each plant for *Achillea, Artemisia annua, Salsola vermiculite* and *Strolled halimus(Atriplex),* respectively.

Table 3: Average biomass per plant for sites using nursery plantation method

Plant species	Biomass in gram/plant
Achillea	325
Artemisia annua	1,200
Salsola vermiculite	1,500
Strolled halimus (Atriplex)	1,250

The results showed that by using the same amount of water plantation in a nursery would give lower yield than seeding site as the number of plants was higher in seeding site than plantation in a nursery site. The size of the plants using nursery method was much bigger than nursery site and it is expected after full growth of the seeding plants the yield would be much higher than what is reported here. Therefore, it is recommended to use seeding method rather than nursery method.

The results of this study are not in accordance with other studies done elsewhere. In Sonoran desert, USA with 190 mm of rainfall, and Colorado Plateau in Arizona/USA with rainfall of 160 mm/year out planting was found to be more effective in establishing range of native perennial species than seeding [6, 8] .