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State of the Environment in Jordan and Management Options: Case Study

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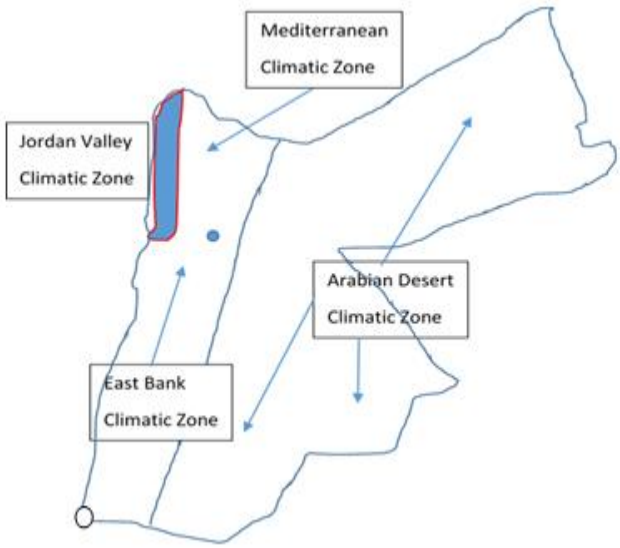
Abstract: ***In this paper, the most important components of the Jordanian environment will be discussed the challenges it faces, and suggest ways to preserve it to remain honorable for current and future generations. Water is the most important environmental component and represents the greatest environmental challenge for Jordan, which suffers from a severe scarcity of water resources making Jordan the second-lowest country in water availability per capita worldwide. Water scarcity is one of the biggest challenges to sustainable development in Jordan. Wastewater pollution accompanied by lack of proper administration is further reasons for limiting the availability of usable water. Depletion of groundwater represents another challenge impacting the quantity and quality of most groundwater sources. Emphasis should be concentrated on the conservation of water, reclamation of wastewater, agriculturally productive land, and the quality of air, of which, the contamination or loss of them would bring rapid and significant improvement or deterioration to Jordan.***

Keywords: Environmental components of Jordan, water scarcity, pollution. Wastewater, Bio-solids

1. Introduction

Jordan's total land area is 88.78 thousand km^2, three-fourths of which is desert receiving ≤ 200 mm/year of rain. From the middle of the last century until now, the population of Jordan was affected by many aspects including, demographic, political, economic and forced migrations from neighboring countries. The forced migration flows have brought more than 2.9 million people during the previous five decades, raising the country's population to more than ten million people. The number of people currently living in the country is estimated at 10.61 million in 2020, 91.5 % of which is urban (9.33 million people). The population is expected to reach 10.84 million, 11.12 million. and 11.84 Mio. In coming years 2025, 2030 and 2035, respectively [DoS, 2021].

Jordan's climate derives its characteristics from its geographical location between the dry climate of the Arab desert in the eastern and southern regions and the semi-humid climate of the eastern Mediterranean region. Despite its small area, Jordan embraces many different climates, which makes it rich in biological and environmental diversity. Jordan includes four main geographic and climatic regions [Abu-Sharar, 2006]: the continental climate that prevails in the interior regions, the dry climate in the southeastern desert region, the Jordan valley climate, and the Mediterranean climate in the highlands and western region. Jordan has a desert climate that prevails in 75 % percent of its area, where the weather is hot and dry in summer and mild to cold in winter with a very low precipitation rate of about (50-100) mm/year. A tropical dry climate prevails in the Jordan Valley with a hot summer and mild winter. Most of Jordan's area is located within the arid climatic classification which covers 95% of the total entire area. This arid climatic zone is characterized by a dry and hot climate and low precipitation rates in winter, while the semi-arid classified region stretches over 4.7% of the country's territory with a hot climate and low to medium precipitation in winter.



Zone	% of tot. Area	Precip. mm/a
Semi-humid	0.7	500 – 640
Semi-arid	3.3	300 – 500
Marginal	2.2	200 – 300
Arid	22.3	100 – 200
Desert	71.5	≤ 100

Figure 1: Jordan's Climatic zones, coverage, and annual precipitation [JMD].

The Mediterranean climate covers only 0.3% of the total area of Jordan. This region is characterized by mild to warm temperatures, rainy winters, and dry and hot summers. The average annual precipitation varies between 638 mm per year in the northern highlands, to less than 50 mm per year in Aqaba in the south and in the eastern and southern desert.95% of the total rain fall occurs from November-March70% of which is between December to February. Winter temperatures drop to record 2°C-5°C in the northern highlands and 2°C-7°C in the dry areas of the south, east,

and Jordan Valley. Average summer temperatures range between 18 and 25 °C in the highlands, while summer temperatures reach 40 °C in the Badia Badia and Jordan Valley [JMD].

The predominating high temperatures and low humidity in Jordan result in an extremely high evaporation rate over the region. The long-term average evaporation rate exceeded80-82% of precipitation over the entire area of Jordan. Potential evaporation ranges from 1600 mm/a in the northern highlands to more than 4000 mm/a in the southern and eastern desert regions. According to 50 years of records, the rainfall rate is between 100-500 mm. The evaporation rate constitutes about 90% of the total rainfall. The infiltration rate is approximately 4-10% [JMD].

In order to explain Jordan's environment precisely and demonstrate its challenges, it is necessary to highlight the components of Jordan's environment separately and show the best ways to deal with these challenges to alleviate their effects, particularly water shortages, wastewater, and solid waste and agricultural land.

Water resources and scarcity

As Jordan's population continues to rise, the difference between supply and urgent demand for water will continue to expand exponentially. The per capita water supply will decrease from 145 m^3/year to only 91 m^3/year by year, placing Jordan in the category of arid regions characterized by absolute water shortage. Based on per capita share, most experts consider countries with per capita water production of less than 1, 000 cubic meters per year to be water-poor countries [UNICEF, 2021], while Jordan's per capita share does not exceed 12% of this figure. Jordan may face a serious and chronic water crisis caused by a number of natural and human factors. Due to the arid and semi-arid climatic conditions prevailing in most parts of the country and the frequency of dry periods during most of the year, the available water resources are very limited and it is difficult to replenish them. In addition, the rapid population growth, industrial and agricultural development, and the expansion of infrastructure projects increase the demand for available water resources in a way that exceeds what the country can offer.

The high temperatures and the temporal and spatial changes in rainfall patterns that characterize the prevailing climate in most Jordan regions exacerbate the water scarcity problem and may lead to a deteriorating health situation and delay development. The water scarcity in Jordan is due to limited surface and groundwater resources and the low annual precipitation rates. The desert climate accounts for about 80 % of Jordan's area, which is characterized by aridity with long-term rainfall that does not exceed 50-100 mm/year, and evaporation rates of up to 93% of rainfall. In addition, excessive pumping of groundwater from renewable and non-renewable basins leads to a decline in its quality and accelerates depletion.

The water supply in Jordan depends mainly on the resources located at considerable distances from consumers. Consequently, the water sector consumes energy extensively by operating large water pumping, boosting, treatment, and distribution facilities. In 2014, the power requirement for water pumping amounted to about 15 % of the total power production of Jordan, which relies predominantly on imported fossil fuels with a significant impact on the environment [MWI, 2016a].

1.1 Surface water resources

Jordan's surface water reserves include rivers, springs, and the flow of some valleys in the rainy winter, as well as flood waters in the winter. The total amount of surface water is estimated at 713 million cubic meters located in 15 surface water basins. The surface water reserves in Jordan depend mainly on rainfall over the country's territory. In addition, some water enters Jordan through cross-border Rivers. Treated wastewater constitutes about 18% of the total available surface water.

Table 1: Average annual rainfall rates, evaporation, groundwater recharge rates and flood rates in (MCM) /a for the period 2007-2017 [MWI, 2016a]

year	Aver. annual Precipitation	Long-term Rate of rainfall	Evaporation rate	Groundwater Recharge rate	Floods share
2006/2017	7480.36	8224.63	6976.45 ≈ 93%	326.54 ≈ 4.26%	176.72 ≈2.36 %

Table (1) clearly confirms the limited Jordanian water resources in general and explains the imbalance of the water equation. As most of the annual rain evaporates (93 %) again, causing a significant loss of the water balance, only 4.36 % infiltrates into the ground to equalize the soil moisture, and a small part may reach the groundwater after a while. The portion that appears in the form of surface run-off or floods, its percentage does not 2.36 2.36 % of the total annual rainfall.

It is true that surface water resources are limited and cannot be developed or increased, but the biggest challenge facing surface water is pollution. The Zarqa River, the main tributary of the King Talal Dam, is polluted with industrial waste and receives wastewater from four sewage treatment plants discharging into it (Khirbet al-Samra, Jrash, Suchna, and Baqa) [Al-Omari et al.2019). As for the Jordan River, it is very saline because all the springs of salt water are diverted around the Sea of Galilee to it. The Yarmouk River is a shared river between Syria and Jordan, although its water quality is currently in an acceptable condition, it may change due to the discharge of sewage water from the Ramtha treatment plant to it.

1.2 Groundwater resources

The Jordanian groundwater exists in 12 underground water basins, ten of which are renewable and two are non-renewable .The extracted amount is about 620 MCM/year, while the amount of safe yield is estimated at 424 MCM/year, which means an over-pumping rate of about 150% from all basins is occurring. All basins experience

over-extraction rates ranging from 20%,-365%. Jordan's groundwater resources are generally, of good quality, however, there are many potential sources of groundwater contamination. Industrial and municipal wastes, excessive use of pesticides and chemical fertilizers in agriculture, over-pumping far beyond the safe yield, and the intrusion of saline water and the content of septic tanks in certain aquifers are just examples. These discouraging statistics about the state of the groundwater basins and the experienced decline year after year, cause the drying up of the main water layers in the northern regions and their salinization in other regions [Odeh et al.2019). Declining groundwater levels and increasing the depth of unsaturated areas as a direct result of over-extraction will have serious environmental, economic, and operational consequences for Jordan. Pumping water from deep basins requires more energy to raise water and therefore higher operating costs. Moreover, existing groundwater wells must be deepened in some cases, rising lines need to be extended and pumps should be replaced with more powerful pumps to adapt to lower depths. In some cases and due to excessive salinization of water, the operation has to be stopped [Radaideh, 2022). According to the reports of the MWI [MWI, 2020], Jordan will be able to meet the urgent demands for water by a maximum of 81% for the years 2022-2025, due to the limited available water, making a deficit of 19% between what is required and what is available.

Water scarcity in Jordan is a chronic problem and will remain so in the coming years. If the water resources are not better managed and the current domestic, agricultural and industrial water consumption practices improved, the water supply in Jordan will be exhausted in both quantity and quality in the very near future. Maintaining a balance between supply and demand has been a serious challenge in recent years, and may become even more difficult in the future. The durability of surface water sources cannot be assured due to geopolitical reasons and to the variability of annual precipitation, which can be made worse by climate change. Renewable groundwater is overexploited and in the medium term depends on erratic rainfall. Deep and saline fossil resources are also at risk of deterioration in the medium to long term and will be completely depleted within several years. In short, water resources will suffer so severely that the balance between supply and demand becomes increasingly negative and will be difficult to adjust. In addition, it should be noted that the most important challenge facing water supply and may contribute to the aggravation of the water situation is climate change. Climate change raises the potential for low precipitation, increase temperatures, and potential evaporation, which lead to poor recharge of water resources, reduced surface water reserves, and causes soil degradation. Consequences of climate change effects are: it could accelerate desertification rates, worsen future conditions, and deteriorate agricultural productivity.

2. Non-Conventional Water Resources

In the past five decades, Jordan has made great efforts to conserve its limited water resources by providing and exploiting non-conventional water supplies to deal with the demands of agriculture. However, several challenges have still to be defeated in terms of wastewater treatment and reuse such as scientific, public acceptance, institutional and legal aspects. Several monitoring programs for domestic wastewater were conducted according to Jordanian standard JS 893/2006 to examine the wastewater quality produced and its suitability for reuse. Data from these monitoring programs provide information about the reclaimed water quality and ensure its safety for irrigation.

Given the constant shortage of water resources, Jordan has seriously practiced the use of treated wastewater for irrigation purposes. According to the National Water Strategy 2016-2025 [MWI 2016a), Jordan is one of the countries that use the most treated wastewater in the region, with reuse rates reaching about 91%, most of which is for agricultural uses. From an environmental point of view, the experience of farmers with regard to the use of treated wastewater for irrigation of crops has not been positive. Where farmers have shown many negative effects of using treated wastewater in agriculture; As a disturbance in the quality of the soil and a decrease in the agricultural production of citrus trees, this was directly reflected in their inability to meet the export market and the international standards required for product quality. Farmers also demanded their urgent need to provide better and reliable information to help them choose suitable crops for sewage irrigation.

Treated wastewater according to international standards is mixed with freshwater in storage tanks and then used in agriculture. In 2020, over 146MCM of treated wastewater was used for irrigation, representing about a quarter of all water used for irrigation in Jordan. However, wastewater reuse can also be risky for human health and crop consumers as wastewater can contain enteric viruses, pathogenic bacteria and protozoa. Some chemical wastewater components, such as nitrogen, and phosphorus, may have negative effects water resources and the surrounding environment. Other constituents such as suspended solids, high salt levels loads, can be disadvantageous for agricultural soils and irrigation installations.

3. Balancing supply and demand

Water use in Jordan targets three different main sectors: agriculture, municipal, and industry. Agriculture is by far the largest user of the country's water resources, accounting for roughly 51% of the total water supply, while 45% goes to municipal uses, and 4% goes to industry. Recent trends appeared a rapid increase in the water consumption for municipal use. The data indicate that municipal water consumption increased by an average of 8% per year while it ranged 6.6% and 3% within the industrial and agricultural sectors respectively. This fact has resulted from both the increasing population in the urban areas and the greater water requirements due to raised standards of living and accelerated development in agriculture, industry, and urbanization. Increases are expected to continue in the future as urban populations get higher and consequently claim more water to meet needs. The domestic water supply in the Jordanian communities is generally intermittent. Water is delivered once a week in big cities like Amman, Zarqa, and

Irbid, and once every twelve days in some rural areas. The recorded average consumption per capita in the municipal sector reaches 118 l/day in 2020 compared to 147 and 145 l/day/capita in 2010 and 2011 respectively [MWI 2020).

In the case of domestic (urban) use, over three-quarters of all water supply is groundwater based, about 50 % of which originates from non-renewable deep fossil sources. Industrial water use is about 4.4 percent of overall water consumption, mainly coming from groundwater sources.

4. Water quality

Water quality and suitability for different uses pose a major challenge to the water sector. The severe scarcity of water in Jordan necessitates great efforts to conserve every drop of water. Apart from the chronic shortage of water resources, pollution is one of the main reasons limiting the availability of usable water for different purposes. Jordan should do more to protect its available water resources through the implementation of water quality monitoring programs and according to their results to meet the right decisions required to protect these sources.

Pollution of water resources is attributed to high population growth, agricultural activities, industrialization, and arid to semiarid climate. Combined, these factors help the wastewater access water sources, leading to their pollution. In towns and villages of Jordan, lacking public sanitation services, discharges of wastewater from septic tanks and cesspools infiltrating into the groundwater escalates the pollution problems. This increases the pressure on the water resources by deteriorating their quality such as salinity, nitrogenous compounds, sulfates, phosphates, and organic materials content.

For the assessment of water quality in Jordan, instantaneous samples were taken from different water sources by a comprehensive study conducted in 2016-2017 [MoEnv 2018). The Jordanian Standard for Drinking Water 286/ 2015 [JMS 286/2015) was used as a basic reference to evaluate the physical and chemical properties, in addition to the microbiological criteria for the quality of raw water for drinking water purposes.

Table 2: Monitored water quality parameters [MoEnv 2018).

Quality Parameter	Maximum	Minimum
TDS mg/L	1417	194
TH mg/L	861	23
$NO3^-$ mg/L	46	<1.0
$SO4^{-2}$ mg/L	605	9
TCC #/100 mL	1.6E+04	<1.8
E. coli MPN/100 mL	5.9E+2	<1.8

JS 286/2015 for Drinking water: TCC: <1.1, E. coli: <1.1, TDS: <1000, TH: <500, NO3: <50, SO4: <500

4.1 Microbial contamination

The microbiological contamination of spring water was studied over a five-year period in several locations in Jordan [MoEnv.2020]. The results of the water analysis carried out on the spring water confirmed the positive presence of Escherichia coli (E. coli) micro species. Results indicate that the concentration of E. Coli in water was influenced by natural and anthropogenic sources, and announce that all studied wells and springs were contaminated as indicated in (table 3). Point and non-point pollution of springs caused mainly by agricultural activities and wastewater discharges from widespread cesspits and septic tanks. Springs located near residential areas have been affected by wastewater disposal more than other springs. These springs are fed directly by wastewater effluents through fractures, joints, faults, and cracks of sandstone aquifers.

4.2 Levels of electrical conductivity measurements (EC)

The electrical conductivity (EC) of water is a thermo-physical character of surface water and an important indicator of water quality and in determining its suitability for use. The EC has a linear relationship with Total Dissolved Solids (TDS), which in turn indicates the increased concentration of sulfates and other ions. Therefore, the monitored value of EC indirectly indicates the level of pollution in surface waters. Moreover, measurement of EC is much easier than direct measurement of TDS, thus showing an easier path for pollution monitoring in shallow surface waters. Measurements of TDS in water can be converted to EC values (Conductivity = TDS ÷ conversion factor). Fig.2 shows values of EC measurements is some dams in Jordan.

As shown in Fig.2, results of electrical conductivity measurements made for water samples in several dams in the country show that EC-values are fluctuating among locations and are less than 1000 µS/cm, except that of King Talal dam where EC values > 2000 µS/cm were recorded. A convincing explanation for this phenomenon may lie in the fact that the King Talal dam mainly feeds on water from the Khirbet Essamra plant, the largest treatment plant in Jordan.

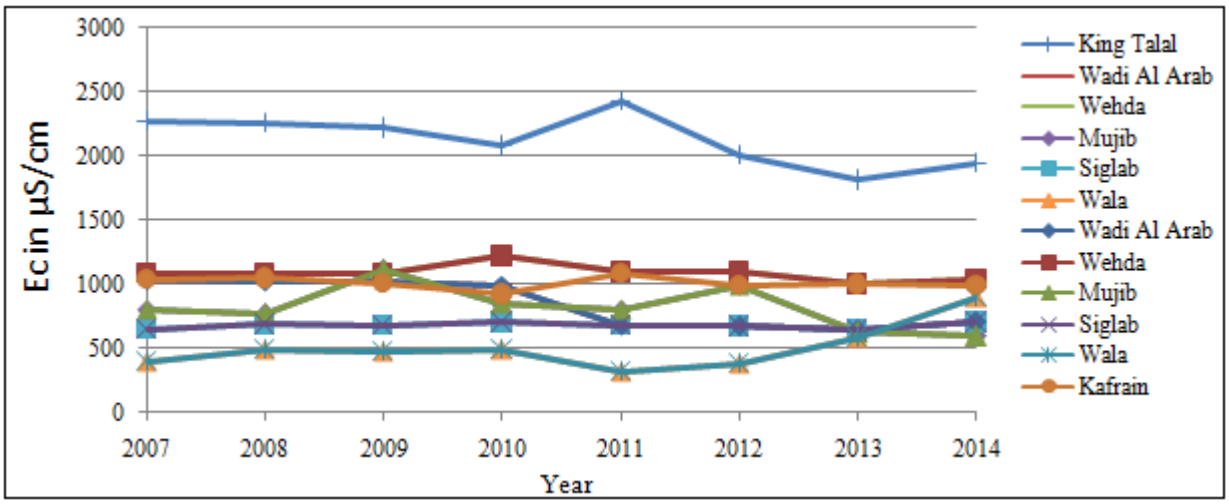


Figure 2: EC in µS/cm measurements as monitored in different dams in 2007 – 2018 [MoEnv.2020]

4.3 Heavy metals in Jordan's water sources

Batayneh [Batayneh, 2010] has studied heavy metal content in water springs of the Yarmouk basin, and confirmed that this basin in the north of Jordan is contaminated with heavy metals that might affect human health as well as the health of the ecosystem. In addition, another study [Alomary, 2012) has determined trace metals in drinking water in Irbid (Jordan), and results showed that the level of most elements determined (As, Ba, Cd, Pb, Cr, Cu, Fe, Zn, Mn, Ni, and Se) was within the Jordanian and WHO standards for drinking water.

5. Wastewater/ Problems and challenges

Approximate 65% of the population in Jordan is served by public sewerage systems. It is a common practice to discharge untreated sewage either to bodies of water or to agricultural land and to conventional centralized systems (septic tanks). These septic tanks, if not lined properly, may leak into the groundwater aquifers and contaminate them, causing significant health and economic risks.

It can be said that all forms of wastewater treatment systems have been practiced in Jordan, but the problem with these treatment technologies is that they lack efficiency and sustainability. Many operated treatment systems are not successful and therefore unsustainable, since they were simply copied from Western treatment systems without considering the appropriateness of the technology for the type of wastewater generated, culture, land, and climate. Many of the implemented installations are abandoned due to the high cost of running the system and repairs [DWA, 2019).

The characteristics of wastewater in Jordan are very different from other countries in terms of salinity and biological load. The average salinity of the municipal water supply (580ppm) of total dissolved solids and the average domestic water consumption is very low, around 130 liters per capita per day. This results in very high organic loads and higher than normal salinity in wastewater. For example, compared to the United States and Europe, domestic wastewater in Jordan is concentrated up to five times higher for oxygen demand per volume of wastewater. This is extremely high requires too much energy to treat and stabilize and may cause a large amount of sludge production. In addition, high organic loads impose operational problems where the plants are biologically overloaded with only a portion of their hydraulic loads [MoEnv, 2018]. The wastewater problem in Jordan faces many challenges:

Rehabilitation of old and damaged sewage networks remains a major problem. Ineffective treatment processes also lead to an increase in the nutrient content, especially nitrogen and phosphorous, in the water leaving the plants, which leads to eutrophication problems in the receiving water bodies such as the formation of algal blooms on the surface of King Talal Dam (KTD). The lack of maintenance in wastewater treatment plants due to financial and operational constraints, eads to insufficient treatment in some industrial facilities, and consequently, the poor quality of liquid waste. A lot of funding is needed to enhance the efficiency of the domestic and industrial wastewater treatment plants and even in building new ones, which puts additional financial burdens on the government. There is an accumulation of large quantities of biological residues (sludge) in wastewater treatment plants. Although there is a Jordanian standard for the quality of treated sludge for reuse in agriculture, there are many social and religious restrictions that prevent the reuse of this sludge. Plant loading and sludge characteristics are the main factors affecting the efficiency of its uses. Overloading (hydraulic/biologically) of treatment plants, deteriorates wastewater quality and produces unpleasant odors. This situation leads to an increase in the retention time of the wastewater inside the treatment plant or the generation of treated wastewater but it does not comply with the Jordanian standards for chemical and organic testing. Most of the detergents used in Jordan are solid and thus reduce the efficiency of wastewater treatment plants. The effect of these detergents is toxicity, environmental impact and interference in processing processes. Solid detergents may impair the aerobic function of ponds by a factor of three and sludge digestion can be reduced in anaerobic ponds. The best solution to the problem of hard detergents is to use soft detergents (biodegradable). Regarding the detailed microbial examinations of Escherichia coli bacteria for the treatment plants, the results showed that the non-conforming samples were 53.9% and not more than the parasite tests. For non-sewage areas, the main problem of uncollected sewage is its

collection in septic tanks and transport to treatment plants or dumping sites. This puts a lot of pressure on the treatment plants, from a hydraulic and biological point of view, which ultimately affects the quality of the outlet [UNDP, Jordan 2019).

Treatment of wastewater should be focused on producing effluents of a quality for reuse in irrigation that meets requirements of JS893/2006as a minimum. The transfer of advanced wastewater treatment technologies is to be endorsed and encouraged. However, appropriate wastewater treatment technologies shall be selected with due consideration to operation and maintenance costs and energy savings, in addition to their efficiency in attaining and sustaining quality standards [MWI, 2016b). Priority shall be given to agricultural reuse of treated effluent for unrestricted irrigation. The dilution of treated wastewater with fresh water shall be made to improve quality where possible. Crops to be irrigated by the treated effluent or blend thereof with freshwater resources shall be selected to suit the irrigation water, soil type and chemistry, and the economics of the reuse operations. Wastewater treatment plants located near groundwater and surface-water resources will affect water quality and soil properties in several ways.

Although the agricultural sector in Jordan has been using treated water for decades and the coverage rate is about 91% of the total generated water, the direct use of TWW is still not common in Jordan. In social terms, wastewater has major impacts on public health, as most rural areas lack public sanitation. Improper treatment of wastewater will adversely affect the surrounding environment and the aesthetic aspect. Proper planning is essentially recommended of how this water resource will be used, information exchange, and guidance for farmers on how to use wastewater. This appears crucial and important for the water sector and in increasing the use of fresh water for supplying the population and improving water security for other sectors.

6. Sludge and bio-solids

Sludge is the solid organic matter formed during the treatment process of wastewater and consists mainly from solids accumulated at the bottom of the treatment ponds, and the microorganisms that have led to the degradation of the organic matter in the wastewater. According to Jordanian Standard JS 5411/6002, for sludge resulting from domestic wastewater treatment, sludge is divided into: Wet materials resulting from domestic wastewater treatment processes with a solids content ranging from 50% to 98%. Dry materials resulting from domestic waste water treatment processes, with moisture content exceeding 10%. Sludge treatment (primary and secondary) aims at reducing its size, completing the processing of the remaining organic matter, as well as the biomass that constitutes the largest proportion of the total sludge components, in order to convert it into inactive and stable elements. The appropriate processes for the sludge treatment and disposal option depend on the properties of the sludge. The process of sludge production must be monitored because the prolonged improper disposal of untreated sludge can damage humans and the environment, especially land and water sources. The process of dealing with untreated sludge is an increasing challenge, especially with the increasing number of purification plants in Jordan

The total amount of sludge generated from all treatment plants is estimated at 5000 CM/day. Of the 38 wastewater treatment plants (WWTPs) in Jordan, the largest is the Al-Samra plant, which treats about 60 percent of the total wastewater generated in the country. Only two plants, Al-Samra and Wadi Al-Shalala, use sludge as an energy source. None of the other 36 wastewater treatment plants implement an appropriate sludge management plan (SMP). Sludge from these plants is being treated either by sludge stacking within plant boundaries or transported to open solid waste landfills, ignoring that the accumulated sludge is a major source of health and environment and can contribute to greenhouse gas (GHG) emissions. As such, the challenge is to shift the focus to using sludge as an alternative energy source and means to combat desertification rather than a harmful product that is being disposed of [JS 962, 2011).

7. Solid Waste Issue

Municipal Solid Waste (MSW) is solid and semi-solid materials produced by households, as well as other waste similar in nature and composition resulting from any activity (commerce, offices, public institutions, etc.) and not included in the definition of harmful and hazardous waste. Solid waste in Jordan is legally controlled through Environment Protection Law No.52 of 2006 and related regulations which set the direct responsibilities of the Ministry of Environment and sets overarching principles for environmental protection. The issue of solid waste became one of the major environmental problems in Jordan, which has been aggravated over the past 15 years by the sharp increase in the volume of waste generated as well as qualitative changes in its composition. Jordan produces 2.5 Million tons/year of municipal solid waste, 2740 tons of medical waste, and 45 thousand tons of hazardous industrial waste. The average generation rate is about 0.99kg/cap/day in urban areas and 0.87kg/cap/day in rural areas, while collection coverage is estimated at 90% and 70% for urban and rural areas respectively.

There are currently 23 landfills in Jordan, including a hazardous waste landfill in the Swaqa in the Amman area. While there is an improvement in the collection of solid waste ranging between 70-90%, the waste management in Jordan still lacks proper environmental procedures. The absence of suitable infrastructure for these landfills, except for the landfill Ghabawi, which is under the management of the Greater Amman Municipality.

A large part of the waste, such as spent mineral oils and lead acid batteries, is also recycled and transported to the hazardous waste treatment/recovery center. The predominant fraction in Jordanian MSW is organic matter which makes up as much as 50-60 percent of the solid waste stream, and the percentage of recyclable plastics is 53%. The current Solid Waste Management (SWM) services within the local municipalities are no longer of the same standard as that prior to the massive influx of refugees and the daily generation rate of MSW has dramatically increased by more

than 50% of the capacity of the dumping sites. The solid waste issue in Jordan is faced with many challenges:

1) The amount of waste generated in Jordan is constantly increasing, due to the increase in the population, especially due to refugees flux, and its effect on changing the content and quality of waste and raising its quantities to increase by more than 50% of the capacity of the dumping sites. An increase in the amount of collected waste to approximately 58% for the period between (2000-2013) is observed. The collected solid waste amount rises from (1.3-2.5) million tons/ yr, i. e. between 286-393 kg/capita. This quantity is expected to increase to 420 kg/capita in the near future due to the increase in population and changes in consumption patterns.
2) The lack of adequate policies and strategies for waste management in Jordan. Currently, there is no specific legal framework or national strategy for solid waste management in Jordan.
3) Municipalities lack enough funds to setup modern waste collection infrastructures, recycling facilities, waste disposal systems, and waste-to-energy plants. Source segregation is not being practiced in the country. Rather, mixed waste is being collected and diverted daily to the closest unsanitary landfills and/or open dumping sites without any treatment. Recycling practices, both formal and informal, are at the early stages due to a lack of trained manpower, funds, and modern machinery. Only 5-10% of Jordan's solid waste is being recycled.
4) Al Ghabawi landfill is the largest final disposal site (FDS) in Jordan operated by (Greater Amman Municipality) and is the only engineered sanitary landfill that receives 50% of the total solid waste in Jordan. The rest 17 dumping sites spread over Jordan are dumpsites of variable and non – sanitary conditions and disposal practices.

8. Agriculture/lands

The most important challenges that the agricultural sector in Jordan is suffering from are; the accelerated urbanization expansion on agricultural lands, the limited water resources due to the lack of rain, its fluctuation and the irregularity of its distribution, the varying amounts of available water due to frequent droughts, and the increasing problem of climate change, which leads to desertification.

In the Jordanian agricultural sector, about one million people from the rural population find work; however, the agricultural land areas do not exceed 10% of the total area of Jordan. About 65% of Jordan's water goes to agriculture, 90% of which is concentrated in vegetables, despite that, the Jordanian agricultural sector contributes only about 2% to 3% of the country's gross domestic product.

Agricultural lands in Jordan do not exceed 6% of its total area and are dependent upon rainfall and the availability of irrigation. Agricultural lands are continually being lost due to urban expansion, soil erosion, and pollution from the overuse of fertilizers, pesticides, and various types of insecticides. Areas lost during the second half of this century were estimated at 25% of the total agricultural lands [UNEP] . In addition, the agricultural land of Jordan suffers from deterioration of quality due to many factors such as lack of precipitation, repeated drought-periods, and waves of refugees [Abu-Sharar, 2006]. The phenomenon of desertification is one of the most dangerous environmental problems that threaten agricultural lands in Jordan. According to the United Nations Environment Program [UNEP] , the annual production value lost in developing countries due to desertification is estimated at $16 – $50 billion every year.

The Jordanian Ministry of Agriculture estimated the annual average number of forest fires and fire attacks at 800, as a result of which more than 31 thousand trees were damaged, and more than 6000 dunums were destroyed. Annually 5, 000 trees are cut down. Increased soil salinity and erosion, and overgrazing contribute to reducing the number of trees. This negatively affects the climate and leads to an increase in desertification and a decrease in soil productivity.

One of the biggest challenges facing agricultural lands is plastic materials that farmers use to cover seedlings immediately after planting to protect them from weather changes and to preserve the soil moisture, thus accelerating their growth. There is no enough information or specific guidance on how farmers can dispose of these plastic materials in safely. It is often left in the ground where it ruptures and break down into small pieces and mixes with the soil, altering its properties and texture. Sometimes being piled up and carried away or be attached to weeds and shrubs for a very long time, especially since it is not biodegradable under normal weather conditions. These substances contribute to the deterioration of soil fertility, reduction of product quality, and contribute death of livestock and plants. Although there are no accurate figures for the quantities of plastic used in the agricultural sector, estimates in the Jordan Valley indicate that the current agricultural needs about 100, 000 tons of plastic in addition to hundreds of thousands of tons that are used in open and covered agriculture, or as sterilization covers.

9. Conclusions

The Jordanian environment is described as fragile, its elements are depleted, and exploited in an unsustainable way, and its condition has reached a dangerous level in terms of exploitation and pollution making it difficult to find effective solutions to save or even conserve it. Initiatives to encourage efficient use of scarce natural resources will significantly contribute to reducing environmental problems and represent an opportunity to achieve sustainability.

Agriculture is the predominant consumer of Jordan's water resources. Strategic planning should be directed to wastewater as a reliable and trusted water resource for agriculture, at the same time ensuring that high-quality water is used effectively.

Pollution and lack of proper administration are further challenges for the Jordanian environment. Wastewater should be properly collected and treated. Greater efforts should be given to the generated bio-solids at treatment plants regarding the collection, treatment, and safe disposal.

The Ministry of Environment sets waste management plans and policies in the Kingdom in partnership with the competent authorities. The various municipalities in Jordan are responsible for collecting, transporting, and disposing of solid waste, with the help of joint service councils that manage solid waste dumps, and in some cases private contractors to transport waste. However, the role of municipalities and local authorities in other aspects of environmental resource protection is still limited, and this may be attributed to the weak ability of most of them to plan medium and long-term and interact with local economic and social development programs.

Environmental issues constitute one of the topics that Jordanian researchers address in their various types of research; however, the degree of linkage between environmental scientific research topics and national priorities still needs to be strengthened, in addition to finding institutional mechanisms to employ research results in the service of environmental policy and decision-makers.

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