Evaluation of the Quality of Irrigated Soil by Wastewater in Taiz City, Yemen

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Abstract:

A field study was conducted for soil which was irrigated by partially treated and untreated sewage in the Surroundings of Taiz City. The study aims at evaluating the level of degradation on agricultural soil in the study area as a result of the wastewater application. Four samples of soils have been collected from four different sites within the areas of Al-Qurf, Al-Hawajalah, Al-Buraihy and Hidran Al-Dabab, in addition to a control sample of soil from agricultural land irrigated only from seasonal rainwater at Mafraq Sharab. The results of mechanical analysis of the soil showed that the soil texture at the four different sites varied from one location to another. For instance, at Al-Qurf and al-Hawjalah areas, the soil texture was found to be Silt-Loam, whereas at Al-Buraihy and Hidran Al Dabab, the soil texture was clay, while the soil texture in Mafraq Sharab was loam. The results of the chemical analysis of the soil samples indicate that the soil irrigated from partially treated and untreated wastewater compared to the irrigated soil of rainwater was most affected by the high level of salinity and the calcium carbonate ratio. In addition, the chemical and heavy metals elements contents of the soil are high which is probably accumulated in soil over several years. This suggests an action of rapid treatment of land where salinity has accumulated significantly through soil rehabilitation, including soil tillage mixed with limited quantities of gypsum and soil leach with fresh, low-salty water, and thus soil cultivation with barley or sorghum yield and rotation of freshwater and treated wastewater irrigation.

Keywords: Taiz city, Irrigated Soil, Quality, Treated Sewage, Untreated.

تقييم نوعية التربة المروية بمياه الصرف الصحي في ضواحي مدينة تعز.

الملخص

نفذت دراسة ميدانية من ترب الأراضي الزراعية في ضواحي مدينة تعز التي تروى من مياه الصرف الصحي المعالجة جزئيا وغير المعالجة. تهدف الدراسة إلى تقييم مستوى تدهور التربة الزراعية نتيجة لاستخدام مياه الصرف الصحي في منطقة الدراسة. لقد تم جمع أربع عينات من الترب في أربعة مواقع تتضمن مناطق القرف، الحوجلة، البريهي، حذران الضباب، بالإضافة إلى عينة تربة كشاهد من الأراضي الزراعية المروية بمياه الأمطار في مفرق شرعب. أظهرت نتائج التحاليل الميكانيكية للتربة أن قوام الترب في المناطق المختلة تفاوتت من موقع لأخر. مثلا، مناطق القرف والحوجلة تبين أن قوام التربة سلتي غريني، أما في البريهي وحذران الضباب فقوام التربة طيني، بينما قوام التربة في مفرق شرعب فهو غريني. بينت الدراسة أن الأراضي التي تروى من مياه الصرف الصحي المعالجة جزئيا وغير المعالجة بالمقارنة مع التربة المروية من مياه الإمطار كان غالب تأثرها بارتفاع مستوى الملوحة وكذا نسبة كربونات الكالسيوم بالإضافة إلى محتوى الترب من بعض العناصر الكبرى والثقيلة والتي قد تتراكم في التربة خلال عدة سنوات. وتم اقتراح معالجة سريعة للأراضي التي تراكمت فيها الملوحة، بإعادة التأهيل للتربة من خلال إجراءات تشمل حرث للتربة وخلطها بكميات محددة من الجبس وغسل للتربة بمياه عذبة قليلة الملوحة، وبالتالي زراعة التربة بمحصول الشعيرة أو الذرة الرفيعة، إضافة إلى المناوبة في الري بالمياه العذبة ومياه الصرف الصحي المعالجة.

الكلمات الافتتاحية : مدينة تعز، التربة المروية، نوعية، مياه المجاري المعالجة، مياه المجاري غير المعالجة.

1.Introduction:

It is natural that the quantity of wastewater is steadily increasing as a result of population growth and urbanization increase in cities, and the expansion of water and sanitation services in Yemeni cities. The current estimates of the daily flow water supply to municipal treatment plants in the main cities in Yemen are about 200 thousand cubic meters. These amounts of wastewater constitute about 4 to 5% of the total annual groundwater consumption in the Republic of Yemen, which is estimated at 4325 million cubic meters, according to the Ministry of Planning and International Cooperation [1]. In Yemen, wastewater collection, treatment and reuse are weak or absent. There should be an institutional policy framework for the treatment of wastewater for reuse which will be based on guidance on the most cost-effective technologies for wastewater treatment and treated wastewater use in agriculture. Wastewater uses are common in the surrounding Yemeni cities by pumping directly to the farms from the manholes in the trunk line or the use of partially treated effluents in many major cities. Hence, the use of untreated or partially treated sewage as it is the case in the surroundings of Taiz city, without having guideline controls that effects on the agricultural crops and on the farmers as well as the consumer's use of irrigated crops. In addition to that controlling pollution and soil degradation is happened as result of the reuse of wastewater for a period of time. Soil which is irrigated by treated wastewater is unsuitable for many crops especially fruits and vegetables, because this soil will be accumulated with chemical elements and nutrients over times that have poisonous effects. These substances may be transmitted to humans by eating these crops as food chain [2]. The harmful side of untreated wastewater is the toxic effects on the environment, agriculture, and biological life as a whole and this is the conclusion of the studies of many researchers [3,4, 5,and 6]. Despite the negative potential consequence, wastewater stream have also multiple benefits. These include: reliable and continuous source as a water resource not being influenced by rainfall, as additional non-conventional source of nutrients (N, P), and reducing costs of fertilizing [7]. Treated wastewater from domestic use is used for irrigation of fodder, food and wood production in agro-agro forestry systems requiring secondary wastewater treatment, with the advantage of reducing soil organic matter [8]. In the light of the above stated advantages and disadvantages of wastewater, in order to ensure the farmers health and consumers of agricultural crops. Wastewater must be treated before used

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in irrigating crops in order to avoid health and environmental hazards. In addition to adopt plans to reduce agricultural soil degradation and make it suitable and viable land for the beneficial exploitation of both humans and animals.

2.Objectives:

The objectives of this paper is to investigate the mechanical and chemical properties of the study area, Evaluate the level of degradation in agricultural soil as a result of the wastewater irrigation and to suggest plans and recommendations to address the current situation.

3. The Study Area:

This study carried out in four different sites of wastewater irrigated soil, located within the Central and AL-Hawban regions in the surroundings of Taiz City. The areas includes Al- Qurf, Hidran Al -Dabab, Al Hawjalah and Al-Buriahy in addition to Mafraq Sharaab as a control site as shown in (Fig. 1).

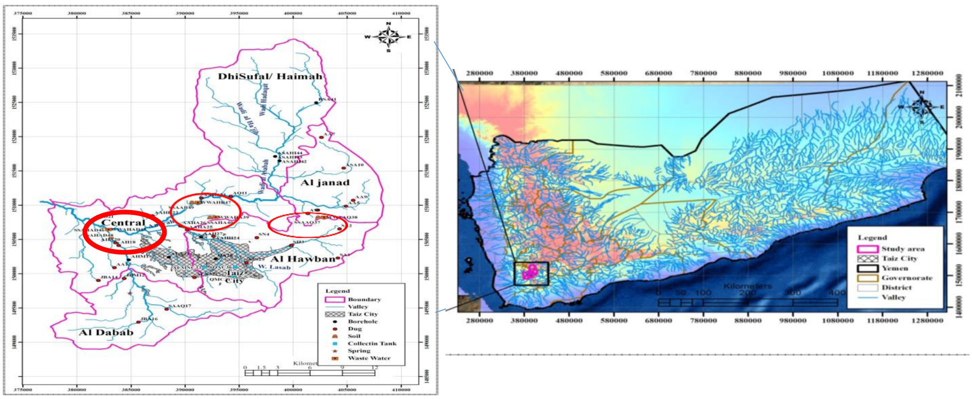

Figure 1: Locations of study area

4. Methodology of the Study:

The study includes the following steps:

1. Field visits of the study area and the Laboratory of Agricultural Research Authority to collect preliminary data.
2. Five soil samples were collected from (Al Qurf, Al- Hawjalah,, Hidran Al-Dabab, Mafraq Sharaab and Al- Buraihy) as shown in photos 1 and 2 as the specific soil sampling sites and subjected to mechanical and chemical

analysis. The samples were taken from the surface and at a depth of 30 cm, according to [9].

Photo 1: Al- Hawjalah soil sample location of the study area

Photo 2: Al- Buraihy soil sample location of the study area

4.1. Analytical Techniques of Soil Samples:

Soil analyses were carried out in the Laboratory of Agricultural Research Authority, and at the laboratory of Central Health / Taiz governorate. Due to the limitation of the time and security situation in the study area, only one sample is collected.

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4.1.1. Mechanical Analysis of Soil:

According to the standard methods APHA, [10] . Five soil samples were subjected to mechanical: Soil mechanical analysis is to determine the percentage of the aggregates of the primary particles in the soil sample. There include sand, salt and clay. This is called the particle- size distribution of soil. It is considered a relatively fixed feature and has been taken as a basis for soil assessment in many countries of the world. In order to estimate the percentage of the primary particle's groups in the soil sample, the following steps should be followed:

1. Processing the soil sample: After collecting the soil sample from the field and bringing it to the laboratory, the following steps were carried out:

   a. Air drying.

   b. Crushing the sample to get rid of large blocks and impurities.

   c. Sieve the sample through a diameter sieve of 2 mm holes for fine soil.

2. Deactivation of cementing agents of soil particles which are found in the form of aggregates linked to each other by cementing agents such as organic matter, calcium carbonate, iron oxides, aluminum and dissolved solids.
3. Differentiation of the soil particles: The process of differentiation is to complete the process of separating the particles from each other and maintain their survival in individual forms using one of the salts of sodium and the using of mechanical differentiation at the same time.
4. Separation of the primary particles and measuring their proportion: Each size particle is separated from other soil particles in several ways. The most important method of sedimentation depends on the speed of the fall of particles in suspense and its relationship to particle sizes, this theoretical basis depends on the law of Stokes as shown by the following relationship;

$$v = \frac{2}{9}\frac{g\, r^2 (\rho_s - \rho_l)}{\eta}$$

V - The speed of falling soil granules in the middle (cm/sec).

g - Earth gravity wheel (980 cm/s)

r ,- Granular radius- ρ_s - Solid granular density(g/cm)

ρ_l - Density of liquid or water (gm. /cm).

η - Liquid viscosity (gm./cm/sec) .

The results are determined by calculating the percentage of the aggregate of the primary soil: Sands, Clay and Silt. Consequently this will enable us to know the soil texture throw using triangle of texture.

4.1.2. Soil water Extraction:

The soil samples extracted by addition volume distilled water to a specific weight of soil 15-1 ,1-. The saturation of extracts is used to determine the Salt, Cation, Anion and heavy metal in the soil. In the preparation work of extracting soil samples the ratio of water to soil must be known because the variation of the analysis result may lead to variation in an involved extracted of component and consequently lead to difficultly of comparing the results with other results[11].

4.2. Chemical Analysis of soil

4.2.1. Hydrogen Ion Concentration (pH)

According to the standard methods APHA [10]. pH- meter (211- Micro process pH meter) was used in situ to measure the pH of extract soil samples. The pH meter was calibrated prior to using samples measure by buffer solutions of pH 4 and 7.

4.2.2 Electrical Conductivity (EC)

The electrical conductivity (EC) of Extract soil samples were measured directly by using the conductivity meter (WTW521). Electrical conductivity was calibrated before using samples measure by measuring the electrical conductivity of potassium chloride solution.

4.2.3. Total Dissolved Solid (TDS)

Total dissolved Solids (TDS) were calculated from the summation of Cations and Anions concentration which was estimated from the EC values of extract soil samples according to the following equation [10]:

$$TDS\ (mg/l) = 0.65 \times EC\ (\mu s/cm)$$

4.2.4. Calcium Carbonate (CaCO3):

According to USSLS [11], Calcium carbonate was estimate for five soils by using Acid Neutralization method, through weighing of 2gm of soft soil dry aerobically and the addition of hydrochloric acid by 0.5 N and heated in the flask, transfer the contents to the filter paper and receive the filtrate contains and add to it 2- 3 Phenol naphthalene guide and filtrate Sodium Hydroxide

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until the color changes to red and pink.

$$CaCO3\% = \frac{(\text{milli equivalent of total Acid add - milli equivalent of Sodium Hydroxide}) \times \text{milli equivalent of calcium carbonate} \times 100}{\text{Weight of soil (gm)} \times 1000}$$

4.2.5. Organic Matter Determination of Soil (O.M):

According to NRC [12] Walkley- Black method was used to estimate organic matter in the soil samples, by oxidation of organic matter to add size potassium bicarbonate that is known to increase the oxidation of organic matter in the presence of sulfuric acid and then estimated the remaining quantity of potassium bicarbonate that not include antioxidants organic matter by ferrous sulfate.

$$\text{Organic Carbon \%} = \frac{H1- H2 \times N \times 0.336}{\text{Weight of soil (gm).}}$$

$$\text{Organic Matter} = 1.72 \times \text{Organic Carbon \%}$$

4.2.6. Total Nitrogen in Soil (N):

The sum of the process of digestion takes place in two stages, oxidation of organic matter and reduction of nitrogen to ammonium and then it is measured according to principle Kjeldahl method that relies on converting organic nitrogen and nitrate in the soil to ammonium sulfate, where the sample is then digested. Distillation of ammonia resulting from digestion by adding Caustic soda and receives in Boric acid, and then calibrated by acid hydrochloric [13].

$$\text{Total N \%} = \text{Volume acid}_{(sample)} - \text{Volume acid}_{(blank)} \times \text{Titer acid} \times 14 \times 250 \times 100$$

4.2.7. Phosphor in the soil (P)

According to Jackson, [13] Phosphor measured by digesting sample of soil acids and the transfer of dissolved phosphorus to the image, followed by discretionary chromatically and measured on a spectrometer at a wave length 480 ml. micron.

4.2.8. Potassium in the soil (k):

Potassium is determined by using flame photometer (Jenway Model pep7, UK) through extracted potassium from the soil by ammonium acetate.

4.2.9. Trace elements:

Trace elements (Pb, Zn, and CO) of Extract soil samples were determined by using Atomic Absorption Spectrophotometer (AAS).

5. Results and Discussion

Soil texture is one of the main criteria for the identification of different soils and an important indicator of soil fertility and moisture maintenance. The soil texture in the study area is described according to the results of the laboratory Analysis shown in the table (1). The soil texture was found in the areas of Al-Qurf and Al-Hawajla, are Silt- loam. This texture is considered to be of an average medium for water storage capacity and soil moisture, in addition to the ability to hold nutrients, and to supply the plants with low elements. In the areas of Hidran Al-Dabab and Al-Buraihy, the soil texture is clay that is characterized with this type of soils that keep water between the granules for a long time, in addition to the ability to hold nutrients and to supply the plant with high elements.

Table 1: Mechanical analysis of soil samples in the study area

Sample NO.	Site Name	Type of soil / Type of water	Depth (cm)	Particle Size distribution%			Texture class	Locations		No. Irrigation/ year.
				Sand	silt	clay		Longitude (E)	Latitude (N)	
1	AL-Qurf	Untreated	30	34	50	16	Silt- Loam	402870	1508233	30
2	Al -Hawjalah	Untreated	30.	26	52	22	Silt- Loam	392853	1508200	25
3	Hidran Al -Dabab	Partially treated	30	18	40	42	clay	382910	1506451	25
4	Al-Buraihy	Partially treated	30	22	26	42	clay	391186	1510399	25
5	Mafraq Sharab	Rain water	30	50	34	16	loam	383722	1505308	------

In the area of Mafraq Sharaab, the soil texture is loam, and it is characterized by its retention of water for a period of time, it has the ability to maintain a medium degree of nutrients and to supply the plant with the same elements [14]. The results of the chemical analysis' of soil are shown in table (2). As for pH, this is an important indicator of fertility in soil. This fact of pH is negatively affects the possibility of plant utilization of many nutrients, especially phosphorus and some minor elements. The pH of the soil samples at the sites of Al-Qurf and Al-Hawjalah showed a clear variation in values.

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In Al-Qurf site, the value of pH is within the alkali range 7.6, whereas the soil sample in the Al-Hawajalah site is within the acid range 5.7. The first site is irrigated with sewage from Nadfood Factories in Al-Hawban Taiz, which contains mostly salts and semi-neutral organic compounds. The second site is directly discharged from municipal sewerage system of Taiz city, whose wastewaters are municipal. The low pH value may be due to the multiplicity of municipal wastewater sources, including acid compounds resulting from Hospitals and Photography Centers, etc., and by wastewater treatment products directly occurring in agricultural soils that convert sulfur compounds to sulfuric acid and then a decrease of the value pH in Al-Hawjalah site. Therefore, the amount of lime that is needed to correct a soil acidity problem is affected by a number of factors, including soil pH, texture, structure and amount of organic matter [15]. While the pH values of the soil samples at the Hidran Al-Dabab, Al- Buraihy and Mafraq Sharab sites were 8.80, 8.45 and 8.73, respectively, within the alkali range. These results are

Table 2: Chemical analysis in soils samples in the study area

sample NO	Site Name	Elements / Type of Water	Depth (cm)	PH value	EC (mS/m)	TDS .mg/l	Caco 3%	O) (%M.	Total %N	Avail p mg/kg	Avail K mg/kg	.No Irrigation/ year
1	AL-Qurf	untreated	30	7.57	2.320	1508	12.6	5.40	0.38	105	424.8	30
2	Al-Hawjalah	untreated	30	5.68	8.180	5317	9.6	5.66	0.38	195	465.6	25
3	Hidran Al-Dabab	Partially treated	30	8.45	13.730	8924.5	25.9	2.34	0.38	24	104.88	25
4	Al-Buraihy	Partially treated	30	8.73	3.030	1969.5	30.3	3.12	0.05	72	387.6	25
5	Mafraq Sharab	Rain water	30	8.88	0.350	227	13.3	0.23	0.112	5	92.52	------

Consistent with the results of studies [16 and 17] that a decrease in acidity in soil irrigated with wastewater in the soils is irrigated with well water. This means that irrigation with partially treated wastewater did not directly affect the value of this indicator as the case for the pH value of the site Mafraq Sharab irrigated by rainwater (Fig.2).

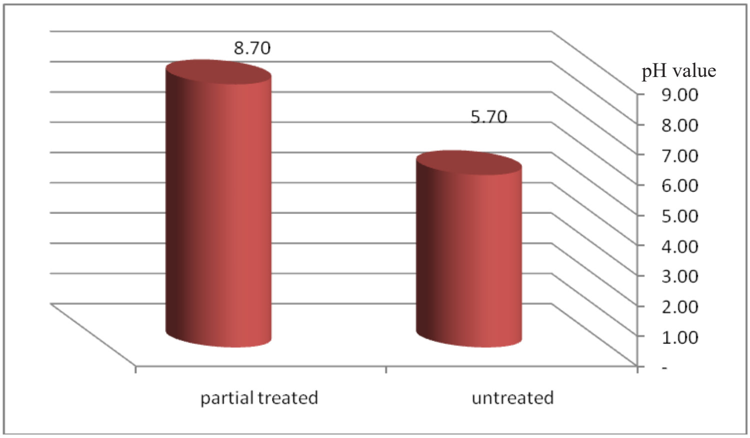

Figure 2: pH value comparison between untreated and partially treated wastewater pollution

As for the degree of electrical conductivity (EC) of the soil sample shows a clear indicator of the total dissolved solids in the soil. According to the Classification of the American Center for the Study of Salt land, the soil that has an electrical conductivity (EC) between 0 to 2 mS /m has low content of salts [18]. As for the degree of electrical conductivity (EC) which is a reflection of the level of soil salinity in the study area. The salinity varied from one location to another, whereas the soil sample that was irrigated from untreated industrial wastewater in the site of Al-Qurf is 2.320 mS/ m, which means that this value within the high salinity range. However this decrease in the electrical conductivity in the Al-Qurf soil is explained by the fact that the electrical conductivity of the wastewater discharged from the treatment plant is 2.970 mS/ m. Whereas the electrical conductivity of wastewater from the treatment plant Al-Buraihy is 6.860 mS/ m[19], and then increased significantly to reach 8.180 mS / m in the irrigated soil sample of untreated municipal wastewater at Al-Hawajalah site. This very high value of electrical conductivity at the Al-Hawjalah site indicate that the soil also receives a high quantity of the suspended solids, oil mineral fats, and grease, That contributes to bridging the gap between soil particles, which accumulate salts on the surface and thus impedes the movement of salts in the soil, and the continuation of irrigation by untreated wastewater for a long years. The sample of the partially treated wastewater irrigated soil at the Hidran Al-Dabab site contains the highest level of electrical conductivity, which is 13.730 mS / m, Although this water is treated at Al -Buraihy Lagoons, However, it is noticed that the level of accumulation of the electrical conductivity in the

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site of Hidran Al-Dabab is could be attributable the strength of the heavy soil by increasing the clay content, that impedes the process of leaching the soil and the movement of the salts. In addition to this, the process of evaporation caused by the flow of water about 10 km after treatment at the treatment plant till the arrival area of Al-Multaqa in Hidran Al-Dabab .In the soil sample of the Mafraq Sharab, the electrical conductivity (EC) decreased to 0.350 mS / m, indicating that the electrical conductivity is within the low salinity level because the irrigated water to this site is dependent on rainfall. Salinity again increased in the irrigated soil sample from partially treated wastewater at Al- Buraihy site to reach 3.030 mS /m .The increase in salinity at the site may be due to the nature of the soil, which consists of clay, which impede the movement of salts and the leaching process of the soil, as well as the continued reuse of wastewater for a long time without stopping between irrigation or the reuse of partially treated sewage and other fresh water, (Fig.3).

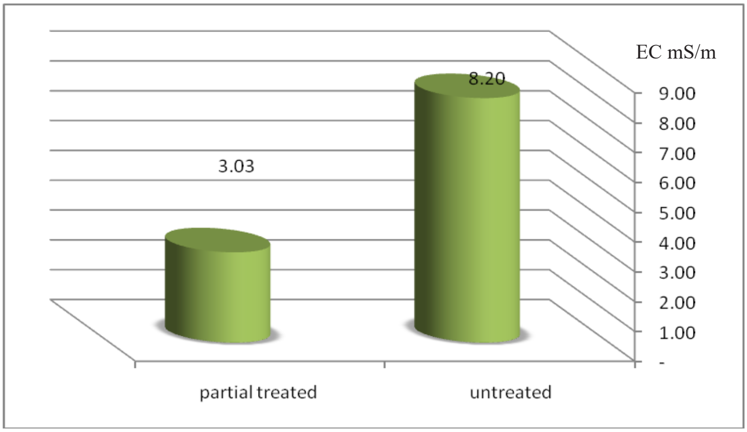

Figure 3: EC mS/m. Comparison between untreated and partially Treated wastewater pollution

These results are consistent with the results of studies [1] and [17] that treated wastewater contains high concentrations of salts. Chemical analyses results in the Central Region of Taiz city and its surroundings showed that the soil content of Calcium carbonate varies from one location to another in the study area. The content of Calcium Carbonate ranged from low at the site of Al-Hawjalah, the soil content of Calcium Carbonate was 9.6%, and the irrigation of untreated wastewater did not affect the carbonate content of the soil. In contras, there was a decrease in this indicator in the soil irrigated by sewage for many years. This is confirmed the results of the study [1] that the soil content of calcium carbonate decreased in the soil irrigated with wastewater for ten years compared to the soil irrigated groundwater in the Valley of Maitam in Ibb. It was increased in the soil of the sites of ALQurf and Mafraq Sharab to 12.6% and 13.3% respectively. In general, the effect of irrigation by sewage water is weak and does not show its effect in the long term. This is confirmed by the ratio of Calcium Carbonate to the two sites referred to previously as Al-Qurf and Mafraq Sharab. Although the Al-Qurf is irrigated by the wastewater, the Mafraq Shraab is irrigated only by rainwater. In the sites of Hidran Al-Dabab and Al-Buraihy were relatively high in Calcium Carbonate to 25.9 and 30.3 respectively, (Fig.4). This increase in Calcium Carbonate content in both sites may be due to the origin of the soil, which is rich in Calcium Carbonate.

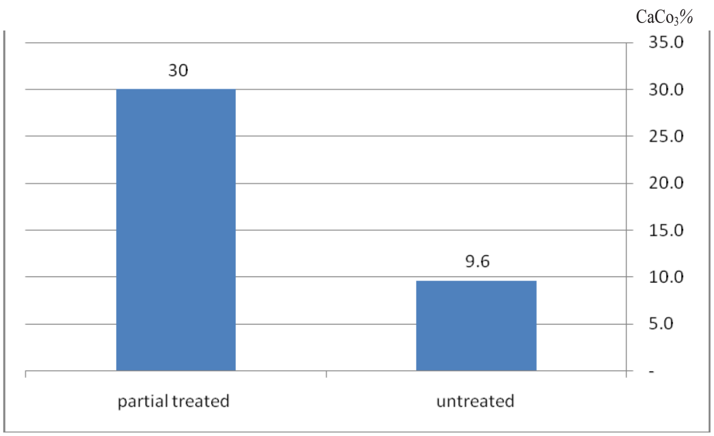

Figure 4: CaCo3% Comparison between untreated and partially treated wastewater pollution

In addition, the sites of Hidran Al- Dabab and Al-Buraihy have been irrigated by wastewater since the 1990s. The soil content of the organic matter (O.M), which is of great importance, as the main source of nutrients supply to the plant and also increasing the soil› ability to retain moisture. The soil fertility rate in the study area showed that the sites of Al-Qurf and Al-Hawjalah were very high and it reached 5.40% and 5.66% respectively. This increase is due to the fact that the untreated wastewater irrigated the agricultural soil in both sites contains high organic matter, which resulted in a high level of irrigated soils by untreated waste water. In addition, the two sites are used to grow the crop of alfalfa, and thus increasing the organic matter content in the agricultural soil. As for Hidran Al-Dabab, the soil content of organic matter decreased to 2.34 % compared with the sites of Al-Qurf and Al-Hawjalah.

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This discrepancy is due to the increasing of the salinity in the soil of the Hidran Al-Dabab site. This led to reduction of organic matter as a result of decomposition and degradation into less complicated compounds. While the organic matter content at Al-Buraihy site improved slightly by 3.12%, possibly due to the cultivation of alfalfa at this site, this increases the soil organic matter content, despite the high salinity at the site, (Fig.5). These results are consistent with the results of studies [1] and [17] that treated wastewater leads to higher soil content of organic matter and thus increase its ability to retain a large a mount of water for a longer period, improving soil properties and increase the productivity of agricultural crops. At the Mafraq Sharab site, the soil organic matter content was very low, to 0.23%, this was due to the fact that the site was cultivated during rainy seasons. In addition, the site was almost deserted, and therefore the level of organic matter is low.

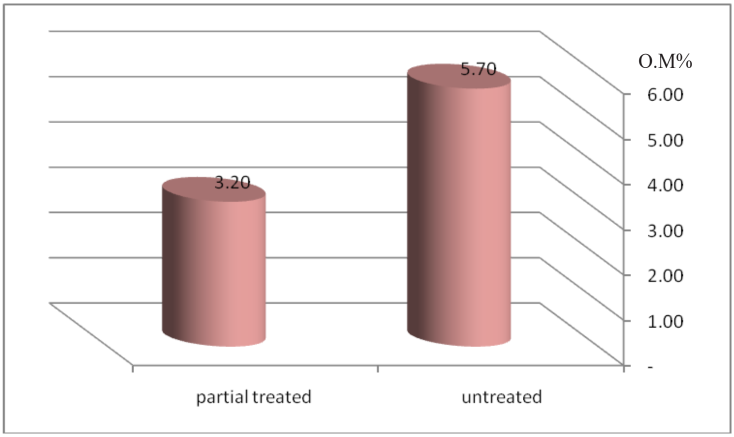

Figure 5: O.M% comparison between untreated and partially treated wastewater pollution

Phosphorus is an important element influencing the growth of soil productivity of various agricultural crops. In view of the phosphorus content available in the study area, was 5, 24, 72, 105,195 mg / kg, in soil sites of Mafraq Sharab, Hidran Al-Dabab, Al-Buraihy, Al-Qurf,and Al-Hawjalah, respectively .The amount of phosphorus is clearly proportional to the quality of irrigation water in different sites. The Mafraq Sharaab site mainly irrigated by rainwater only, while the Hidran Al-Dabab site is irrigated with partially treated wastewater at Al-Buraihy Lagoons, indicating that the content of the irrigation water has relatively high the phosphorus element compared to the Mafraq Sharaab site. However, a decrease in the amount of phosphorus in Hidran Al-Dabab is recorded in the flow of water from the treatment plant in Al-Buraihiy to Al-Multaqa area with a distance of not less than 10 km compared to Al-Buraihy site, which is irrigated from the partially treated wastewater at the Al-Buraihy lagoons where the site is located next to the plant, therefore Phosphorus in soil is accumulated by 1 to 3 compared to the Hidran Al-Dabab site. It is also clear that the phosphorus content at Al-qurf site and Al-Hawjalah site has increased significantly because the untreated wastewater discharged into these sites, and therefore the concentration of phosphorus is high in the wastewater, which also accumulates in agricultural soil. In addition, the amount of irrigation water exceeds the crop needs (Fig. 6).

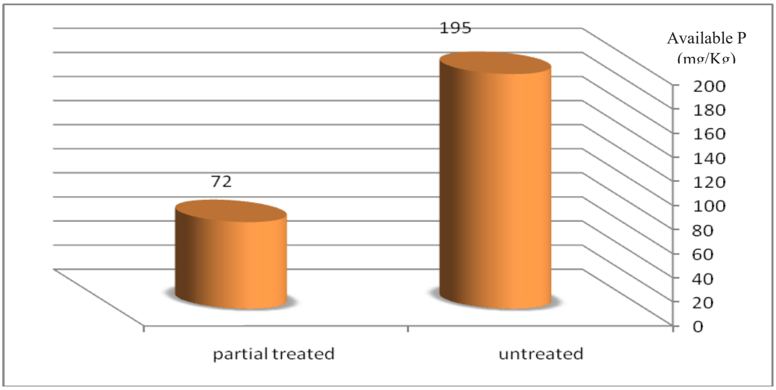

Figure 6: Available P (mg/Kg) comparison soils irrigated by untreated and partially Treated wastewater pollution

The results of the chemical analysis in the study area showed that the potassium component was found in the soil content at high concentrations, especially in the sites of Al-Hawjalah and Al-Qurf. It recorded quantities as (465.6), (424.8) mg / kg respectively. These are due to the effect of irrigation of untreated municipal and industrial wastewater on the soil, leading to higher amounts of major elements such as phosphorus and potassium, and the continuing to discharge wastewater to the sites more than is required by plants. In addition, the chemical fertilizers were effective in accumulating soil beside to untreated sewage.While the soil content of the potassium component in Al-Buraihy site decreased by 387.7 mg / kg, as was the case with the phosphorus component because the partially treated for wastewater, (Fig.7). However, this limited decrease in the concentration of potassium is due to the porous.

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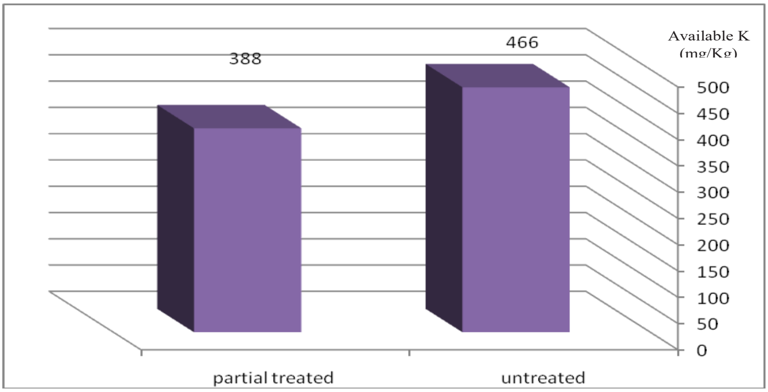

Figure 7: Available K (mg/kg) comparison between untreated and partially treated wastewater pollution

Of clay soil nature, which leads to accumulate of nutrients in the upper layer of the soil, is including potassium. In addition, the use of wastewater in agriculture reduced the value of pH, which availability the absorption of nutrients in the soil, increasing the water capacity as well as increasing the cation exchange capacity [20].These results are consistent with result of the study [21] that decreased macro pore numbers and macro porosity in the sewage- irrigated farmland may strongly intensify the accumulation of metals and nutrients in the upper layer. At the same time, the soil content of the potassium component decreased significantly in the two sites of the Hidran Al-Dabab and Mafraq Sharab a difference in quantities of 104.88 and 92.52 mg / kg, respectively. This is attributable to the fact that sewage water which is used in irrigating Hidran Al-Dabab site has additionally treated during its flow from treatment plant till its arrival to ALmultaqa area (Hidran Al-Dabab), whereas Mafraq Sharaab site has not been irrigated by sewage water, but rather is irrigating by rain water during rain seasons. This was confirmed by the results of the study [22] that the content of soils irrigated by treated wastewater was high of major elements such as phosphorus, potassium, calcium and nitrogen. Potassium (K^+) is an essential nutrient and the most abundant cation in plants, whereas the closely related ion sodium (Na^+) is toxic element to most plants at high concentrations. K^+ deficiency and Na^+ toxicity are both major constraints to crop production. K^+ counteracts Na^+ stress, while Na^+, in turn, can to a certain degree alleviate K^+ deficiency [23]. Atmospheric air is the primary source of nitrogen in the soil. The surface content of mineral deposits of nitrogen ranges from 0.02 to 0.5 % at an average of 0.15 % [14]. The importance of nitrogen is due to the fact that this element accompanies all interactions in living organisms. The results of chemical analyses have shown that the total nitrogen ratio at the different locations of the study area was variable. It was found that the nitrogen content at the sites of Al-Qurf, Al-Hawjalh, and Hidran Al-Dabab were identical by 0.38%. This ratio is more than two times higher than the average, but does not exceed the maximum 0.5%. This increase in the nitrogen ratio in these sites is due to the effect of untreated wastewater and the processor continuation of flowing amounts of sewage into the soil at these sites. In addition to plant community structure was investigated in old fields, also the incorporation of crop residues in soils and the application of organic fertilizers were effective in an increasing soil organic matter, Whereas the application of organic fertilizers a long combination with chemical fertilizers were effective for accumulating total soil nitrogen [14]. The percentage of nitrogen at the sites of the Mafraq Sharaab and Al-Buraihiy significantly is below the average. The soil content of nitrogen at the Mafraq Sharab is 011 % and the Al-Buraihy is 0.05 % (Fig.8). Nitrogen is found in the soil in the form of Ammonium (NH4), which is the result of the wastewater used in the soil of the Al-Buraihy site, which has a low nitrogen ratio content. This decrease may explain that the site's soil is weakly acidic, so ammonia (NH3) is lost by volatilization due to the low cation exchange capacity of the soil, high temperature and limestone soil. In addition, ammonium is consumed by soil microbes, absorption by plant, and stabilization in clay minerals [14]. Nitrogen also is converted by certain types of bacteria during biological treatment of wastewater in the treatment plant or during biodegradation in agricultural soils to nitrate or nitrite. The reason is that Mafraq Sharaab site is irrigated only by rainwater but it is likely that the increased nitrogen content is twice as that of Al-Buraihy site due to traces of nitrogen fertilizers that is used in previous periods, while Al-Buraihy site is irrigated by partially treated wastewater without fertilizers.

Which is the result of the wastewater used in the soil of the A-L-Buraihy.

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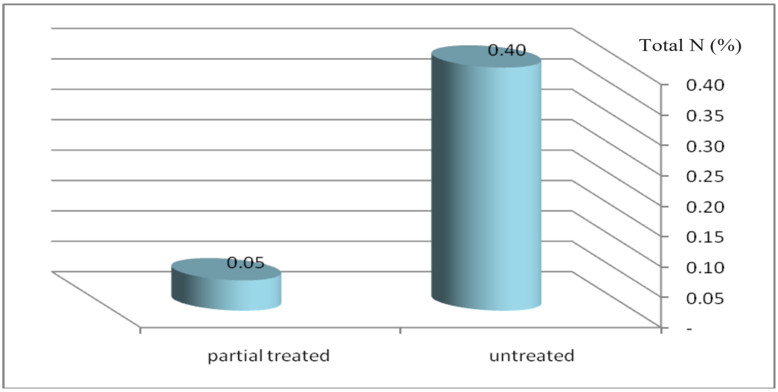

Figure 8: Total N (%) comparison between untreated and partially treated wastewater pollution

Table (3) shows that the levels of the micro and heavy elements were different between the soil samples at the Mafraq Sharab site, which was irrigated by rainwater and other sites samples that were irrigated by the wastewater . It was found that the lead element had a concentration a level of 0.37 mg/l in the site of Mafraq Sharab. Its level in the site of Al-Buarihy reached 7.35 mg/l, and its level was slightly higher than Al-Buraihy in the site of the Hidran Al-Dabab , reached to 7.61 mg/l and these sites irrigated by partially treated wastewater.

Table 3: level of some heavy elements in the soil samples in the study area, mg/l

NO sample	Site Name	Elements Type Of water.	Lead (Pb) mg/l	Cobalt (Co|)mg/l	Zink (Zn) mg/l	No. Irrigation./ year	Depth (cm)
1	Al-Qurf	untreated	8.26	*ND	0.37	30	30
2	Al-Hawjalah	untreated	8.74	*ND	0.55	25	30
3	Hidran Al-D-abab	Partially treated	7.61	*ND	0.34	25	30
4	Al-Buraihy	Partially treated	7.35	*ND	0.29	25	30
5	Mafraq Shrab	Rain water	0.37	*ND	0.13	----	30

ND: No Detected While it was 8.26, and 8.74 mg/l, in Al-Qurf site and Al- Hawajalah site respectively, (Fig, 9).

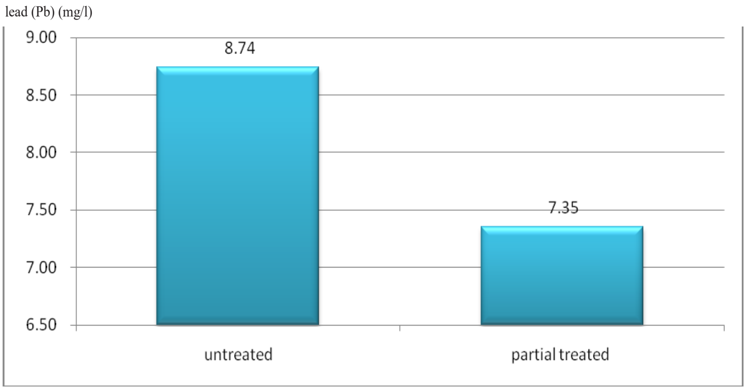

Figure 9: lead (Pb) (mg/l) comparison between untreated and partially treated wastewater pollution

This means that the level of concentration at the Mafraq Sharab site is low, while the other sites are considered to be high. This confirms that there is a cumulative effect of this element and continued irrigation with partially treated and untreated wastewater in the study area. Therefore, the allowable range in soil is from 10 to 84 mg/l [14]. But this increase in the concentration of lead in the soil may be poisonous to some plants. In general, the contamination of lead in soil that results from Car exhaust and other remains on the top surface of the soil and it is difficult to leach the soil for many years. The increased concentration of lead in the added soil is due to the presence of high concentrations of lead in this wastewater. In general, the transport of lead from the soil to the eaten part of the plant is slightly small [14].As for the Zinc element, it followed by the same pattern of lead element, with a concentration of 0.13 mg/l in Mafraq Sharab site, and its level in Al-Buraihy site reached 0.29 mg/l. This level may not have been affected in the short term with irrigation by partially treated wastewater, and it is continued to increase further in the Hidran Al-Dabab site, and in Al-Qurf site to 0.34 and 0.37 mg/l, respectively. While its level in the Al-Hawajala site doubled to 0.55 mg/l. Continuing increase above this level of concentration may affect to some crops, (Fig.10).

The results of the study showed an increase in the concentration of Lead and Zink in Al-Hawjalah site, due to the increase of the acidity in the soil, which works to dissolve the heavy elements in the soil. This is confirmed by [24], where the use of wastewater or organic fertilizer of soil must be coupled with a pH higher than 6, I.e., the soil is weak acidic in order to prevent the

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dissolution of heavy elements. It prevents access to groundwater.

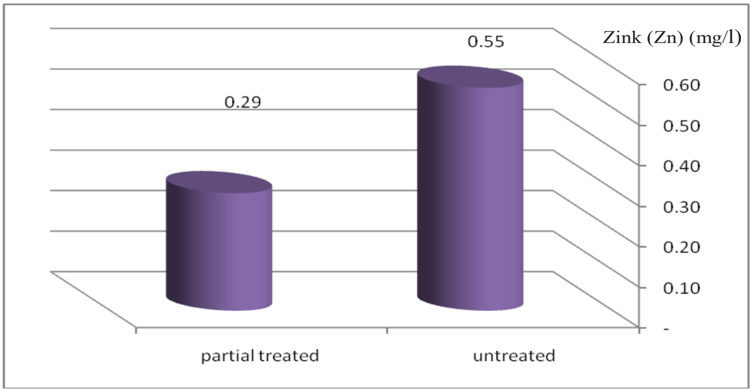

Figure 10: Zink (Zn) (mg/l) comparison between untreated and partially treated wastewater pollution

However, its soil fertility rate is still low and does not exceed the permissible limits of 17 to 125 mg/l [14]. In the same vein, the Zinc is present in the soil depends on the oxidizing state Zn+2. In the aerobic conditions of the acid dust, the movement of the Zinc is medium, where it is reciprocated on the surfaces of clay minerals and organic matter. This is shown by the results of the chemical analyses of the soil sample at Al-Hawjalah site, where the concentration of Zinc in the soil content that is irrigated by untreated sewage is increased. While Zinc deficiency is present in the Alkalis soils due to the reduction of Zinc dissolve ability. This is explained by the decrease in the soil content of the Zinc element in the soil samples of Al-Qurf, Hidran Al-Dabab, Mafraq Sharaab and Al-Buraihy sites. As for the Cobalt component has not shown any trace in the soil. Since the lack of Cobalt exist in the heavy soil textures, acid dust leached and Lime soil as well as soil rich in Homs [14]. This explains why Cobalt does not exist in different locations of the study area. Moreover, soil $CaCo_3$ has often been found to increase soil metal retention, the addition of organic matter may also affect metal mobility [25].

6. Conclusions:

- The degree of concentration of pollutants resulting from the use of untreated wastewater in irrigation of agricultural soils is higher than in irrigated soils by partially treated wastewater in the study area.
- Soil in the study area is considered to contain total dissolve solids, organic matter, calcium carbonate and some major elements such as phosphorus and potassium that are high in the irrigated sites by wastewater, especially by untreated wastewater.

- The soil content of the heavy elements is often low and is not dangerous at the present time, except for the lead element, which has increased significantly in all the irrigated sites.
- The high level of some heavy elements in soils that are irrigated by partially treated and untreated sewage may be attributable to the increase in the amount of irrigation water that created reduced soil conditions.
- The lower pH value that is less than the average of 6 in Al-Hawjalah site, which is irrigated by untreated wastewater through discharging directly to the farms from the Taiz sewerage system, has a negative indicator will affect the accumulation of heavy elements in the agricultural soil..
- The amount of wastewater that is used to irrigate the crops is much higher than their needs which led to soil salinity that, contamination and rapidly degrading the soil, whose treatment may in cure high costs.

7. Recommendations:

- Issue the regulatory and policy framework for wastewater treatment and reuse of treated wastewater for agriculture.
- Manage treated wastewater, collect and coordinate data and information related to wastewater treatment and reuse in Taiz governorate in particular and Yemen in general.
- Identify responsibilities for service provision when using treated wastewater.
- Conducting more field tests of the soil of the areas that reuse the sewage water for irrigation and the detection of the risks that result from pollution in the soil as a result of the reuse of wastewater without safe and appropriate treatment.
- Rapid treatment of land where salinity has accumulated significantly through soil rehabilitation, including soil tillage mixed with limited quantities of gypsum and soil leach with fresh, low-salty water, and thus soil cultivation with barley or sorghum yield and rotation of freshwater and treated wastewater irrigation.
- The decision makers in the local authority, the branch of Ministry of Agriculture and the Agricultural Research Authority in Taiz Governorate should work to prevent the reuse of sewage water in irrigation of agricultural crops by untreated wastewater.
- Conducting awareness to the population in areas that reuse irrigation by wastewater, about the risks and the negative impacts on soil and environment.
- Conduct nutrient guidance in wastewater in order to determine the needed wastewater for irrigating crops.

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