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Evaluating the Wastewater Impacts on Soil Characteristics

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Abstract

The effect of irrigation with treated wastewater on soil physical, chemical and biological properties was evaluated in this study. Therefore, soil samples were collected from three sites different dimensions and directions of the Ismailia Canal, and the chemical, physical and biological properties of the collected soil samples were determined, and various soil analyzes were performed, such as pH, electrical conductivity, and macro and micro elements. Dehydrogenase activity was determined. Results showed that the use of treated irrigation water led to a slight increase in pH, EC, as well as macro and microelements. In addition, led to a decrease in microbial activity expressed by the dehydrogenase enzymes activity, compared to other sectors.

Keywords: Wastewater, Soil Characteristics, Microbial activity.

Introduction

The Ismailia Canal, one of Egypt's most important irrigation and drinking water resources, was built in 1862 to provide drinking water to villages along the Suez Canal zones as well as workers digging the Suez Canal Navigation Route. Because the Nile River Egypt's primary source of water, the traditional concern about ensuring enough water for Egypt's survival and economic development cannot overstated. Uncontrolled wastewater discharges, **on** the other hand, have immediate and long-term health consequences for users. **(Abdel-Satar et al., 2017).**

The review region size has an all-out size of roughly 183136 sections of land and is arranged in the north-east Nile Delta, north Ismailia, and south Port Expressed Governorates on the west side of the Suez Trench. The fundamental piece of soil natural matter is a these properties impact air and water developments in soil and consequently the capacity of soil capability. Soil is assuming significant part in to evaluate the physical, synthetic and natural boundaries that affect complex array of little natural atoms, collectivity called as the humic substances (Johannes and Markus, 2015).

Polluted water and soil pose a serious threat to plants, affecting crops and thus causing health risks by entering the food chain. Soil pollution has negative effects on food safety as well as result in increased health risks **(Abhang et al., 2018).** Significance things of actual cycles are a decay the design of soil and prompts crusting, desertification, disintegration, compaction, anaerobium, ecological contamination and unreasonable utilization of normal assets (**Arunkumar et al., 2016**). Contamination of the dirt climate by inorganic synthetics has been viewed as a significant danger to organic entities and plant development. The horticultural waste water containing pesticides and manures and effluents of modern exercises and spillovers notwithstanding sewage effluents supply the water bodies and dregs with gigantic amounts of inorganic anions and weighty metals **(Sharma et al., 2018).**

Heavy metals pollution (HMP) is a major class in our world arising principally from natural and anthropogenic sources. Because of the release of a lot of metal-defiled wastewater, ventures bearing weighty metals, like Cd, Cr, Cu, Ni, As, Pb, and Zn, are the most unsafe among the synthetic concentrated businesses. The heavy metals commonly found in soil are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni) **(Ma et al., 2013).**

They occur in soil naturally, as a result according **(Kure et al., 2018).**Reuse of drainage wastewater because of the fact that water demand is larger than the conventional supply in Egypt, the utilization of non-conventional water resources became essential. Egypt is one of the pioneer countries in the reuse of water. This process started by 1920 **(Abu-Zeid et al., 2014).**

Soil compound exercises are firmly connected with soil properties, Soil types and ecological circumstances and are presently generally utilized as significant marks of soil quality and soil natural exercises **(Yuan et al., 2004).**

mentioned that soil dehydrogenase activity (DHA) is considered an indicator of aver all soil microbial activity because dehydrogenate as accrue intracellular in all living microbial cells and don't accumulate intracellular in the soil **(Das et al., 200; Filipavic et al., 2020)** found that, DHA was reduced with increasing soil salinity. Soil pollution effect in poor countries, the lack of clean water causes serious diseases **(Bibi et al., 2016).** Physical pollution results from organic and inorganic materials suspended in water. This type of pollutants changes the color, taste, and smell of water. One of the forms of physical pollution is the hot temperature because of pouring the cool water of factories and nuclear reactors into water bodies. It leads to a decrease in the amount of dissolved oxygen and harms aquatic organisms (**Ewaid and Abed, 2017**).

With concerns about contamination in cases where sewage cannot be managed in an environmentally sound manner **(Ferronato and Toretta, 2019).** Many soil pollutants are byproducts of human activity, such as manure, household and industrial waste, incorrectly kept waste, and biological waste. These pollutants will alter the earth's metabolism.

The increased soil degradation due to anthropogenic heavy metal contamination has raised researchers 'interest in the microbiological imbalances of soil. Many pollutants have a significant reservoir in soil **(Sandu and Vista, 2018).** Anthropogenic activities produce soil compounds are better marks of saline seaside soil quality biological pollution with pathogenic bacteria that can spread from soil to water or contaminate cultivated plants, harm animals by ingesting contaminated plants, and reach food **(Petcu et al., 2020).** These pathogenic microorganisms can also damage humans by contaminating humans with their products consumion. This study aimed to investigate the effect of irrigating soil by treated water on the physical, chemical and microbial activity properties and microbial activity.

Materials and methods

Description of the study area Ismailia Canal is one of the most important irrigation canals in Egypt. It was constructed to transport fresh water from River Nile in north Cairo (El-Mezalat) to Ismailia, Port Said, and Suez governorates. It is 128 km long, 2.1 m in depth, and 18 m in width. The soil samples used in this study was takenat 30, 60 and 90 cm depth supplied from three sites: site 1: before petroleum company with one Km, site 2: after petroleum company by 1Km and site 3: after petroleum company by 5 Km. from Agric. Res. Station (ARC), EL- Ismailia Governorate (Fig. 1) for physio-chemical analysis were collected in plastics bags. In our research involves determining physicochemical parameters in soil as well as the presence of heavy metals Couper, lead and iron. Initial soil analysis in the experimental field soil was sampled initially before collected and determined. Pysical and chemical analyses according to Jackson (1976) are shown in Table 1.

Table 1. Soil physical and chemical analysis.

Soil particles%	**Sand %**			**Silt %**			**Clay %**				
	38.28			33.02			28.72				
Textural class	**Clay loamy**										
	pH	**EC (µS/m)**	**Sp**	**Ca+2**	**Mg+2**	**Na+**	**K+**	**Co-3**	**Hco-3**	**cl-**	**So42-**
				ppm							
	7.69	906.5	170	3.99	2.93	2.34	0.2	--	1.42	4.8	3.54

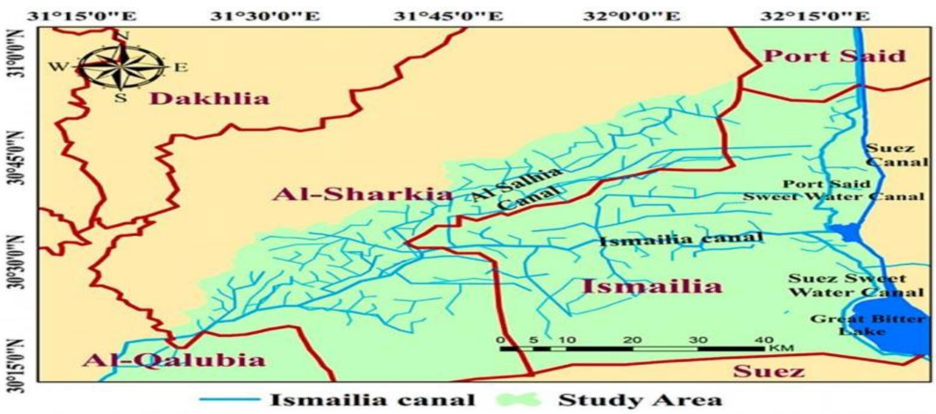

Fig.1. Ismailia canal.

Determination of Soil physical, chemical and biological analysis

Physical and chemical properties of the collected profile soils were determined consistent with standard methods **USDA (2004).** According to the soil survey laboratory methods manual **USDA (2014),** soil texture is determined by the proportion of sand, silt, and clay in the soil. Field measurements at the sampling site, pH, electrical conductivity (EC) and Laboratory analysis was the physicochemical parameters cations calcium (Ca^{++}), magnesium (Mg^{++}), sodium (Na^{+}), and potassium (K^{+}), anions (chloride (Cl^{-}), sulfate (SO_4^{--}), bicarbonate (HCO_3^{-}), and carbonate (CO_3^{-})), heavy metals (Cu^{++}, Pb^{++}, Zn^{++}, and Fe^{++}). pH and E.C was determined using CG 710Schott Great pH meter and Electrical Conductivity (E.C) was determined using Inaba Cond 710 conductivity meter.

Determination of total nitrogen

Total nitrogen (TN) was determined by Kjeldahl according to the method described by **(Cottenie et al., 1982).** K and Na were determined using flame photometer model 400, while P was determined using spectrophotometer and Mn, Zn, Cu, Fe,Mg and Ca were determined using atomic absorption spectrophotometer according to the methods described by **(Cottenie et al., 1982).**

Determination of dehydrogenase activity

Dehydrogenase activity from soil samples was determined according to the method described by **(Casida et al., 1964)**. Enzyme activity was calculated in µg of triphenyl formazan (TPF) /dry soil/day).

Statistical analysis

The statistical analysis for the traits was performed by using the General Linear Model (GLM) procedure according to **SAS (2003)**. Significant differences among means were achieved using the Duncan's of multiple range test **(Duncan, 1955)**. Significant level was set at 5%

Results and Discussion

Regarding in to Table 1 data showed that soil textures as study area were clay loamy soil as mean average (sand% 38.28, silt% 32.02 and clay %28.72).

The physical properties of soil include color, texture, structure, porosity, density, consistency, temperature, and air. NPK and micronutrient status of soils around Ismailia canal in Egypt. Generally**,** the soil are sandy and characterized by low organic matter status. Despite the importance of the region in the agriculture sector, the data is available on detailed spatial information showing the physiochemical and nutrient status of the soil (**Palequ and Muley, 2017**). An attempt was made to study the physio-chemical properties and macro and micronutrient status of this area. Soil is made of various parts; the piece of soil and degree of these parts amazingly influence the soil real properties which integrate the soil development and porosity. These properties influence air and water advancements in soil and appropriately, the limit of soil ability **(MWRI Egypt/USAD, 2013).**

Soil chemical characteristics

Data presented in Table 2 show the effect of irrigation water from Ismailia canal as secure of irrigated water on soil pH. Results indicated that the lowest value of soil pH was 7.23 as site 1 at 90 cm while the highest value was 8.20 and the average value was 7.69. The effect of treated water on pH Site 1 was the lowest value at 90 cm depth 7.23 while the site 1 indicated that Ismailia canal reclaimed soils had a soil reaction (pH) that was slightly alkaline **(Abdel Kawy and Ali, 2012)**.

Soil Electrical Conductivity

Also, data presented in Table 2 show EC values that range from 404.8, 1227.8 and 640.3 of sites No. 1,2 and 3 at 30 cm depth respectively, and 525.7, 1268.9 and 529.9 µS/cm in all sites at 60 cm depth but the sites recorded at depth 90 cm at566.6, 1302.7 and 840.4/cm respectively. The maximum EC values were 1302.7µS/cm at the site3 90 cm had been discovered in study areas, which stimulates salt migration to the soil's surface **(Rasha et al., 2018).**

Furthermore, EC values were found in soils around Ismailia canal in range according data, which is consistent with findings. There was a positive relationship between depth of the soil and EC values but there is an inverse relationship between electrical conductivity (EC) of samples and distance from Ismailia canal.

Table 2. Effect of irrigation with treated wastewater on soil pH and EC.

Sample of soil									
No.	***(Control) site 1**			**Site 2**			**Site 3**		
Depth	**30cm**	**60cm**	**90cm**	**30cm**	**60cm**	**90cm**	**30cm**	**60cm**	**90cm**
pH	7.56	7.50	7.23	8.20	7.75	7.72	7.60	7.86	7.79
EC (mgL)	404.8	525.7	566.6	1227.8	1268.9	1302.7	640.3	529.9	840.4

*Control site (1) soil before petroleum company with 1 Km, site (2) soil after petroleum company with 1 Km and site (3) after petroleum company with 5 Km.

NPK content in samples soil

Data presented in Table 3 declared that values of macro element in soil sites. Data in Table 3 recorded the value of nitrogen content was 28, 14 and 14 mg/kg^{-1} soil at 30 cm depth for all sites, respectively. Also, 10, 21 and 7mg/kg^{-1} soil at 60 depth for all samples, respectively and7, mg/kg^{-1} soil at 90 cm depth for all samples. The maximum value of nitrogen content was 28mg/kg^{-1}.

1soil at 30 cm depth of soil and 21 mg/kg^{-1} soil at 60 depth in site1 and them in imum value was 7 at 90 cm for site 1 at60 cm and 90 cm for site 2 and 90 cm for site respectively. These results were variable due to microorganism's activity in rhizosphere. The phosphorus content value recorded in Table3 at the highest value was 5.61mg/kg^{-1}soil at 30 depth in site 1 and the lowest value was 3.51g/kg^{-1}soil. Phosphorus is second element after nitrogen in significance as a fundamental harvest supplement. It is basic for plant development, particularly in the early jointing stage sand for improving grain endlessly yield parts **(Aliand Klein, 2014).**

Table 3. Effect of irrigation with treated wastewater on macro nutrient (ppm).

Samples of soil									
No.	***(Control) site 1**			**Site 2**			**Site3**		
Depth	**30m**	**60cm**	**90cm**	**30cm**	**60cm**	**90cm**	**30cm**	**60cm**	**90cm**
N	14^{b}	10^{b}	7^{a}	28^{a}	21^{a}	7^{a}	14^{b}	7^{c}	7^{a}
P	5.61^{a}	5.29^{a}	5.11^{a}	4.11^{b}	3.68^{c}	3.51^{c}	5.11^{a}	4.07^{b}	4.72^{b}
K	6.79^{a}	6.32^{a}	4.85^{a}	2.53^{b}	2.12^{b}	1.18^{b}	2.50^{b}	2.06^{b}	1.23^{b}

*Control site (1) soil before petroleum company with 1 Km, site (2) soil after petroleum company with 1 Km and site (3) after petroleum company with 5 Km. The same latter between the same depth has not significant effect according to Duncan test.

Data for potassium content Table 4 was recorded highest value at 6.79mg/kg^{-1} soil at 30 cm depth for site 1 and the lowest value was 1.18 mg/kg-1 soil at the 90 cm depth for site 2, respectively. A blended application has a better impact than a single application. Potassium (K) is a fundamental plant macronutrient and assumes a significant part in numerous physiological cycles essential to establish supplement and water take-up, supplement transport, and development, particularly under unfriendly circumstances **(Jiang et al., 2018).**

Soil microelements

Soil micronutrient for the studied soil trace elements of substances for plants and soil is their primary sources of both two micronutrients and contaminants. There are sever soil for both micronutrients and pollutants, soil is the primary source of trace elements for plants. Some exceptions include cases of significant air pollution deposition or floods from contaminated rivers. Also, in general, several trace metals, especially Cu^{++} and Zn^{++}, are easily mobile and available to plants in well-aerated (oxidizing) acidic soils, whereas they are less so in poorly aerated (reducing) neutral or alkaline soils. Trace element behavior is significantly influenced by soil conditions. However, data presented in Table 4 confirmed that, salinity increase in some microelements, Fe^{++}, Mn^{++} and Zn^{++}, also, slightly increase in heavy metals Pb^{++} and Cu^{++}**.**

However, the impact of treated wastewater in site 2 that received treated water compared site 1or site 3.on soil depends on the quality of water as well as the characteristics of soil such as texture (sand, silt and clay), structure and pH of soil. Moreover, soil hydraulic conductivities, water retention capacity, and water infiltration rate in soil are also sensitive factors.

Table 4.Effect of irrigation with treated wastewater on soil micro-nutrient (mg/kg^{-1} soil).

Samples of soil									
No.	***(Control) site 1**			**Site 2**			**Site 3**		
depth	**30cm**	**60cm**	**90cm**	**30cm**	**60cm**	**90cm**	**30cm**	**60cm**	**90cm**
Fe^{++}	0.361^{b}	$0.411a^{b}$	0.395^{b}	0.621^{a}	0.402^{ab}	0.376^{b}	0.584^{a}	0.499^{a}	0.499^{a}
Mn^{++}	0.171^{b}	0.157^{b}	0.185^{a}	0.183^{ab}	0.173^{a}	0.165^{b}	0.192^{a}	0.180^{a}	0.176^{ab}
Pb^{++}	0.078^{ab}	0.076^{ab}	0.074^{a}	0.087^{a}	0.085^{a}	0.075^{a}	0.084^{a}	0.076^{ab}	0.075^{a}
Zn^{++}	0.021^{b}	0.025^{b}	0.020^{b}	0.021^{b}	0.027^{b}	0.025^{a}	0.029^{a}	0.032^{a}	0.026^{a}
Cu++	0.45^{a}	0.40^{a}	0.29^{b}	0.51^{a}	0.44^{a}	0.41^{a}	0.49^{a}	0.43^{a}	0.37^{a}

Control site (1) soil before petroleum company with 1 Km, site (2) soil after petroleum company with 1 1Km and site (3) after petroleum company with 5 Km. The same latter between the same depth has not significant effect according to Duncan test.

Data in Table 4 for site1 recorded the maximum value for (Fe^{++}, Mn^{++} , Pb^{++} ,$Zn^{++}$and Cu^{++}) was 0.411mg/kg^{-1}soil at 60 cm depth for Fe^{++}, 0.185 mg/kg^{-1}soil for Mn^{++} at 90 cm depth, 0.087 mg/kg^{-1} soil for Pb^{++} at 30 cm depth , 0.025 mg/kg^{-1} soil for Zn^{++} at 60 cm depth and 0.45 mg/kg^{-1} soil for Cu^{++} at and the minimum value was 0.361mg/kg^{-1} soil for Fe^{++} at 30 cm depth, 0.157 mg/kg^{-1} soil at 60 cm depth for Mn^{++}, 0.076 mg/kg^{-1} soil at 60 cm depth for Pb^{++} , 0.020 mg/kg^{-1} soil at 90 depth for Zn^{++} and 0.29 mg/kg^{-1} soil at 90cm depth forCu^{++}. Also, data in Table 4 as site 2 recorded the maximum value for (Fe^{++} , Mn^{++} , Pb^{++} , $Zn^{++}$and Cu^{++}) was 0.621mg/kg^{-1}soil at 30 cm depth for Fe^{++}, 0.183 mg/kg^{-1}soil for Mn^{++} at 90 cm depth, 0.087mg/kg^{-1} soil for Pb^{++} at 30 cm depth , 0.021mg/kg-1 soil for Zn^{++} at 30 cm depth and0.51 mg/kg^{-1} soil for Cu^{++} at and the minimum value was0.376 mg/kg^{-1} soil for Fe^{++} at 60 cm depth, 0.165 mg/kg^{-1} soil at 30 cm depth for Mn^{++}, 0.075 mg/kg^{-1} soil at 90 cm depth for Pb^{++}, 0.021 mg/kg^{-1} soil at 30 depth for Zn^{++} and 0.41 mg/kg^{-1} soil at 90cm depth for Cu^{++}.Data in table 5 for sample 3 recorded the maximum value for (Fe^{++} , Mn^{++} , Pb^{++} , $Zn^{++}$and Cu^{++}) was 0.584 mg/kg^{-1}soil at 30 cm depth for Fe^{++} , 0.192 mg/kg^{-1}soil for Mn^{++} at 60 cm depth, 0.087 mg/kg^{-1} soil for Pb^{++} at 60 cm depth , 0.032 mg/kg^{-1} soil for Zn^{++} at 60 cm depth and 0.49 mg/kg^{-1} soil for Cu^{++} at and the minimum value was0.376mg/kg^{-1} soil for Fe^{++}at 90 cm depth,0.165mg/kg^{-1} soil at 90 cm depth for Mn^{++}, 0.075 mg/kg^{-1} soil at 90 cm depth for Pb^{++},0.021mg/kg^{-1} soil at 30 depth for Zn^{++} and 0.37 mg/kg^{-1} soil at 90cm depth for Cu^{++}.

Therefore, in order to effective utilization of the treated wastewater for agricultural activities without further damage of land site select ion must be based on appropriate crop pattern, soil, hydrological and climate conditions and water quality **(Santos et al., 2017) .**

Dehydrogenase enzyme activity

The same latter between the same depth has not significant effect according to Duncan test. Table 5 show the Dehydrogenase enzyme activity recorded the highest values in depth 30cm at samples recorded that 6.97, 5.95 and 6.35 µg TPF/ 100 g dry soil /day at site 1, 2 and 3 respectively, and the highest value was 6.97 and the minimum value was 1.06 , µg TPF/ 100 g dry soil /day at depth 90 cm in the soil respectively, According to **(Meena and Rao, 2021)** reported that dehydrogenase enzyme activities (DHA) are indicators of fertility and soil health.

Table 5. Dehydrogenase activity in rhizosphere soil (µg TPF/100 g dry soil / day).

Depth of soil	Sample (1)	Sample (2)	Sample (3)
30cm	6.97[a]	5.95[a]	6.35[a]
60 cm	3.18[b]	4.23[a]	4.61[a]
90 cm	1.06[c]	1.53[a]	1.25[b]

Conclusion

One of the primary feeders of the Nile Waterway in Egypt is the Ismailia Trench. The essential target of this study was to assess how the utilization of treated water delivered by oil organizations and its expansion to the Ismailia Trench influences the physical and synthetic properties of the dirt. Consequently, soil tests were gathered from various aspects and headings of the Ismailia Trench, where three areas were made for every area under review, the primary before the organization, one kilometer, the second was one kilometer after the organization, and the third a good ways off of 5 kilometers. The compound and actual properties of the gathered soil not entirely settled, and different soil examines were performed, like pH, electrical conductivity, and large scale and microelements. The outcomes showed that the utilization of treated water system water prompted a slight expansion in pH and the level of electrical conductivity, as well as the miniature and full scale components. Moreover, it prompted a lessening decrease movement communicated in the dehydrogenase enzymes, contrasted with different areas.

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