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# A Study of the Soil Properties Contaminated with Sewage Water in the New Residential Neighborhoods at Al-Zafaraniya District

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**Abstract**

The present investigation was performed to investigate the impact of untreated sewage water discharged from the new residential neighborhoods to the adjacent areas in the study area in “Al-Zafaraniya city” on the physicochemical properties of the soil. Samples were gathered at a 10-15 cm depth at various distances to determine Calcium, Magnesium and chloride, in addition to analyzing soil electrical conductivity, pH, total dissolved salts, and total hardness. The study results revealed that the concentration of calcium, magnesium and chloride elements increased significantly in soil samples close to the main source of pollution and affected by untreated sewage, compared to soil samples collected from another location (D) located 100 meters from the main source. It was also observed that the concentration of dissolved salts increased in the soil, coinciding with the increase in the concentration of these elements, which in turn was considered the reason for the increase in the total hardness and conductivity of this soil. This indicates that the soil near the main stream is polluted, as this pollution seriously affects human, plant and animal life in the area. The importance of the study lies in the need to find urgent solutions to reduce water pollution, whether for human use or for agriculture, by equipping a sewage treatment plant for the residential neighborhood in Zafaraniya and any similar city, directing the construction of sewage networks in residential neighborhoods to the nearest sewage treatment plant, and not discharging untreated water directly into the soil to ensure environmental safety.

**Keywords:** Sanitation, Pollution, Soil, Chemical and Physical Properties.

## 1. Introduction

Soil pollution is defined as a process that influence the natural characteristics of soils such as physical, chemical or biological aspects which makes it negatively affected, directly or indirectly, on the people, animals and plants living above its surface. Also, we can define the pollution occurring in the soil as a set of physical or chemical changes to the land, which in turn cause obstruction of the exploitation of this soil [1]. There are many sources that contaminate soils; one of these pollutants is wastewater that transported using underground pipes embedded in soil. The appropriate reuse of wastewater is seen as an environmentally favourable practice compared to discharging treated wastewater into surface water. This approach can conserve substantial amounts of freshwater presently utilised for irrigation, addressing the increasing need for freshwater in urban areas of emerging nations. The growing strategic significance of controlling and utilising reclaimed urban wastewater for agricultural use in water-scarce locations is also acknowledged. Wastewater is one of the most important causes of environmental pollution, whether it is domestic or industrial wastewater, which directly affects the quality of the environment. Most of these reasons are considered serious and require serious study and research to reduce their effects by working immediately to find appropriate solutions represented by finding a number of treatment plants covering residential and even industrial areas.

The reclamation of wastewater serves two primary objectives: it enhances environmental conditions by diminishing the volume of both treated and untreated waste released into aquatic systems, and it acts as a conservation strategy for water resources by lowering the demand for freshwater extraction. Furthermore, wastewater influences the physical and chemical characteristics of soil, including infiltration rate, hydraulic conductivity, organic carbon content, and water retention. The wastewater includes elevated levels of harmful heavy metals, including cadmium, chromium, lead, and nickel, which adversely affect both the soil and vegetation. If the concentration of toxic metals is higher than the permissible limits, then this water is considered dangerous to the lives of humans and animals [3]. The random use of treated and untreated wastewater leads to a significant and harmful environmental effect on soil, agricultural crops, surface and groundwater, public health and the environment in general. It may be toxic to humans, plants and animals, including heavy metal elements, organic and inorganic materials, especially when Its presence in high concentrations, it accumulates in the soil. Moreover, it can propagate through the food chain to flora, fauna, and humans, resulting in severe illnesses. This may result in significant alterations to the physicochemical parameters of the soil. [4].

Numerous researchers have demonstrated that treated water offers various advantages, including environmental preservation through its treatment and subsequent reintegration into nature. In certain circumstances, utilising treated water for the irrigation of crops and green areas aids in the preservation of agriculture. It functions as a supplementary source of irrigation water for several agricultural crops worldwide [5]. Sewage, commonly referred to as black water, is seen as a significant public health issue in many developing countries due to the absence of an integrated sewage system in most of these nations. In fact, in some cities there is no sanitation in example in Iraq is the Zaafaraniya district, which is located southeast of the capital city Baghdad (near the Tigris River) and selected as the case study of the current research. In this district, the most of the new residential neighborhoods is suffered from lack of sewage networks and forces the residents to drain wastewater into the street or make septic tanks. Finally, the wastewater drains to the soil and Tigris River causes to increase the percentages of pollutants in both.

## 2. Study Area and Working Methods

The study area was chosen in the district of Al-Zaafaraniya, one of the largest districts of Baghdad city, in terms of area and population and located southeast of Baghdad at a point where the Tigris River meets the Diyala River, see Figure 1. The Zaafaraniya district is characterized by the presence of orchards and abundant trees in it. It is located also within area considered as one of the most important industrial areas in Baghdad. Several soil samples were taken from zones near the sewage area or the so-called stagnant water pools between the riverbed and the orchards, see Figure 2. These samples were collected from four locations, coded with the letters A, B, C. and D, as:

- The initial site is designated with symbol A, and these samples are extracted immediately from the pond.
- The second site, designated as symbol B, is situated 5 metres from the stream.
- The third location, designated with symbol C, is situated 50 metres from the creek.
- The fourth location, designated with symbol D, is situated 100 metres from the creek.

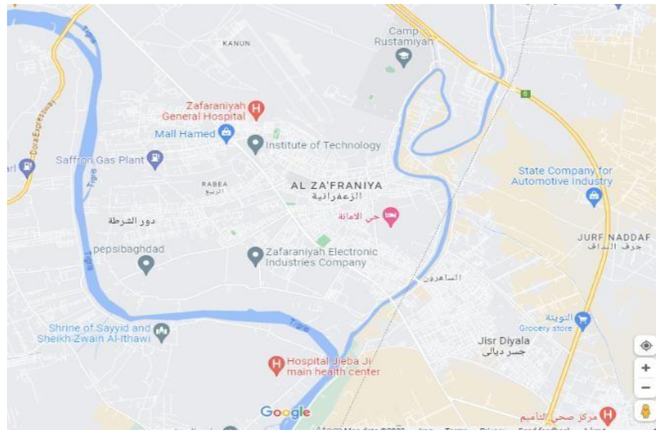


**Figure 1.** An aerial photograph of the study area, Al-Zafaraniya.

**Figure 2.** Picture of the wastewater pond exist in the residential area of Al- Zaafaraniya.

Furthermore, three replicate samples were collected from each location at shallow depths "10-15 cm" and were immediately transferred to sterile plastic containers. The collected soil samples are tested using a suitable experimental test according to the following testing program steps:

1. The soil specimens were prepared to determine Calcium, Magnesium, and Chlorine.

2. The concentrations of the elements selected for this study were measured for each of the calcium Ca++, magnesium Mg++, and chlorine $Cl^-$ present in the soil samples in units of mg/L as they were examined using an atomic absorptiometry flame according to the method used [6].

3. Assessment of Total Hardship (TH) in soil samples, quantified in mg/l, following the methodology established by Abbawi and Hassan. [7].

4. Measurement of soil specimen conductivity (EC), expressed in mS/cm, utilising the electrical conductivity device model "multi 340i" from the German company WTW, in accordance with the methodology established by Abbawi and Hassan [7].

5. Assessment of "Total Dissolved Salts (TDS)" based on the quantification of dissolved salts in soil samples, using the methodology of Chaturvedi and Sanka. [8].

6. Determining the pH value of the soil samples by weighing 10 grammes from each specimen and combining it with 20 cm³ of distilled water, followed by agitation to make the aqueous extract. The pH value was ultimately assessed via a pH metre. [8].

## 3. Results and discussion

The examination results of the samples taken from the contaminated soil, which represents the average of three samples for the four locations (A, B, C, and D), are shown in Table 1. While Figures (2) to (8) are shown the results of each of these examinations were illustrated graphically.

**Table 1.** Average results of the analysis of soil samples at different distances

| Analysis Type | at the pond (A) | at 5 m (B) | at 50 m (C) | at 100 m (D) |
|---|---|---|---|---|
| Ca++ (mg/l) | 38.8 | 35.1 | 59.1 | 13.4 |
| Mg++ (mg/l) | 6.7 | 1.9 | 9.7 | 1.3 |
| Cl¯ (mg/l) | 80.1 | 266.2 | 376.7 | 60.1 |
| TDS (mg/l) | 468 | 679 | 898 | 111 |
| EC (ms/cm) | 751 | 1059 | 1399 | 166 |
| TH (mg/l) | 80 | 97 | 133 | 65 |
| Ph | 8.5 | 8.4 | 8.1 | 8.8 |

### 3.1 The Concentration of Calcium Ions Ca++, Magnesium Mg++, and Chloride Cl¯

Tables 1 and Figures 3 to 5 are shown an increase in the concentration of $Ca^{++}$, $Mg^{++}$, and $Cl^{-}$ ions in soil samples extract from sites close to the stream. The ratio escalated from the pond to soil specimens at distances of 5 and 50 metres.. Moreover, it was noticing a significant decrease in their concentration in samples at distance 100 m as they are not affected by sewage water. This in match with the results found by a study of [9].

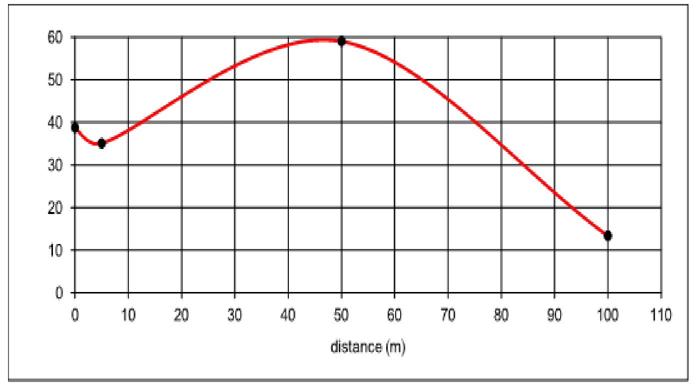


**Figure 3.** The percentage of calcium ions Ca++ (mg/l) in the polluted soil.

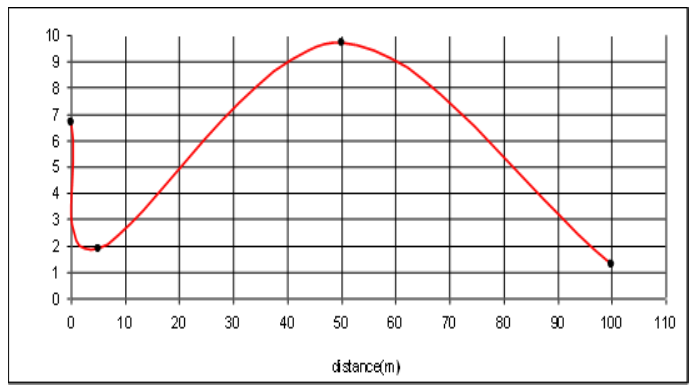


**Figure 4.** The ratio of magnesium ions Mg++ (mg/l) in the polluted soil.

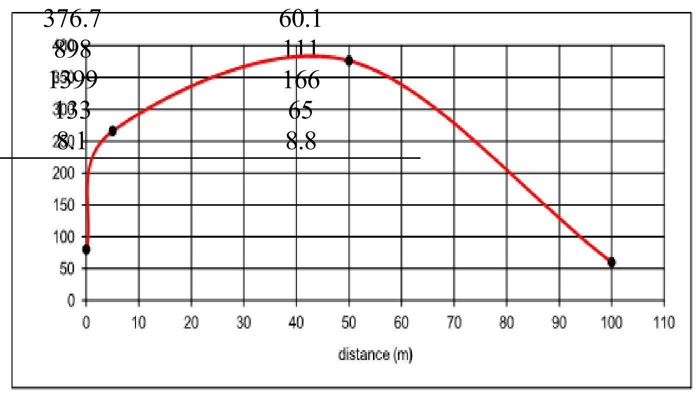


**Figure 5.** Percentage of chloride ions Cl¯ (mg/l) in the polluted soil.

### 3.2 Total Dissolved Salts, TDS

According to Table 1 and Figure 6, the observed concentration of total dissolved salts TDS in soil samples were close to the pond and it was high with a range between 468 - 898 mg/l. Unlikely, the samples taken at a distance of 100 m contains a percentage of total dissolved salts TDS around 111 (mg/l). An other significant observation revealed a disparity among soil sample D and samples near the pollution source at locations B and C. The disparity in TDS concentrations between soil sample D and the adjacent soil samples along the main stream was significant. This constitutes evidence of soil pollution near the pond, corroborating the findings of Mleitan et al. [9] and Al-Rasheed and S. Mutawakel. [10].

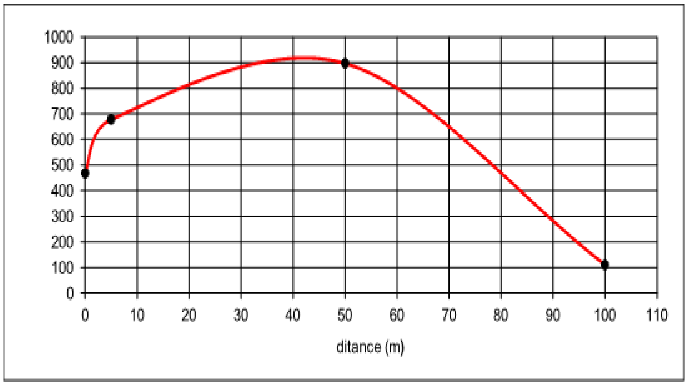


**Figure 6.** Total dissolved salts (mg/l) in the polluted soil.

### 3.3 Electrical Conductivity of Soil, EC

The EC is proportional to the TDS, and according to Table 1 and Figure 7, it was found that the soil samples near the pond with a high percentage of total dissolved salts (TDS) contains a high conductivity, ranging from 751 - 1399 (ms/cm). In contrast, the conductivity of the soil sample D that contains lower amount of total dissolved salts (TDS) was found around 166 (ms/cm).

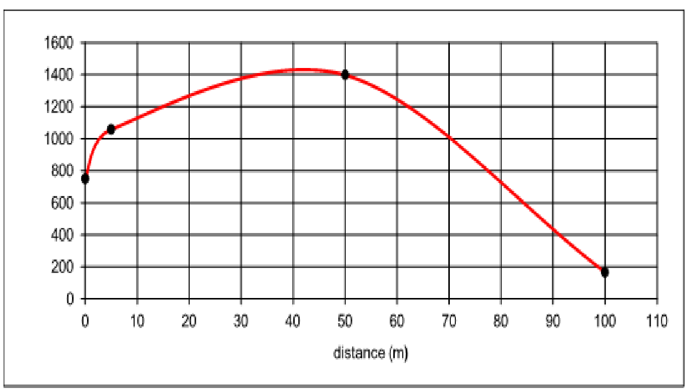


**Figure 7.** Electrical conductivity EC (ms/cm) of the polluted soil.

This finding was confirmed by eye observation at site about the difference between the soil samples of D and samples located nearby the pollution source at locations (B, C). Also, these findings observed by other researchers [9-10].

The reduction in electrical conductivity in certain soils, particularly around the pond, may be ascribed to water inundation in the research area. Continuous flooding of the fields results in the downward migration of water to lower horizons, accompanied by soluble salts, which causes a reduction in EC [11]. The increase in electrical conductivity (EC) in certain soils irrigated with wastewater is due to the substantial presence of ionic substances and soluble salts resulting from the salt concentration in the local wastewater [12].

### 3.4 Total Intractability, TH

The analysis of total hardness content in multi-distance dirt samples revealed that samples near the pollution origin, ranging from 80 to 133 mg/l, exhibited higher concentrations than sample D, located farther from the pollution source, which measured 65 mg/l. A distinction was also observed among the samples D. Sample C is located near the pollution source, as illustrated in Table 1 and Figure 8. A distinction was seen between sample D and sample C near the contamination origin. This was considered a natural result of the heightened concentrations of chloride ions, calcium, and magnesium in the contaminated soil near the source of pollution. The overall hardness escalates with the rising concentration of these elements, as observed in Figures (2) to (4), indicating soil pollution adjacent to the stream. This aligns with the findings of the investigation study referenced in Mleitan et al. [9].

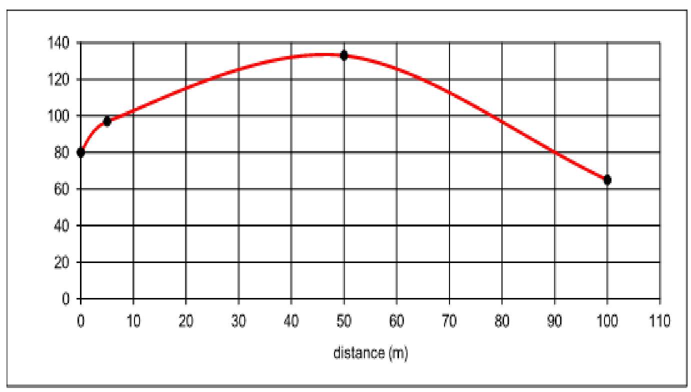


**Figure 8.** Total hardness TH (mg/l) of the polluted soil.

### 3.5 Degree of Acidity, pH

The variation in soil pH can be ascribed to several reasons, including the filtration process of water, the soil's characteristics, and its mechanical composition. The soil's acidity differs among various types and might also fluctuate based on its geographical location. The pH values presented in Table 1 and Figure 9 indicate that the lake samples and adjacent samples exhibit an average pH ranging from 8.1 to 8.5. Therefore, the soil near the main stream is classified as moderately alkaline. As for the sample D, the pH rate was about 8.8, and therefore the soil is classified as alkaline. The soil analysis results indicate that the mean pH of the polluted soil is lower than that of the unpolluted soil, with the pH reduction attributed to an increase in salt concentration. This is consistent with the results of the research study of [10]. It was also noted that no differences were noticed between soil samples close to the source of pollution and the reason for the low pH in some types of soil irrigated with sewage water, the reason for this may be the decomposition of organic matter and organic acids in the soil.

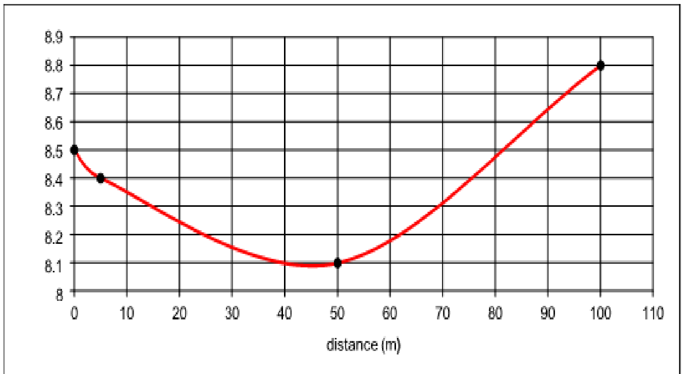


**Figure 9.** The pH values of the polluted soil.

## 4. Conclusions

1. The study proved the large and dangerous contamination of the area surrounding the sewage water pool discharged from the adjacent residential neighborhood and its human, animal, plant and even psychological effects. It was noted that the characteristics of the studied soil had witnessed a remarkable change, which indicates the pollution of the area, with an increase concentration of calcium, magnesium and chloride elements in proportions (59.1, 9.7 and 376.7) mg/l respectively, which were significantly in soil samples close to the main source of pollution and affected by untreated sewage. In addition, the presence of these elements in the soil at high concentrations is the reason for the increase in the percentage of dissolved salts, and thus the reason for the increase in the total hardness and conductivity of this soil.

2. Also, the wrong method of draining wastewater to the new residential neighborhoods and the absence of actual sewage stations leads to making these areas unsuitable for agriculture, which causes a lack or absence of vegetation cover, which is an important factor in providing a healthy environmental system and reducing global warming, which has become a growing global problem.

To minimize and reduce the impact of the wastewater on the quality and environmental of soil and water in the study area, the following recommendations were proposed:

1. The need to find an urgent solution to provide a sewage treatment plant in the district under study, as well as similar sites, in which the sewage performance of the studied area was found at zero level.

2. Connecting or directing the sewers of the new residential neighborhoods to the nearest sewage station serving resident units, in turn this will reducing the damage caused by wastewater that not drained properly.

3. Educating the community through various means that necessitate preventing them from discharging household or industrial pollutants into the river or into the soil.

4. Proposing an efficient solution to reuse the wastewater after treatment for various purposes according to the degree of treatment.

5. Showing effective and serious interest in the subject of the current study to avoid or reduce the large and dangerous damage to human, animal and plant life, as well as follow-up and study of the area and research in the various aspects of pollution.

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**Conflict of interest**

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

**Author Contribution Statement**

Abdalqadir N.A.: Proposed the research problem; developed the theory and performed the computations; verified the analytical methods.

Both authors discussed the results and contributed to the final manuscript.

**AI Declaration Statement**

The author confirm that the manuscript has been written without the assistance of generative AI or AI-based writing tools.

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