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# Chemical Characterization of Some Low Quality Water (Sewage Effluent) Used for Irrigation in Egypt: Case Study

Mohamed Saber[1]*, Salah Abu-Sedera[1], Ibrahim A. Matter[1,] and Alaa M. Zaghloul[2]

[1]Agricultral Microbiology Department, National Research Centre, Dokki, Giza, Egypt.
[2]Soil and Water Use Department, National Research Centre, Dokki, Giza, Egypt.

**Abstract :** Two low quality sewage effluents monthly collected during January 2012 to July 2012from Abu-Rawash and Zenine sewer plants were chemically analyzed and compared with Nile river water to evaluate their irrigation suitability. Sewage effluent samples were characterized for their pH, electrical conductivity (EC), sodium adsorption ratio (SAR) as well as their soluble cations and potential toxic elements (PTE's). Results pointed to significant variations in the chemical characters of sewage effluent samples and Nile water, as well as between the two sewage effluent samples. Significant increases in EC, pH and SAR in both sewage effluent were recorded compared to Nile water as well as to the save levels of irrigation water given by FAO. Results confirmed that all over the year the contents of $Cd^{2+}$, $Cu^{2+}$, $Mn^{2+}$ far exceeded the safe levels. The case was somewhat different for $Zn^{2+}$ where its content exceeded the safe level only during some months of the year. According to Doneen parameter for water quality, both sewage effluent samples are not safes to irrigate edible crops.
**Key words**: sewage effluent, chemical characters, PTE's, Abu-Rawash, Motamadia, Doneen parameter.

## Introduction

During the last decade's many water resources in Egypt were apt to varied types of chemical and biological contaminants. Population increases are always parallel to an increase in fresh water demand[1]. Egypt has a negative water balance and is considered an arid country[2]**.** At the time being, it is estimated that untreated sewage effluent is used to irrigate about 10% of the world's crops, according to the first ever global survey of waste water irrigation[3]. Saber et al.,[4] stated that continuous evaluation of low quality water regarding their biological, hygienic, chemical and physical as well as aesthetical characteristics is a must.

An upcoming strategy for increasing water supply in Egypt includes the use of low quality water in irrigation. As far as numerous problems related to soil contamination and reduced yields are expected, hence special management practices were adopted to maintain acceptable safe harvests.

The current study aims to evaluate and spot light on the chemical characterizations of some low quality water resources (sewage effluent) that are already used in Egyptian farming and their adverse impacts on soil ecosystem.

## 3. Material and methods

### Study areas:

Sewage effluents were collected from two main drains at Abu-Rawash and Konbera. Together with sewage effluent discarded in these drains, some industrial effluents are also disposed. Different edible crops are cultivated in these areas and marketed. Control water samples were collected from River Nile.

### Sampling:

Representative periodical monthly samples were collected between the periods from January 2012 to July 2012 (5 liter each) from the two main canals as well as from River Nile at El-Kanater El-Khairia.

### Chemical methods:

Chemical characterizations were carried out according to APHA [5]. Some parameters such as temperature, DO, electrical conductivity (EC), and pH value were measured directly in the field. Temperature was measured by thermometer while EC was measured by EC meter (YSI Model 33. S.C.T). Bicarbonate was determined directly by titration with standard 0.02M HCl and phenolphthalein using methyl orange indicators. The pH value was determined using a portable pH meter. Total chloride was measured by titration of 50-mL samples against 0.0141N silver nitrate solution using potassium chromate as indicator. Total dissolved salts (TDS) were determined gravimetrically.

### Instrumentation and analysis of PTEs:

Flame atomic absorption spectrometry (FAAS) is frequently used in determining PTEs in natural aquatic samples. A Perkin–Elmer flame atomic absorption spectrometer (FAAS) and HACH DR890 colorimeter were used in this study. Atomic absorption measurements were carried out using air: acetylene flame, while the provided test kits was used for HACH colorimeter measurement. The operating parameters for working elements were followed of recommended by the manufacturer.

## 4. Results and discussion

Both studied sites received sewage effluents since 45 years, and were selected on the basis of land use and soil types[6].

### pH:

The pH value in Konbora canal ranged between 7.2 and 7.7, and in El-Motamadia canal between 7.0 and 7.8 (Fig. 1), which indicated that El-Motamadia canal, received more sewage effluent than Konbora. On the other hand, the pH in River Nile water ranged within the limits given by WHO and Egyptian standards for irrigation water i.e. 7.5.

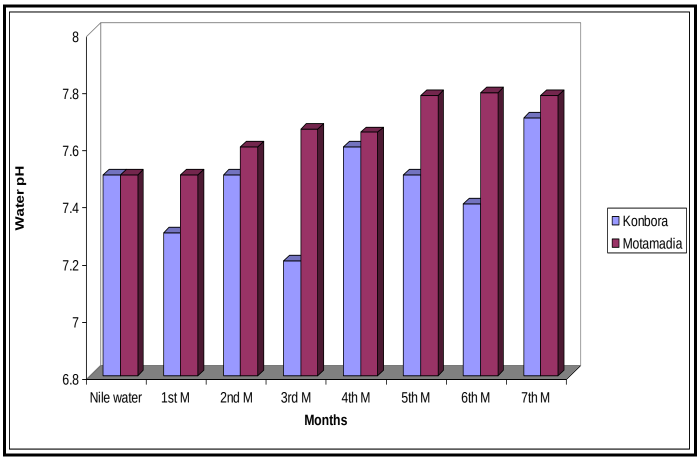


**Fig (1) pH values in Konbora and El-Motamadia**

Water according to Target Water Quality Range (TWQR) for domestic use is within a pH range of 6.0–9.0. The pH values from 7.2 to 8.7 are suitable for aquatic organisms. In general, it could be concluded that the pH value at both studied sites lied within the permissible range. The pH of an aquatic ecosystem is important because it controls all the chemical and biological processes. Although the tolerance of individual species varies, pH values between 6.5 and 8.5 usually indicate a good water quality and this range is acceptable in most major drainage basins all over the world.

**Electrical conductivity EC:**

The Electrical conductivity (EC) of the water samples collected from Konbora ranged between1.41 and 1.8 dS/cm (Fig 2) and were 1.32 and 1.77 dS/m in El-Motamadia samples (Fig 3). In all cases as shown in Fig (2), a significance variation was found between the EC in River Nile water, which ranged between 0.5 and 0.6 dS/m, and water samples collected from either Konbora and El-Motamadia sites. Data exhibited increases in EC values through summer months compared to winter months in Konbora site, as they ranged between 1.5 and 1.7 dS/m, during January to March while slightly increased to reach a maximum level of 1.75 dS/m in July. The same trend was observed in El-Motamadia water samples with maximum level reaching to 1.75 dS/m. This, however is linked with the varied inputs disposed at both sides.

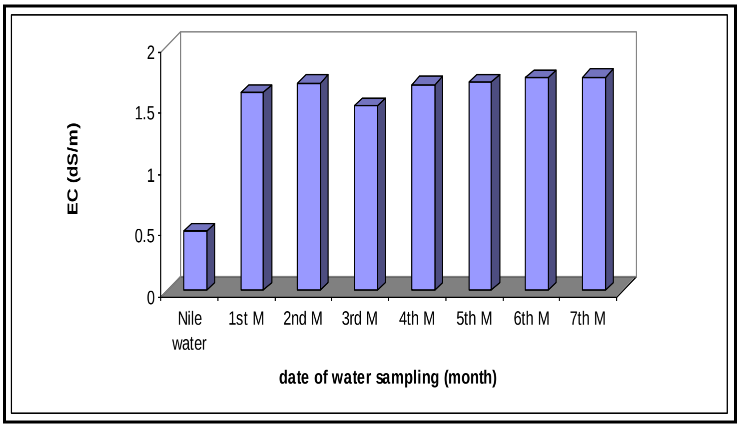


**Fig (2) Electrical conductivity (EC) in konbora compared to River Nile Water**

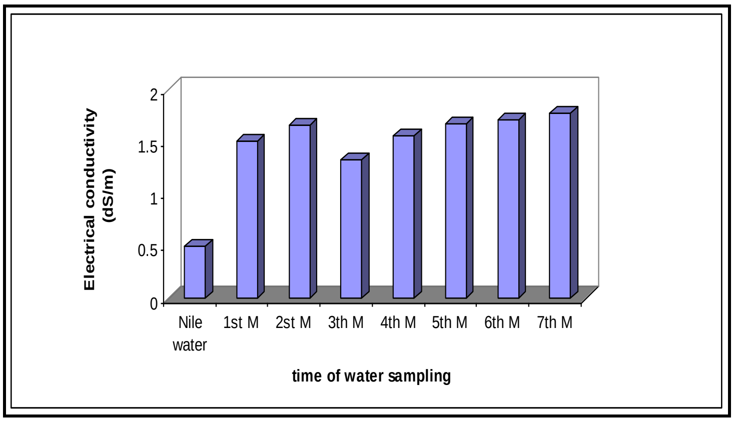


**Fig (3) Electrical conductivity (EC) in El-Motamadia site compared to River Nile Water**

**Soluble cations:**

Results drawn in Figs (4 & 5) indicate that all soluble cations determined at both studied sites were significantly higher than those found in River Nile water. The magnitude of the cations were in the order of Na> Mg > Ca > K at Konbora site, while being Na > Ca > Mg > K at El-Motamadia site. This is very imperative parameter controlling the extended use of water in farming. It is worthy that the found EC values in Konbora samples were generally higher than those found in El-Motamadia. The soluble sodium concentrations, that were the highest compared to other cations at both sites, ranged between 7 and 9 meq/L at El-Motamadia site and were somewhat higher at konbora ranging between 8 and 10 meq/L through the studied months.

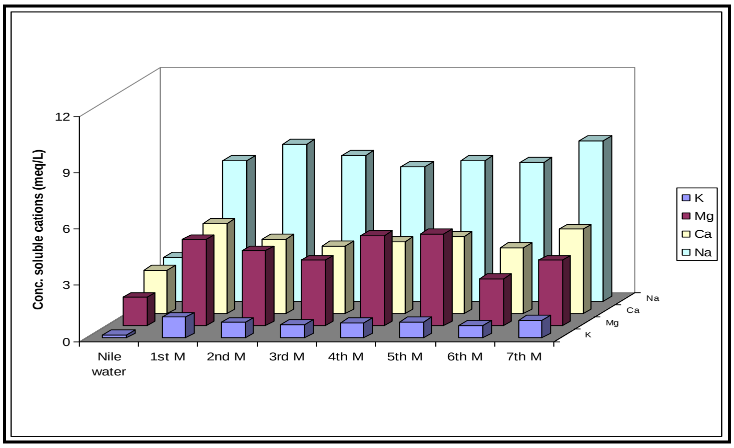


**Fig (4) soluble cations in water samples collected from Konbora site**

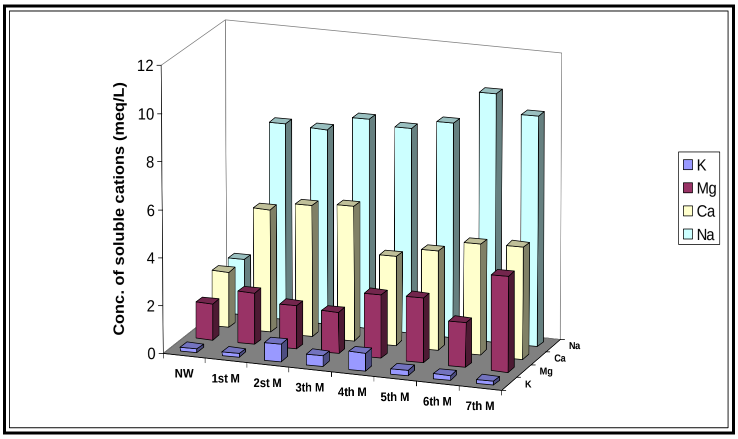


**Fig (5) soluble cations in water samples collected from El-Motamadia site**

Potassium, and other determined mono-valent cation, was the lowest compared to other cations with significant increases at Konbora compared to El-Motamadia sites. For divalent cations, data showed an increase in Ca at El-Motamadia site. On the other hand, Mg cation showed a significant increase at Konbora site. Temperature slightly increased the soluble cations during summer season compared to winter season possibly due to higher evaporation.

**Sodium adsorption ratio:**

Sodium adsorption ratio (SAR) is as important parameter evaluating the use of water in irrigation. Data given in Fig (6) show increasing SAR values at Konbora site compared to River Nile water, the numerical SAR values ranged between 2.45 and 3.69 against 1.60 in River Nile water with slight increases in summer season. The corresponding values of SAR at El-Motamadia site (Fig 7) ranged between 3.5 and 5.5 exhibiting the same trend.

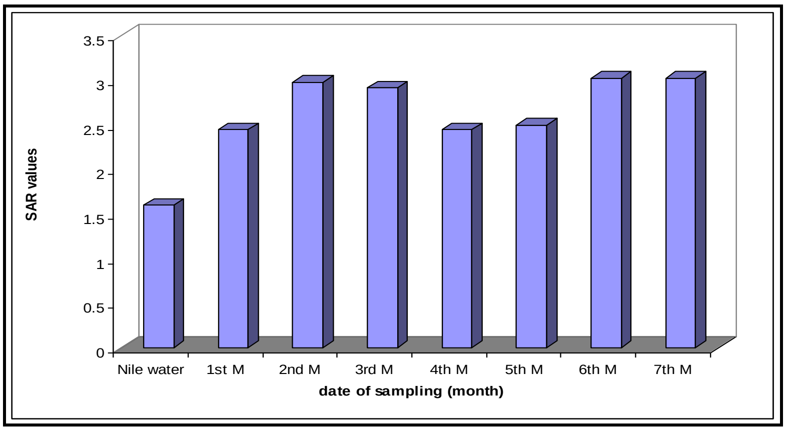


**Fig (6) Sodium adsorption Ratio (SAR) in Konbora compared to River Nile**

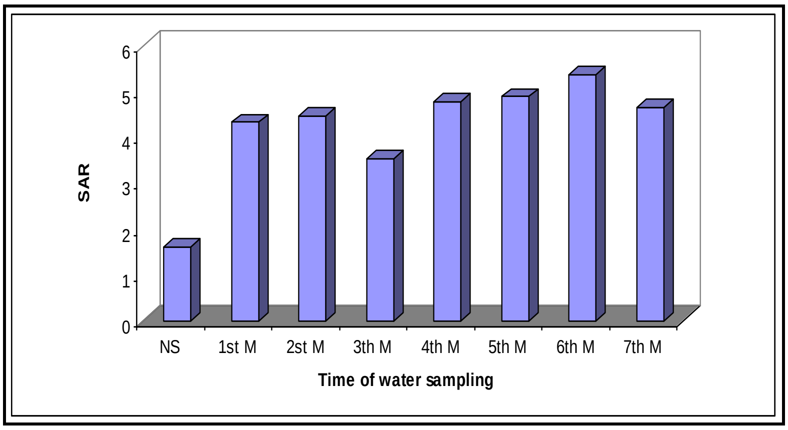


**Fig (7) Sodium adsorption Ratio (SAR) in El-Motamadia compared to River Nile**

According to the Irrigation Water Quality Standards and Salinity Management Strategies, the SAR values of the studied sites are within the permitted values, however, as will be shown later the long term application of such water in light textured soil might lead to serious adverse impacts on soil ecosystem.

**Doneen parameter** represent is an excellent indicator defining the suitability of water to be used in irrigation[7]. In the main, results indicated an unsuitability of the waters at both sites for irrigation purposes. Doneen parameter, is calculated represented by the equation (0.5 $SO_4^{--}$+$Cl^-$), and should not exceed 5. It ranged between 10 and 14.5 in water samples collected from Konbora (Fig 8), and between 8.5-12.5 in water samples collected from El-Motamadia (Fig 9).

The highest calculated Doneen factor was found in July reaching 12.5 and 14.4 in El-Motamadia and Konbora respectively.

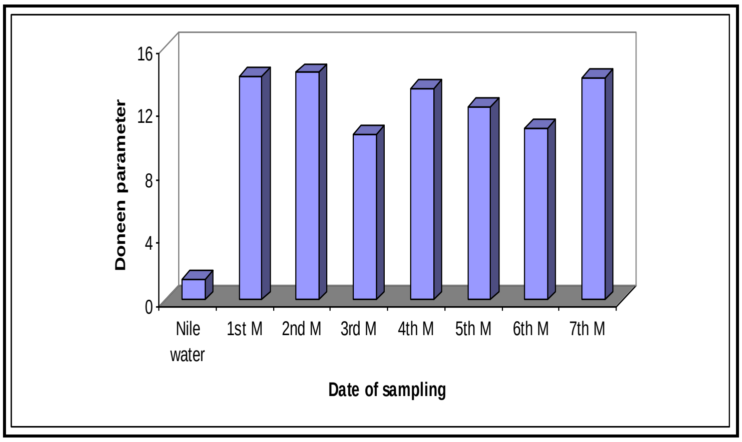


**Fig (8) Doneen factor in Konbora site compared to River Nile**

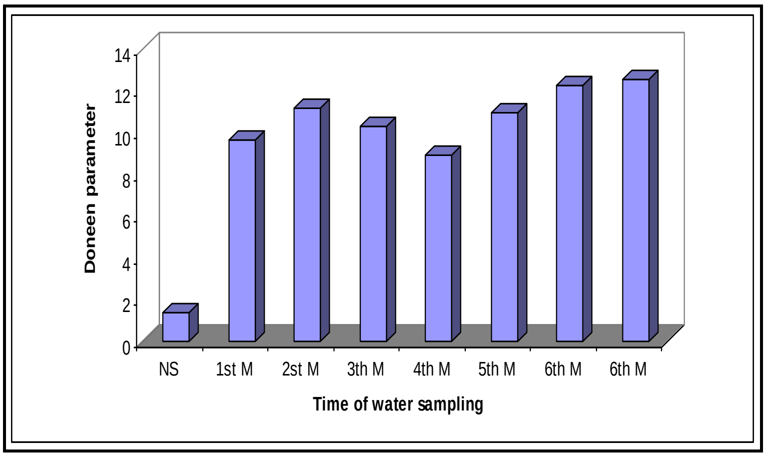


**Fig (9) Doneen parameter in El-Motamadia site compared to River Nile**

It should be mention, however, that the maximum values calculated for Doneen parameter in River Nile did not exceed 1.32. This result might declare the injury of using such waters in irrigation particularly for extended periods on the soil ecosystem.

**PTE's concentrations:** Municipal and industrial effluents frequently contain significant contents of phosphate, nitrate and potential toxic elements. Those are accumulated in the soil ecosystems, and presumably enter food chain after being biomagnified. The presence of PTEs in ecosystems might be estimated by a variety of living species[8]. Unlike organic contaminants, PTEs are non-biodegradable and their removal is essential to shade a light on the hazardous impacts of sewage farming particularly light textured soils. Worthy to mention that the concentration of PTE's varied from site to site according to types of received effluent[9].

Results given in Table (1) show that Ca, Zn, Mn and cu concentrations in the water samples collected from the main canal of Konbora were higher than the save level and consequently higher than those found in River Nile.

**Table (1) Changes in PTEs concentrations in water samples at Konbora**

| **Date of sapling** | **Cd** | **Cu** | **Fe** | **Mn** | **Pb** | **Zn** | **Ni** | **comment** |
|---|---|---|---|---|---|---|---|---|
| | **mgl$^{-1}$** | | | | | | | |
| Safe level | 0.01 | 0.2 | 5 | 0.2 | 5 | 2 | 0.2 | Unsafe to use such water for long time without percussions and remediation treatments for soil |
| Nile water | - | 0.01 | 0.02 | - | - | 0.01 | - | |
| Jan-12 | 0.05 | 0.2 | 3 | 0.1 | 1.4 | 2 | 0.1 | |
| Feb-12 | 0.04 | 0.2 | 2 | 0.16 | - | 2.5 | 0.15 | |
| Mar-12 | 0.04 | 0.3 | 1.5 | 0.25 | 2.5 | 3 | 0.2 | |
| Apr-12 | 0.04 | 0.5 | 1.2 | 0.33 | - | 3 | 0.2 | |
| May-12 | 0.05 | 0.5 | 2.5 | 0.35 | 3 | 3.4 | 0.15 | |
| Jun-12 | 0.06 | 0.4 | 2.9 | 0.3 | - | 3.5 | 0.2 | |
| Jul-12 | 0.06 | 0.5 | 1.8 | 0.35 | 2.5 | 3.2 | 0.2 | |

On the other hand Pb, Ni and Fe were found to be within a safe level. For instances, in July sample, the concentration of Cd was 0.06 mg/L while its safe level in irrigation water should be less than 0.01 mg/L. Worth to mention that River Nile water was free from this contaminant. Accordingly, the use of such water in farming is not safe and especial precautions should be applied to minimize the expected hazards of such water on the soil ecosystem and harvests.

Except Fe and Pb, data in Table (2) showed that all PTEs contents were higher than those found in River Nile water, or the safe permissible levels. Cd content ranged between 0.05 and 0.08 ppm where it safe level should not exceed 0.01 ppm. The same trend was also observed in other PTEs found in water samples. On the other hand, PTEs in River Nile water did not exceed the permissible level.

**Table (2) Changes in PTEs concentrations in water samples at El-Motamadia**

| Date of sapling | Cd | Cu | Fe | Mn | Pb | Zn | Ni | Co | comment |
|---|---|---|---|---|---|---|---|---|---|
| | mgl$^{-1}$ | | | | | | | | |
| Safe level | 0.01 | 0.2 | 5 | 0.2 | 5 | 2 | 0.2 | 0.01 | Unsafe to use such water for long time without percussions and remediation treatments in both soil and water |
| Nile water | - | 0.01 | 0.02 | - | - | 0.01 | - | - | |
| Jan-12 | 0.06 | 0.6 | 3 | 0.3 | 3 | 3 | 0.35 | - | |
| Feb-12 | 0.05 | 0.5 | 3 | 0.3 | 2.5 | 3 | 0.2 | 0.06 | |
| Mar-12 | 0.08 | 0.6 | 4 | 0.3 | 2 | 3 | 0.25 | - | |
| Apr-12 | 0.07 | 0.5 | 3 | 0.4 | 4 | 4 | 0.3 | - | |
| May-12 | 0.06 | 0.4 | 2 | 0.5 | 4 | 2.5 | 0.35 | 0.05 | |
| Jun-12 | 0.08 | 0.5 | 3 | 0.4 | 3 | 3 | 0.3 | 0.03 | |
| Jul-12 | 0.07 | 0.5 | 4 | 0.5 | 4 | 4 | 0.4 | 0.04 | |

A case study was performed by Saber *et al* [10] to monitor changes in microbial biomass and bacterial pathogens at El-Mohtamadia and Konbora sites following sewage farming for extended periods. The studied effluents were collected monthly for microbiological analyses from both sites as well as from River Nile (Tanash village). Their results confirmed the existence of high densities of microbial biomass at both studied sites. Also, pathogens, represented by the classical pathogenic indicators, pathogenic bacteria, and new pathogenic indicators were present in both sites. The intensities of the studied microorganisms were always higher at low quality water collected from both sites compared to River Nile. The counts being always higher in summer samples compared to winter ones.

In the current work, the application of low quality water presented by sewage effluent should be done with caution and if it is intended to be applied, soil characteristics should be checked periodically to determine the type and rate of needed decontamination amendments. For sure high or low pH-values as well as high contents of salts and inorganic or organic contaminants lead to negative impacts on agriculture. The accumulation of PTEs in soils and plants are of entail hazards. The aesthetical quality is an important criterion for the successful sales management and advertisement of soils products irrigated with sewage effluent.

In conclusion, together with the use of River Nile water in irrigation, sewage effluent is becoming an important and potential source of irrigation water in Egypt. The significance of this source could be also created from its content of significant amounts of plant nutrients.

## 6. Acknowledgement

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