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# Probable Accumulation of Heavy Metals in Some Long-Term Irrigated Soils with Zarga River Water in Jordan

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**Abstract**
Heavy metals are bio-accumulated and bio-transferred both by natural and anthropogenic sources. The contamination by heavy metals in plants and water is one of the major issues to be faced throughout the world and requires attention because heavy metals above their normal ranges are extremely threatened to both plant and animal life. It was therefore of interest to conduct study to estimate levels of heavy metals in water and soil at Zarga River. Soil and water samples were also analyzed for physico-chemical parameters such as pH, and electrical conductivity. The aims of this study were to determine level of some heavy metals in water of Zarga River and to examine the probable accumulation of heavy metals in soils irrigated with Zarga river water in contrast with adjacent soils in the area. Results showed that the pH, EC, and water electrolytes (Ca, Mg, Na, K, Cl, HCO3, SO4) of water samples at the middle of the river (B) were higher than that at the beginning or at the end of the river . On the other hand, it was shown that the pH, EC, Cd, Pb, and Ni values of soil samples near the river (location A) were higher than other samples that were away including (B location) and (C location).
**Keywords:** Soil, Heavy metals, Water, pH, Electrical conductivity

## 1. Introduction

There is an increasing deficit in water resources for agricultural production all over the world in general and in Jordan in special. Water shortages in arid and semi-arid regions promote the use of water resources such as contaminated or relatively high salinity level water for agricultural irrigation (Lucho-Constantino *et al*., 2005; Baveye *et al*., 1999; Anikwe and Nwobodo, 2002) Zarga river water is an important example for such water. However, Zarga river water irrigation may pose certain environmental risks, most significantly the pollution of soil with heavy metals (Hu *et a*l., 2008).

Heavy metals are one of the important types of contaminants that can be found on the surface and in the tissues of fresh vegetables. The prolonged human consumption of unsafe concentrations of heavy metals in foodstuffs may lead to the disruption of numerous biological and biochemical processes in the human body (Al-Jassir *et al*., 2005). Balkhair and Ashraf in 2016 reported that Vegetables, especially leafy vegetables grown in heavy metal-contaminated soils, accumulate higher amounts of metals than do those grown in uncontaminated soils because they absorb these metals through their leaves

Elements such as Cd, Cr, and Pb tend to accumulate over years of river irrigation (Lucho-Constantino *et al*., 2005); as a result, significantly greater heavy metal contents have been found in the topsoil (0-20 cm) of farmland that has been irrigated with river for more than 10 years. It has been predicted that the soil contents of certain heavy metals would surpass standard limits after 5 to 60 years of river irrigation (Mapanda *et al*., 2005). These metals tend to be transferred downward with soil depths increasing as the irrigation duration increases (Xu *et al*., 2010). It has been predicted that after 50 to 100 years of treated river irrigation, the soil content of certain heavy metals would reach the current thresholds for environmental concern (Smith *et al.,* 2007).

Studies have been carried out towards the river water irrigated topsoil in which certain heavy metals have accumulated. The possibility that the river water effluent reclamation process could lead to heavy metal accumulation in soils and crops and the accompanying risks to groundwater safety and human health may limit the long-term and widespread use of river water irrigation in agriculture (Yadav *et al*., 2002). Thus, the study of the heavy metal content in the topsoil and the overall soil profile in areas irrigated with river water effluents for different durations is crucial for establishing the safety of river water irrigation. To the best of our knowledge, no studies are available to indicate the effect of long-term irrigation of the soils with Zarga river water on the level of heavy metals in these soils.

The aims of this study were to determine level of some heavy metals in water of Zarga River and to examine the probable accumulation of heavy metals in soils irrigated with Zarga river water in contrast with adjacent soils in the area.

## 2. Methodology

*2.1 Study Area and Sample Collection:*

Three water samples were taken at three locations along Zarga River between Zarga city in the east and king Talal dam in the west river. Non-metallic containers were used during sample acquisition, preservation, and processing to avoid any contamination before laboratory analysis. Regarding Soils samples; they were taken after digging in six zones. Three of these zones were in the area that was near the river. The other three zones were in the area that was away from the river. The soil samples were stored in plastic bags, placed in a small refrigerated box, and transported to the laboratory for chemical analysis.

*2.2 Chemical Analysis*

*2.2.1 Zarga River Water Samples Analysis*

Water samples ware symbolized (A, B, C). (A symbol) represent the water sample that was taken at the beginning of the river, (B symbol) represent the water sample that was taken in the middle of the river, and (C symbol) represent the sample that was taken at the end of the river. All samples were analyzed. These parameters include Electrical Conductivity (EC), pH, and water electrolytes.

*2.2.2 Soil Samples Analysis*

Soil samples ware symbolized (A1, A2, A3, B1, B2, B3 C1, C2 and C3). The first three symbols represent the locations near the river. The next three symbols represent the locations at the middle away from the river. Meanwhile, the last three symbols represent the locations that are far from the river. At each location; three samples were taken and the average values were recorded. The samples were air dried and sieved, and then chemical analysis was performed. Parameters include Electrical Conductivity (EC), pH, and heavy metals (Cd, Pb, and Ni).

*2.3 Statistical Analysis*

The experimental data were analyzed using Graduate Pack SPSS 22.0 (SPSS Inc., Chicago, IL, USA).

## 3. Results

It was shown that the pH, EC, and water electrolytes (Ca, Mg, Na, K, Cl, HCO3, SO4) of water samples at the middle of the river (B) were higher than that at the beginning or at the end of the river (Table 1,Figure 1). On the other hand, it was shown that the pH, EC, Cd, Pb, and Ni values of soil samples near the river (location A) were higher than other samples that were away including (B location) and (C location) (Table 2, Figure2).

## 4. Discussion

Present study was conducted in order to assess the heavy metal contamination of water and soil at Zarga River area. As water pollution is dangerous for both aquatic and human health so it is the need of hour to assess the water quality of rivers and dams as this is a very important issue related to human and environment. For this purpose water samples were collected from three locations of the Zarga River. Soil samples were also collected from three locations at different distances from the river. Water and soil samples were subjected to heavy metal analysis and also for chemical parameters including pH, electrical conductivity. Results were presented in the form of tables and figures. It was shown that the pH, EC, and water electrolytes (Ca, Mg, Na, K, Cl, HCO3, SO4) of water samples at the middle of the river (B) were higher than that at the beginning or at the end of the river. These results explained by that it is normal to water electrolytes to be accumulated at the middle of the river (Figure 1). On the other hand, it was shown that the pH, EC, Cd, Pb, and Ni values of soil samples near the river (location A) were higher than other samples that were away including (B location) and (C location). The results of heavy metals could be explained by that heavy metals near the river are not diluted compared to samples at far distances from the river (Figure 2).

**Table 1: values (pH, EC, and water electrolytes) of different water samples**

| | water samples / Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **pH** | **EC (µS/cm)** | **Ca (mg/l)** | **Mg (mg/l)** | **Na (mg/l)** | **K (mg/l)** | **Cl (mg/l)** | **HCO3 (mg/l)** | **SO4 (mg/l)** |
| **A** | 7 | 2.15 | 3.73 | 5.47 | 11.13 | 0.9 | 11.5 | 5.5 | 4.23 |
| **B** | 7.4 | 2.98 | 3.92 | 6 | 12.1 | 0.99 | 12.2 | 5.66 | 4.9 |
| **C** | 7 | 2 | 3.2 | 5.22 | 8.99 | 0.39 | 9 | 3.87 | 4 |

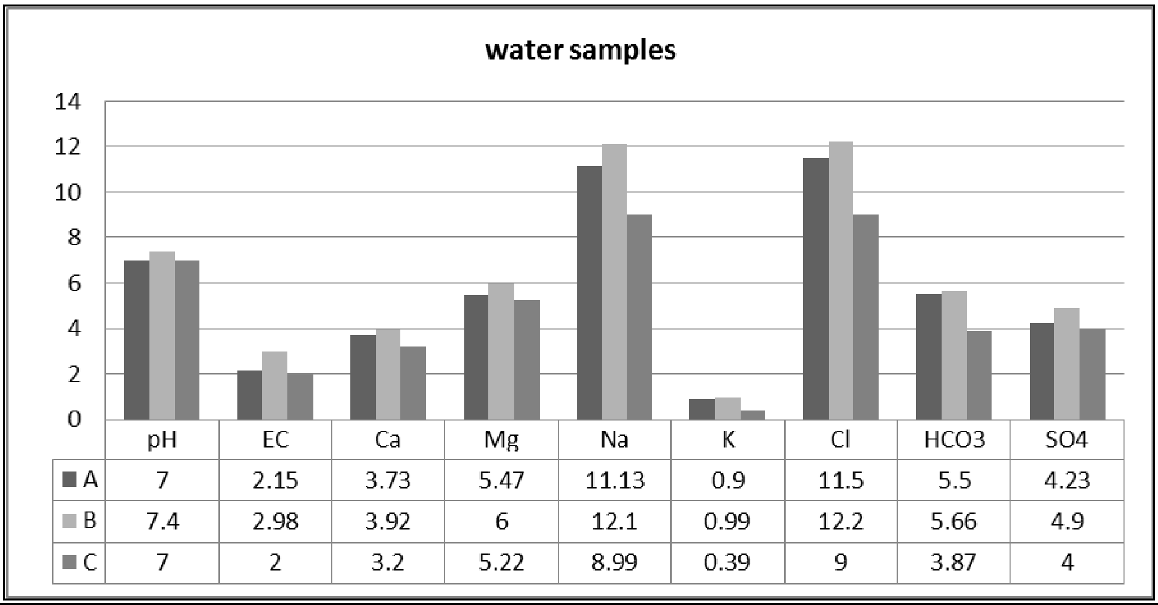


**Figure 1: values (pH, EC, and water electrolytes) of different water samples**

**Table 2: values (pH, EC, Cd, Pb, and Ni) of different soil samples**

| Soil samples / Parameter | | | | | |
|---|---|---|---|---|---|
| **Location** | **pH** | **EC (µS/cm)** | **Cd (mg/kg)** | **Pb (mg/kg)** | **Ni (mg/kg)** |
| **A1** | 8.3 | 0.74 | 0.82 | 0.17 | 0.7 |
| | 8.2 | 0.78 | 0.79 | 0.15 | 0.63 |
| | 8 | 0.7 | 0.68 | 0.11 | 0.52 |
| **Average** | **8.2** | **0.74** | **0.76** | **0.14** | **0.62** |
| **A2** | 8.2 | 0.79 | 0.8 | 0.14 | 0.66 |
| | 8.2 | 0.76 | 0.79 | 0.14 | 0.6 |
| | 7.9 | 0.7 | 0.61 | 0.09 | 0.49 |
| **Average** | **8.1** | **0.75** | **0.73** | **0.12** | **0.6** |
| **A3** | 7.9 | 0.61 | 0.71 | 0.11 | 0.41 |
| | 7.8 | 0.62 | 0.61 | 0.1 | 0.52 |
| | 7 | 0.59 | 0.49 | 0.06 | 0.33 |
| **Average** | **7.6** | **0.61** | **0.6** | **0.09** | **0.42** |
| **B1** | 7.8 | 0.68 | 0.67 | 0.11 | 0.62 |
| | 7.8 | 0.63 | 0.65 | 0.09 | 0.56 |
| | 7.1 | 0.51 | 0.61 | 0.08 | 0.51 |
| **Average** | **7.6** | **0.61** | **0.64** | **0.09** | **0.6** |
| **B2** | 7.8 | 0.61 | 0.62 | 0.08 | 0.59 |
| | 7.2 | 0.61 | 0.64 | 0.08 | 0.53 |
| | 7 | 0.51 | 0.58 | 0.07 | 0.5 |
| **Average** | **7.3** | **0.58** | **0.61** | **0.08** | **0.54** |
| **B3** | 7.1 | 0.56 | 0.54 | 0.08 | 0.51 |
| | 7 | 0.54 | 0.59 | 0.08 | 0.51 |
| | 6.9 | 0.43 | 0.51 | 0.07 | 0.48 |
| **Average** | **7** | **0.51** | **0.55** | **0.08** | **0.5** |
| **C1** | 6.7 | 0.41 | 0.39 | 0.07 | 0.42 |
| | 6.3 | 0.43 | 0.46 | 0.07 | 0.46 |
| | 6 | 0.4 | 0.41 | 0.06 | 0.41 |
| **Average** | **6.3** | **0.41** | **0.42** | **0.07** | **0.43** |
| **C2** | 6.1 | 0.39 | 0.31 | 0.05 | 0.38 |
| | 6.1 | 0.39 | 0.42 | 0.05 | 0.35 |
| | 5.8 | 0.31 | 0.31 | 0.05 | 0.39 |
| **Average** | **6** | **0.36** | **0.35** | **0.05** | **0.37** |
| **C3** | 5.9 | 0.3 | 0.25 | 0.04 | 0.21 |
| | 5.7 | 0.36 | 0.31 | 0.04 | 0.19 |
| | 5.4 | 0.22 | 0.32 | 0.03 | 0.22 |
| **Average** | **5.7** | **0.3** | **0.3** | **0.04** | **0.21** |

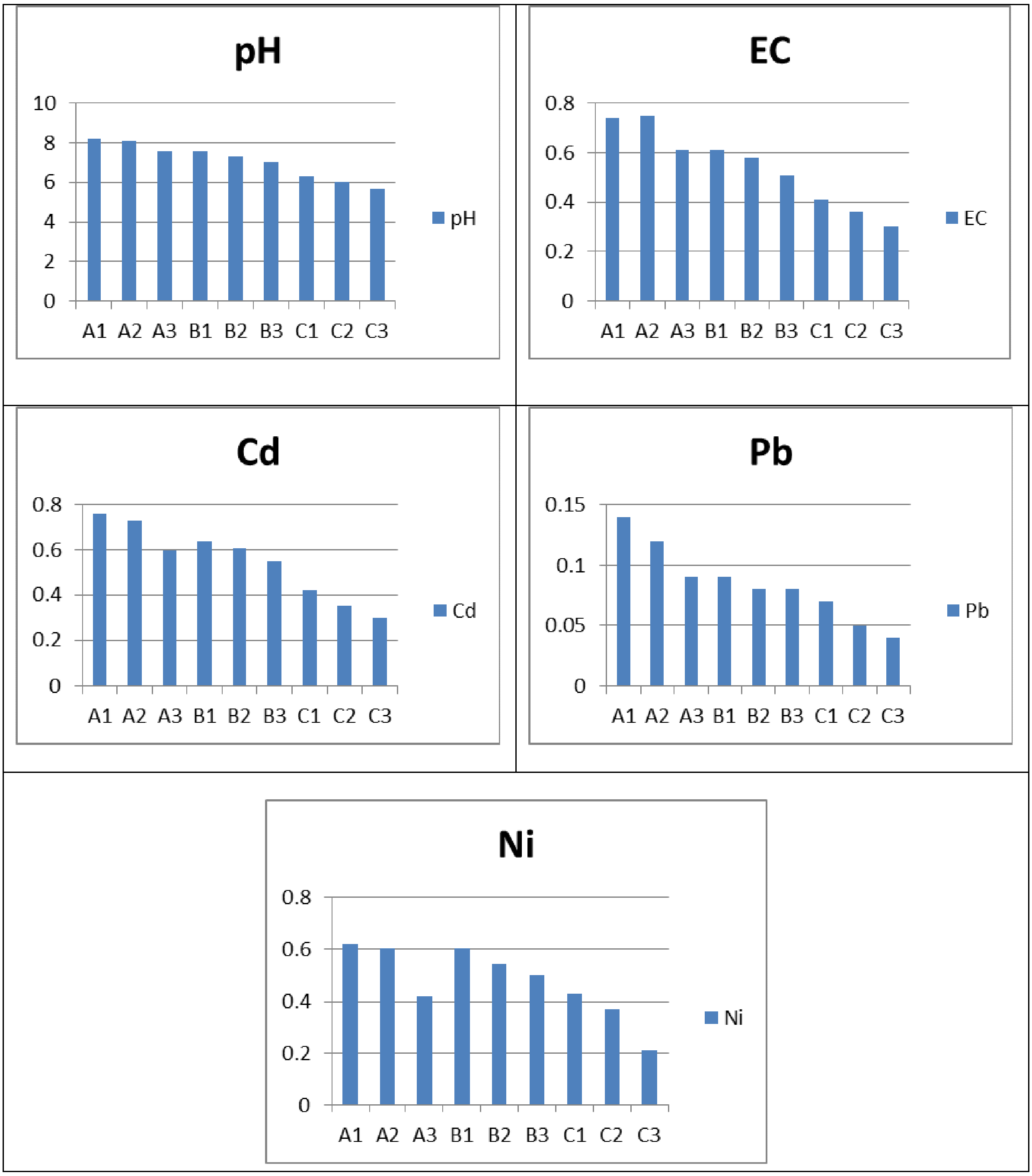


**Figure 2: Values (pH, EC, Cd, Pb, and Ni) of different soil samples**

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