# Artesian Water Contamination with Heavy Metals at Different Distances at Borg El Arab, Alexandria – Egypt

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## ABSTRACT

**Twenty four water samples were collected from six artesian wells in Borg El Arab region, Alexandria, from June 2015 to May 2016, and analyzed for the determination of Fe, Mn, Zn, Cu, Pb, Cd, Co, and Ni, The obtained results showed that Nile water contained 0.31-1.23 Fe 0.06-0.65 Mn, 0.08-0.52 Zn, 0.01 -0.16 Cu, (mgL$^{-1}$), while Pb, Cd, Co, Ni were not detected. The artesian water contained: 0.17-2.81 as Fe, (0.06-0.95) as Mn, (0.0 - 0.90) as Zn, (0.0 -0.3) Cu (mgL$^{-1}$).The concentrations of Co, Pb, Cd, and Ni were nil. All values were below the safe limit of water suitability for irrigation. Artesian water can be used under special management. The higher values of Fe, Mn, Zn Pb, and Cu were found in the soil irrigated with artesian water. Regular monitoring of heavy metals in crops is essential to prevent excessive accumulation of these metals via the food chain. Long-term daily intake of contaminated crops is likely to be a detrimental health hazard for consumers.**

**Keywords: Artesian water, Trace elements, Heavy metals, Borg El Arab**

## INTRODUCTION

The soils Borg El Arab region is considered highly calcareous soil. The studied area is a part of the eastern section of the north – western costal region of Egypt. It was selected at Borg El Arab, 48 Kilometer west of Alexandria city. It is located approximately between latitudes 30 ˚ 45 and 30˚ 55 N, and longitudes 29˚ 30 and 29˚ 50 E The study area covers about 5000 feddans and has differences in elevation and relief (Abdelrazek, 2014)

The Nile River and artesian water are the sources of irrigation in Bahig canal for orchards and farmland. Water quality means different things to different people depending on the objectives and purposes of water use. Good quality water should have several specifications and standards as drinking water requires high specifications and standards; The Guidelines of WHO, (2011) followed by different countries in the world and each country has its own guide.

Boyd, (2000) and Abdelrazek (2007) found that the concentrations of of Zn, Pb, Cd, and Co in plants (wheat grain, radish, pepper, cabbage, barley and Jews mallow) were dependent on their concentrations in the polluted soil

As part of national survey of geological and water quality assessment program in the United States, concentrations of trace elements (boron, iron, lead, molybdenum, cadmium, lithium, zinc) were measured in samples of ground water collected from 1992 to 2003. Results revealed differences and diversity in the concentration of trace elements that have been studied due to the diversity of geological crust in USA, and reported an increase in the solubility of trace elements in groundwater with pH less than 7.0, except for molybdenum which dissolved in alkaline pH (Ayotte et al., 2011).

The objectives of this study therefore were (i) to assess artesian water quality used in irrigation in Burg El Arab region and comparing it with control area, (ii) to study the influence of artesian water quality on soil and plant contents of potentially toxic elements.

## MATERIALS AND METHODS

### Sampling:

**Water:** Sampling processes based on scientific methodology that will preserve as much as possible the chemical and physical properties of water. After cleaning the glass bottles, acid solution (HCl) was used to wash the bottles, followed by tap water, then several times with distilled water. The bottles were finally dried in an oven temperature at 60 C$^{o}$. The aim of this process is to remove any pollutants (APHA, 1998). The sources of irrigation water were Nile water and artesian water. Six water samples from Nile irrigation canal, six samples from artesian water were collected (In summer and winter season) for chemical analysis.

**Soil:** Forty eight soil samples (0 -20 and 20-40 cm) were collected. These samples represented variations in cropping patterns, and different irrigation water sources. The present cropping patterns include potatoes (*Solanum tuberosum* L.).

**Plant:** Twenty four Potatoes plants grown in the study area were sampled. These samples were thoroughly washed with tap to remove all adhered soil particles, cut into leave which were washed by distilled water then air-dried for 2 days then oven dried at 70$^{o}$C overnight, ground and kept in plastic bottles for analysis.

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**Analysis:**

**Water analysis**: Sub sample of 500 ml water were preserved with 2 ml nitric acid to prevent precipitation and adhesion of metals on the bottle walls (APHA, 1998)

**Soils analysis :**The Heavy metals (Fe, Mn, Zn, Cu, Pb, Ni, Cd, Co) were extracted using DTPA (Lindsay and Norvell, 1978) and the metals concentration was measured by atomic absorption spectrophotometer, Perkin-Elmer 560.

**Plant analysis:** One gram of oven - dried plant leaves was ashes in a muffle furnace and then evaporated and treated with HCl. Samples were then boiled in 10 ml distilled water diluted to 50ml, and filtered. The extracted samples were then analysed for their contents of Fe, Mn, Zn, Cu, Pb, Cd, Co and Ni by atomic absorption spectrophotometer Perkin-Elmer by (Farrukh, 2012).

**Statistical analysis**

All obtained data of soil, plant and water were statistically analyzed using statistical software SYSTAT- 12. One-way analysis of variance was carried out to compare the means of different treatments and least significant differences at $P < 0.05$ were obtained using Duncan's multiple range test (DMRT) (Duncan, 1955). The data were also subjected to Pearson correlations analysis, and cluster analysis, to identify the relationship between the variables and to find out the key soil parameters that are sensitive to heavy metals exposure.

## RERSULTS AND DISCUSSION

**Heavy metals in irrigation water**

Table (1a) showed that Nile water contained 0.31-1.23 Fe, 0.06-0.65 Mn, 0.08-0.52 Zn, 0.01 -0.16 Cu ($mgL^{-1}$), while Pb, Cd, Co, Ni metals were not detected in the artisan water (Table 1b). The concentrations of heavy metals values increased near polluted source and decreased with distance increase and its concentration were higher in winter than in summer (Table 1b).

Table (1b) revealed that the artesian liquid wastes discharged in irrigation canals increased the levels of heavy metals in the water, to reach a level below that recommended by (FAO, 1995). The concentration of heavy metals decreased by getting far away from the source of irrigation (Fattah and Abdelrazek, 2014)

Similar results were reported by Pichtel *et al* (2000) ; Ramadan (1995); Abou-El-Naga *et al.* (1996); Eissa and El-Kassas (1999); Ahmed(2001) Superphosphate fertilizer, pesticides and brick factories emission were the main sources of pollution by heavy metals in this area (Elsoury *et al*., 2015; Omran *et al*., 1996; El-Sebaey, 1995; USDA, 1997; Ahmed, 2001).

**Heavy metals in soil**

Table (2a and 2b) showed the amount of DTPA extractable Fe, Mn, Zn, Cu, Pb, Cd Co, in soil with distance from water source. Regarding to the concentrations DTPA of heavy metals in soils, the data clearly demonstrated large different between polluted and non-polluted soil irrigated with Nile water according to the distance from the industrial source. It is clear that usually the levels of heavy metals are much higher in the soils near the industrial centers of Borg El Arab City .

**Table 1a. The concentrations of heavy metals ($mgL^{-1}$) in irrigation water sources at Bahig area (Nile water)**

| | | Nile water | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Distance irrigation water sources m** | **Seasons** | **Fe** | **Mn** | **Zn** | **Cu** | **Pb** | **Cd** | **Co** | **Ni** |
| | | | | | **$mgL^{-1}$** | | | | |
| 50 | S | 1.23 | 0.65 | 0.52 | 0.16 | nd | nd | nd | nd |
| | W | 1.23 | 0.71 | 0.52 | 0.16 | nd | nd | nd | nd |
| 250 | S | 0.71 | 0.43 | 0.31 | 0.07 | nd | nd | nd | nd |
| | W | 0.93 | 0.61 | 0.31 | 0.07 | nd | nd | nd | nd |
| 500 | S | 0.62 | 0.25 | 0.21 | 0.09 | nd | nd | nd | nd |
| | W | 0.73 | 0.26 | 0.21 | 0.09 | nd | nd | nd | nd |
| 1000 | S | 0.58 | 0.07 | 0.06 | 0.07 | nd | nd | nd | nd |
| | W | 0.71 | 0.02 | 0.06 | 0.07 | nd | nd | nd | nd |
| 1500 | S | 0.44 | 0.09 | 0.05 | 0.02 | nd | nd | nd | nd |
| | W | 0.61 | 0.01 | 0.05 | 0.02 | nd | nd | nd | nd |
| 5000 | S | 0.31 | 0.06 | 0.08 | 0.01 | nd | nd | nd | nd |
| | W | 0.21 | 0.01 | 0.08 | 0.01 | nd | nd | nd | nd |

S: summer W: winter L.S.D: Least significant difference nd: not detected

**Table 1b. The concentrations of heavy metals ($mgL^{-1}$) in artesian water at Borg El Arab area**

| | | Artesian water | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Distance irrigation water sources m** | **Seasons** | **Fe** | **Mn** | **Zn** | **Cu** | **Pb** | **Cd** | **Co** | **Ni** |
| | | | | | **$mgL^{-1}$** | | | | |
| 50 | S | 2.81 | 0.95 | 0.90 | 0.31 | nd | nd | nd | nd |
| | W | 2.82 | 0.91 | 1.0 | 0.35 | nd | nd | nd | nd |
| 250 | S | 0.91 | 0.58 | 0.20 | 0.21 | nd | nd | nd | nd |
| | W | 1.66 | 0.81 | 0.26 | 0.24 | nd | nd | nd | nd |
| 500 | S | 0.82 | 0.35 | 0.16 | 0.11 | nd | nd | nd | nd |
| | W | 0.93 | 0.36 | 0.17 | 0.16 | nd | nd | nd | nd |
| 1000 | S | 0.78 | 0.17 | 0.90 | nd | nd | nd | nd | nd |
| | W | 0.81 | 0.12 | Nd | nd | nd | nd | nd | nd |
| 1500 | S | 0.74 | 0.09 | 0.7 | nd | nd | nd | nd | nd |
| | W | 0.91 | 0.8 | nd | nd | nd | nd | nd | nd |
| 5000 | S | 0.17 | 0.06 | nd | nd | nd | nd | nd | nd |
| | W | 0.21 | 0.06 | nd | nd | nd | nd | nd | nd |
| Guideline for water irrigation agricultural (FAO,1995) | | 5.0 | 0.30 | 2.0 | 0.2 | - | - | - | - |
| L.S.D at 5% level Between (table 1a) and ( table 1b) | | 0.16 | 0.11 | 0.08 | 0.06 | --- | ---- | -- | - |

S: summer W: winter L.S.D: Least significant difference nd: not detected

The concentrations of these metals in soil samples at 50 m from water sources in summer 2011 were about 5-9 times higher than their concentrations at 5000 meter from the industries. The concentrations decreased with increasing distance from factories and could be arranged decendingly between distance 50 m (summer 2011) and at 5000 m (winter 2012) as follows: (i) Artesian water: Fe (2.3 -11.2), Mn, (2.1 - 9.5), Zn (1.3 - 9.1) Cu (0.2 -2.2), Pb (0.7 -1.5), Cd (0.3 - 0.5), Co (0.2 -1.2), Ni (0 - 4.1) (Table2b) and (ii) Nile water (Bahig canal): Fe (1.3 - 9.3), Mn, (1.1- 4.6), Zn (1.1- 3.1), Cu (0.08-1.3), Pb (0.0 -0.0), Cd (0.0 -0.0), Co (0.0 – 0.0), Ni (0.0 -0.0) (Table 2a). These results agreed with those obtained earlier by other researchers. (Elsokkary, 1980; Morsy, 1990; Abdel- Mottaleb et al., 1993; Venni and Muthuvel, 1997). Also, Shalby et al., (1996a) and Schbmacher et al. (1997) found that the higher values of Fe, Mn, Zn Pb, and Cu were found in the soil beside the artesian water

Table (2a and 2b) revealed that the the total amount of Fe, Mn, Zn Pb, Cu, Pb, C, Co, Ni in different layers of the investigated soils samples differed according to the water source used for irrigation.

Long-term application of phosphate fertilizers to soil for vegetable production has increased the concerns about the potential health risks of heavy metal contamination in crops grown on contaminated soils in Borg El Arab province, western Alexandria city. In the present study, long-term fertilizer use led to a growing accumulation of heavy metals in soils. High concentrations of As, Cd, Cr, Cu, Pb, and Zn were found in potatoes grown in over used phosphate fertilizer soils which increased the daily intake of metals in food.

**Effect of Artesian water on plant**

**Heavy metals in potato leaves:** Concentrations of Fe, Mn, Zn, Cu, Pb, Cd, Co and Ni in potato leaves in (Table 3) showed that heavy metal contents decreased with increasing distance from the source of pollution and could be arranged descendingly and as follows: Fe (46.9 –13.5), Mn (5.3 -4.9), Zn (6.1 -1.3) Cu (2.4 -0.7) respectively; the metals: Pb, Cd, Co and Ni were not detected.

It is clear from the present study that continuous irrigation with polluted water elevated the levels of metals in the soil which is concentrated in plants grown these soils. These plants when enter the food chain, they could be harmful to animal and human being nourished with these heavy metal (Sharma et al., 2007 and Elsokkary et al., 2011). Also, Eissa and El-Kassas (1999) stated that the concentration of heavy metals in seven different plant species grown in different soils irrigated with artesian water were as follows: Pb (25 - 182) > Mn (19 – 73) > Zn (12 – 65) > Cu (15 -25) > Co (2.1 – 18.8) >Ni (3.9 – 12.1)> Cd (3 -9). These results agree with our findings.

Generally, this work may express a vital point in heavy metals accumulation in the environment (water – soil – plants system). Our data therefore, are in harmony with those reported by (Eissa and El-Kassas (1999); Abou El- Naga et al., (1996) and Shalaby et al., (1996a).

**Table 2a. Heavy metals content (mg kg$^{-1}$) in soils at different distance from different water resources (Nile water)**

| Distance irrigation water sources W.I.R (m) | Depth (cm) | Fe | Mn | Zn | Cu | Pb | Cd | Co | Ni |
|---|---|---|---|---|---|---|---|---|---|
| | | (mgKg$^{-1}$) | | | | | | | |
| Nile water | | | | | | | | | |
| 50 | 0 - 20 | 9.3 | 4.6 | 3.1 | 1.3 | nd | nd | nd | nd |
| | 20 -40 | 10.5 | 4.7 | 3.3 | 1.2 | nd | nd | nd | nd |
| 250 | 0 - 20 | 4.4 | 3.2 | 2.6 | 0.9 | nd | nd | nd | nd |
| | 20 -40 | 4.3 | 3.6 | 2.3 | 0.7 | nd | nd | nd | nd |
| 500 | 0 - 20 | 3.3 | 2.3 | 2.4 | 0.5 | nd | nd | nd | nd |
| | 20 -40 | 2.6 | 2.2 | 2.3 | 0.7 | nd | nd | nd | nd |
| 1000 | 0 - 20 | 2.4 | 1.5 | 1.6 | 0.7 | nd | nd | nd | nd |
| | 20 -40 | 1.2 | 1.4 | 1.3 | 0.6 | nd | nd | nd | nd |
| 1500 | 0 - 20 | 1.7 | 1.2 | 1.2 | 0.3 | nd | nd | nd | nd |
| | 20 -40 | 1.4 | 1.3 | 1.2 | 0.2 | nd | nd | nd | nd |
| 5000 | 0 - 20 | 1.4 | 0.9 | 1.1 | 0.09 | nd | nd | nd | nd |
| | 20 -40 | 1.3 | 1.1 | 1.1 | 0.08 | nd | nd | nd | nd |

nd : not deducted * Refers to output of human uses * W.I.R: Water Irrigation Source

Table (3) shows also that the micronutrients and heavy metals content in leaves of potato plants irrigated with artesian water at different distance from the polluted source contained different concentration of Fe in leaves which is always higher than that in the other parts of plants. Such trend could be attributed mainly to the translocation of Fe and its tendency to accumulate in leaves.

These data indicate that the content of Fe in the leaves of potato is above the requirement range for plant nutrition while in other two parts (peel and juice) it is around the normal range and it is similar to the data of Jones (1972). Concerning Cu, Zn and Mn contents in the different parts of plant (leaves, peel and Juice), the higher values was found in the leaves and the lower values were found in the juice. However, when comparing the content of this micronutrient in plants grown in normal soil with those in this study,

**Table 3.Effect of different irrigation water sources on heavy metals concentrations in leaves of potato plants** (*Solanum tuberosum* L.) **after 45 days planting at Bahig region**

| Distance (m) | Fe | Mn | Zn | Cu | Pb | Cd | Co | Ni |
|---|---|---|---|---|---|---|---|---|
| | (mgKg$^{-1}$) | | | | | | | |
| Nile water | | | | | | | | |
| 50 | 46.9 | 5.3 | 6.1 | 2.4 | nd * | nd | nd | nd |
| 250 | 38.8 | 3.2 | 4.2 | 1.3 | nd | nd | nd | nd |
| 500 | 31.8 | 2.3 | 3.1 | 1.1 | nd | nd | nd | nd |
| 1000 | 26.5 | 1.9 | 2.1 | 0.9 | nd | nd | nd | nd |
| 1500 | 25.9 | 2.7 | 1.2 | 0.7 | nd | nd | nd | nd |
| 5000 | 13.5 | 4.9 | 1.3 | 0.7 | nd | nd | nd | nd |
| Artesian water | | | | | | | | |
| 50 | 81.7 | 15.2 | 16.1 | 3.3 | nd | nd | nd | nd |
| 250 | 78.5 | 13.1 | 14.2 | 2.1 | nd | nd | nd | nd |
| 500 | 68.9 | 12.2 | 13.1 | 1.2 | nd | nd | nd | nd |
| 1000 | 56.3 | 11.9 | 12.1 | 1.8 | nd | nd | nd | nd |
| 1500 | 45.9 | 9.2 | 8.2 | 1.6 | nd | nd | nd | nd |
| 5000 | 33.5 | 8.8 | 7.2 | 1.7 | nd | nd | nd | nd |
| L.S.D at 5% evel | 5.84 | 2.36 | 2.65 | 0.51 | 0.69 | 0.19 | 0.23 | 0.49 |

* nd: not detected

it is clean that irrigation with artesian water increased the levels of Cu, Zn and Mn in the different parts of the plants, nevertheless this increase is not toxic to the plant. This finding agreed with that of Jones (1972). Regarding to the content of Co and Pb in potato leaves; both are lower than the toxic level (Hammond and Aronson, 1964).

## CONCLUSION

All values were below the safe limit of water suitability for human uses, according to safe limits laid down by (W.H.O, 2011) Artesian water can be used under special management. Long-term daily intake of contaminated crops is likely to be a detrimental health hazard for consumers. Improved standards have encouraged people to take an interest in food quality, and the dietary intake of foods may constitute a major source of long-term low level accumulation of heavy metals in the body. Thus, the detrimental impacts may only become apparent after several years of exposure. Therefore, regular monitoring of heavy metals in crops is essential to prevent excessive accumulation of these metals via the food chain. Long-term daily intake of contaminated crops is likely to be a detrimental health hazard for consumers.

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## الملخص العربي

## تلوث المياه الارتوازية بالعناصر الثقيلة عند مسافات مختلفة بمنطقة برج العرب – الإسكندرية – مصر

سعد عبد الصمد السيد عبد الرازق

تم جمع أربع وعشرين عينة مياه من ستة آبار ارتوازية في منطقة برج العرب بالإسكندرية من يونيو ٢٠١٥ إلى مايو ٢٠١٦، وتم تحليلها لتحديد الحديد، والمنجنيز، والزنك، والنحاس، والرصاص، ،الكادميوم ،الكوبلت، النيكل، عند تحليل عينات مياه النيل الواردة ومحتواها من الحديد (٠.٣١ – ١.٢٣ ) والمنجنيز(٠.٠٦ – ٠.٦٥ ) والزنك (٠.٠٨ – ٠.٥٢) والنحاس (٠.٠١ –٠.٠ ١٦) بينما لم يظهر التحليل قيم الرصاص و الكاديوم والكوبلت والنيكل، وكان محتوى الماء الاتوازى من الحديد (٠.١٧ – ٢.٨١ ) والمنجنيز(٠.٠٠٦ –٠.٩٥) اما الزنك (٠.٠ – ٠.٩٠) والنحاس (٠.٠ – ٠.٣ ) (مليجرام /لتر) وكان تركيز العناصر الاخرى كالرصاص و الكاديوم والكوبلت والنيكل صفر وكانت جميع القيم فى الحد الآمن لاستخدام المياه للشرب وري النباتات، وكانت جميع القيم أقل من الحد الآمن لملاءمة المياه للري، المياه الارتوازية يمكن استخدامها تحت إدارة خاصة. تم العثور على قيم أعلى من الحديد، المنجنيز، الزنك الرصاص، والنحاس في التربة المروية بالماء الارتوازي، ويعتبر الرصد المنتظم للمعادن الثقيلة في المحاصيل أمرا ضروريا لمنع التراكم المفرط لهذه المعادن عن طريق السلسلة الغذائية. ومن المرجح أن يكون الاستهلاك اليومي الطويل الأجل للمحاصيل الملوثة خطرا على صحة المستهلكين.

الكلمات المفتاحية: الماء الارتوازى ،العناصر ثقيلة، برج العرب