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Health Risk Assessment of Heavy Metals and their Source Apportionment in Drinking Water of Zulfi District, North-West of Riyadh Region

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ABSTRACT

The present study was conducted to investigate heavy metal (Al, As, , Cd, Cr, Fe, Mn , Ni, Pb , Hg, and Zn) concentrations of drinking water (groundwater) samples in Zulfi, north-west of Riyadh region.
Furthermore, the study aimed to ascertain potential health risk of heavy metal (HM) concentrations to local population. HM concentrations were analyzed by using Inductively Coupled Plasma (ICP) spectrophotometer equipped with an ultrasonic nebulizer using Inductively Coupled Plasma (ICP) spectrophotometer.
The minimum and maximum trace metals concentrations in different areas for (Al, As, Cd, Cr, Mn, Ni, Pb, Hg, and Zn) ranged between (1.61-0.19. 2.4-0.5 ,0.34-0.1 ,13.64-1.85 ,420-0.15 ,9.56-0.11, 0.52-0.1 ,0.96-0.18 µg/L) respectively.
The results indicated the presence of iron in all sampled wells. Its concentrations exceeded the maximum contaminant level (MCL) in 69% of the samples. It is recommended that an adequate and suitable treatment must be applied to the wells having elevated concentrations of the metals and supplying drinking water to the consumers.

Keywords: Trace metals, Groundwater, Drinking water sources, Riyadh region -Zulfi district.

Introduction

Water is one of the most necessary resources for the sustenance of human, plants and other living beings. It is required in all aspects of life and health for producing food, agricultural activity and energy generation. Ground water is one of the dominant solution to provide water for human and agricultural (Donald B.Aulebeach, 1968). In Saudi Arabia 80% of water resources are used for irrigation in agriculture (A Symposium; Walid Abderrahman, 2001). Ground water represent about 49-80% from water resources in In Saudi Arabia (Arani Kajenthira, *et al* 2011). In arid regions, such as Zulfi, available water resources are largely restricted to ground water. The quantification of available ground water resources plays therefore an important rote for the management of the limited resources Assessment of groundwater quality requires determination of heavy elements concentrations which decide its suitability for drinking, agricultural and industrial uses (MIT). The main objective of this study is the assessment of environmental impact of trace elements in Zulfi district.

Heavy metals constitute as ecological and human health issue, since heavy metals do not undergo biological degradation, contrary to certain organic pollutants (M.Makkawi). Metals exert biological effects that can be essential for humans. May metals such as Fe, Cu, Co, Mn, Zn and Cr are essential for humans, (Anthony Ewusi, *et al* 2013). However, high doses of these essential elements can cause toxic effect. Other metals such as Hg, Pb, Cd, and As are not essential for any animals (Emmanuel E, *et al* 2007).

Study Area

The present study is carried out at Zulfi District Riyadh region of Saudi Arabia which is geographically bounded by 26° 17' 41" N latitude and 044° 49' 06 E (Figure 1) (Caussy D, et al 2003). Ground water samples were collected from wells (n=10) located in the Zulfi Province in Riyadh region. The sampling was carried out over four month period. The location of the wells was recorded using Geological Positioning System (GPS). The different locations of the sampled wells are shown in (Figure 2). All of the sampled wells were the main source of irrigation water for the local farmer.

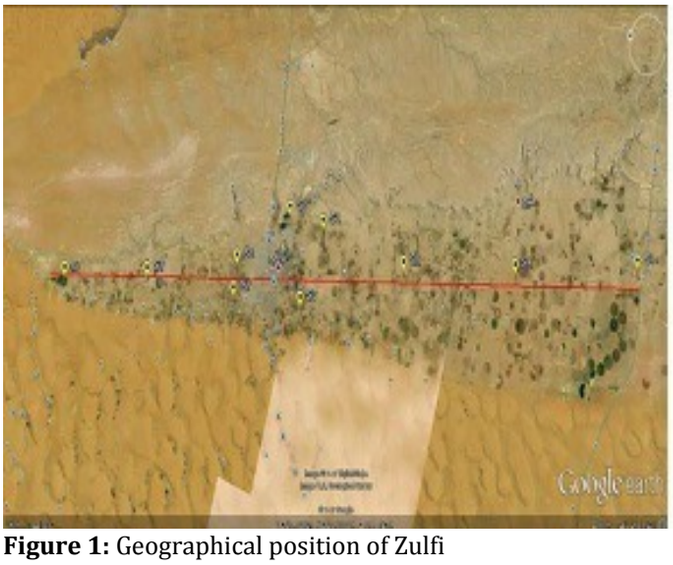

Figure 1: Geographical position of Zulfi

Figure 2: locations of sampled wells district

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Materials and Methods

Collection of Samples

Ground water samples were collected in 0.5-liter plastic bottles Fig 2, which were previously thoroughly washed with tap water and rinsed with distilled water. These were immediately acidified to pH_2 with HNO_3 in order to keep metals in solution and prevent them from adhering to the walls of the bottles. All samples were transported to the laboratory in iceboxes and refrigerated at 4°C until analyzed.

Sampling protocol was designed in such a way that samples collected in one sampling schedule were analyzed.

Sample Analysis

Samples were analyzed for trace metals (Al, Cd, Cr, Fe, Mn, Ni, Pb, Hg, As, and Zn) The analytical determination of trace metals was carried out by ICP-MS (Inductively Coupled Plasma-Mass Spectrometer): NexION 300D (Perkin Elmer, USA). The ICP-MS calibration was carried out by external calibration with the blank solution and four working standard solutions (100, 200, 300 and 400 µg/L) for all ten elements, starting from a 1000 mg/L single standard solutions for ICP-MS (Aristar grade, BDH laboratory supplies, England for the trace elements. High purity water obtained from Millipore Milli-Q water purification system was used throughout the work.

Result and Discussion

The minimum, maximum and average trace metal concentrations in different parts of Zulfi province in Riyadh region has been presented in Table 1.

Table 1: Summary of trace elements of water samples collected from Zulfi ground water , together with WHO guidelines values (WHO)

No.	Element	Maximum concentrations	Minimum concentrations	Average	WHO's drinking water standards
1	Al	1.61	0.19	0.71	200
2	Hg	0.96	0.18	0.47	500
3	As	2.4	0.5	1.05	100
4	Ni	9.56	0.11	0.47	200
5	Cr	13.64	1.85	3.69	500
6	Fe	9488.2	1512.2	5290.81	500-50000
7	Mn	420	0.15	64.75	3000
8	Zn	49.05	2.68	12.12	3000
9	Cd	0.34	0.01	0.03	3
10	Pb	0.52	0.1	0.16	500

Aluminum (Al): all samples had measurable aluminum concentrations are not exceeded the drinking water specified limits prescribed by World Health Organization (WHO) (Table1) Figure (3) (WHO).

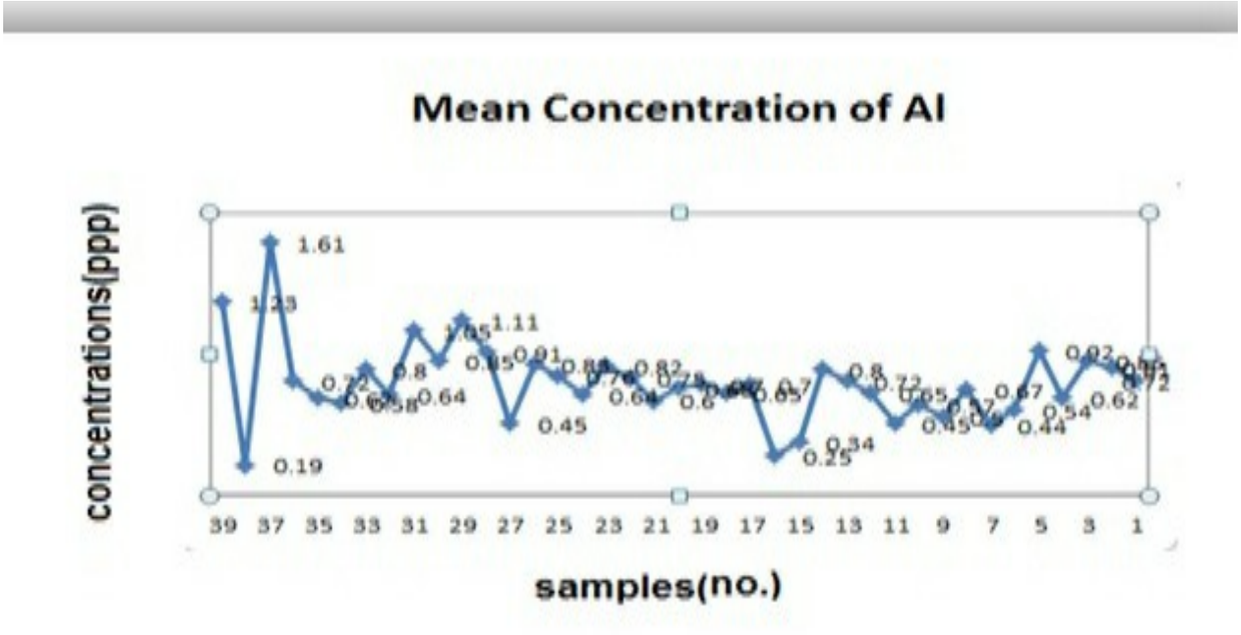

Figure 3: Aluminum concentrations

Arsenic (As): The minimum 0.5ìg/l, maximum 2.4 µg/l and average 1.05 µg/l concentrations of As were respectively (Table 1). The standard deviation within the Riyadh region was 1.26 (APHA, 1999). None of the samples exceeded the maximum contaminant limits for irrigation water (Table 1). (Figure 4).

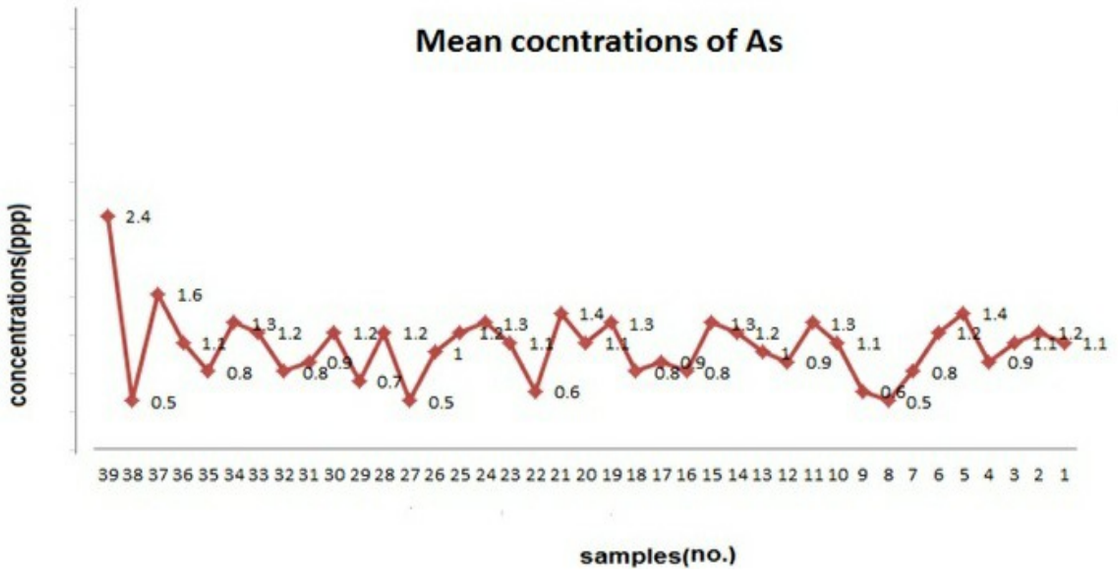

Figure 4: Arsenic concentrations

Cadmium (Cd): For the Cd metal, none of the samples exceeded the relevant maximum contaminant limits prescribed for Cd in drinking water (Table 1) The minimum 0.01 µg/l, maximum 0.34 µg/l and average 0.03 µg/l concentrations of As were respectively. (Figure 5).

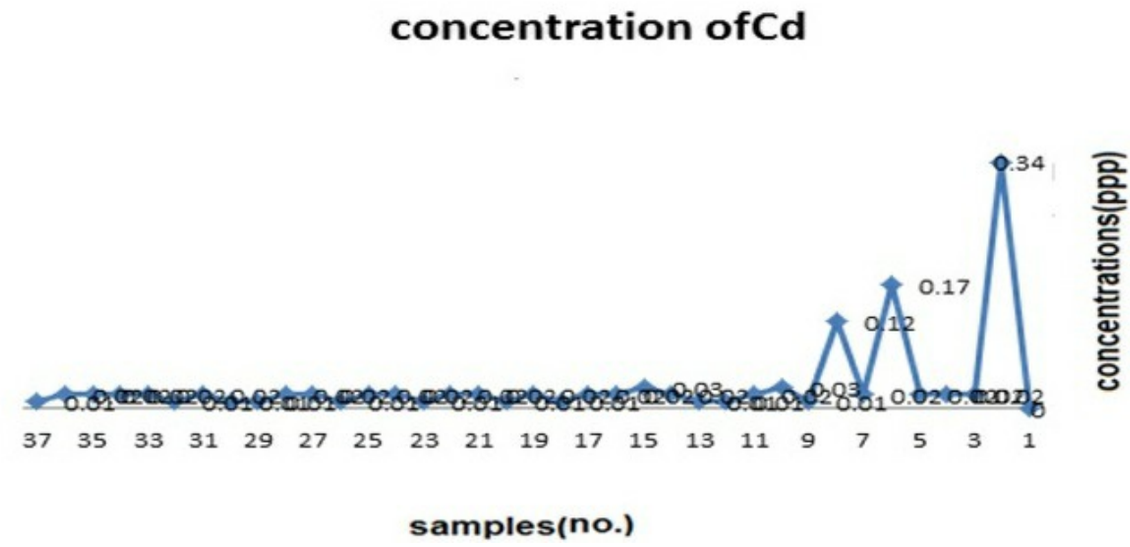

Figure 5: Cadmium concentrations

Chromium (Cr): The minimum 1.85 µg/l, maximum 13.64 µg/l and average 3.96 µg/l concentrations of Cr were respectively (Figure 6). However, none of the sample exceeded the Cr maximum contaminant limits stipulated for drinking water (Table 1).

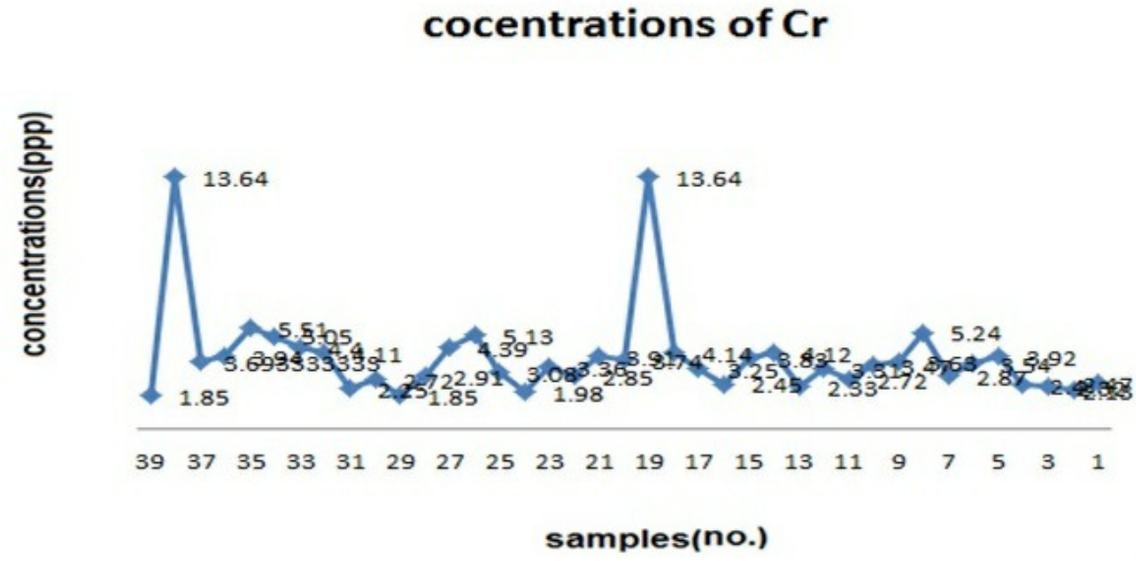

Figure 6: Chromium concentrations

Mercury (Hg): The minimum and maximum mercury concentrations varied between 0.96 µg/L as maximum value to 0.18 µg/L as minimum value (Fig 7). Measurable concentrations of Mercury not exceeded the relevant prescribed limits for drinking water for that metal (Table 2). (APHA, 1999).

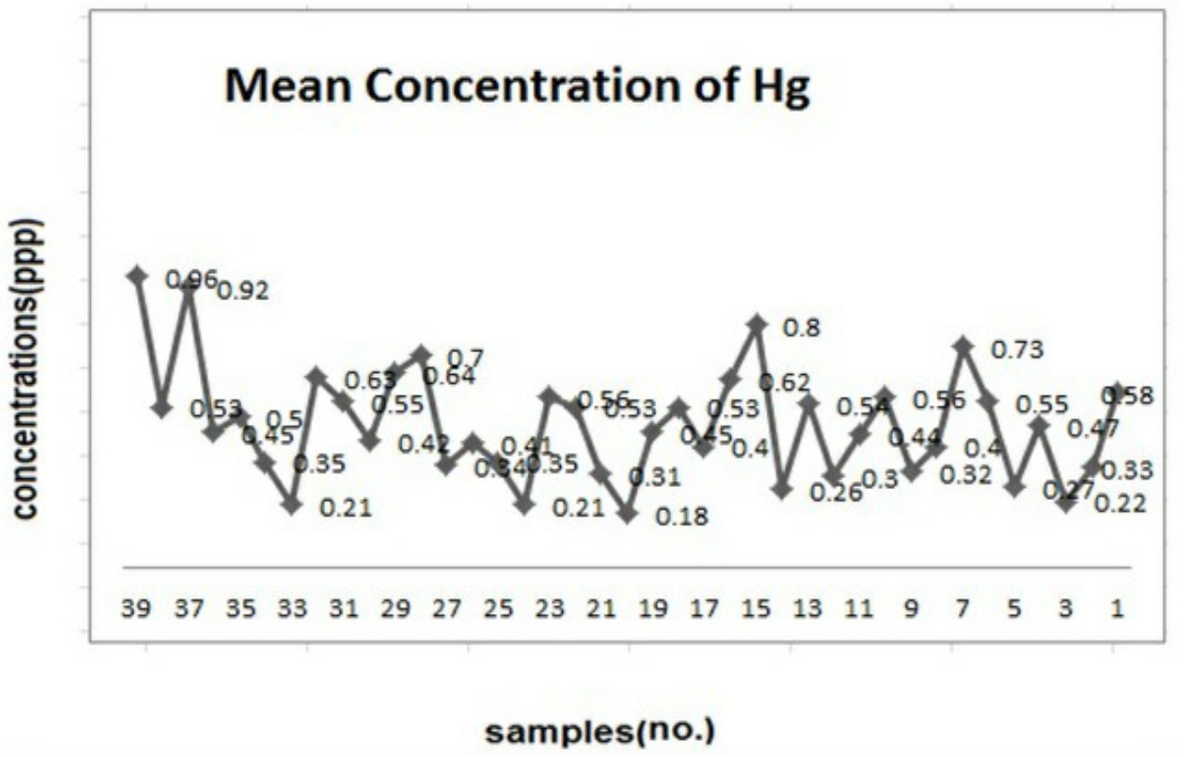

Figure 7: Mercury concentrations

Iron (Fe): The minimum and maximum iron concentrations varied between 9448.2 µg/L and 1512.2 µg/L. Measurable concentrations of the metal were found in samples, (68.96%) of the samples exceeded the relevant prescribed limits for drinking water (Table 2). (APHA, 1999) At some localities problems with higher concentrations of iron found in ground water. These higher concentration of these metals result in metallic taste of water, effect color and flavor of food and cause staining of different products like paper, cloths, and plastics (mapland.com).

Manganese (Mn): The minimum and maximum manganese concentrations varied between 420.00 µg/L as maximum value ,0.15 µg/L minimum value ,and average of 64.75 µg/L (Figure 8) all samples not exceeded the relevant prescribed (APHA, 1999) limits for drinking water for that element (Table 1).

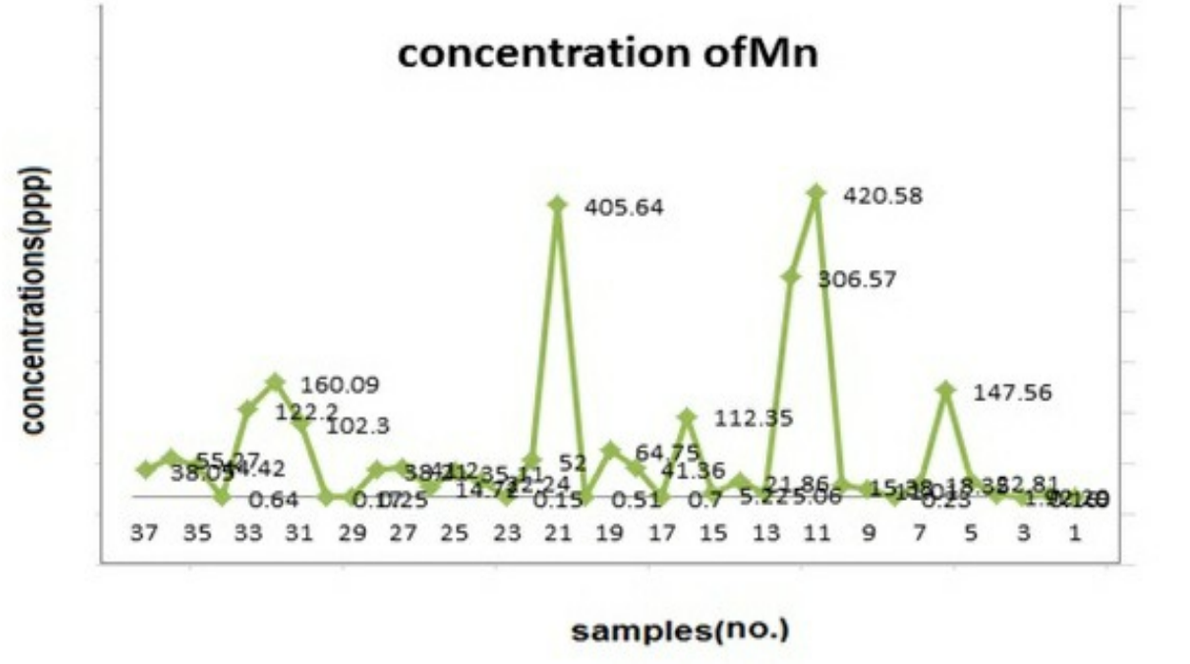

Figure 8: Manganese concentration

Nickel (Ni): The minimum and maximum manganese concentrations varied between 9.56 µg/L as maximum value ,0.11 µg/L minimum value, and average of 0.47 µg/L (Table 1) , none of Ni samples exceeded the maximum contaminant limits stipulated for drinking water (Table 2) (figure 9).

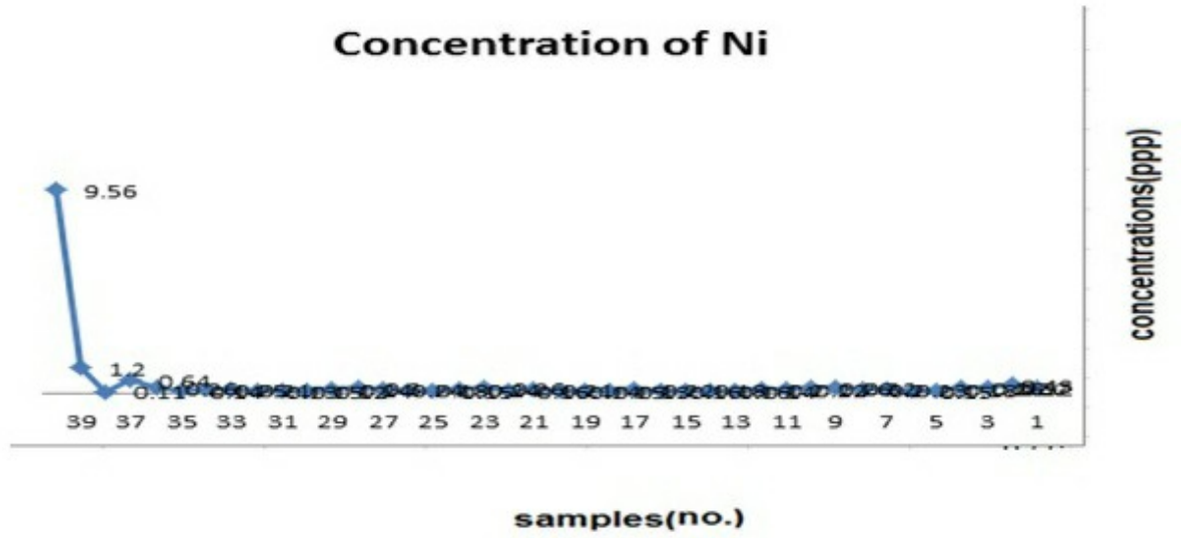

Figure 9: Nickel concentrations

Lead (Pb): The minimum and maximum lead concentrations varied between 0.52 µg/L as maximum whereas the average metal concentration was 0.16 µg/L. However, none of the samples exceeded the relevant prescribed limits for drinking water for that element (Table 2), (Figure 10).

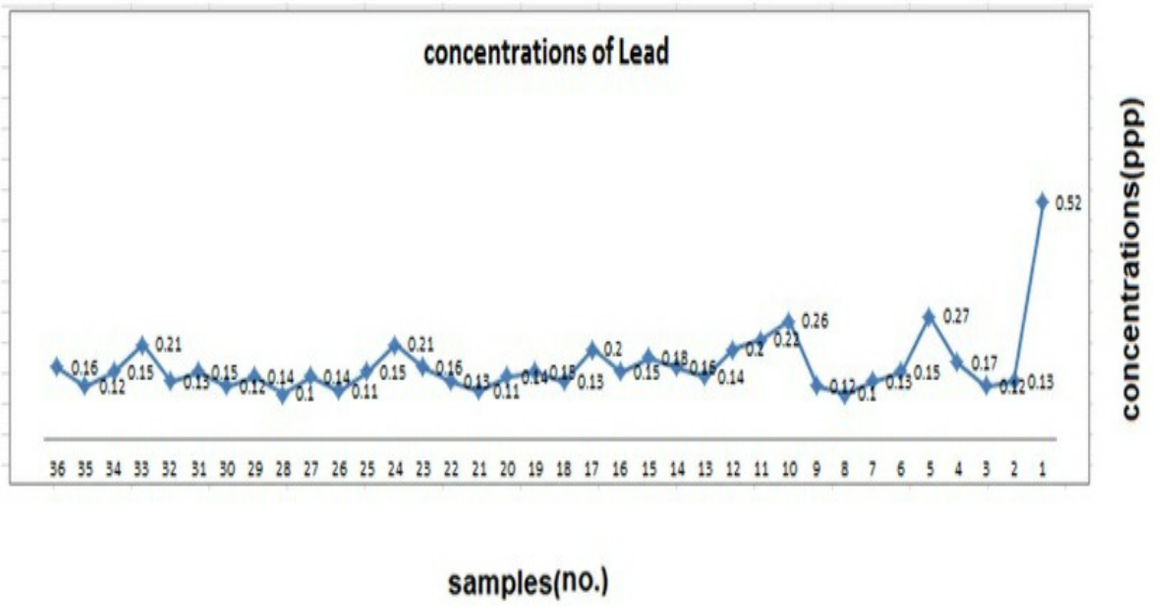

Figure 10: Lead concentrations

Zinc (Zn): The minimum and maximum zinc concentrations varied between 2.68 and 49.05 µg/L. However, none of the samples exceeded the relevant prescribed limits for drinking water for zinc (Table 2), (figure 11).

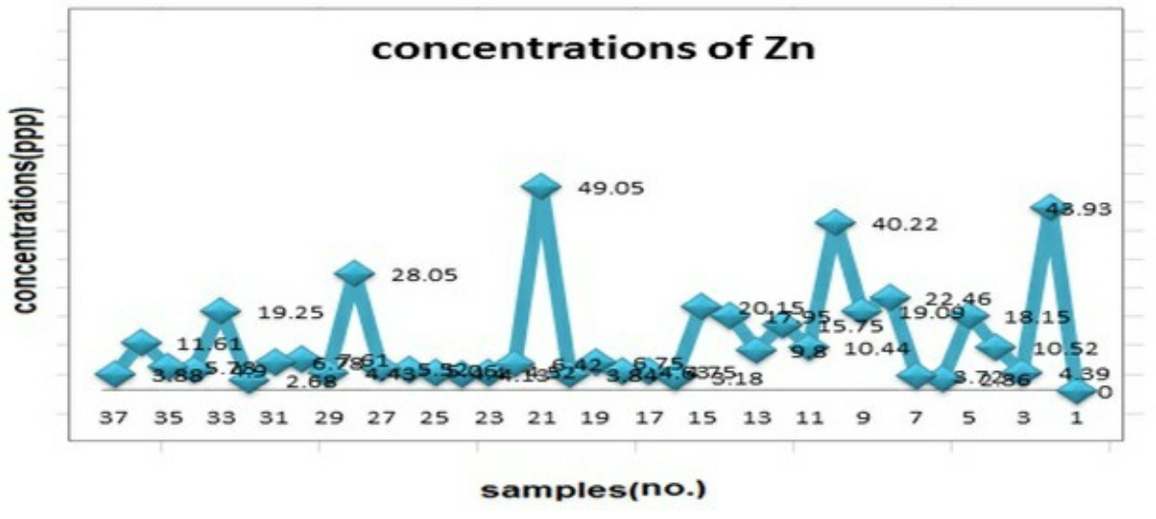

Figure 11: Zinc concentrations

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pH of Zulfi groundwater

The pH scale ranges from 0 to 14. A pH of 7 indicates neutral water; greater than 7, the water is basic; less than 7, it is acidic. (Virtual Chembook, 2003).

Ground water pH is an important geochemical control that can affect the solubility and mobility of trace elements, often through sorption/desorption processes (Mansoor Ahmad, 2012; WHO 4th Ed; Deverel, *et al* 1988). For many metals such Al, Cu, Fe , Mn, and Zn solubility can decrease with pH. For others, such as As, and U solubility can increase with increasing pH over normal range of most natural resources . For this analysis, all samples of ground is greater than 7.

Conclusions

- Water samples were collected from 10 wells (for three levels), Water desalination(one treated and other untreated), and from tanker used for drinking in industrial area (39 samples).
- The minimum and maximum trace metals concentrations in different areas for Al, As, Cd, Cr, Mn, Ni, Pb, Hg, and Zn are found not to the relevant prescribed WHO limits for drinking water.
- Ferrous exceed the maximum limits for drinking water it found to be about 69% of tested sampled wells in the Zulfi district.
- pH of groundwater in Zulfi district is greater than 7 in all samples.

Finally, it is concluded that, the drinking water in the study area does not pose chronic health risk. But as some of the selected HM exceeded their safe levels, therefore, it suggested that, the water from contaminated sites should not be used for drinking without treatment and Government of Saudi Arabia may provide drinking water alternatives to these areas.

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