Review Article

Assessment of Ground Water Pollution with Heavy Metals in Al-Zaatari area, North Jordan

Abstract

Heavy metal (Zn, Cu, Cd, Fe, Mn, Pb, Ni and Cr) concentration in fifteen groundwater samples of the Zaatari area were analyzed using inductively coupled plasma-optical emission spectroscopy (ICP-OES) for determination of the impact of Zaatari refugee camp on groundwater pollution with the above mentioned heavy metals. The aims of this study is to assess the potential pollution of the groundwater in Al-Zaatari area with heavy metals (Zn, Cu, Cd, Fe, Mn, Pb, Ni and Cr) through measuring their concentrations in the groundwater samples obtained through wells located at the study area. The sources of Mn, Pb, Ni and Cr was found to be from natural sources related to the weathering of the basaltic rocks whereas Zn and Pb, Cu, Cd was attributed to anthropogenic sources such as fertilizers and pesticides in the agriculture, and various anthropogenic activities.

The concentration of heavy metals in groundwater ranged between, 1.43 to 4.87 mg/l for Mn, 0.85 to 1.85 mg/l for Pb 0.7 to 0.26 mg/l, for Ni, 0.05-0.081 mg/l for Cd and 0.30 to 0.19 mg/l for Cr. The allowable limits for JISM, 2008 are Mn = 0.1 mg/l, Pb = 0.01 mg/l, Ni = 0.02 mg/l, Cd = 0.003 and Cr = 0.005 mg/l respectively. The results also showed that the concentrations of Mn, Pb, Cd, Ni and Cr are exceeding the desirable limits in many groundwater sample which was attributed to anthropogenic activity whereas Cu, Zn, Fe were below the desirable limits and was attributed to natural source related to rock formation of basaltic origin.

Keyword: Ground water, pollution, Heavy Metals, Al-Zaatari area, Jordan.

1. Introduction

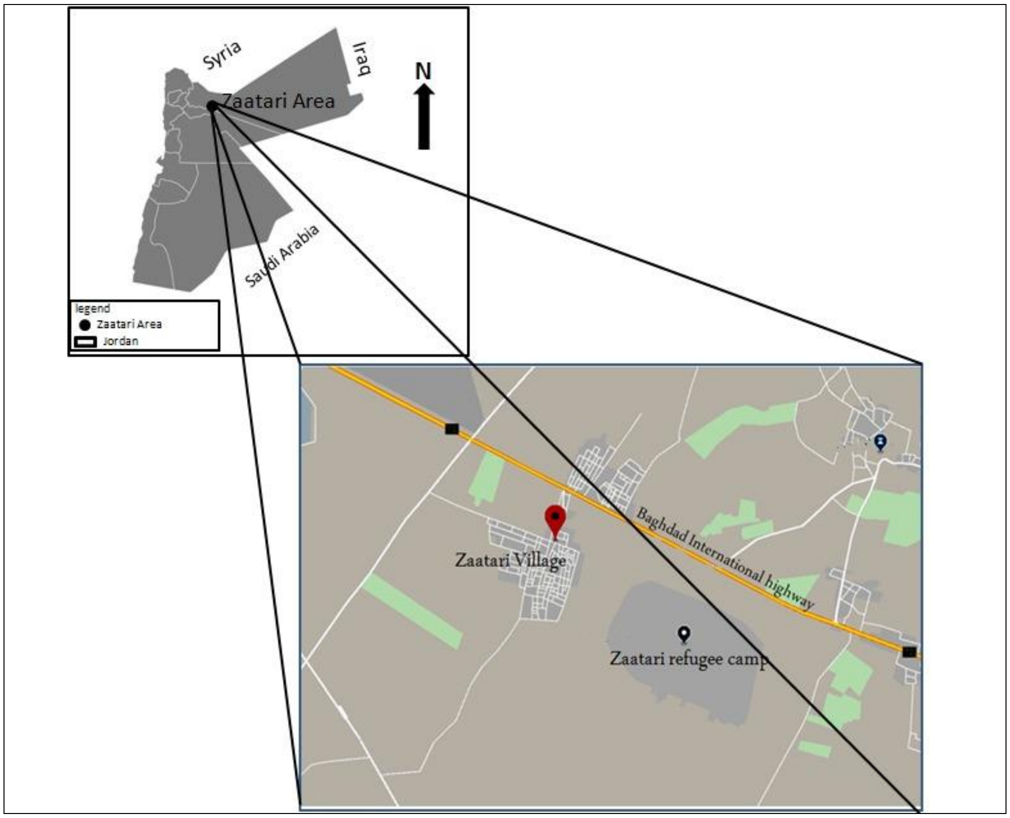
Water is the essence of life and the underlying economy of any country and without the existence of water life will come to the end. Jordan is a prime country to examine due to its even more dire lack of fresh water resources, as compared with its regional neighbors that are more blessed with water, or have the wealth to create it with desalination technology. Jordan is considered one of the driest countries in the world, and suffers shortage of water which is not surprising due to the desert environment that encompasses 92% of its land area (Denny et al., 2008). Recently the groundwater quality has been deteriorating in many parts of the country due to rapid development, expansion of agriculture, and industrialization. However, the country cannot afford a situation in which maintains precious water resources from being lost due to pollution resulted from a wide variety of sources that including agricultural, domestic, and industrial (Awawdeh and Jaradat, 2009). Groundwater is a major source of water supply for domestic and agricultural purposes, especially in arid and semiarid regions (Nayak et. al., 2006; Kumar and Remadevi, 2006; Ahmadi and Sedghamiz, 2007). Agricultural activities in semiarid regions consume large quantities of water due to high evaporation rate. Irrigation exerts a heavy toll on the available scarce groundwater. as it consumes more than 65% of the water budget in Jordan. The demand of water for domestic and industrial use is also increasing (Ta`any et. al., 2007).

Heavy metals are those metals with specific gravity greater than 5.0, high atomic number and high atomic weight. Heavy metals are not biodegradable and can be accumulative in the ecosystems and human bodies. (Abu-Rukah, and Osama 2001). Some of the heavy metals are usually toxic even at low concentrations and others are not toxic even when they present at high concentrations. In this content heavy metals are restricted to only toxic metals. Heavy metals are natural component of the earth it is impossible for human being to exist on earth without heavy metals, therefore wherever human are found usage of heavy metals exists. Improper discharge of the used heavy metals in the environment causes an adverse impact on the environment. Once they are discharged, they are transferred from one place to another and could reach the groundwater deteriorate its quality. The toxicity of heavy metals depends on its concentration in the aquatic system as well as its toxicity that various heavy metals showed different health effect (Ejazul et al., 2007).

The contamination of groundwater by heavy metals, originating either from natural soil sources of from anthropogenic sources is a matter of utmost concern to the public health. The main objective of this study was characterization of selected heavy metals concentration (Lead, Cadmium, Copper, Zinc, Nickel, Iron, Manganese and chromium) in groundwater of the area surrounding Zaatari refugee cacmp. Identifying the source of heavy metals in groundwater at Zaatari area.

2. Study area

The study area which is a part of Amman -Zarqa basin is located within Mafraq Governorate about 20 km east of Mafraq city in the northern part of Hashemite Kingdom of Jordan. The study area is about 17.8 km² at longitudes between (E36º 299′ 265″ /N32º 170′ 13″), and between latitudes (E36º 539′ 237″ /N32º 335′ 71″). It is located in the North East Jordan (Figure 1). Zaatari refugee’s camp which was established in 2012 after the breakout of the civil war in Syria. It contains more than 80,000 refugees are living over an area of 5.3 Km². Zaatari refugee camp is listed as the second largest refugee camp in the world and the fourth largest city in Jordan (UNHCR, 2017). Where it forms part of the study area. The amount of wastewater product within the camp was estimated to be around 3,600 m3/d. The wastewater is transported to a small wastewater treatment plant located within the camp. The anthropogenic activities within the camp is restricted to very small commercial shops along the main commerce street, includes vegetable stands, butchers, clothing stores, footwear stores, black smiths, rotisseries, small restaurants, and pet shops. The climate of the investigated site is characterized by dry and hot summer seasons with cold and low precipitation during winter season. The dry climate, atmospheric dust and low intensity of precipitation affect the precipitation quality by increasing its salt content (Salameh, 1996).



Figuer (1) : Location map, of the study area.

3. Sampling and analytical techniques:

Fifteen water well samples have been collected from groundwater wells in the surrounding areas of Zaatari camp within the Amman-Zarqa basin (**Figure 2**). The water samples were collected in 1 L polyethylene bottles and 1.5 mL of 1N HNO3 (preservation of sample) has been added. The method of heavy metals analysis was done using (ICP - OES) in Hamdy Mango analytical analysis Center at Jordan University. The procedure for the samples preparation as follows:

a. Transfer a 100-ml representative aliquot of the well-mixed sample to a 250-ml flask and add 3 ml of concentrated HNO_3 (preservation of sample).

b. Place the beaker in a water bath or equivalent heating source and cautiously heat it up to 80°C for 1 hr, then add another 3 ml of concentrated HNO_3 and heat it up to 95°C for one hour.

c. Cool the beaker. Add 10 ml of 1:1 HCL, heat for 15 min.

d. Filter the sample, and adjust the volume to 100 ml with volumetric flask.

The detection limit (ppb) for each heavy metal analysis for ICP-OES shown in Table 1.

e. Measurement of PH and EC of the water samples were carried out in the field to avoid any alteration through transportation. These values of each sample were rechecked in the lab.

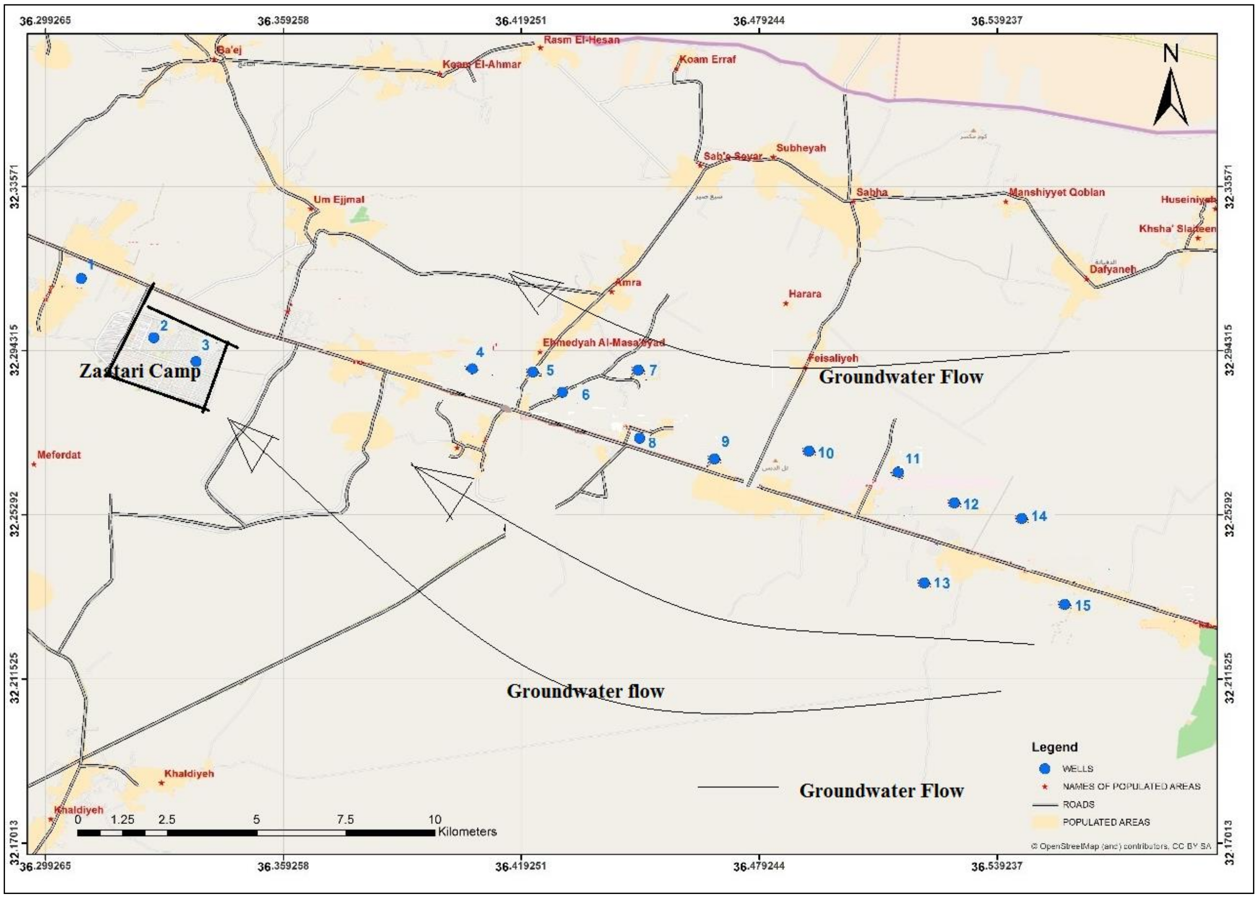


Figure (2): Location map of the collected water well samples and direction of ground water flow.

Table (1): ICP - OES detection limit for each element study

Element	Detection limit (ppb)
Mn	0.2
Fe	0.7
Cu	0.9
Pb	10
Cd	0.5
Ni	3

4. Geological setting

The study area covered by upper cretaceous with Toronyan age formation rocks for Wadi Es- Sir and Neogene - quartet basalt Formation and soil. The Wadi Es- Sir formation consists of five units with rocky content in the most of the study area: The first unit: composed of limestone mass with bright white colored in the form of wall on the boundary of Shuayb formation. The second unit: it is a coarse of coquina, composed of limestone rich in fossils and the thickness of each cycles reaches up to 1m. The Third unit consists of marl stone yellow colored Marley with a clear layer’s cluster. The fourth unit is limestone sequence holding flint or thin layers of flint. The five units composite a massive limestone, with high economic value, and functions as excellent construction stone, in this unite of large fossils appear intensely in some classes. Depositional of it is shallow and open marine environment (Smadi, 1997). The Basalt Formation is the subsidiary of volcanic of Harrat Sham (the era of Neogene - quartet) on the eastern edge of the study area, where most Casts basalt stream from the north to the south, consisting of a sequences of continental basaltic follows a series of basalt alkaline. It has been derived as a result of melting partial and minor upper coat has be accompanied by a few degrees of secondary distinctions (Bender, 1974). The basalt composite of two units: Abed Olivine Basalt Formation (AOB) and Fahda Vesicular Basalt formation (FA). The Abed Olivine Basalt Formation has a distinct dark basalt, dark gray, full crystallization, medium to fine grained of olivine and microscopic holes in most field discoveries in clusters field and tubular and cylindrical. The characteristic of this unit presence of vertical cracks in them, this configuration shrinks in the southeast and southern regions of the study area (Abed, 2009). The Fahda Vesicular Basalt formation is the most recent volcanic eruption attributable to Al Bshirah group; it consists of conglomerate solid volcanic granules. The composition is dark basalt and basalt gray fine-grained, and clusters of olivine pure green - yellow, and is limited in the southeast of the study area regions (Smadi, 1997). The study area covering two main type of soil, First the Mediterranean (red) that resides in the southern regions of Western and Central of the study area. The Second one is the yellow desert soil that covers the northern eastern and south of the region areas (Abed, 2009).

5. Hydrogeology of the study area:

Two groundwater basins in Jordan were straddles in Al-Mafraq, the first one is called Yarmouk basin, while the second is Amman-Zarqa basin. In general, the shallow groundwater in the Yarmouk basin is found in the B2/A7 aquifers. The overlying geologic formations consist of marly layers and form aquicludes dipping with increasing angles towards Yarmouk and Jordan rivers. The recharge of the aquifer takes place in the highlands of Irbid and Ajlun and further to northeast beyond Jordan`s territories (Salameh, 1996). The second is Amman-Zarqa basin has two main aquifers, namely the deep A4 and the shallow complex which consists of the B2/A7 or A7 alone or B2/A7 together with Wadi full of basalts. This basin can be divided into two parts: the area northeast of Wadi Zarqa and the western part extending to the west of Wadi Zarqa (Odat, 2015).
Mafraq Governorate within synthesis Basin (Catchment Area) Valley Al Zarqa (Amman- Zarqa Basin), which covers an area of 4049 km² and extends from the foothills of Jabal Al Druze and even to the Jordan River, is (Amman- Zarqa Basin). The aquifer is one of the most important water basins in the Kingdom approximately 3739 km² of its area, which is located within Jordan accounts for 89% of the overall basin area of the study area, and 355 km² in Syria forming 11% (Salameh, 1996).
This aquifer system consists of two formations; Wadi Es-Sir (A7) and Amman formation separated by Um -Al Ghudran, which disappears in some places. Amman together with Wadi Es-Sir formation form one of the most important and extensive aquifer outcropping in the high rainfall areas, where most of recharge occurs. This aquifer is located in the western parts of the study area and some of the studied wells derive their water from this complex. According to the (BGR & MWI: 2001) the recharge of groundwater in (B2/A7) to Yarmouk basin is through three sources. First, Ajloun Mountains, where Ajloun dome is located. Secondly, underflow from the northeastern desert basin toward the studied area at Um Essurab area. Finally, underflow moving towards the Yarmouk River from Syrian territories. This is the most important aquifer in the basin. It has continuous extent, and a relatively high permeability. It receives the highest amount of recent recharge and it is considered to be the principle source of fresh water for domestic as well as for irrigated agriculture in the plateau. The estimated total recharge within the basin is about 40-45 MCM/y. prior to aquifers depletion, an additional amount of about 23 MCM/y used to be transferred to the B2/A7 from a basalt aquifer in the upper Zarqa valley area. The Transmissivity

of aquifer is between (9.0-900.0) m^2/d. and the Storage Coefficient of it is between 0.01-0.30 (Ministry of water and irrigation, 2012).

5.1.Upper aquifers:

This aquifer consists mainly of two systems; the first one is the Basalt aquifer which extends from the Syrian Jabel Druz area southward towards the Azraq and Wadi Dhuliel region. The second main aquifer is located in the eastern parts of the study area. This one consists of sedimentary rocks and alluvial deposits of Tertiary and Quaternary ages. These rocks form the local aquifers overlain partly by the basalt aquifers. Recharge takes place directly into these aquifers, or from the surrounding aquifers (Sabahin, 2007). The main aquifers cavers in the study area are basalt and Amman- Wadi Es- Sir Aquifer formation. The movement of the surface water in the study area draining to southeast direction.

5.2. Groundwater movement

Regarding the movement of underground water, there are two levels of underground water, the first one is confined in an area contour lines 520-525 m between Sabha, and Al Koum Al Ahmar, Um El jemal, and the second one is between 500-510 m lines Baij, Um Es Sarab and Sama Al Sarhan (Serwan et al., 2001). The groundwater flows of traffic and reflects on the first level area shipping water, which is coming from rain water filtration process through the basalt spills in the region of high rainfall in the Jabal al-Arab region in southern Syria which comes from the South to North from North- East to South-West and dominantly from East to West Figure (2) (Serwan et al.,2001; AL-Ansari et al., 1996). Thce Groundwater movements depend on the groundwater's level, the direction is toward the North-East, and to South-West and dominantly from East to West. Aquifers are fed by water from Syrian territory (Jebel Arabs) extraction security layers of basalt layers and estimated Amman – Wadi Es- Sir with an amount of about 31 million cubic meters per year, moreover, it is extracted from the groundwater for drinking purposes of this region. It is currently about 22 million cubic meters per year supplies the branch and some areas of Irbid zones. Additionally, where the layers of water in the region along the inside Syrian territory adjoin it, the extraction of water from the same class extended inside Syria will affect the water in the Northern Badia region (Al-Ansari et al., 1996).

6. Result

The concentration of heavy metals, EC and pH values in the groundwater samples are shown in Table 2, which are compared with the Jordanian drinking water guidelines recommended by JISM (2008). The mean concentration of heavy metals in the groundwater samples follows the order: Mn>Pb>Ni>Cr>Cu>Cd>Zn>Fe. Concentrations of dissolved Mn, Pb, Ni, Cr, Cu, Cd, Zn, Fe in groundwater were determined, with a mean value of 2.4 mg/l for Mn, 1.5 mg/l for Pb, 0.5 mg/l for Ni, 0.25 mg/l for Cr, 0.06 mg/l for Cd, 0.04 mg/l for Zn and 0.035 mg/l for Fe. All the heavy metals studied (Zn, Fe, and Cu) are likely to be derived from the natural water-rock reaction processes in the aquifers since none of these metals exhibited concentration values outside the JISM (2008) limits while the other analyzed heavy metals are derived from both natural and anthropogenic sources since their concentration exceeded the JISM (2008) (Table 3). The chemical characteristics for the heavy metals are as follows:

6.1. Copper

Copper concentration of the investigated wells are shown in Table (2), the concentration ranged from 0.182 to 0.279 mg/l with an average concentration of 0.222 mg/l**.** The low Cu concentration of the investigated wells was within JISM (2008) limits although it is widely used in many different anthropogenic activities indicating natural origin rather than anthropogenic source. This can be explained by the slightly alkaline soil and slightly alkaline water of pH 7.34 to 7.65, retarding copper mobility.

Table (2): Concentration of Cu, Zn, Fe, Mn, Pb, Cd, Ni, Cr in mg/L for the investigated water wells samples.

Well No.	Wells Name	Cu	Zn	Fe	Mn	Pb	Cd	Ni	Cr	pH	EC
B1	#3 station	0.182	0.035	0.032	1.62	1.4	0.063	0.44	0.21	7.48	1696
B2	AL1485	0.193	0.026	0.025	2.09	1.3	0.055	0.52	0.248	7.34	942
B3	AL3423	0.249	0.023	0.025	1.83	1.15	0.06	0.56	0.26	7.55	610
B4	AL3004	0.261	0.034	0.065	1.77	1.85	0.06	0.57	0.265	7.50	657
B5	AL1193	0.279	0.156	0.02	2.75	1.54	0.081	0.7	0.262	7.65	636
B6	AL3513	0.237	0.042	0.029	2.8	1.7	0.062	0.65	0.257	7.54	599
B7	AL1265	0.211	0.014	0.025	2.4	1.61	0.064	0.59	0.254	7.62	1023
B8	AL1273	0.208	0.025	0.03	3.24	1.62	0.06	0.5	0.27	7.47	1897
B9	AL3517	0.209	0.018	0.023	1.3	1.62	0.053	0.47	0.251	7.39	2160
B10	AL2689	0.198	0.023	0.12	1.213	1.63	0.05	0.43	0.25	7.65	671
B11	F 1389	0.251	0.026	0.03	3.42	1.77	0.07	0.41	0.252	7.49	1178
B12	Mercy (1)	0.194	0.044	0.025	2.24	1.35	0.051	0.26	0.19	7.48	1145
B13	Mercy (3)	0.234	0.021	0.03	2.93	1.7	0.058	0.4	0.30	7.45	676
B14	Private well	0.212	0.032	0.0268	4.87	1.35	0.064	0.5	0.25	7.45	826
B15	AL3452	0.214	0.069	0.026	1.46	0.85	0.058	0.45	0.25	7.61	846
Max.		0.279	0.156	0.12	4.87	1.85	0.081	0.7	0.30	7.65	2160
Min.		0.182	0.014	0.02	1.213	0.85	0.05	0.26	0.19	7.34	599
Avg.		0.222	0.04	0.035	2.4	1.5	0.06	0.5	0.25	7.51	1037
(JISM, 2008)		1.0	4.0	1.0	0.1	0.01	0.003	0.02	0.05	6.5- 8.5	2343

6.2. Zinc

The range of zinc ion concentration in drinking water that has been analyzed from the wells, and the collected water samples were between the samples (0.014 – 0.156 mg / L) Figure 3. Zinc concentration in the study of all wells was within the Jordanian standards for drinking water, which is identified by institution for Jordanian Institution for Standards and Metrology (JISM,2008), The limit for the concentration of zinc in drinking water equal 4.0 mg/l (Table 3). The average concentration showing a low concentration of zinc, this can be attributed to the slightly alkaline water enhance its precipitation rather dissolved in the collected samples, where range pH 7.34 to 7.65 (EPA: 2005; World Health Organization, 2003c).

6.3 Manganese

The concentration of manganese for the water well samples study ranges between (1.213 to 4.87 ppb) Table 2 Figure 4. This result is higher than the allowable limits the Jordanian standards for drinking water (JISM, 2008) (0.1 mg/l) (Table 3). The major anthropogenic sources of environmental manganese include municipal wastewater discharges, sewage sludge, mining and mineral processing and iron production as well as combustion of fossil fuels.

6.4 Lead

The concentration of lead in the study samples ranges between (0.85-1.85 ppb) Table 2, Figure 3. These concentrations do not conform to specifications and Jordan standards. Moreover, this result is not in conformity with the Jordanian Institution for Standards and Metrology have identified the Jordan institution (0.01 mg/L) (JISM, 2008) (Table 3). The primary sources of lead ion in water are motor vehicle exhaust, industrial solid, gaseous, and liquid wastes (World Health Organization. 2003b).

Table 3**:** The maximum allowed concentration (ppm) for some heavy metal elements (JISM, 2008), and the concentration (PPM) (Maximum and minimum) for the heavy metal in the study sample.

Heavy Metal	Jordanian Institution for Standards and Metrology (2008)	Range of heavy metals concentration (ppb), in the investigated wells
Iron	1.0 ppm	0.02 - 0.12
Zinc	4.0 ppm	0.014 – 0.156
Copper	1.0 ppm	0.182 - 0.279
Manganese	0.1 ppm	1.213 - 4.87
Lead	0.01 ppm	0.85 - 1.85
Cadmium	0.003 ppm	0.05 - 0.081
Nickel	0.02 ppm	0.26 - 0.7
Chromium	0.05 ppm	0.19 - 0.30

.6.5 Cadmium

Cadmium derives its toxicity from its chemical similarity to zinc an essential macronutrient for plant, animals and human. Cadmium once absorbed by an organization remains resident for many years (over decades for humans), although it is eventually excreted. The cadmium concentration of investigated wells is shown Table 2 and Figure 3. The concentration was very low as it ranged from 0.081 to 0.005 ppb. Although the concentration was low but it was higher than the allowable limits of the Jordanian Institution for Standards and Metrology limit (JISM, 2008) for the concentration of cadmium (0.003 mg/l), (Table 3). The sources of cadmium contamination are from anthropogenic sources such as artificial fertilizers, vehicle emission and others (World Health Organization, 2003d).

6.6. Iron

The concentration of iron in all wells ranges between 0.12 to 0.02 ppb. It appears to be within the range of the Jordan Specifications for drinking water (0.1 mg/l), and Jordanian Institution for Standards and Metrology (0.003 mg/l) (JISM, 2008a) Table 3, this indicating natural source rather than anthropogenic. The concentration of iron showed a low concentration which can be attributed to the slightly alkaline water of pH 7.34 to 7.65enhancing its precipitation rather dissolved in the collected samples (World Health Organization, 2003a).

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6.7. Nickel

The ion concentration of nickel in all wells ranges between 0.7 to 0.12 ppb (Table 2 and Figure 3). It appears to be that this result is higher than allowable limits the Jordanian standards for drinking water (JISM, 2008) (0.02 mg/l) (Table 3), these reflect to the anthropogenic activity, natural resources for basaltic aquifer and such as agriculture activity.

6.8. Chromium

The chemical analysis of investigated samples showed that the Cr concentration in all wells were relatively high as it ranged between 0.19 to 0.30 ppb (Table 2 and Figure 3). It appears to be that this result is higher than allowable limits the Jordanian standards for drinking water (JISM, 2008) (0. 05 mg/l) (Table 3). Chromium can be transported by surface runoff to surface waters in its soluble or precipitated form. Soluble and un-adsorbed chromium complexes can leach from soil into groundwater. The leach ability of Cr^{+6} increases with increasing soil PH**.**

7. Discussion

The concentrations of Cu, and Fe in all the water samples were within the maximum permissible limits of Jordanian standard for drinking water and (JISM, 2008). Copper is classified as a priority pollutant because of its adverse health effects (Borah et al., 2009; World Health Organization, 2003). These menaces provoke the studies on the monitoring of these heavy metals in this chain as it is important for the protection of public health (Pettersson and Rasmussen, 1999; Malle, 1992). The concentrations of Mn, Pb, Ni, Cd and Cr in all of the water samples were high and above the allowable limits of the Jordanian standards for drinking water and (JISM, 2008). Lead is not an essential trace element; if it gets concentrated in living organism it has no known biological function. It can cause a variety of harmful health effects (Botkin and Keller, 2005) and it is known as a fatal neurotoxic (Thomson and Parry, 2006).

High concentration of chromium was detected in well No.3 and it was above the maximum permissible limits of Jordanian Drinking Water and (JISM, 2008) Table (3) (Figure 5). This site is located at within Zaatari camp, the high concentration is related to the near sewage sludge and municipal wastewater discharges. On the other hand, wells No.8 and well number 9 showed also high concentrations and above JISM, 2008 standard Table (3). The source of Cr at these wells is due to its location along Bagdad highway, these reflect to the anthropogenic activity, such as car traffic, handwork, blacksmithing, machines repair and painting (Jaworski, 1980). The concentration of Cr in well No.12 is higher than the maximum permissible limits of Jordanian Drinking Water and (JISM, 2008) Table (3) (Figure 4), these reflect to the natural resources for basaltic rock and anthropogenic activity such as agriculture activity (fertilizer and pesticide).

The concentration of nickel is elevated in all samples, it is higher than the maximum permissible limits of Jordanian Drinking Water and (JISM, 2008) Table (3), (Figure 4). All the wells which located far from Bagdad highway, the concentration of Ni in well No. 9 and 10 is higher than JISM. (2008),, these reflect to the anthropogenic activity, natural resources for basaltic aquifer and such as agriculture activity. It is due to the site of wells which located near the highway, so they affected by cars exhaust, car washing stations, and human activities such as municipal wastewater discharges, sewage sludge, mining and mineral processing and iron production as well as combustion of fossil fuels (Dunnick et al., 1995).

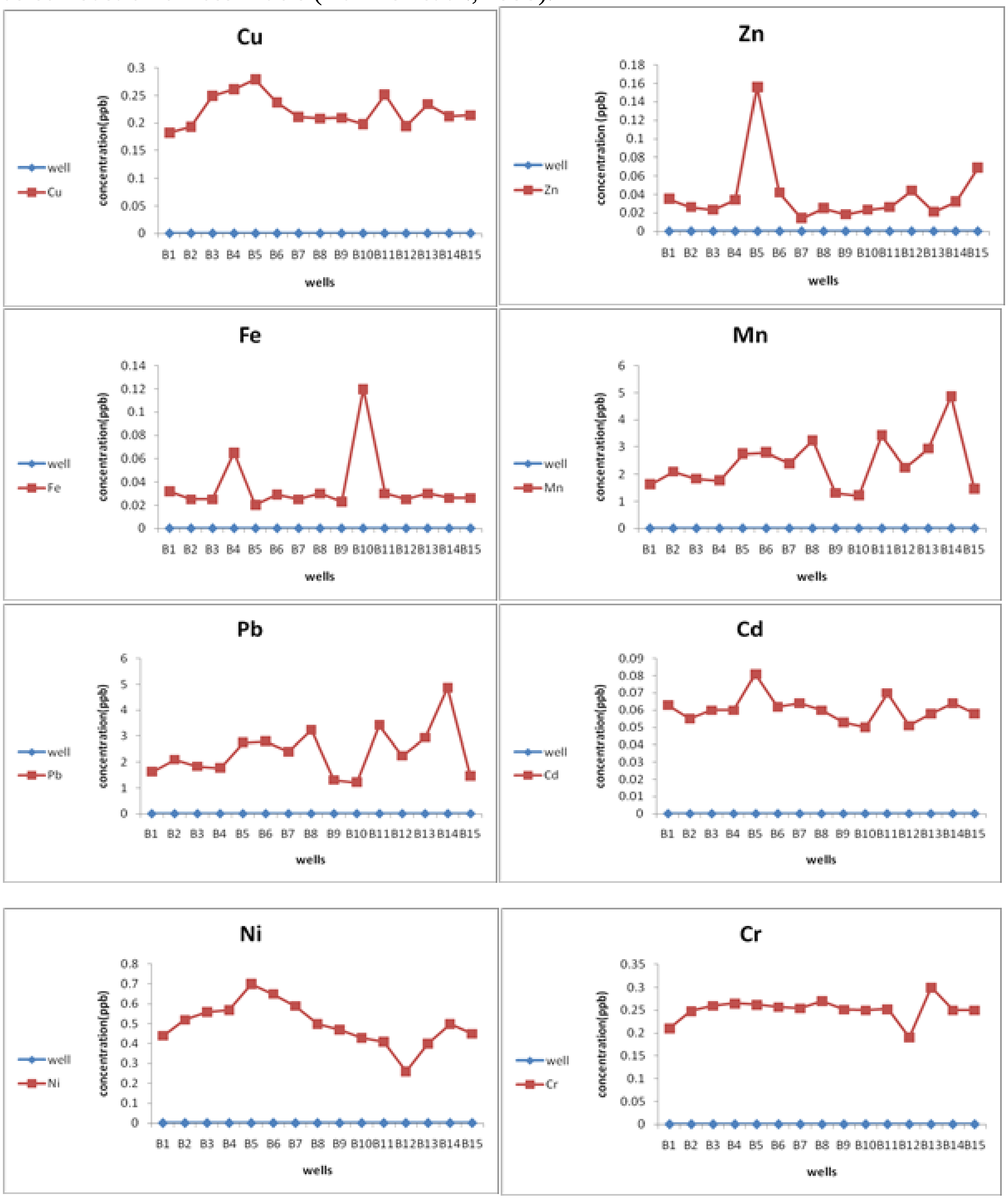

Figure (3): Concentration (ppb) for the elements Cu, Zn, Fe, Mn, Pb, Cd, Ni and Cr in the study water well samples.

The increasing of lead concentration in the environment can be caused by various anthropogenic activities such as the use of leaded fuel, batteries, solders, bearings, cable covers, ammunition, plumbing, pigments and caulking (Wuana et. al. 2011). Lead concentration in all wells is higher than the maximum permissible limits of Jordanian Drinking Water and (JISM, 2008), Table 3, (Figure 4). It is due to the site of wells which located near the Bagdad highway, so they affected by use of leaded fuel, batteries, solders, bearings, cable covers, ammunition, plumbing, pigments and caulking. The concentration of lead in well No.8 is higher than JISM. (2008), the possible cause is the location in agricultural area where the pesticides and fertilizers are used, in addition to other agricultural activities. The concentration of lead in well No.15 is higher than JISM. (2008), these reflect to the natural resources for basaltic rock and anthropogenic activity such as agriculture activity. The concentration of lead in well No.3 is higher than JISM. (2008), which located inside the Zaatari camp, the high concentration is related to the near sewage sludge and municipal wastewater discharges.

The concentration of manganese for the water well samples study ranges between (1.213 to 4.87 mg/l), The major anthropogenic sources of environmental manganese include municipal wastewater discharges, sewage sludge, mining and mineral processing and iron production as well as combustion of fossil fuels (Hrones et, al. 2010). Manganese concentration in wells is higher than the maximum permissible limits of Jordanian Drinking Water and JISM. (2008), Table (3), (Figure 5). The concentration of Mn in well No.4 is higher than JISM. (2008), this can be due to location of well along Bagdad highway where vehicle emission from the traffic along it impact the heavy metals concentrations of groundwater. The concentration of Mn in wells No.12, it possible to cause the location in agricultural area where the pesticides and fertilizers are used, in addition to other agricultural activities. The concentration of Mn in well No.15 is higher than the maximum permissible limits of Jordanian Drinking Water and JISM. (2008), Table (3), (Figure 5), reflecting the natural condition of these site. The higher levels of exposure to manganese in drinking water are associated with increased intellectual impairment and reduced intelligence quality in school-age children (Elsner et al., 2005; Siegel and Siegel, 2000).

The sources of cadmium contamination are artificial fertilizers (WHO, 2003d). The natural average abundance of cadmium in the earth crust has been reported from 0.1 to 0.5 ppm. The natural sources for Cd in igneous and metamorphic rocks tend to be shown a low value ranging from 0.02 to 0.2 ppm, whereas the sedimentary rocks have a higher value between 0.1 to 25 ppm (Winter, 2001). The concentration of the Cd has increased in environment due to anthropogenic activity. The highest levels of Cd are from vehicle emission and smoking tobacco and others. The concentration of cadmium is elevated in wells No. 1, 4, 9 and 11 is higher than the maximum permissible limits of Jordanian Drinking Water and (JISM, 2008) (Figure 4), Table (3) , It is due to the site of wells which located near the highway, so they affected by anthropogenic activities, such as cars exhaust, industrial batteries, artificial fertilizers, smoking tobacco and others. The concentration of Cd in well No. 15 is higher than (JISM, 2008), these reflect to the natural resources for basaltic rock and anthropogenic activity such as agriculture activity (fertilizer and pesticide). Cadmium exposure is a risk factor associated with a large number of illnesses including kidney disease, early atherosclerosis, hypertension, and cardiovascular diseases (Fechner et al., 2011).

The Lead can accumulate in soils, especially those with a high organic content, where it remains for hundreds to thousands of years. It can take the place of other metals in plants and can accumulate on their surfaces, there by retarding photosynthesis, and preventing their growth or killing them. Contamination of soils and plants then affects microorganisms and animals. Affected animals have a reduced ability to synthesize red blood cells, which causes anemia (Greene, 2014). Lead can cause severe damage to the brain and kidneys and, ultimately, death. by mimicking calcium, lead can cross the blood-brain barrier. It degrades the myelin sheaths of neurons, reduces their numbers, interferes with neurotransmission routes, and decreases neuronal growth (Rudolph

, 2003). Symptoms of lead poisoning include nephropathy, colic-like abdominal pains, and possibly weakness in the fingers, wrists, or ankles. Small blood pressure increases, particularly in middle-aged and older people, may be apparent and can cause anemia. Several studies, mostly cross-sectional, found an association between increased lead exposure and decreased heart rate variability *(* Navas-Acien, Ana 2007; Stenhammar, 1999) . In pregnant women, high levels of exposure to lead may cause miscarriage. Chronic, high-level exposure has been shown to reduce fertility in males (Sokol , 2005).

The concentration of Zn, Cu, and Fe in all the water well samples B2 and B3 in Zaatari Refugee camp is within the maximum permissible limits of Jordanian Drinking Water and (JISM, 2008), as it appears there is not any effect of pollution from the camp and the water is safe for drink. This study explains there are no effect of Zaatari camp on the groundwater pollution. However, the concentration level of Mn, Pb, Ni, Cd and Cr is higher than the maximum permissible limits of Jordanian Drinking Water and (JISM, 2008), is reflect the anthropogenic activities within the camp is restricted to very small commercial shops along the main commerce street, includes vegetable stands, butchers, clothing stores, footwear stores, black smiths, rotisseries, small restaurants, and pet shop (Alshira´h, 2018) .

The pH activity ranged in the water that have been between 7.34 to 7.65 samples and with an average of 7.51 for all study wells. Generally, the pH of the groundwater samples falls between a pH range of 6 to 9 in natural conditions (Stumm and Morgan 1996). This is due to the existence of dissolved carbon dioxide and hydrogen carbonate ions (Mokhtar et al., 2009; Al-Harahsheh et al., 2014) (Equations.1 and 2), which form a buffer system.

$H_2O + CO_2 \longrightarrow H_2CO_3 H_2O + CO_2 \longrightarrow H_2CO_3$ Equations.1

$H_2O + CO_3 \longrightarrow {}_2H{+}{+}CO^{-3} H2O + CO3 \longrightarrow {}_2H^{+} + CO^{3-}$ Equations2

The value of pH in all wells within the study allowed by the Institution for Standards and Metrology for drinking water limit. The concentration of TDS ranging in each sample examined between 383.4 mg /l to 1382 mg /l and average of 663.9 mg/l. The concentration of TDS in well No.9 is higher than the Jordan Standard and Metrology of drinking water. The set value of 1000 mg/l. Electrical Conductivity (EC) value of the water samples for all wells study has been between 599 to 2160 µS/Cm and at a rate of 1037µS/Cm. It is higher than specifications of Jordan and standards identified by the value of EC 1400 µS/Cm. The values of EC in all wells within specifications of Jordan and standards. The likely sources and causes of the major contributors to the elevated TDS concentrations and related EC (which increased with increment of STD) are: 1) increased alkalinity and calcium concentrations resulting from the weathering, efficient delivery, and accelerated dissolution of calcium carbonate found in the increased expanses of impervious surfaces and drainage systems 2) increased sulfate concentrations most likely resulting from more efficient delivery of deposited or spilled sulfur compounds from impervious areas and wastewater leaks or illicit discharges; and 3) elevated chloride concentrations resulting from varied sources as wastewater leakage, runoff of lawn fertilizers, and spills or discharges of varied substances containing chlorides, including road salts (Mikalsen, 2005).

The average concentration showing a low concentration of zinc, copper and iron, this can be attributed to the slightly alkaline water enhance its precipitation rather dissolved in the collected samples.

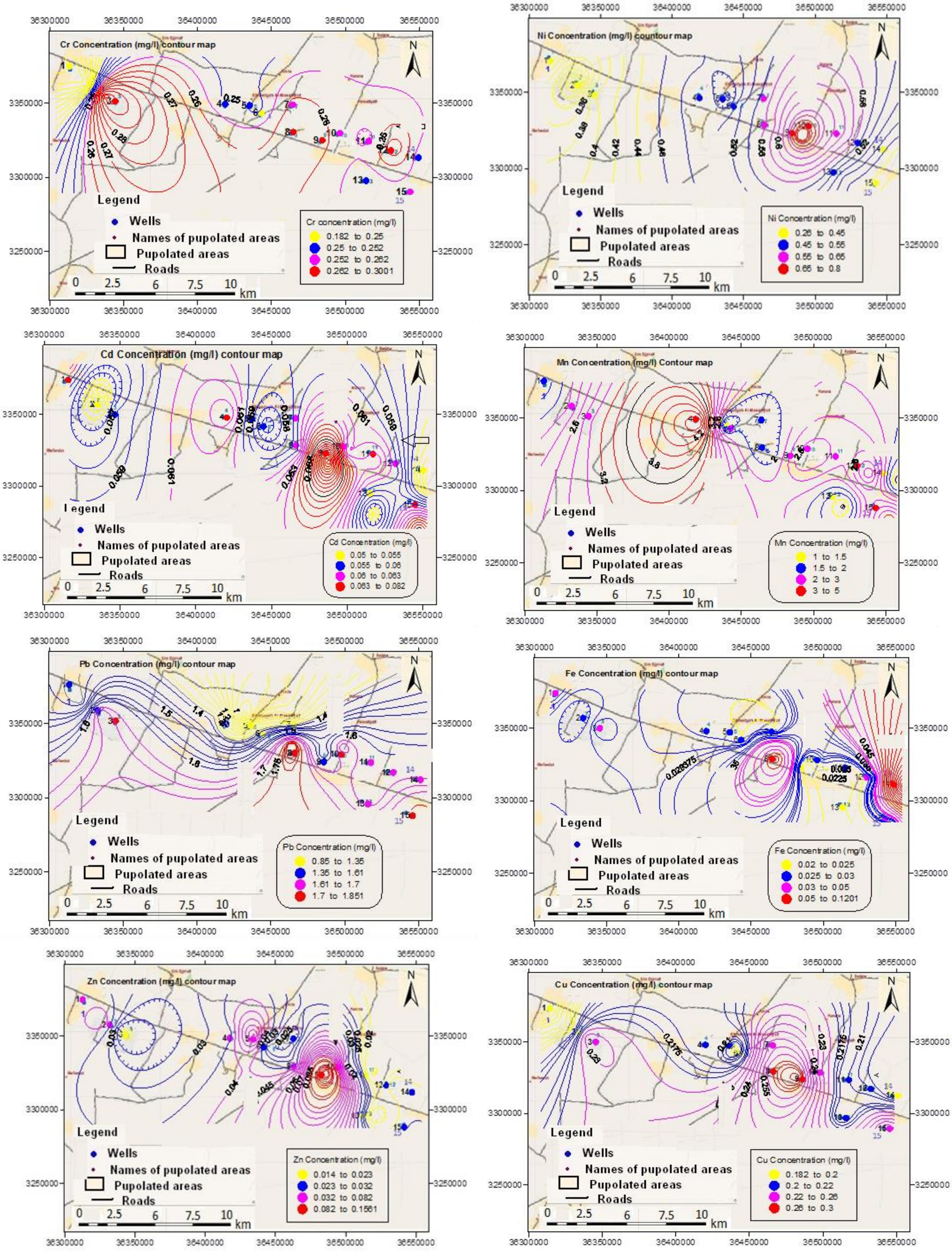

Figure (4): Contour map shows the concentration (mg/l) of Cr, Ni, Cd, Mn, Pb, Fe, Zn and Cu for the study water well samples.

8. Conclusions

The results of the study show that concentration of the heavy metal in the groundwater around Zaatari Refugee Camp, Zarqa-Amman basin area appear as follows:

- Pollution by refugee camp did not reach the groundwater resources of the area and the water is safe for drink.
- Zinc concentration is 0.014 to 0.156 mg/l, it lies within the Jordanian specifications for drinking water (4.0 mg/l) (Jordanian Institution for Standards and Metrology, 2008).
- The concentration of the Cu ion range between 0.182 to 0.279 mg/l lies within the limit of the Jordanian Institution for Standards and Metrology (JISM, 2008) (1.0 mg/l), and Jordanian Institution for Standards).
- Iron concentration is between 0.12 to 0.026 mg/l lies within the range of Jordan Specifications for drinking water and within Jordanian Institution for Standards and Metrology (2008) (1.0 mg/l).
- The level concentration of Mn 1.43 to 4.87 mg/l , in wells No. 4, 12 and15 are higher level than the Jordanian Drinking Water limits and (JISM, 2008), the natural resources for basaltic aquifer and anthropogenic activity such as agriculture activity such as fertilizer and pesticide
- Cadmium concentration in the studied samples range between 0.081 to 0.05 mg/l , in all wells study samples. Therefore, well No. 1, 4, 9 and 11 it seems to exist and was higher than the allowable limits of the Jordanian Institution for Standards and Metrology limit (JISM, 2008) for the concentration of cadmium (0.003 mg/l). It’s due to the site of wells which located near the highway, so they affected by cars exhaust, car washing stations, and human activities such as municipal wastewater discharges, sewage sludge, mining and mineral processing and iron production as well as combustion of fossil fuels.

- The concentrations of Mn, Pb, Ni and Cr for all the water well samples are higher than the allowable limits of the Jordanian standards for drinking water (JISM, 2008) and Standards Institution of Jordan. The elements concentrations are range between, Mn (1.43 to 4.87 mg/l), Pb (0.85 to 1.85 mg/l), Ni (0.7 to 0.26 mg/l) and Cr (0.30 to 0.19) respectively. The allowable limit for (JISM, 2008) are Mn = 0.1mg/l, Pb = 0.01 mg/l, Ni = 0.02 mg/l and Cr = 0.005 mg/l respectively. These high concentrations are due to the location of wells, which located near the Bagdad highway, so they affected by cars exhaust, car washing stations, and human activities such as municipal wastewater discharges, sewage sludge, mining and mineral processing and iron production as well as combustion of fossil fuels; other possible cause is the location in agricultural area where the pesticides and fertilizers are used, in addition to other agricultural activities.
- The concentration of Zn, Cu, Cd and Fe for all the water well samples and B2 and B3 in Zaatari Refugee camp are within the maximum permissible limits of Jordanian Drinking Water and (JISM, 2008), it is evident that there isn't any effect of pollution caused by Zaatari Refugee camp on the groundwater with respect to heavy metals. This study explains that the groundwater is not polluted by heavy metals and that no effect of Zaatari Refugee camp on the groundwater around the study area within Zaatari Refugee Camp.

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