

# Assessment of impact of Zaatari refugee camp on groundwater pollution by 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 **aim** 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 were found to be from natural sources related to the weathering of the basaltic rocks whereas Zn and Pb, Cu, Cd were 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, 0.05-0.08 mg/l for Cd and 0.30 to 0.19 mg/l for Cr. The allowable limits for **Jordanian Institute of Standards and Metrology (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 samples which was attributed to anthropogenic activity whereas Cu, Zn, Fe were below the desirable limits and **could be** attributed to natural sources related to rock formation of basaltic origin.

Keyword: Groundwater, 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 an end. Jordan is a prime country to be examined due to it even more dire lack of **freshwater** resources, as compared with its regional neighbors that are more blessed with **water** 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 it maintains precious water resources from being lost due to pollution resulted from a wide variety of sources that including agricultural, domestic, and industrial (Awawde and Jaradat, 2009). Groundwater is a major source of water supply for domestic and agricultural purposes, especially in arid and semi-arid regions (Nayak et al., 2006; Kumar and Remadevi, 2006; Ahmadi and Sedghamiz, 2007). Agricultural activities in semi-arid 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 the heavy metals are restricted to only toxic metals. Heavy metals are a natural component of the earth it is impossible for human being to exist on earth without heavy metals, therefore wherever **humans** 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 **and deteriorate groundwater 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 (Ejaz et al., 2007).

The contamination of groundwater by heavy metals, originating either from natural soil sources or 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 Zaatar refugee camp. Identifying the source of heavy metals in groundwater at Zaatar area.

## 2. Study area

### 2.1 Geographical Location

The study area which is a part of Amman-Zarqabasin 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 km<sup>2</sup> at longitudes between (**E36°29'265"/E36°53'237"**), **and between latitudes (N32°17'13"/N32°33'5'71")**. It is located in the **North east** Jordan (Figure 1). Zaatar refugee's camp which was established in 2012 after the breakout of the civil war in Syria. It contains more than 80,000 **refugees living over an area of 5.3 Km<sup>2</sup>**. Zaatar 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 produced within the camp was estimated to be around 3,600 m<sup>3</sup>/d. The wastewater is transported to a small wastewater treatment plant located

within the camp. The anthropogenic activities within the camp are restricted to very small commercial shops along the main commerce street, includes vegetable stands, butchers, clothing stores, footwear stores, blacksmiths, 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).

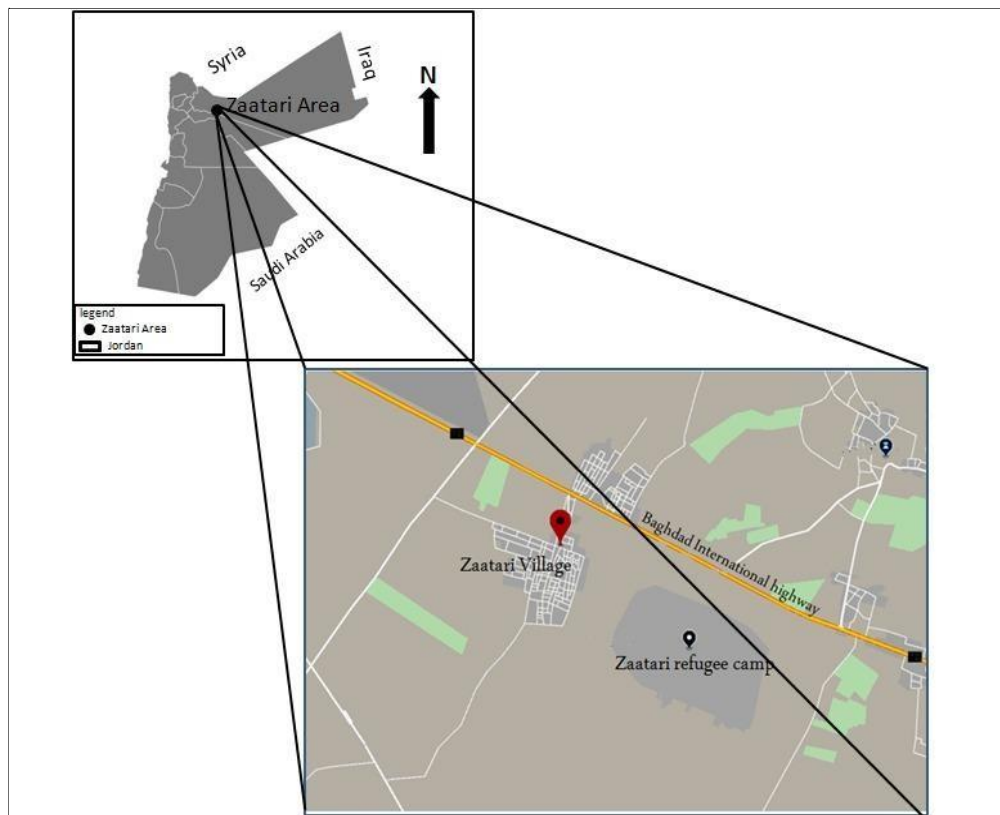


Figure (1) :Location map, of the study area.

## 2.2 Geological setting

The study area is covered by upper Cretaceous with Toronyanage formation rocks for Wadi Es-Sir and Neogene-quaternary basalt formation and soil. The Wadi Es-Sir formation consists of five units with rocky content in 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: is a coarse coquina, composed of limestone rich in fossils and the thickness of each cycle reaches up to 1m. The third unit consists of marlstone 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 is composite a massive limestone, with high economic value, and functions as excellent construction stone, in this unit 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-quaternary) on the eastern edge of the study area, where most Casts basalt stream from the north to the south, consisting of a sequence of continental basaltic follows a series of basalt alkaline. It has been derived as a result of melting partial and minor upper which has been 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 the 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 types of soil, first the Mediterranean (red) that resides in the southern region of Western and Central of the study area. The second one is the yellow desert soil that covers the northerneastern and south of the region areas (Abed, 2009).

### **2.3 Hydrogeology of the study area**

Two groundwater basins in Jordan were straddled 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 a aquiclude dipping with increasing angle towards Yarmouk and Jordan rivers. The recharge of the aquifer takes place in the highlands of Irbid and Ajlun and further to the northeast beyond Jordan's territories (Salameh, 1996). The second is Amman-Zarqa basin in 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 Fullof 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 its synthesis Basin (Catchment Area) Valley Al-Zarqa (Amman-Zarqa Basin), which covers an area of 4049 km<sup>2</sup> and extends from the foothills of Jabal Al-Druze and event to the Jordan River, is (Amman-Zarqa Basin). The aquifer is one of the most important water basins in the Kingdom approximately 3739 km<sup>2</sup> of its area, which is located within Jordan accounts for 89% of the overall basin area of the study area, and 355 km<sup>2</sup> in Syria forming 11% (Salameh, 1996).

This aquifer is in the 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 part 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 freshwater 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 a aquifer is between (9.0-900.0) m<sup>2</sup>/d. and the Storage Coefficient of it is between 0.01-0.30 (Ministry of water and irrigation, 2012).

#### **2.3.1 Upper aquifers**

This aquifer consists mainly of two systems; the first one is the Basalt aquifer which extends from the Syrian Jabel Druze area southward towards the Azraq and Wadi Dhuliel region. The second main aquifer is located in the eastern part 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 are 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 the southeast direction.

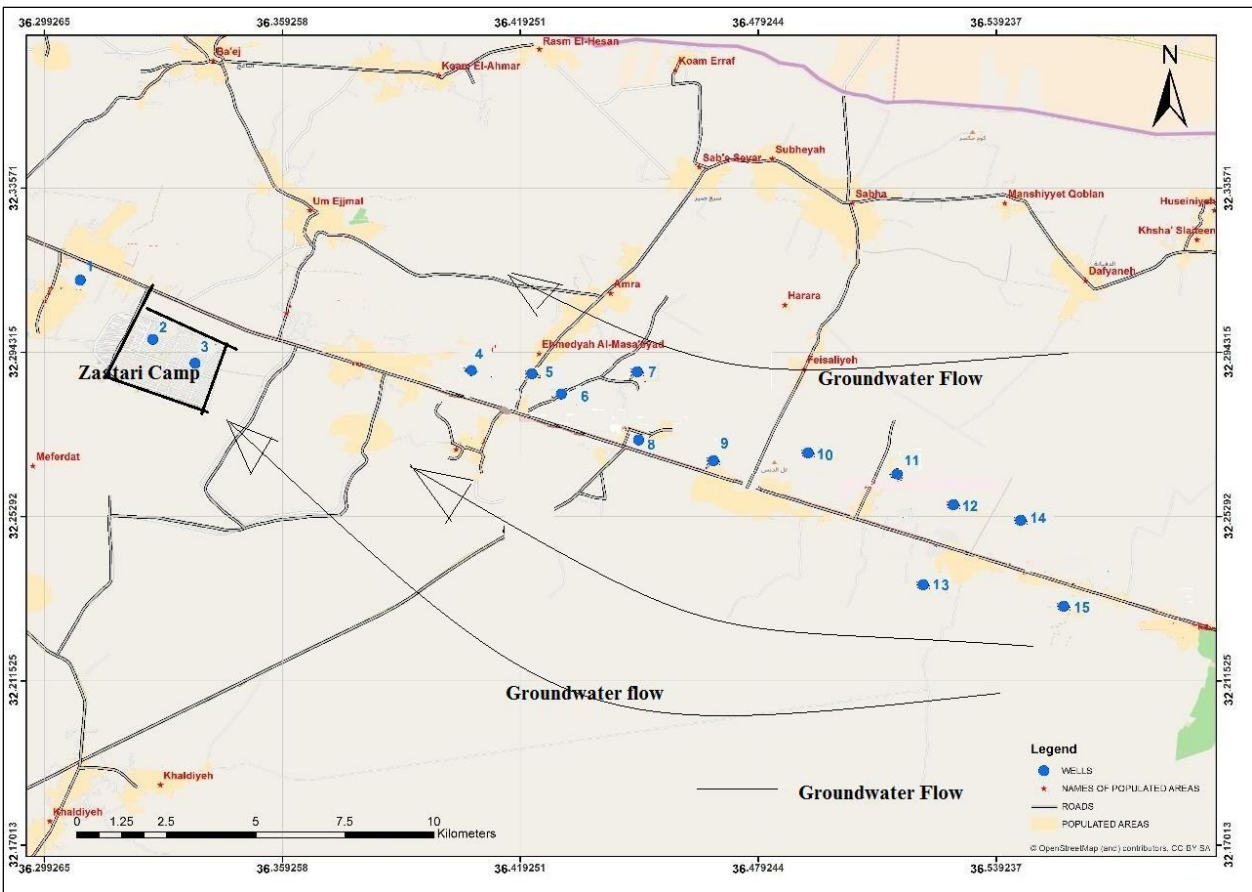
### 2.3.2 Groundwater movement

Regarding the movement of underground water, there are two levels of underground water, the first one is confined in an area between contour lines 520-525 m between Sabha, and Al Koum Al Ahmar, Um Eljema, and the second one is between 500-510 m lines Baij, Um Es Saraband Sama Al Sarhan (Serwan et al., 2001). The groundwater flow of traffic and reflects on the first level area shipping water, which is coming from rainwater 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). The 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 Badi region (Al-Ansari et al., 1996).

## 3. Methodology

Fifteen water wells samples have been collected from groundwater wells in the surrounding areas of Zaataricamp within the Amman-Zarqabasin (Figure 2). The water samples were collected in 1L polyethylene bottles and 1.5 mL of 1N HNO<sub>3</sub> (preservation of sample) has been added. The method of heavy metals analysis was done using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) in Hamdy Mango 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<sub>3</sub> (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<sub>3</sub> 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.
- 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. The detection limit (ppb) for each heavy metal analysis for ICP-OES shown in Table 1.



Figure(2):Location map of the collected water wells samples and direction of groundwater 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. 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, [Camiloetal.,2021](#),since their concentration exceeded the JISM(2008)(Table3).The chemical characteristics for the heavy metals are as follows:

#### 4.1. 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 a natural origin rather than an 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.

WellNo.	WellsName	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	F1389	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

#### 4.2. Zinc

The range of zinc 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 concentrations showing 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).

#### 4.3 Manganese

The concentration of manganese for the water wells samples study ranges between (1.213 to 4.87 ppb) Table 2 Figure 3. This result is higher than the allowable limit 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.

#### 4.4 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 Jordanian institution (0.01 mg/L) (JISM, 2008) (Table 3). The primary sources of lead in water are motor vehicle exhaust, industrial solid, gaseous, and liquid wastes (World Health Organization, 2003b) [Muhammad et al., 2022](#).

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

#### 4.5 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 in 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 (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 **Burning of fossil fuels** (World Health Organization, 2003d), **Muhammad et al., 2022**,

#### 4.6. Iron

The concentration of iron in all the 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 7.65 enhancing its precipitation rather than dissolved in the collected samples (World Health Organization, 2003a).

#### 4.7. 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 of 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 and **Traffic oil combustion for heat and electricity, Stainless steel products and Vegetation** (Muhammad et al., 2022).

#### 4.8. Chromium

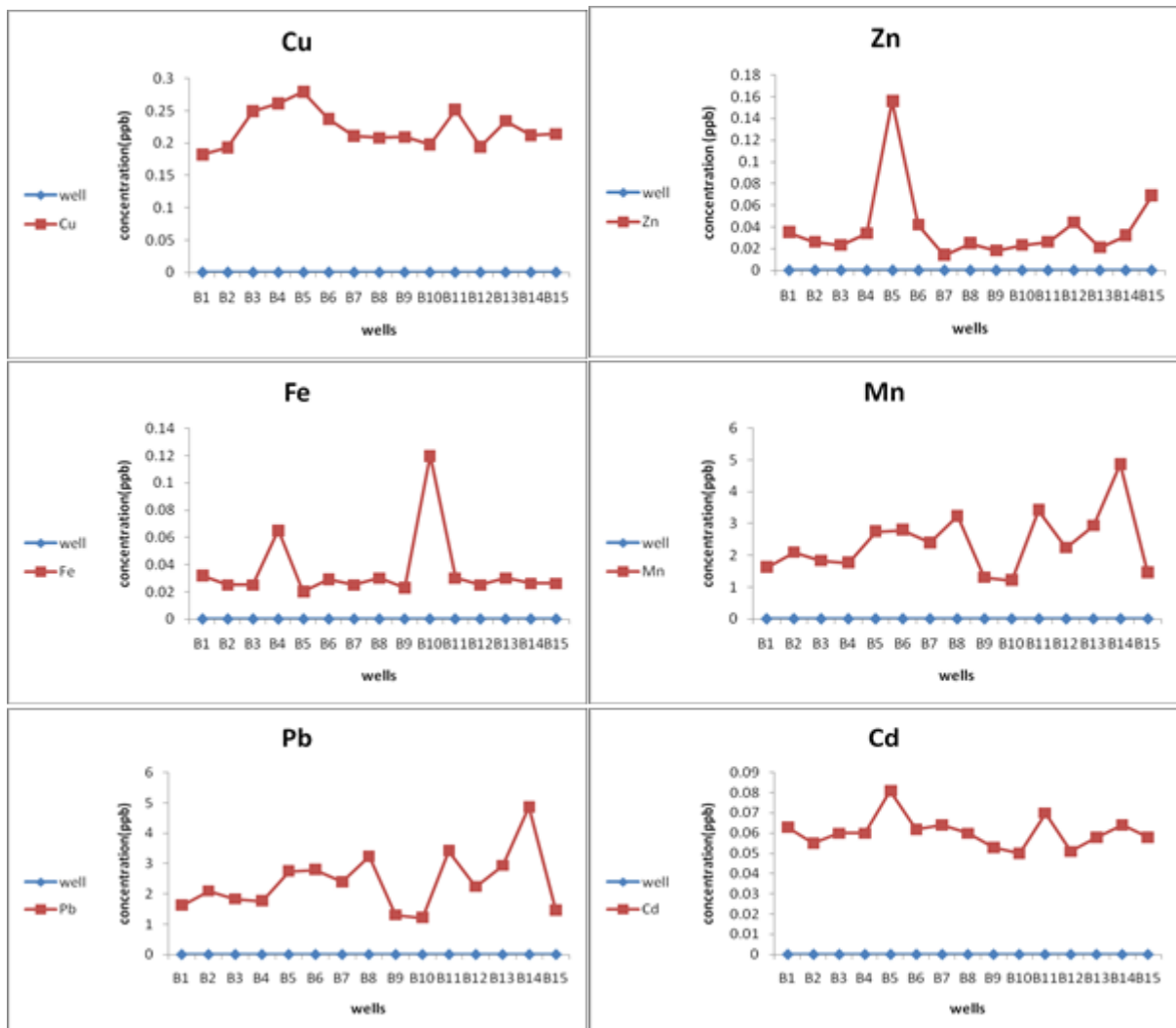
The chemical analysis of investigated samples showed that the Cr concentration in all wells were relatively high as it ranged between 0.19 to 0.30 ppb (Table 2 and Figure 3). It appears to be that this result is higher than allowable limits of the Jordanian standards for drinking water (JISM, 2008) (0.05 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 leachability of  $Cr^{+6}$  increases with increasing soil pH. **The main sources of Cr Electroplating industries, Leather tanneries, Textile industries, Steel, Industrial combustion, Wood burning, Reuse incineration and fertilizers** (Muhammad et al., 2022).

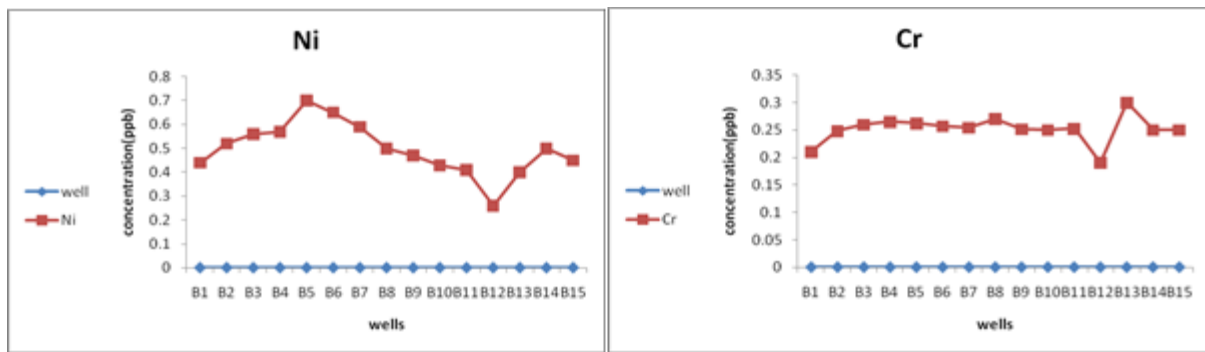
## 5. Discussion

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). **According to Jessica et al., 2020 reported to the heavy metals may enter human in four ways from; ingestion of contaminated food; inhalation from the atmosphere, drinking contaminated water; and due to skin contact from agriculture, pharmaceutical, manufacturing, residential and industrial areas.** 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 limit of Jordanian Drinking Water and (JISM, 2008) Table (3) (Figure 4). This site is located at within Zaatar 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 Baghdad 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 limit 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 limit of Jordanian Drinking Water and (JISM, 2008) Table (3), (Figure 4). All the wells which located far from Baghdad 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 are affected by car 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 (Dunnicket al., 1995).





Figure(3): Concentration(ppb) for theelements Cu, Zn,Fe, Mn, Pb, Cd, Ni and Cr in thestudy waterwellsamples.

Theincreasingofleadconcentrationintheenvironmentcanbecausedby various anthropogenic activitiesuchasthe use of leadedfuel,batteries,solders,bearings,cable covers, ammunition,plumbing,pigmentsand caulking (Wuana et.al.2011).Leadconcentrationinall wellsishigherthanthemaximumpermissiblelimitsofJordanianDrinkingWaterand(JISM, 2008),Table3,(Figure4).ItisduetothesiteofwellswhichlocatedneartheBagdadhhighway,so theyaffected byuse of leaded fuel, batteries, solders, bearings, cable covers, ammunition, plumbing, pigmentsandcaulking.Theconcentrationof lead in wellNo.8ishigher than JISM. (2008),thepossiblecause isthelocationinagriculturalarea where thepesticidesandfertilizers are used,inadditionto other agriculturalactivities.TheconcentrationofleadinwellNo.15is higherthanJISM.(2008),thesereflecttothenaturalresourcesforbasalticrockandanthropogenic activity suchasagricultureactivity.TheconcentrationofleadinwellNo.3ishigherthanJISM. (2008),whichlocatedinsidetheZaataricamp,thehighconcentrationisrelatedtothenearsewage sludge and municipal wastewaterdischarges.

Theconcentrationofmanganeseforthewaterwellsamplesstudy rangesbetween(1.213 to4.87mg/l),Themajoranthropogenicsourcesof environmentalmanganese includemunicipal wastewaterdischarges,sewagesludge,miningandmineralprocessingandironproductionaswell ascombustionoffossilfuels(Hroneset,al.2010).Manganeseconcentrationinwells ishigher thanthemaximumpermissiblelimitsof JordanianDrinking WaterandJISM.(2008),Table(3), (Figure 4).The concentrationofMninwellNo.4ishigher thanJISM.(2008), thiscanbe due to locationofwellalongBagdadhhighwaywherevehicleemissionfromthetrafficalongitimpactthe heavymetalsconcentrationsofgroundwater.TheconcentrationofMninwellsNo.12,itpossible tocausethe locationinagricultural areawherethe pesticidesandfertilizersareused,inaddition tootheragriculturalactivities.TheconcentrationofMninwellNo.15ishigherthanthemaximum permissiblelimitsofJordanianDrinkingWaterandJISM.(2008),Table(3),(Figure4),reflecting thenaturalconditionofthesite.

Thehigherlevelsofexposuretomanganeseindrinking waterareassociatedwithincreasedintellectualimpairmentandreduced intelligencequalityinschool-age children(Elsneret al., 2005; Siegel and Siegel, 2000).

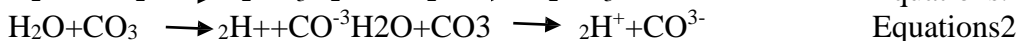
Thesourcesofcadmiumcontaminationareartificialfertilizers(WHO,2003d).Thenatural average abundance of cadmiumintheearthcrusthasbeen reportedfrom0.1to0.5ppm.The naturalsourcesfor Cdinigneousandmetamorphicrockstendto be showna lowvalueranging from0.02to0.2ppm,whereasthesedimentary rockshaveahighervaluebetween0.1to25ppm (Winter, 2001).The concentrationof theCdhasincreasedinenvironmentdue toanthropogenic activity. Thehighest levels of Cdarefrom vehicle emission and smokingtobacco and others.The concentrationof cadmiumiselevated inwellsNo.1,4,9and11 ishigher thanthe maximum permissiblelimits of JordanianDrinking Waterand(JISM,2008)(Figure4),Table(3),Itisdue tothesiteofwellswhichlocatednearthehighway,sothey affectedby anthropogenicactivities, suchascarsexhaust,industrialbatteries,artificialfertilizers,smoking tobaccoandothers.The concentrationofCdinwellNo.15ishigherthan(JISM,2008),thesereflecttothenatural

resources for basaltic rock and anthropogenic activities 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, thereby 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 sheath 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), it reflects 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 (Alshirah, 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-Harash et al., 2014) (Equations 1 and 2), which form a buffer system.

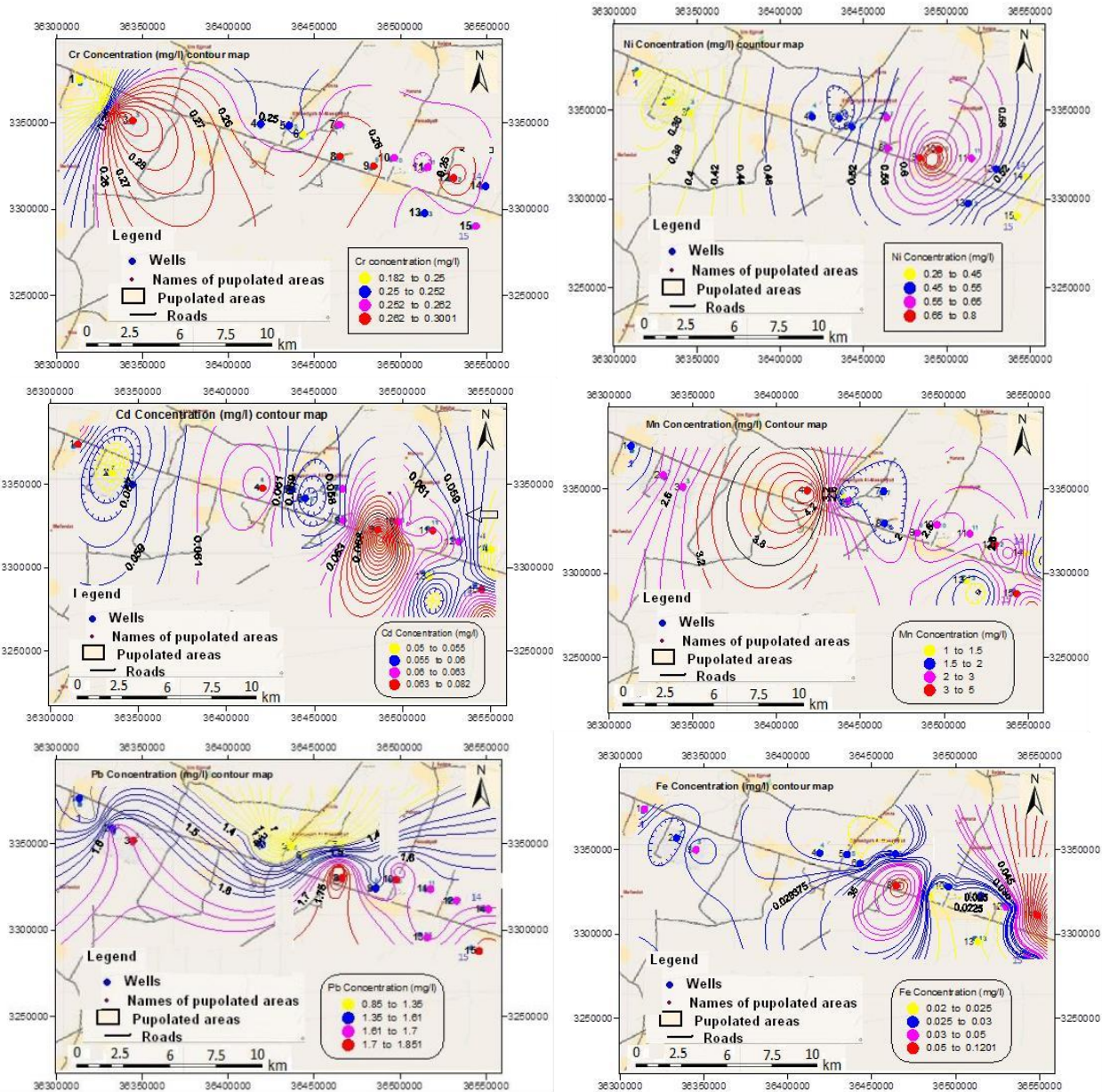


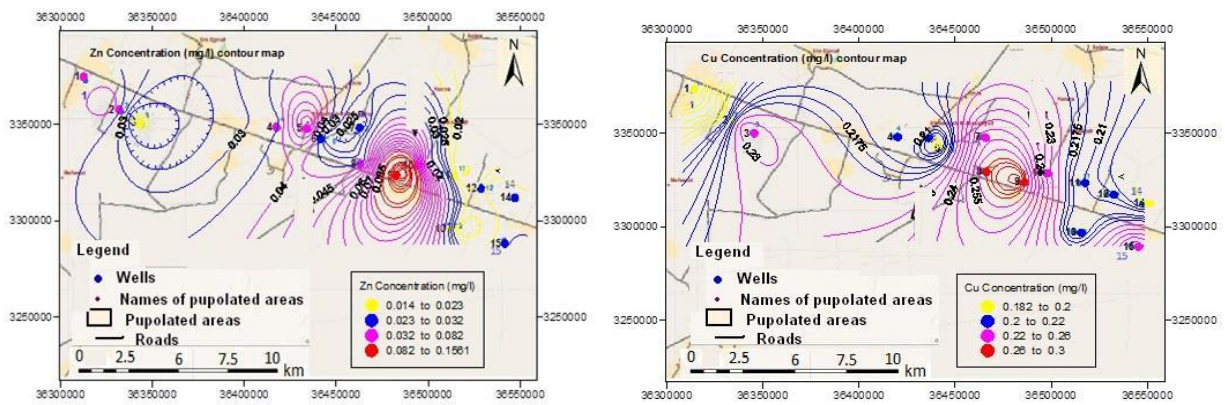
The value of pH in all wells within the study allowed by the Institution for Standards and Metrology for drinking water limit. The concentration of TDS ranging in each sample examined between 383.4 mg/l to 1382 mg/l and an average of 663.9 mg/l. The concentration of TDS in well No. 9 is higher than the 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  $\mu\text{S}/\text{Cm}$  and a rate of 1037  $\mu\text{S}/\text{Cm}$ . It is higher than specifications of Jordan and standards identified by the value of EC 1400  $\mu\text{S}/\text{Cm}$ . The values of EC in all wells within specifications of Jordan and standards. The likely sources and causes of the major contributor 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 concentrations showing a low concentration of zinc, copper and iron, this can be attributed to the slightly alkaline water enhances its precipitation rather than 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.

## 6. Conclusions

From the study carried out on the groundwater around Zaatari Refugee Camp, Zarqa-Amman basin area, the results obtained show various levels of concentration of the heavy metal. The study observed that pollution from the 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 ranges between 0.182 to 0.279 mg/l, it 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, it lies within the range of Jordanian 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 and 15 are higher level than the Jordanian Drinking Water limits and (JISM, 2008), the natural resources for basaltic aquifer and anthropogenic activity such as agriculture activities such as fertilizer and pesticide. Cadmium concentration in the studied samples ranges between 0.081 to 0.05 mg/l, in all wells studied samples. Therefore, well No. 1, 4, 9 and 11 seem to exist and wash higher than the allowable limit of the Jordanian Institution for Standards and Metrology limit (JISM, 2008) for the concentration of cadmium (0.003 mg/l). It is due to the site of wells which is located near the highway, so they are affected by car 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 limit of the Jordanian standards for drinking water (JISM, 2008) and Standards Institution of Jordan. The elements concentrations are in the range of 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 = 0.1 mg/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 is located near the Baghdad highway, so they are affected by car 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 limit of Jordanian Drinking Water and (JISM, 2008), it is evident that there is no effect of pollution caused by Zaatari Refugee camp on the groundwater with

respect to heavy metals.

This study concludes that the groundwater is not polluted by heavy metals and that there was no negative effect of Zaatari Refugee camp on the groundwater around the study area within Zaatari Refugee Camp.

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