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Heavy metals in well's waters within Southern Basrah Province / Iraq.

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Abstract .Due to continuous decline of water discharge in southern Iraq, the need arises to use ground water as alternate source for water required for different purposes in which it suppose to be clean and free of pollutants such as, petroleum hydrocarbons, heavy metals, pesticides, ..., etc. Within this study, ten well's of water spread in Southern part of Iraq, two in each site represented by Safwan (1 and 2), Zubair (3 and 4), Khor Al-Zubair (5 and 6), Al-Burjisiah (7 and 8), and Shuaibah (9 and 10) were investigated to estimate their contents of heavy metals. The collected water samples from the selected well's were analyzed for total heavy metals: Cd, Cu, Fe, Mn, Ni, Pb, and Zn, on a monthly basis for the period Jan. - Dec. 2015. Atomic absorption spectroscopy technique was adopted for the determination of heavy metal concentrations. All studied metals are present in the water of wells' spread in Southern part of Basrah Province of Iraq. Certain metals present in little amounts ($\mu\text{g/l}$) in the range 0 - 0.5649 for Pb, 0 - 4.3909 for Ni, 0 - 32.0170 for Cu, and 0 - 8.5486 for Cd, while other metals were higher in the range 0 - 107.9698 for Mn, 4.336 - 312.1651 for Fe, and 11.982 - 439.3581 for Zn. Fe and Zn are exist in all wells' and during all periods of study. As a mean values the trends of heavy metals in well' water of southern Iraq is as follows: $\text{Zn} > \text{Fe} > \text{Mn} > \text{Cd} > \text{Cu} > \text{Ni} > \text{Pb}$. High concentrations of studied heavy metals were recorded in wells' no. 7&8 at Burjisiah and 9 &10 at Shuaibah due to proximity to fields of oil production and transportation. Moreover, high levels of heavy metals in the wells' waters at studied, area were recorded during the rainy months: Jan., Feb., Mar., April as well as May and June which indicates that rain water is a major source for pollution by heavy metals in the ground water at Southern Iraq.

Key Words: Pollution, Ground Water, Wells', Heavy metals, Southern Iraq.

Introduction

In recent years, surface water in Iraq suffered from a decrease in flow rates due to the policy of neighboring countries as an origin sources (Al-Imarah, 2014), this state causes water shortage problems in Southern Iraq for drinking and irrigation especially all areas along the main river Shatt Al-Arab in the southern part of Iraq other areas deep south covering Safwan, Al-Zubair, Khoar Al-Zubair, Burjisiah and Shuaibah which are little bit far away from rivers of fresh water, they depend mainly upon ground water for irrigation (Hamdan,2016). This area is characterized by a



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certain formation known as Dibdibba formation which has high value of permeability and it is directly recharge with direct rain fall, therefore rain storm is represents as the main source for recharge (Manhi, 2012).

Therefore, it is an important issue to study the water quality of wells' within this area for their suitability as a domestic and irrigation purposes.

Ground water quality assessment in the west of Basrah region is represented by Safwan - Zubair area were studied thoroughly and found unsuitable for human drinking (Al-Abood, 2003), or unsuitable for direct human use, industrial, or construction (Manhi, 2012). Certain wells' were used for plant irrigation successfully due to their high infiltration soil conditions and continuous irrigation.

According to their physico - chemical characterizations, most of well waters spread overall Southern Basrah Governorate which covers Safwan, Zubair, and Umm Qasser areas were varied from very poor to unsuitable for human drinking purposes (Abbas, et al., 2016).

Among wide spread pollutants which exert great effects upon the water quality of wells' and human health are the heavy metals. It is important to measure their concentrations in wells' water to find whether they are safe or potentially harmful and toxic (Hussein, 2015).

Al-Tememi, (2015), studied ground water quality within Dibdibba aquifer/ Southern Basrah in which certain heavy metals Cd, Ni, Pb, and Zn in well waters were reported. Higher values reported were 980 and 70 **µg/l for Pb and Zn due to contact between ground water and the parent rocks in sandstone Dibdibba formation that contains Pb and Zn** (Al-Bassam and Yousif, 2014).

Pollution by heavy metals of well waters in Al-Jaderiah district/ Bagdad governorate was studied (Hussein, 2015), it is reported that concentration ranges were 0.12 - 0.29 **µg/l** for Fe, 16.00 -443 ng/l for Mn, 0.13 - 0.71 **µg/l for Zn in most of studied wells along Tigris River, all were lower than allowable limits set by WHO (2011) as 0.3 - 1 µg/l** for Fe, 500 ng/l for Mn, and 3.0 **µg/l for Zn. Moreover results revealed absence of Cd, Co, Cu, Ni, and Pb in the water of all studied wells.**

Makkah city is not an industrial center and, as such, does not have significant human-caused air or groundwater pollution. The presence of contaminants such as heavy metals in well water, therefore, must be due to the geological features surrounding Makkah (Khdary and Gassim, 2014).

Due to the importance of water which is the lifeblood of the environment, essential to the survival of all living things : plant, animal and human, it is important to maintain it clean and unpolluted. Therefore, this study is attempted to evaluate the levels of certain heavy metals in waters of wells within the area of Southern Basrah Governorate.

Study area

The study area lies in the South West part of Basrah Governorate / Southern Iraq. Five sites were selected ,two wells from each site, total of 10 wells: Safwan (S1 and S2), Khor Al-Zubair (S3 and S4), Zubair (S5 and S6), Burjisiah (S7 and S8), and Shuaibah (S9 and S10), Figure 1. They are located between Latitude lines 30:00 and 30:25 and Longitude lines 47:45 and 48:15 which involve within the Dibdibba Formation that characterized being sand-gravel soil with rising ground surface level towards the North Eastern (Macfadyen, 1938).

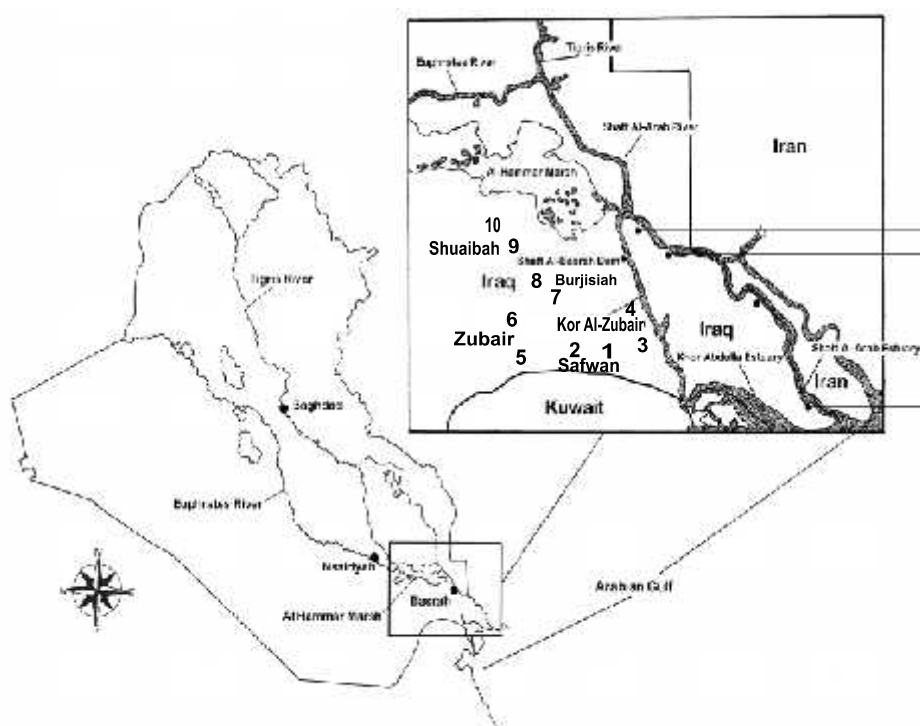


Figure 1. Map of Iraq and Southern Part of Basrah Province showing the locations of studied wells (1-10)

Methodology

The wells that were sampled were those designated for domestic use and irrigation purposes for different vegetables and plants. The field work was carried out during January - December 2015. Different wells were chosen from different areas of Southern Basrah Governorate: Safwan (1 and 2), Khoar Al-Zubair (3 and 4), Zubair (5 and 6), Burjisiah (7 and 8), and Shuaibah (9 and 10), Figure 1. The groundwater samples are collected after (10) minutes of pumping to avoid unpredictable change in characteristics of groundwater according to standard procedures (APHA, 1995). Sampling was done by using polyethylene bottles of one liter volume (Rainwater and Thatcher, 1960), and the samples were transported to the laboratory within the same day of collection. The depth of the wells ranged between 100 and 200m. Heavy metals (Cd, Cu, Fe, Mn, Ni, Pb, and Zn) analysis was done at analytical laboratory of Marine Science Center/Basrah University. Heavy metals were determined by digesting a known volume of water sample with HNO_3 (analytical grade). The digested sample was filtered into a 50 ml standard flask, made up to the mark with distilled-deionized water. This was stored in a nitric acid prewashed polyethylene bottle in the refrigerator, prior to the instrumental analysis. The water-extract was analyzed for presence of heavy metals by Atomic Absorption Spectrometer, in which Angstrom AA320N air acetylene flame Atomic Absorption Spectrophotometer fitted with special Hollow Cathode Lamps for each element was used. Each sample was analyzed in triplicate so as to ascertain the validity of the method, and the average of the results reported.

Results and Discussion

Some of the results of heavy metal analysis in wells' of Southern Basrah Province samples are listed in Tables (1) for well No. 4 in Khoar Al-Zubair site and table 2 for well No.9 in Al-Shuaibah site.

Low and moderate concentration levels for heavy metals were recorded in wells' Nos. 1-6 while high concentration levels were recorded in wells' 7-10.

Table 1. Concentrations of heavy metals (in $\mu\text{g/l}$) measured monthly in well No. 4 (Khor Al-Zubair) throughout the year 2015.

Heavy metal	Cd	Cu	Fe	Mn	Ni	Pb	Zn
Month							
Jan. /2015	7.157007	0	9.780631	3.501418	0.35634	0	84.87599
Feb.	0.198806	5.277797	35.86231	0	0	0.410899	39.44237
March	2.385669	0.659725	25.26663	3.501418	0.71268	0	82.87891
April	2.78328	0.659725	72.53968	3.501418	0.71268	0	174.7447
May	6.162978	1.979174	17.1161	58.35696	3.207058	0	89.36943
June	1.39164	0	28.52684	17.50709	0.71268	0.20545	28.45842
July	4.174921	3.298623	33.41715	7.002835	1.781699	0	228.6659
Aug.	3.180892	2.638898	57.86873	21.00851	2.138039	0.154087	125.3169
Sept.	6.162978	1.979174	36.67736	11.67139	2.138039	0	94.8614
Oct.	4.970144	0	57.05368	0	0	0.20545	63.40736
Nov.	3.777309	4.618072	189.9072	1.167139	0	0.154087	24.46426
Dec./2015	7.157007	1.319449	69.27947	4.668557	0.35634	0.051362	346.4938

Table 2. Concentrations of heavy metals (in $\mu\text{g/l}$) measured monthly in well No. 9 (Shuaibah) throughout the year 2015.

Heavy metal	Cd	Cu	Fe	Mn	Ni	Pb	Zn
Month							
Jan. /2015	0.449787	3.492772	164.8058	107.9698	0.439099	0.051362	82.87891
Feb.	3.14851	2.328515	8.673987	33.74056	3.07369	0.410899	174.7447
March	1.799149	0.582129	66.50057	6.748112	1.317296	0.20545	89.36943
April	4.947659	0.582129	5.782658	78.72797	1.317296	0.154087	28.45842
May	4.947659	433.1038	89.6312	58.48363	0.439099	0.20545	228.6659
June	4.497872	6.403416	8.673987	17.99496	2.195493	0.154087	125.3169
July	6.297021	3.492772	11.56532	15.74559	1.317296	0.051362	94.8614
Aug.	5.172553	18.04599	10.11965	2.249371	1.317296	0.154087	63.40736
Sept.	0.899574	1.164257	2.891329	47.23678	3.951887	0.20545	24.46426
Oct.	2.47383	18.04599	10.11965	11.24685	3.07369	0.154087	346.4938

Nov.	3.373404	1.164257	10.11965	24.74308	2.195493	0.20545	110.3388
Dec./2015	3.598298	1.164257	13.01098	38.2393	2.195493	0.154087	140.295

All studied metals are present in the water of wells' spread in Southern part of Basrah Province of Iraq. Certain metals present in little amount ($\mu\text{g/l}$) in the range 0 - 0.5649 for Pb, 0 - 4.3909 for Ni, 0 - 32.0170 for Cu, and 0 - 8.5486 for Cd, while other metals were higher in the range 0 - 107.9698 for Mn, 4.336 - 312.1651 for Fe, and 11.982 - 439.3581 for Zn. Fe and Zn are exist in all wells' and during all months of the study year 2015. As a mean values the trends of heavy metals in well' water of southern Iraq is as follows: $\text{Zn} > \text{Fe} > \text{Mn} > \text{Cd} > \text{Cu} > \text{Ni} > \text{Pb}$. High concentrations of studied heavy metals were recorded in wells' no. 7 & 8 at Burjisiah and 9 & 10 at Shuaibah due to proximity to fields of oil production and transportation, except that for Pb which was undetected in well No. 10 during Oct. 2015. But Cd is exists in all wells' during the whole months of study except that in well No. 7 during May 2015 and Well No. 8 during Dec. 2015 which are both from the same site. Moreover, high levels of heavy metals in the wells' waters at studied area were recorded during the rainy months: Jan., Feb., Mar., April which indicates that rain water is a major source for pollution by heavy metals in the ground water at Southern Iraq.

Iron is the fourth most abundant element by mass in the earth's crust. In water, it occurs mainly in ferrous or ferric state (Ghulman et al., 2008). It is an essential and non conservative trace element found in significant concentration in drinking water because of its abundance in the earth's crust. Usually, iron occurring in ground water is in the form of ferric hydroxide, in concentration less than 500 $\mu\text{g/L}$ (Oyeku and Eludoyin, 2010). Iron is an essential nutrient for erythropoiesis. The shortage of iron causes disease called "anemia" and prolonged consumption of drinking water with high concentration of iron may lead to liver disease called as haemosiderosis (Rajappa et al., 2010; Bhaskar et al., 2010). In this study, iron content varied from 4.3369 $\mu\text{g/l}$ in well No. 10 within Shuaibah site to 312.165 $\mu\text{g/l}$ in well No. 10 within Safwan site.

The concentration of manganese ranged from below detection levels 0.00 $\mu\text{g/l}$ in most investigated wells' during a certain time of study to 107.9698 $\mu\text{g/l}$ in well No. 6 at Zubair site and wells' Nos. 9 and 10 at Shuaibah site. Manganese can interfere with absorption of dietary iron which can result in iron deficiency anemia. It also increase bacterial growth in water. Excessive manganese intake can also cause hypertension in patients older than 40 years.

Lead is the most significant of all the heavy metals because it is toxic and harmful even in small amounts (Gregoriadou et al., 2001). Lead enters the human body in many ways, inhalation of polluted dust, or waste gases from vehicle used leaded gasoline. Most of the lead taken by humans are removed from the body in urine. As exposure to lead is cumulative over time, there is risk of buildup, particularly in children. Acute effects of lead are inattention, hallucinations and delusions. Poor memory and irritability are symptoms of acute intoxication. Lead absorption in children may affect their development and also results in bone stores of lead. High concentration of lead in the body can cause death or permanent damage to the central nervous system, the brain, and kidneys (Hanaa et al., 2000). In this study, maximum level of lead concentration (0.5649 $\mu\text{g/l}$) was found in water sampled from well No. 7 during different months, and a minimum concentration obtained was below detection level (0 $\mu\text{g/l}$) for water sampled from different wells' and during different

months of study. The concentration of lead obtained from most samples, wells' 1,2,3,4,5, and 6 were below the undetectable limits while the concentration obtained from wells' 7,8,9, and 10 were found to be slightly higher compared to the rest, indicating the highest level of lead contamination in the sampled wells.

Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms. Zinc is a nutritionally essential metal, and its deficiency results in severe health consequences (Curtis et al., 1996). Nevertheless, higher concentrations of zinc can be toxic to the organism (Rajkovic et al., 2008). Zinc plays an important role in protein synthesis and is a metal which shows fairly low concentration in surface water due to its restricted mobility from the place of rock weathering or from its natural sources (Rajappa et al., 2010). In this study, a minimum of 11.982 µg/l was recorded in Well No. 8 during Dec. 2015 and a maximum concentration of 439.358 µg/l also recorded in well No. 3 during Oct. 2015. This indicates that the concentration of zinc in water samples from wells' within Southern part of Basrah Governorate as a minimum and maximum levels were the highest among the studied heavy Elements.

Copper is an essential component of several enzymes. It is essential for utilization of iron (Curtis et al., 1996). Contamination of drinking water with high level of copper may lead to chronic anemia (Acharya et al., 2008). Copper in excess could impart a bitter taste to water and could promote the corrosion of galvanized iron and steel fittings (Chukwu et al., 2008). The concentration of copper detected in samples within this study is alternative between above and lower than the permissible limits of the WHO. The range was from undetectable 0.0 µg/l in most investigated wells' No. to a maximum value of 32.0170 µg/l in Well No. 10 during May 2015, compared to 2 µg/l set by WHO (WHO, 2011) due to presence of huge amounts of waste left since the 2nd Gulf War 1991.

Nickel is a silver-white metal found in the earth's crust, certain amounts of nickel are useful to the human body, but too much nickel can be toxic especially on inhalation which leading to increased risk of respiratory infections, asthma and sinus problems. In this study, minimum concentration of nickel was undetectable 0.0 µg/l in most of investigated wells' while maximum concentration was detected as 8.5486 µg/l, maximum allowable limit of 20 µg/l for Ni in drinking water (WHO, 2011).

As a comparison with other studies for heavy metals in surface or ground waters, levels within this study either comparable or lower than other studies and allowable limits set by WHO. For wells' waters in Al-Jadiriah /Iraq levels of heavy metals were 0.0, 0.0, 0.09-0.29, 0.016-0.339, 0.0, 0.0, and 0.01-0.732 µg/l for Cd, Cu, Fe, Mn, Ni, Pb, and Zn respectively (Hussein, 2015). In well waters from Mekkah City levels were 0.0088-0.07, 0.35-3.87, and 0.0034-0.022 µg/l for Cd, Cu, and Pb respectively (Khadary and Gassim, 2014). In wells' water in Nigeria, ranges recorded for heavy metals were 100-300, 100-500, 10-50, 0.0-30, and 10-50 µg/l for Cu, Fe, Mn, Pb, and Zn respectively (Adegbola, and Adewoye, 2012). In wells' waters from Tabriz mean concentrations were 6.55, 16.23, 4.94, 0.79, and 49.33 µg/l for Cd, Cu, Ni, Pb, and Zn respectively (Taghipour et al., 2012). In wells' at deep southern west to Basrah Province levels of some heavy metals were in the range undetectable 0.0, undetectable 0.0, 20 - 180, and 100-2200 µg/l for Cd, Ni, Pb, and Zn respectively (Al-Tememi, 2015). and finally during this study ranges in concentrations were 0.0 - 0.5649, 0.0 - 4.3909, 0.0 - 32.0170, 0.0 - 8.5486, 0.0 - 107.9698, 4.336 - 312.1651, and 11.982 - 439.3581 µg/l for Pb, Ni, Cu, Cd, Mn, Fe, and Zn.

Conclusion

The assessment of groundwater quality in the rapidly oil industrialized Basrah Province /Southern Iraq was achieved by evaluating the concentrations of certain heavy metals from various locations within the area. From the results of the analyses, most of the investigated heavy metals were found to be present in high concentrations for Mn, Fe, and Zn, while for other heavy metals Cd, Cu, Ni, and Pb were found in lower concentrations. Also, most of the water sample collected from wells' 1,2,3,4,5, and 6 within Safwan, Khor Al-Zubair, and Zubair sites were found to be at lower concentrations of heavy metals, while other wells' 7,8,9, and 10 within Burjisiah and Shuaibah sites were found to be at higher concentrations for all studied heavy metals because these sites are within the locations of oil production and transportation.. It is recommended that water from sampled well 7, 8, 9, and 10 should not be used for domestic purpose in view of high level of heavy metal contaminant. The effects of the presence of heavy metals in the water samples revealed that rapid industrialization coupled with inadequate planning and monitoring are responsible for the pollution of groundwater in Southern part of Basrah Province. If the present trend of pollution is not abated, in the near future, consumption of water abstracted from shallow wells will pose a serious health hazard to the generality of the residents in Burjisiah and Shuaibah. Wells' should be sited far away from any visible pollution source, and regular inspection and monitoring of existing wells should be prompt, and be on the priority list of the relevant local authority.

Recommendations

According to the results of our study and the local conditions, the following items were recommended:

- 1) The concentrations of heavy metals in well waters in the studied areas were less than toxicity threshold limit of agricultural water for wells' No. 1,2,3,4,5, and 6 which are safe to be used for irrigation and agriculture of different crops, while waters of wells' Nos. 7,8,9, and 10 are not suitable for such purpose.
- 2) Although the studied wells' 7-10 are located in oil fields region, fortunately groundwater of that region is not polluted by heavy metals only, they are polluted by petroleum hydrocarbons and hence the water is not even suitable for human or animal consumption

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