

## ASSESSMENT OF GROUNDWATER CONTAMINATION WITH HEAVY METALS IN RURAL AREA. CASE STUDY OF BAREBUHAR VILLAGE, DUHOK GOVERNORATE, KURDISTAN REGION OF IRAQ

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(Received: July 23, 2019; Accepted for Publication: October 16, 2019)

### ABSTRACT

Heavy metals are considered dangerous due to their tendency to bioaccumulate in a biological organism (tissues) over time. Their toxicity can result in damaged or reduced central nervous function, energy levels, lungs, kidneys, liver and other vital organs. This study was conducted to determine some heavy metals levels (Mn, Pb, Cu, Co, Ni, and Zn) in 15 deferent water sources collected from Barebuhar village, Duhok governorate. The concentration of heavy metals was determined via atomic spectrophotometer. The obtained results show that Mn and Pb concentration in some water sample were higher than recommended levels set by deferent organization such as WHO, EPA, and EC for drinking water. Since the concentrations of these heavy metals were above the standard levels in some water sources, these high levels can cause the adverse effects on human health if the water from these sources taken for drinking purposes. Also high concentrations physico-chemical parameters like EC (up to 2399  $\mu\text{S}/\text{cm}$ ) and TDS (up to 1243 mg/l) were detected in some water sample above permissible levels for drinking purposes.

**KEYWORDS:** Heavy metals, Contamination, Lead, Drinking water, Groundwater

<https://doi.org/10.26682/ajuod.2019.22.2.10>

### 1. INTRODUCTION

In arid and semi-arid regions, water is becoming one of the major environmental issues due to drought sensitivity, increasing consumption, and high rate of contamination (Ragab and Prudhomme, 2002; Yousuf *et al.*, 2018; Mohammed and Bamarni, 2019). Water resources contaminants such as toxic (heavy) metals, nitrates and salt have found their way into water resources due to insufficient treatment and disposal of waste (human and livestock), industrial discharges, use of chemical fertilizer and pesticide in agriculture, and over-use of limited water resources (Singh and Mosley, 2003). Moreover, natural sources are also likely to contribute higher levels of metals and other chemicals that can negatively affect human health. Various trace elements are micronutrient for living system, their absence or surplus can impact adversely human body (Jinwal *et al.*, 2009), while, some heavy metals can be toxic even at low concentration because of their tendency to accumulate in the body tissue (Domenico and Schwartz, 1998). Heavy metals in groundwater are generally dissolved in very

minute quantities in most of the cases and its concentration is less than 1 mg/l (USGS, 1993).

Therefore, groundwater pollution and its management has become the need of time since its reaching influence on human well-being. The examination of heavy metal concentrations in water resources is required to provide important information on human influence on the environment and serve as an indicator of pollutant loading (Bayan and Mustafa, 2018; Mustafa *et al.*, 2018).

The main goal of this work is to determine the concentration of some of the physicochemical parameters (pH, EC, and TDS) and heavy metals (Mn, Pb, Co, Cu, Ni, and Zn) in groundwater resources and springs of the Barebuhar village, Duhok governorate, Kurdistan region of Iraq and to compare the values with the international organizations (such as WHO) recommended drinking water standards. This study is useful in local and regional scale for water resource management mainly in rural area.

### 2. MATERIAL AND METHOD

#### 2.1 Study area

The study was conducted in Barebuhar village which is situated 10 Km northeast of Duhok city (Figure 1). The study area is considered as a semi-arid region with temperatures ranging between 1.0 and 40 °C. The average annual precipitation is about 760 mm and rainy season start from September to May with the climate similar to Mediterranean region. Geographically, the study area is located between 36° 52' 42.276" North and 43° 5' 50.0388" East. This village is chosen for this study because it is considered to be well known for intensive cultivating of vineyards, therefore, farmer uses vast quantities of different pesticides and fertilizers that could deteriorate water resource quality (Nerway, 2011).

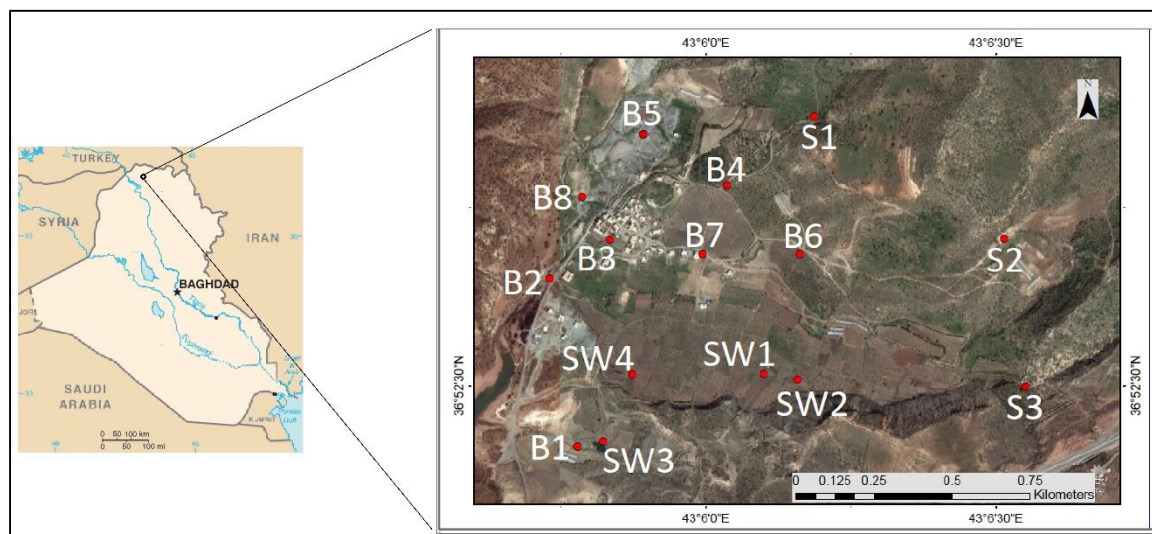
## 2.2 Sampling and analysis

A total of 15 different water sampling points (3 springs, 4 surface wells, and 8 boreholes) were selected to represent the water quality in the study area. The coordinates and locations of

these points are summarized in Table 1 and Figure 1. Water taken once from each selected points during September 2018 and water samples were collected in polyethylene bottle (0.5 litre capacity) under sterile conditions. Water samples were stored in cold condition with temperature around 4 °C and delivered in the same day to the laboratory of the Directorate of the Environment of Dohuk city and analysis were performed within 24 hours of sampling date to avoid any possible changes in water quality parameters. Water temperature (T), pH, electrical conductivity (EC), and total dissolved solids (TDS) were recorded in the field by using a portable multi-metre (Trans ISO 9002). The water samples were analysed for 6 heavy metals including manganese (Mn), lead (Pb), cobalt (Co), copper (Cu), nickel (Ni), and zinc (Zn) by using atomic spectrophotometer.

**Table 1.** Coordinates and depths of the sampling points

Sample ID	Latitude	Longitude	Depth (m)
S1	36° 52' 52.6116"	43° 6' 11.1816"	-
S2	36° 52' 42.3732"	43° 6' 30.8592"	-
S3	36° 52' 29.8992"	43° 6' 33.0372"	-
SW1	36° 52' 30.9576"	43° 6' 5.9544"	3
SW2	36° 52' 30.4932"	43° 6' 9.4788"	3
SW3	36° 52' 25.2984"	43° 5' 49.3368"	1
SW4	36° 52' 30.9504"	43° 5' 52.3752"	1
B1	36° 52' 24.8376"	43° 5' 46.6728"	85
B2	36° 52' 39.0288"	43° 5' 43.8252"	140
B3	36° 52' 42.276"	43° 5' 50.0388"	135
B4	36° 52' 46.8696"	43° 6' 2.1852"	95
B5	36° 52' 51.1392"	43° 5' 53.4948"	125
B6	36° 52' 41.07"	43° 6' 9.7128"	95
B7	36° 52' 41.0448"	43° 5' 59.6256"	100
B8	36° 52' 45.912"	43° 5' 47.1876"	170



**Fig. (1):** Study area location illustrating sampling points

## 2. RESULT AND DISCUSSION

The measured concentration of physico-chemical and heavy metals in both springs and groundwater are given in Table 2. The pH was measured at the sampling collection site which measures the acidity or alkalinity condition of water body and is a good indicator of the water quality (UNEP GEMS, 2008). The values of pH range between 7.7 and 8.5 that show all of the water samples are slightly alkaline possibly due to presence high concentration of carbonates and bicarbonates in the geological formation of the study area (Mohammed and Bamarni, 2019). From human consumption point of view, the samples may be considered fit as they were found within the limit (6.5 – 8.5) for drinking prescribed by WHO (2008) and EC (1998) admissible limit (6.5 – 9.5). The temperature of water samples were in the range of 21.8 to 32 °C.

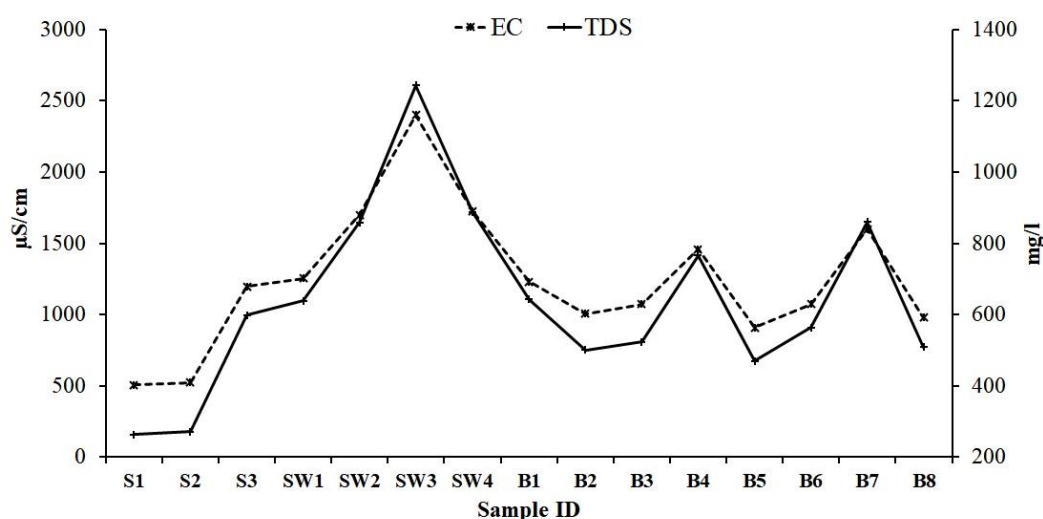
The Electrical conductivity (EC) is a measure of saltiness of the water and is a good indicator of the presence of contaminants in water body.

The range of EC value of the water samples vary from 507 – 2399  $\mu\text{S}/\text{cm}$  (Figure 2). Freshwater is usually has EC value less than 1500  $\mu\text{S}/\text{cm}$  (WHO, 2008), only four groundwater samples have concentrations higher than this value (SW2, SW3, SW4, B7). There is no health related limit for TDS in drinking water, however, palatability of water with TDS concentration below 500 mg/l is generally considered to be good (WHO, 2008). Drinking water becomes significantly and progressively unpalatable at TDS concentrations greater than about 1000 mg/l. According to London et al. (2005), the level higher than 1200 mg/l may be objectionable to consumers and could have impacts for those who have to limit their daily salt intake such as severely hypertensive, diabetic, and renal dialysis patients. Of the 15 samples analysed, 12 were found to contain TDS concentration of greater than 500 mg/l and the highest concentration (1243 mg/l) was recorded in surface well (SW3) which is not used for drinking purposes (Figure 2).

**Table (2):** Concentrations, means and standard deviations of physical parameters and heavy metals from urban area of Barebuhar village.

Sample ID	T°C	pH	EC $\mu\text{S}/\text{cm}$	TDS mg/l	Mn mg/l	Pb mg/l	Co mg/l	Cu mg/l	Ni mg/l	Zn m/l
S1	24	8.2	507	263	0.092	0.026	0.027	0.042	N.D	N.D
S2	28.9	8.1	523	271	0.181	0.107	0.009	0.032	N.D	N.D
S3	25.8	8	1198	599	0.018	0.034	0.019	0.170	N.D	0.006
SW1	27.3	7.8	1255	639	0.202	0.091	0.017	0.094	N.D	0.009

<b>SW2</b>	29.9	7.9	1701	859	0.092	0.164	0.010	0.106	N.D	N.D
<b>SW3</b>	32	8.5	2399	1243	0.062	0.263	0.021	0.142	0.015	0.052
<b>SW4</b>	27	8.4	1723	887	0.410	0.173	0.009	0.102	N.D	N.D
<b>B1</b>	22.5	8.3	1232	643	0.011	0.163	N.D	0.170	N.D	N.D
<b>B2</b>	21.8	8.5	1006	501	0.010	0.046	N.D	0.121	N.D	0.012
<b>B3</b>	23.6	8.1	1073	523	0.024	0.067	N.D	0.136	N.D	N.D
<b>B4</b>	23.3	8.2	1459	766	0.039	0.116	0.009	0.136	N.D	N.D
<b>B5</b>	24.6	7.9	908	470	0.152	0.428	0.008	0.117	N.D	N.D
<b>B6</b>	24.3	7.8	1073	564	0.119	0.118	0.036	0.217	N.D	0.008
<b>B7</b>	26.5	7.6	1601	860	0.121	0.170	0.041	0.310	N.D	0.009
<b>B8</b>	26.7	7.7	981	508	0.022	0.173	0.002	0.109	N.D	N.D
<b>Mean</b>	25.9	8.27	1242.6	639.7	0.104	0.143	0.017	0.134	0.015	0.016
<b>SD</b>	2.86	0.49	486.3	253.8	0.106	0.102	0.012	0.068	--	0.018



**Fig. (2):** The concentrations of electrical conductivity (EC) and total dissolved solids (TDS) of sampled water.

Guidelines for the presence of heavy metals in drinking water have been set by different international organizations such as US EPA, WHO, European Union Commission. Manganese (Mn) is an abundant trace metal in the environment, it is a minor constituent of most rock types and also available in soils from weathering and aerial deposition. Naturally occurring Mn is widely detected in drinking water supplies and is important for human health at low concentrations (Keen and Zidenberg-Cherr, 1994). The world Health Organization (WHO) guideline for Mn set at value of 0.4 mg/l (WHO, 2011), however, most countries have set a lesser limit mainly due to aesthetic and infrastructure problems. For instance, European Committee (EC) and Environmental Protection Agency (EPA) have listed Mn as an indicator at

a concentration of 0.05 mg/l in drinking water (EC, 1998; EPA, 2007). In this study, there was a wide variation in Mn concentrations and ranged between 0.010 – 0.410 mg/l (Table 2 and

Figure 3). The European Committee limit for Mn drinking water of 0.05 mg/l was exceeded in 9 water samples; the WHO health guideline of 0.40 mg/l was exceeded in only one water sample (SW4). Canada Health (2016) concluded that a Mn concentration between 0.01 to 0.02 mg/l is a suitable limit to keep against the discolouration of water. This is supported by many studies of drinking water that have stated that consumer complaints about discoloured water and/or staining of laundry occur at Mn values exceeding 0.02 mg/l (Sly et al., 1990; Casale et al., 2002; Kohl and Medlar, 2006). Both surface and groundwater sources of Mn can

be natural (rock and soil weathering) and man-made (industrial discharge, mining activities and landfill leaching) (Stokes et al., 1988; Kohl and Medlar, 2006; Ljung and Vahter, 2007). High concentrations of Mn in this study could be naturally and man-made particularly landfill leaching and agricultural activities such as pesticides since the area is widely used for grape cultivation (Nerway, 2011).

Lead (Pb) is highly toxic metals and it should normally be available merely in trace amount. Lead shows toxicity to nervous system, accumulate in kidney and skeleton, and reproductive system. Over exposure to lead could cause permanent brain damage, and newborn babies are more sensitive than the adults (Jennings *et al.*, 1996). The concentrations of lead were found to be maximum of 0.428 mg/l at

B5 and minimum of 0.026 mg/l at S1. It is seen that all the samples has lead concentration above the WHO standard of 0.01ppm (WHO, 2008). The elevated level of lead in the groundwater and springs of the study area may highly be the result of entry from agricultural run-off containing phosphatic fertilizers and also from intensive pesticide application to grape farms (Abdul Jameel *et al.*, 2012; Assubaie, 2015).

Cobalt (Co) concentration was found to be below the detected limit in three water samples (B1, B2, and B3). In the other samples, cobalt value ranges from 0.002 and 0.041 mg/l. Nevertheless the maximum admissible limit of cobalt is not mentioned by WHO (2008), all the samples analysed comply the EPA (2007) maximum admissible limits of cobalt in drinking water (0.1 mg/l).

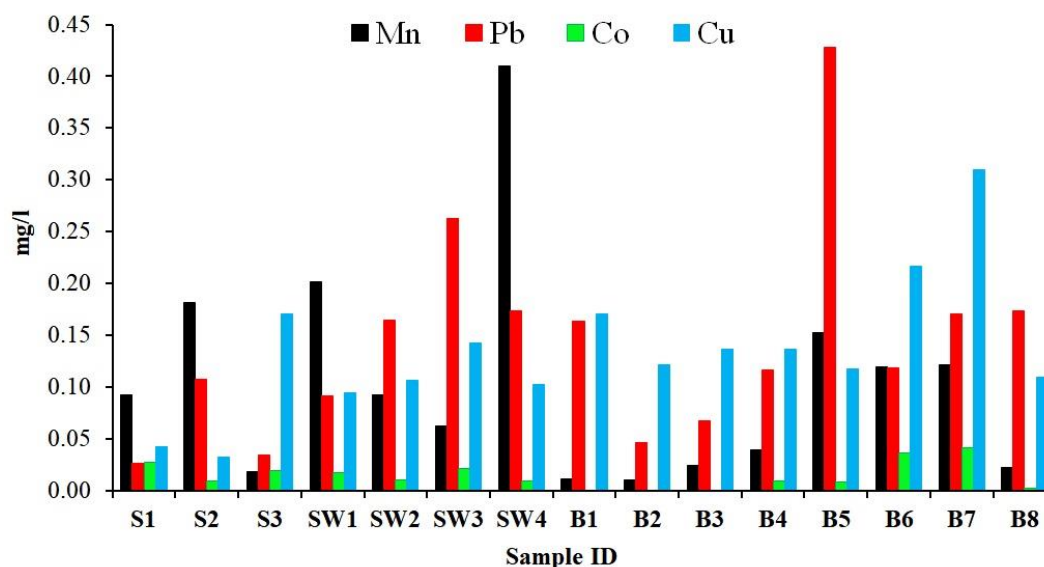


Fig. (3): The concentration of heavy metals in water samples.

Copper (Cu) is an important trace element and needed by biological systems for some enzymes stimulation through the process of photosynthesis, however, at elevated concentrations it shows detrimental influences on the human body and may cause nausea and diarrhea. Cu is also lethal to a range of aquatic organisms even at very small concentrations. The presence of copper in water resources can be from mining, metallurgy, industrial uses, copper

salts for algae control, and corrosion of copper pipes (Sharma, 2015, Kashin and Ivanov, 2008). The concentration of Cu in water samples varied from 0.032 to 0.310 mg/l, these values are lower than the maximum admissible level of 2 mg/l for drinking water set by WHO (2008) and 1.0 mg/l set by EPA (2007).

### 3.CONCLUSION

This study shows that the water collected from 15 water sources from Barehuhar village consists of elevated concentrations of heavy metals mainly manganese and lead which were found to surpass the maximum permissible limits set by various organization such as WHO, EPA, and EC. It was also found that cobalt and copper exist in most samples but in lower concentrations and within permissible level of drinking water. Chemical fertilizers, pesticides, waste water in some extend and rock mineral dissolution could be the main causes of high level of some toxic elements in water samples. Therefore, the results of this study approve the water contamination and hence without prior treatment water should not be consumed, nevertheless water sources are suitable for agricultural activities.

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## پوخته

توخمین دهگمن (ژههراوی) تینه هژمارتن ژ مهترسیا ژ بهر کومبوونا وان دناق شانیت له شی زینده وه راندا ب بورینا ده می. ژ بهر ژههراویا توخمیت دهگمن ده رنه نجام زیان گه هاندنه ل سهر کاری کوته ندامت ده مارا و ریژا هیژ و سیها و گورچیل و میلاکت و نه ندامت له شی بیت دیتر. ئەف قه کولینه هاتیه نه نجامدان ژ بوو دیار کرن ریژا هندهک توخمین دهگمن وهک (مهنگه نیس و قورقوشم و مس و کوپالت و نیکن و زینگ) ل ناک 15 ژیده ریژا جودا بیت ناکت ل گوندی به ریبهار سهر ب پاریزگه ها دهوکت قه , ریژا توخمیت دهگمن و ژههراوی هاتنه دهست نیشانکرن ب ریکا نامیری (spectrophotometer) قه , نه نجامیت ب دهست قه هاتین دیار دکهن کو توخمین مهنگه نیس و قورقوشم ریژه کا به رزتر تومارکریه دناق ناکت دا به رامبه ر نه و ریژا هاتیه دهست نیشانکرن بو قه خوارنی ژلای هندهک ریخراوین جیهانی بین ب ناک و دهنگ وه کی ریخراوا جیهانی یا ساخله می و دهزگه هی پاراستنا ژینگه ها نه مریکی و ریخراوا نه وروپی هه روه سا ریژا خوئی دناق هندهک ژیده ریژا ناکت دا زورتر بو ژ ریژا هاتیه دهست نیشانکرن بو قه خوارنی.

## الخلاصة

تعتبر المعادن الثقيلة خطره على الكائنات الحية اذا ما تم استهلاكها بسبب تراكمها في الانسجة الحية وان لسمية هذه المعادن تأثير سلبي على وظيفه الكثير من الأعضاء مثل الجهاز العصبي المركزي و الرئتين و الكليتين و الكبد و غيرها من الأعضاء. لقد تم تنفيذ هذا البحث بهدف تحديد مستويات بعض المعادن الثقيلة المنغنيز والرصاص و النحاس و الكوبالت و النيكل و الزنك في خمسة عشرة مصدراً للمياه في قرية بريهار في محافظة دهوك و قد استخدم جهاز الطيف الذري في قياس تراكيز هذه المعادن. لقد أظهرت النتائج بان تراكيز كل من الرصاص و المنغنيز أعلى من المستويات الموصى بها من قبل بعض الهيئات و المنظمات مثل المنظمة الصحة العالمية وكالة حماية البيئة الامريكية و المفوضية الاوروبية لذلك فإن أستهلاك هذه المياه مباشرة لشرب ستؤدي الى نتائج سلبية على صحة أهل القرية وقد أظهرت النتائج أيضاً مستويات أكبر من المقبولة لبعض المعلمات الفيزيائية والكيميائية مثل مجموع المواد الصلبة الذائبة و التوصيل الكهربائي في بعض مصادر مياه هذه القرية.