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RESEARCH ARTICLE

ENVIRONMENTAL STUDY OF SOME HEAVY METALS IN LAHJ GOVERNORATE, YEMEN

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ABSTRACT

The problem of water pollution by heavy metals is all over the world especially in developing countries. This problem of groundwater contamination with heavy metals becomes one of the most important environmental issues because some of these metals are toxic in their nature even at low concentrations. Groundwater is the major source of drinking water in urban and rural areas in Yemen, and is an important water supply source worldwide. Groundwater in Lahj Governorate is used exclusively to satisfy the needs of different sectors which use water for drinking, domestic irrigation and industrial use. The heavy metals can cause occupational and accidental harm to humans, and can contaminate water, soil and air as well. The aim of this study is to analyse some heavy metals from groundwater in Lahj Governorate of Yemen and its relation to the developed industrial activities. Twenty groundwater samples were collected from different wells in Lahj Governorate. The groundwater samples were analysed using (AAS) Atomic Absorption Spectrophotometer. The mean concentration of Cadmium (Cd), Copper (Cu), Zinc (Zn), and lead (Pb) is measured. The concentration of these heavy metals ranged from 0 to 0.0735 ppm, 0 to 0.0756 ppm, 0.017 to 0.73 ppm, and0 to 0.4434 ppm respectively.

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INTRODUCTION

The problem of water pollution by heavy metals is all over the world especially in developing countries. The broad risk of water pollution is there due to modern technology, civilization and industrialization. The contamination of water by heavy metals is a worldwide environmental problem affecting water resource (Ghorade *et al.,* 2014; Ibrahim *et al.,* 2015). It is one of the most important environmental issues as some of the heavy metals are toxic even at low concentration (Husam Malassa *et al.,* 2013). Groundwater may contain a high amount of diverse minerals which vary according to the quality of the soil and rocks due to industrialization and other environmental pollution (Sleema *et al.,* 2009). Groundwater is the major source of drinking water in urban and rural areas in Yemen and is an important water supply source worldwide (Essam and Alsharabi, 2015). Heavy metals reach the groundwater through the leakage of contaminated surface water or human activities which include the industrial activities and the use of fertilizers and pesticides in agricultural areas (Ibrahim, 2008). Heavy metals and their occurrence in groundwater and surface water can be attributed to natural sources such as dissolution of naturally occurring minerals containing heavy metals in the soil, or the aquifer material or human activities such as mining, fuels and improper disposal of industrial waste (Musa *et al.,* 2013). The toxicity of heavy metals in water depends on the concentration of the metal below a certain level which could be considered essential for biochemical processes at the high levels as far as bio accumulate raising toxicity concerns (Ackah *et al.,* 2011). Some heavy metals, such as (Cu, Mn, Zn), are essential for living organisms. However, excessive levels of these elements can be detrimental to living organisms. Heavy metals have strong toxicity even at low concentration. They have toxic effects on the environment and life in aquatic system too, such as (Lead, Cadmium, Nickel and Copper) With the increasing industrial use and environmental pollution, concerns have increased about their long term exposure and potentially toxic effects on human health specially infants and young children who are at the peak of their growth (Inamullah and Alam, 2014; Ehi- Eromosele and Okiei, 2012). Heavy metals enter water supply by industrial and household waste, or from acidic rain resulting in the disintegration of soils and releasing heavy metals into groundwater. They enter human bodies via drinking water, food, and air. They are hazardous substances that can cause occupational and accidental harm to humans, and can contaminate water, soil and air (Njar *et al.,* 2012; Helen, 1985). The environmental contamination by heavy metals through industrial waste is one of the main health

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problems in industrial countries. These pollutants do not only change the quality of groundwater and soil but also pose serious problems (Abdullah *et al.,* 2013). Yemen is one of the developing countries where the industry is still in its initial stages compared to other developed countries. The industrial waste resulting from industrial activities has great danger to environment. The contamination of groundwater by heavy metals may cause many problems due to their generally non-biodegradable nature. Heavy metals in drinking water are positively correlated to the occurrence of cardiovascular diseases, kidney related disorders and various forms of cancer. High concentration of heavy metals can cause biochemical effects such as inhibition of enzymes, genetic damage and high blood pressure (Tiwari *et al.,* 2013; Khalid *et al.,* 2014; Mohammed Ilyas Fazil *et al.,* 2012).Heavy metals have the potential to reach levels in the soil and then in the groundwater causing adverse effects to human health. Heavy metals resulting in the effective pollutants have drastic environmental impact on all organisms (Pokkate Wongsasuluk *et al.,* 2014; Samir *et al.,* 2008).There are numerous types of pollutants found in the environment such as organic materials major ions and heavy metals which could be introduced to aquatic environment as a result of urbanization, industrial and agriculture activities (Hassan *et al.,* 2004).

Study Area

The study area is Lahj Governorate which is located in the south – west of the Republic of Yemen between longitudes (43 – 46) to the east of Greenwich, and between latitudes (12 – 14) north of the equator, about (320 km²) from the capital Sana'a. It is bordered by the Governorate of AL- Baida, and AL- Dali from the north; Aden and the Gulf of Aden from the south; Abyan Governorate from the east; and Taiz Governorate from the west. It has an area of about 12,650Km².

The population of Lahj Governorate according to the 2011 census of population is about 875,000. In Lahj Governorate there are 15 districts (Fig.1) The city of AL – Hota is the capital of the Governorate (Yemen facts and figures, 2011). (Fig.2) shows the map and the location of the collected samples for the studied area.

MATERIALS AND METHODS

Twenty representative of groundwater samples were collected from the different wells of Lahj Governorate during the year 2014. The samples were collected in plastic containers of 500 ml capacity and they were preserved by using nitric acid position of 65%.The levels of Cd, Cu, Zn, and Pb were determined in groundwater samples. The groundwater samples were analysed using Atomic Absorption Spectrophotometer (Model, Chemito AA 201). The process of digestion was carried out by using concentrated nitric acid of 65 % and concentrated Hydrochloric acid of 37%where 100 ml of sample was put in conical flasks of 100 ml capacity, and 3ml (HNO3 conce.) of 65%and 10 ml of (HCLconce.) 37%was added. The solution was heated on hot plate until volume is reduced to near 25 ml, making certain that the sample dose not boil. After the sample was filtered using the Whatman No. 42 filter paper, then the filtrate was transferred to the volumetric flask and the volume was adjusted to 100 ml and mixed it well (Greenberg *et al., 1*999; Maiti, 2004).

RESULTS AND DISCUSSION

The present study was undertaken with the objective of analysing certain types of heavy metals of the groundwater samples from Lahj Governorate. The groundwater samples were subjected to the analyses of four metals viz. Cadmium, Copper, Zinc and Lead.

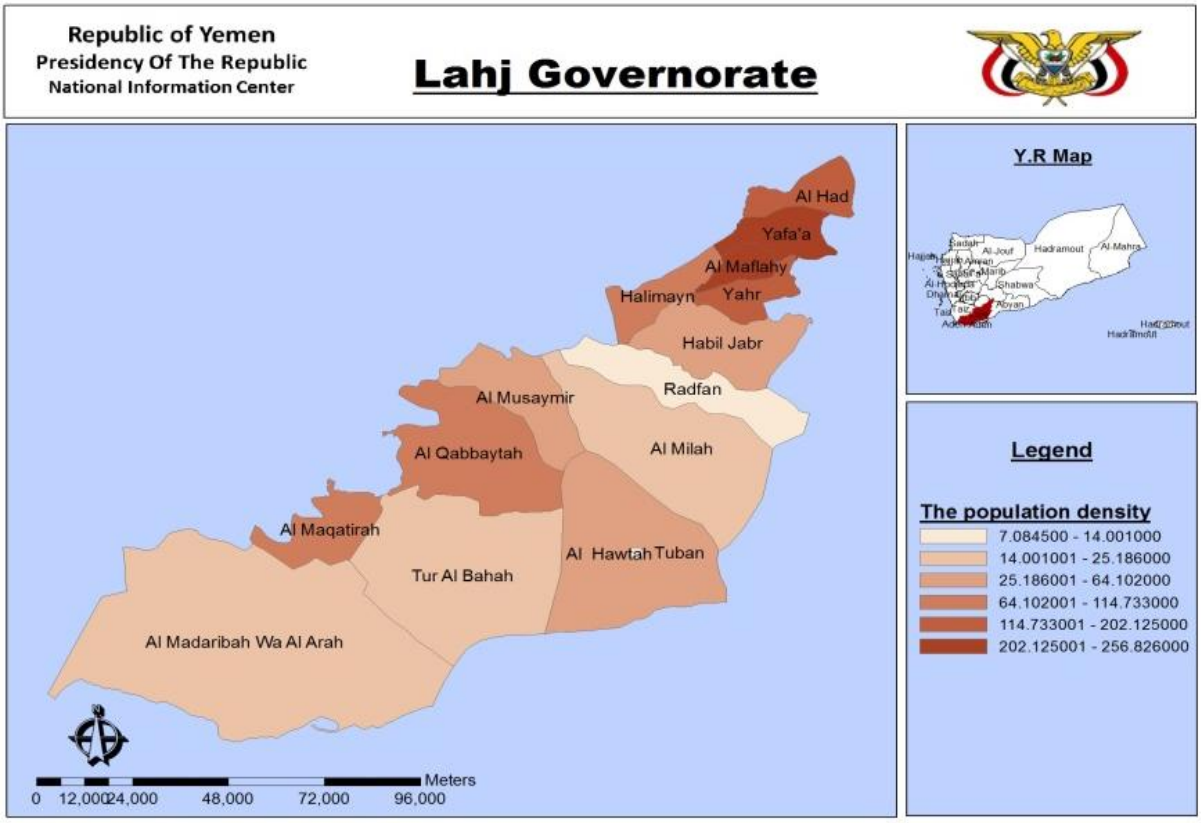

Fig. 1. Map of LahjGovernorate

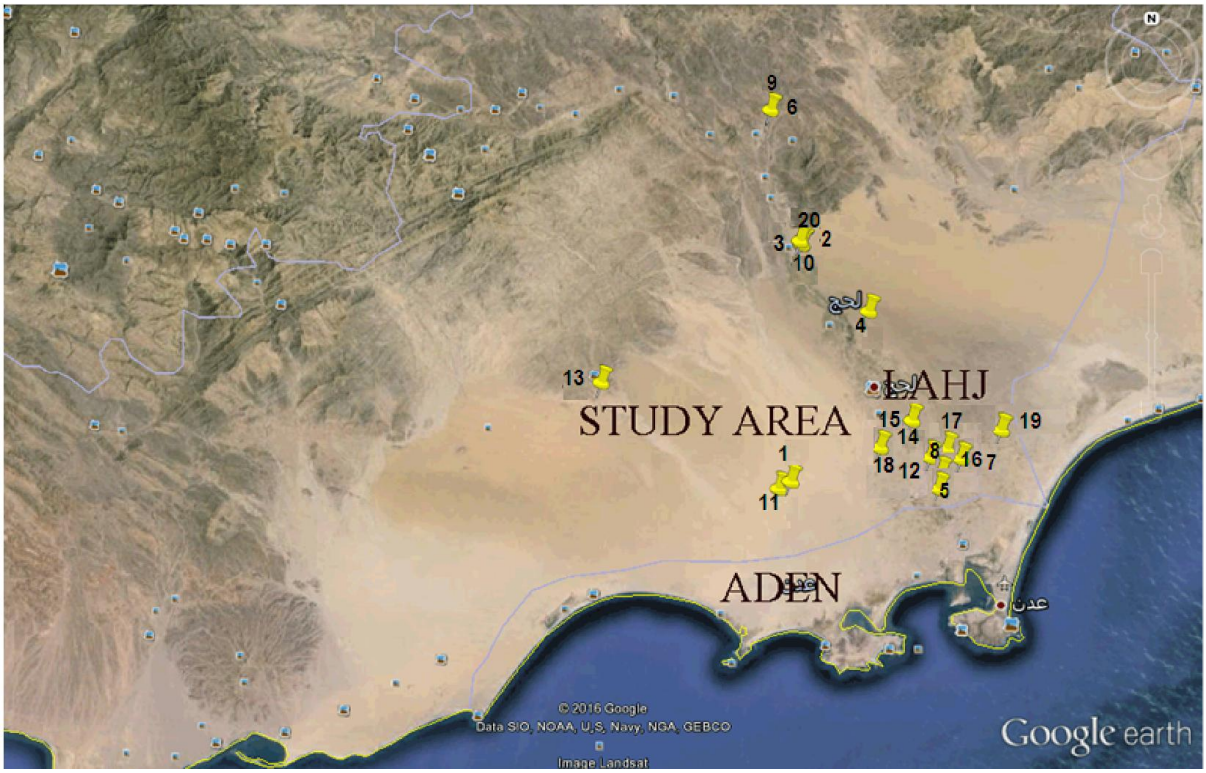

Fig. 2. Location Map of Study Area, Lahj, Yemen

Table 1. Mean concentration (ppm) of heavy metals in water samples of the study

Sample No.	Cd	Cu	Zn	Pb
1	0	0.01664	0.017	0.1389
2	0	0.0166	0.033	0.1156
3	0.0125	0.0498	0.05	0.0406
4	0.0333	0.0833	0.31	0.0799
5	0.01254	0.0333	0.033	0.0744
6	0.0316	0.0333	0.03	0.0816
7	0.0083	0.0332	0.037	0.0554
8	0.0125	0.01664	0.036	0.0567
9	0.0128	0.0499	0.15	0.081
10	0.01253	0.0417	0.076	0.1143
11	0.02084	0.0419	0.06	0.2072
12	0.01254	0.03332	0.214	0.1018
13	0.01246	0.0756	0.038	0.0366
14	0.0254	0.5749	0.95	0.4434
15	0.0157	0.04167	0.028	0.0381
16	0	0.0164	0.03	0.0553
17	0.0735	0	0.73	0
18	0.007	0.014	0.02	0.055
19	0.0086	0	0.030	0.0474
20	0.0555	0.0147	0.026	0.0707
WHO mg/l	0.003	2	3	0.01
Yemeni Standard mg/l	0.005	1	5-15	0.05

The concentrations of these heavy metals have been presented in table1. The results have been compared with the standard as prescribed by the World Health Organization (WHO) and Yemeni standard (WHO, 2008; Yemeni Standard and Specification of drinking water no. (109), 2000).

Cadmium (Cd): The concentration of Cadmium (Cd) in the study area ranged from 0 to 0.0735 ppm with an average 0.01894 ppm. Most of the samples were above the maximum permissible limit of 0.003 ppm and 0.005 as compared toWorld Health Organization standard and the Yemeni standard. Cd in the content of samples No. 1, 2,16 was zero. This means that there was no Cd in the content of these samples which was less than the desirable limit.

The samples No 7, 18. 19 were slightly higher than the maximum permissible limit of Yemeni standard. The content of Cd in the samples No 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 20 was much higher than the maximum permissible limit of World Health Organization standard and Yemeni standard. Waste water is a key source of environmental Cadmium contamination and diffuse pollution occurring through industrial air emission and widespread of fertilizers on agricultural soils (Manju Mahur Pawar, 2015; Tslalom Haileslassie and Kiflom Gebremedhin, 2015). Cadmium metals are used mainly for electroplating on other metal to prevent corrosion for paint, plastics, printing ink, and electrical batteries. The effects of acute Cadmium are high blood pressure, kidney damage, destruction of testicular tissue and red blood cells (Pan Dove and Sahotap, 2015).

Cooper (Cu): The concentration of Cooper (Cu) in the study area ranged from 0.0 to 0.5749 ppm with an average 0.05854 ppm.All of the samples were within the permissible limit according to the Yemeni standard and the highest desirable limit according to World Health Organization standard except sample No. 17, 19 which was zero. Copper is an essential element in the process of metabolism. The problems and effects associated with Cu contaminated drinking water are intestinal distress nausea, vomiting, diarrhoea, stomach cramps and anaemia, and low number of white blood cells.Osteoporosis in infants and children when exposed to high levels can cause devastation of red blood cells and chronic overexposure to copper can damage the liver and kidneys (Pan Dove and Sahotap, 2015; Duruibe *et al.,* 2007).

Zinc (Zn): The concentration of zinc (Zn) in the study area ranged from 0.017 to 0.73 ppm with an average 0.145 ppm. All the samples were within the permissible limit according to the Yemeni standard and the World Health Organization standard which is far below the desirable limit set by (WHO). Zinc is anutritionally essential element.It is necessary for growth and for the normal functioning of the cells and is involved in several physiological functions including protein synthesis and carbohydrate metabolism. The zinc shortage leads to retardation of growth, anorexia and lesion of the skin. The excessive amount of zinc can cause system dysfunction that leads to impairment of growth and reproduction, Zn toxicities such as vomiting, diarrhoea, blood urine, liver failure, kidney failure and anaemia, depression, cough, and headache (Pan Dove and Sahotap, 2015; Burgohain *et al.,* 2009).

Lead (Pb): The concentration of lead (Pb) in the study area ranged from 0.0 to 0.4434 ppm with an average 0.0913 ppm.The content of samples No 1, 2, 10, 11, 12, 14, are much highest than the maximum desirable limit as compared to World Health organization standard and the Yemeni standard. The samples No 3, 13, 15, 19 were within the permissible limit according to the Yemeni standard. The samples No 4, 5, 6, 7, 8, 9, 16, 18, 20 were slightly higher than permissible limit of Yemeni standard. Sample No 17, the content of Pb was zero. Lead is the most significant toxin of the heavy metals and the inorganic forms are absorbed through ingestion by water and food and inhalation. Health effect of lead and the symptoms of severe lead toxicity are headache and irritability besides various symptoms related to the nervous system. Also, children are affected by behavioural disturbances in learning as well as concentration difficulties. The exposure to some metals such as lead may cause autoimmunity development in which a person's immune system attacks its own cells. This can lead to joint diseases such as rheumatoid arthritis, kidney diseases, and circulatory system). Moreover, it causes inhibition of the synthesis of haemoglobin and neurological and can cause severe and permanent brain damage (Duruibe *et al.,* 2007; Jonah *et al.* 2015).

Conclusion

This study aimed at evaluating the human health risk because of some heavy metals in the drinking water from 20 groundwater wells in the Governorate of Lahj in Yemen. It examined the concentration of Cd, Cu, Zn, Pb, in 20 groundwater samples from study area. Some groundwater samples showed higher values of some heavy metals concentrations.A high health risk comes from those heavy metals which are present at higher levels of the WHO. The results showed that the values of Cu of all groundwater samples are within the permissible limit for drinking water given by WHO.All of the groundwater samples contained higher Pb concentrations except sample No.17 which contained zero. However, the concentrations of Pb were all higher than permissible limit according to WHO. The Cd content of most groundwater showed a higher permissible limit except three samples where the content of Cd was zero. The Zn content of all groundwater samples was within the permissible limit for drinking water. Lead and Cadmium represented higher content in the groundwater due to the human and industrial activities. This raises a lot of concerns. So, when the resulting water from these wells is used, it must undergo some measurements to limit the possible chemical risk and the local authorities should be made aware of health risks in order to provide portable water facilities. Most of the samples were within the permissible limit according to the Yemeni standard. Some of the wells were found to be suitable for industrial uses. It may be concluded that there is definite impact of industrial waste on the quality of groundwater wells which are near factories.

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