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RESEARCH ARTICLE

ASSESSMENT OF SOME HEAVY METALS FROM THE GROUNDWATERS OF LAHJ GOVERNORATE, YEMEN

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ABSTRACT

Heavy Metals Pollution denotes any metal component that possesses a relative high density and belongs to aset of metals and metalloids with atomic density more than $4g/cm^3$. The problem of water pollution by heavy metals is worldwideparticularlyin developing countries. The extensive risk of water pollution isbecause ofmodern technology, civilization and industrialization. The Groundwater, which is an important water supply source, getting contaminated by heavy metals is aworldwideenvironmental problem. It is the majorsource of drinking water in urban and rural areas in Yemen. Groundwater in Lahj Governorate is used exclusively to satisfy the demands of different sectors like drinking, domestic irrigation and industrial purposes. Thus, the contamination of water by heavy metals becomes an issue of remarkable public and scientific concern regarding evidences of their poisonousto human life and biological systems. This study aims to analyse some heavy metals from groundwater in Lahj Governorate of Yemen and its relation to the developed industrial activities, and comparing them with WHO specifications and Yemeni standard. The attempt also been made to evaluate the health damage caused by the higher concentration of heavy metals. Twenty representative groundwater samples were collected from different wells in Lahj Governorate. Thegroundwater samples were analysed using (AAS) Atomic Absorption Spectrophotometer. Themean concentration of Nickel (Ni), Chromium (Cr), and Manganese (Mn) has been measured. The concentration of these heavy metals ranged from 0.0452 to 0.1619 ppm, 0.058 to 0.403 ppm, 0.0127 to 0.1106 ppm respectively.

INTRODUCTION

Heavy metal pollution is a crucial environmental problem as a result of its toxic effects and bioaccumulation throughout the food chain (Rajaskaran, R and Abinaya, M, 2014). Heavy Metals Pollution indicates any metal component which contains a relative high density andapplies to aset of metals and metalloids with atomic density more than $4g/cm^3$. Heavymetals are environmentally stable, non- biodegradable and incline to accumulate in plants andanimals causing harmful chronic effect on human life (K. B.L. Shrivast AVA and S. P. Mishra. 2011). Most of the developing countriesare suffering from water pollution by heavy metals. Water pollution is a result of modern technology, civilization and industrialization. This contamination of water by heavy metals becomes a global environmental problem that threatens water resource (Ghorade *et al*., 2014; Ibrahim *et al*., 2015). It also has broughtgreat anxiety owning to their poisonousness to human life and biological systems (Asia Alshikh 2011).

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Heavy metals are considered the more dangerous contaminants in our natural environment owing to their toxicity, fastness and bio-accumulation problems. These elements have direct impact on health and behaviour by damaging the mental and neurological factors. The system of poisonous metal elements include: blood cardiovascular, detoxification directions of body (liver, colon kidney and skin), hormonal, endocrine, energy production paths, digestive system, central and peripheral nervous system, reproductive and urinary tracts (Javad.*et al* 2014).Heavy metals are categorized as class B metals which come under non-essential trace components. Components like Hg, Ag, Pb, and Ni are considered very poisonous. Such heavy metals are insistent, bio accumulative, don not easilymoulder in the environment, and not simply absorbed. These metals increase in food chain through absorption at initial stages and then through digestionat consumer levels. Heavy metals such as Cd, Ni,As and Cr create many risks to humans(Vaishaly A. G. *et al* 2015). They enter in to body by drinking, inhalation, ingestion and skin absorption. Agradual build up of these toxins will happen if heavy metals enter and accumulate in body tissue more rapidly than the body's detoxification path ways can dispose them off. High concentration exposure is notes sential to create a state of toxicity in the body tissues and overtime it can reach toxic concentration levels. Lead in humans onlong term exposure can lead to serious or chronic damage to the nervous system on human (Gaur S, Joshi. *et al* 2011).Heavy metals toxic levels are above the setting concentrations normally existed in nature. However, heavy metals areextremely released into the environment because of fast industrialization, manufacture of fertilizers and great production of industrial waste originated from metal plating, mining activities, smelting, battery manufacture, tanneries, petroleum refining, paint manufacture, pesticides, pigment manufacture, printing or photographic industries. This formed a fundamental international concern as they are non-biodegradable and can be accumulated in living tissues, leading to different diseases and disorders within the food chain. It is obvioustthat most drinking water throughout the world is obtained from groundwater. Theglobal population is 7 billions of people, but nearly 1.1 billion of them cannot get treated drinking water supplies and use unsafe surface and groundwater sources (Fernandez *et al*, 2013).

Groundwater is an important water supply source. It is the main source of drinking water in urban and rural areas in Yemen.In Lahj, a Yemeni governorate, the groundwater is used only to satisfy the needs of various sectors which use water for drinking, domestic irrigation and industrial activities. There is a definite impact of industrial waste on the quality of groundwater from the wells which are in the vicinity of industries. (Mohammed Ali, and Panaskar, 2016). Heavy metals bring about a cute health effects suchas slow growth and development, cancer, organ damage, nervous system damage, and in extreme cases, death. Heavy metals toxicity canlead to damage or reduction in mental and central nervous function, lower energy levels, and damage to blood composition, liver, kidneys, lungs, and other vital organs. Long-term exposure may result in slow and progressive physical and neurological degenerative processes such as muscular dystrophy and multiple sclerosis. Heavy metals are chiefly poisonous to the sensitive, fast developing systems of the fetus, infants and young children. In addition, childhood exposure to some metals can result in learning difficulties, memory impairment, damage to the nervous system, and behavioural problems such as aggressiveness and hyperactivity.

High level of heavy metals exposure maylead to everlasting intellectual and developmental disabilities, including reading and learning disabilities, behavioural problems, hearing loss, attention problems, and disruption in the development of visual and motor function. At higher doses, heavy metals are capable to bring about irreversible brain damage as well. Children cangethigher doses of metals from food than adults as they need more food for their bodies than adults. Therefore, it is vitalto know more about heavy metals and to take preventive measures (Hui Hu, Qian Jin *et al*, 2014, peter *et al*, 2016, and Taher, 2012). Heavy metals are environmentally stable, non-biodegradable and incline to accrue in plants and animals leading to several chronic effects to human life. Anthropogenic activities such as urbanization, industrialization, transportation, indiscriminate use of fertilizers, insecticides and pesticides, improper disposal of sewage and solid wastes material containing toxic chemicals as well as natural process such as precipitation inputs erosion and weathering of crustal materials increase the percentage of these elements in soil and water (Shrivastava and Mishra, 20011).Yemen is one of the developing countries where the industry is still in its initial stages comparing with other developed countries. The industrial waste that comes from industrial activities has great risk on environment. One of the major sources of heavy metal pollution in urban areas in Yemen is human source, whereas the contamination which arises from natural sources prevails in the countryside. Anthropogenic sources of pollution that include those resulting from vehicular emissions, incinerators, industrial waste, effluents, fertilizers, atmospheric deposition of dust and aerosols and other activities have constantly added to the pool of pollutants in the environment.

Study area

The study area is Lahj Governorate which is located in the south–west of the Republic of Yemen between longitudes 43º–46º E and between latitudes 12º–14º N about (320 km²) from the capital Sana'a. It is bordered by the Governorate of Al-Bayda, and Ad- 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 2015 CSO of population is about 939,000. In Lahj Governorate, there are 15 districts. Thecity of AL- Hota is the capital of the Governorate. Figure1 shows the location of the samples from the study area.

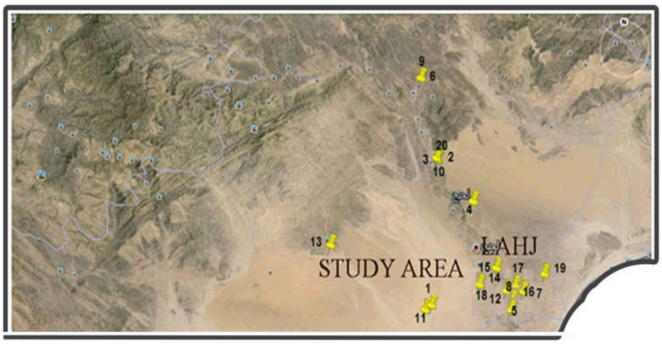

Fig. 1. Location Map of Study Area, Lahj, Yemen

MATERIALS AND METHODS

Twenty representative ground water samples were collected from different wells of Lahj Governorate during the year 2014. The samples were collected in plastic containers of 500 mlcapacity and they were preserved by using HNO3 conc. (65%). The levels of Ni, Cr, and Mnwere determined from groundwater samples. The heavy metals were analysed using Atomic Absorption Spectrophotometer (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 conc. HNO3(65%) and 10 ml of conc. HCL 37% were added.

The solution was heated on hot plate until volume is reduced to near 25 ml, making certain that the sample does not boil. After the sample had been filtered using the What man No. 42 filter paper, the filtrate was transferred to the volumetric flask and the volume was adjusted to 100 ml and mixed it well (Greenberg *et al*., 1999; Maiti, 2004).

RESULTS AND DISCUSSION

The study has been carried out to analyse particular kinds of heavy metals from the groundwater samples of Lahj Governorate. The groundwater samples have been subjected to the analysis of three metals viz. Nickel, Chromium, and Manganese. Three groundwater samples have been collected from each location and total 20 locations have been selected for present study, The mean concentration of three samples for each location have been presented in Table1. The results have been compared with the standards prescribed by the World Health Organization (WHO, 2011).and Yemeni standards.

Table1. Mean concentration (ppm) of heavy metals from ground water samples of the study area

Sample No.	Ni	Cr	Mn
1	0.05555	0.057	0.0334
2	0.05555	0.413	0.04162
3	0.08199	0.234	0.06046
4	0.08298	0.216	0.0918
5	0.08265	0.058	0.06684
6	0.08199	0.246	0.04255
7	0.0821	0.0153	0.02514
8	0.05555	0.056	0.03758
9	0.07406	0.375	0.05976
10	0.1385	0.314	0.05973
11	0.13811	0.156	0.06140
12	0.1390	0.053	0.04042
13	0.05555	0.154	0.08405
14	0.1296	0.4795	0.0886
15	0.08293	0.334	0.04691
16	0.0827	0.125	0
17	0.0307	0.104	0
18	0.1025	0.1481	0
19	0.0384	0.069	0.0404
20	0.0818	0.064	0.0487
Min	0.0307	0.053	0
Max	0.1390	0.4795	0.0918
Mean	0.0836	0.1904	0.0465
SD	0.0322	0.1316	0.0268
WHO	0.07	0.05	0.4
Yemeni standard	0.02	0.05	0.2

Nickel (Ni): The mean Nickel values from Groundwater samples ranged between 0.0307 to 0.1390 mg/l. The minimum Ni value of 0.0307 mg/l has been recorded from sample No 17, while maximum Ni value of 0.1390 mg/l has been recorded from sample No 12.The mean Ni concentration and Standard Deviation is 0.0307 mg/l and 0.1390 mg/l respectively. The Ni content of groundwater samples (65%) was above permissible limit 0.07while 35% of the groundwater samples Ni content was found to be within permissible limit as compared to standards given by WHO. Nickel exists in a number of enzymes in plants and microorganism. In the human body, Nickel affects iron absorption, metabolism and may be a necessary component of the hematopoietic process. Intense exposure of nickel in the human body results invarious chemical symptoms and signs such as nausea, vomiting, headache. Nickel is a possible carcinogen for lung and may bring about skin allergies, lung fibrosis and cancer of respiratory tract in occupationally exposed populations. Such exposures by inhalation, ingestion or skin contact occur in nickel and nickel alloy production plants as well as in welding, electroplating, grinding and cutting operations. The major source of nickel in drinking water is leaching from metals in contact with drinking water such as pipes and fittings. However, it may also exist in some groundwater as a result of dissolution from rocks containing ore nickel. Most of nickel production is utilized to make stainless steel, nickel alloys, and nickel cast iron that includes objects such as coins, electrical equipment, tools, machinery, armaments, jewellery, and household utensils. Nickel compounds are utilized also for electroplating, electroforming, nickel-cadmium alkaline batteries, dye mordant, catalysts, and electronic equipment (Tiwari *et al*., 2013), (Vaishaly A. G. *et al*, 2015), and (Aleksandra *et al*., 2008).

Chromium (Cr): The mean chromium values in groundwater samples ranged between 0.053 to 0.4795mg/l. The minimum Cr value of 0.053 mg/l has been recorded from sample No 12, while maximum Cr value 0.4795 mg/l has been recorded from sample No 14.The mean Crcon centration and Standard Deviation is 0.1904 mg/l and 0.1316 mg/l respectively. Most of the water samples (nearly80%) contain much more higher Cr than the maximum desirable limit as compared to World Health organization standard which is 0.05 mg/l while 20% of the water samples are within the permissible limits per World Health organization standards. Chromium is vital for animals as well as human and it enters into water from various natural and anthropogenic sources with the largest release coming from the industries besides other sources such as metal processing, tannery facilities, chromate production, and stainless steel welding.

Excess amounts of Chromium are toxic particularly the hexavalent form which is a toxic industrial pollutant classified as human carcinogen. The health risks related to the exposure to chromium depend on its oxidation state, ranging from the low toxicity of the metal form to the high toxicity of the Cr (VI) hexavalent form. Chromium is used in metal alloys and pigments for paints, cement, paper, and rubber. Chromium compounds are used in industrial welding, Chrome plating, dyes leather tanning and wood preservation. Also, they are made use of as anticorrosive in cooking systems and boilers and other materials. Electroplating can release chromic acid spray and air-borne Cr-trioxide which is able to cause direct damage to skin and lungs. Moreover, chromium dust is deemed as a likely cause of lung cancer. Sub chronic and chronic exposure to chromic acid can lead to dermatitis and ulceration of the skin. Long-term exposure can bring about kidney and liver damage. Chromium often accumulates in marine life and this creates another problem by eating fish that may have been exposed to high levels of chromium. (Mahipal Singh Sankhla, *et al* 2016 and Tchounwou *et al*. 2014).

Manganese (Mn)

The mean Manganese values in Groundwater samples ranged between 0 to 0.0918 mg/l. The minimum Mn value of 0 mg/l has been recorded from samples No 16, 17, and 18, while maximum Mn value 0.0918 mg/l has been recorded from sample No 4. The mean Mnconcentration and Standard Deviation is 0.0465 mg/l and 0.0268 mg/l respectively. Most of the samples are within the permissible limit according to the World Health Organization standard except 15% of the samples (3 samples out of 2o, which are No. 16, 17, and 18, which show zero content of Mn. Manganese (Mn) is one of the most abundant elements in earth crusts. It is generally distributed in soils, sediment, rocks and water. It is important to the proper functioning of both humans and other animals as it is vital for many cellular enzymes. Furthermore, it is an essential nutrient at low doses, but chronic exposure to high doses can be harmful. There are considerable data proving the neurological effect of inhaled Mn in both humans and animals. However, there is some data that show a link between oral exposure to manganese and toxic effect. Usually happens in several surface and groundwater sources and in soils that may erode into these waters. Nevertheless, human activities are also responsible for much of the water contamination by manganese in some areas. The major sources for groundwater releases are industrial effluent discharge, landfill and soil leaching, and underground injection. Manganese in the form of potassium permanganate can be made use of in drinking water treatment to oxidize and remove iron, manganese and other contaminates. In Addition, Manganese is utilized mainly in the production of iron and steel alloys, manganese compounds, and as an ingredient in various products such as batteries, glass, and fireworks (U.S.EPA 2004), and (Shrivastava and Mishra 2011).

It is an important nutrient involved in the metabolism of amino acids, proteins, and lipids, but in excessive cases it can be a potent neurotoxicity. Transport and partitioning of manganese in water depends on the solubility of the manganese form. Occupational and environmental exposure to airborne manganese has been associated with neurobehavioral deficits in adults and children (Maryse F. Bouchard *et al* 2011).The presence of manganese (Mn) in distributed drinking water may lead to operational problems and consumer complaints related to aesthetic quality such as discoloured water, staining of fixtures. The biochemical reduction of Mn-containing minerals in aquifers and reservoir sediment under anoxic conditions can lead to elevated levels of dissolved manganese Mn(II) in source waters (Arianne A. Bazilio *et al* 2016).

Conclusion

This study aimstoevaluate the dangers that threaten human life due to some heavy metals in the drinking water wells in the Governorate of Lahj in Yemen. The concentration of Ni, Cr, Mn, in 20 representative groundwater samples from study area has been examined. Some ground water samples show 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). Most of the groundwater samples has higher Ni concentrations except samples No 1, 2,8,9,1,13,17 and 19arewhich within permissible limit according to WHO standards. The Cr content of most groundwater samples demonstrates a higher permissible limit except six samples. There is slightly elevated content but these values are close to the permissible limit. According to WHO standard they are not dangerous on the public health.

The results shows that the values of Mn of all groundwater samples are within the permissible limit for drinking water given by WHO standard except three samples, No 16, 17, and 18 which show zero contents. There are higher content of Chromium and Nickel in the ground water samples of the study area which can be attributed to the human, industrial and agricultural activities.. The groundwater from there wells must undergo some measurements to limit the possible chemical risk. Some of the wells are found to be appropriate for industrial uses. Thus, it may be concluded that there is definite effect of industrial waste on the quality of groundwater which are in the vicinity of industries.

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