Analysis Of Heavy Metals In Surface And Groundwater At Lashkergah City, Helmand – Afghanistan.

Niaz Mohammad Zahidi, Ahmad Ansari, Gulam Yahya Sargand, Jailani Achak

Abstract : This study is meant to assess the groundwater and surface water of Lashkergah City; in this study, drinking water pollution in terms of Heavy metal pollution index (HPI) and Correlation analysis performed. The water samples collected from five wells and one sample from surface water during the autumn season (October 2014). The concentration of metals like (Cr, Mn, Fe, Ni, Cu, Zn, Cd, Hg, Pb, and As) was tested and determined by Inductivity Coupled Plasma Mass Spectrometry (ICPMS). For analyzing the standard data methods, the HPI model, and resultant data utilized. Drinking water samples (n = 6), the highest value of heavy metal pollution index HPI = 96.82 has been recorded from the Lashkergah city area. Correlation analysis data showed that the sources of heavy metals in surface and groundwater analyzed between metals such as; Chromium positively correlated with Hg (r = 0.725801) and negative with other heavy metals. Mn has strongly positive correlation with Fe (r = 0.988553) and Arsenic (r = 0.909246), but some correlation with Nickle (r = 0.737467), Zinc (r = 0.664663) and Pb (r = 0.415797). And negative values with Cu, Cd, and Hg. A negative correlation means there is some difference between source amounts of metals. Still, a positive correlation shows that it obtained from the same amount of solid wastes and air pollutants in the study area. Wells and surface water metal-containing concentration is different, because surface water is directly contacted with wastes, air pollutants and used minerals than wells water, so it has less amount of heavy metals. Heavy metals like Cd, Hg, Pb, and As have bad impacts, and some of them are hazardous to all living things, especially to Human beings.

Key words: Heavy metals concentrations, pollution of heavy metal index (HPI) model, Correlation analysis, Lashkergah City.

1. INTRODUCTION

As the lack of superficial and groundwater in several areas around the, world and the fast population growth, Potable water demand has increased sharply. (Marcovecchio et al. 2007). Surface water is essential for agriculture and used as drinking water in rural areas for humans and livestock, and groundwater is a vital source of drinking water supply. The value of groundwater depends not only on its availability but also on its consistent sound quality. Groundwater is a significant source of fresh water for drinking in both urban and rural sections in emerging countries. The consistency of the groundwater deteriorates due to numerous anthropogenic actions. Recent, advances and increasing industrialization, urbanization and developments of mining release numerous pollutants to surface and the groundwater forms. Amongst these, metals are a main pollutant of water supplies; contamination of groundwater is one of the utmost significant environmental problems in the current world, even though the low concentration of metal contamination is due to high toxicity. (J. Varghese D. S. Jaya 2014). Heavy metals join the rivers from several natural or anthropogenic sources (Adaikpoh et al. 2005; Akoto et al. 2008). Typically, in ordinary settings, the metal concentration is minimal and is primarily consequent from minerals and weathering of the geological constructions and soils of those region (Karrbassi et al. 2008). Civic solid trashes may also subsidize significant amounts of metals, to the environment by discarded household materials, inks, paints and plastics, medicines, body care products, and pesticides at home (Bardos 2004).
In a severe ecological issue, surface and groundwater pollution is produced by heavy metals, because some of them, such as As, Hg, and Pb, etc., are environmentally and human toxic, even at little absorptions, are non - degradable and can accrue over the food chain. While certain metals such as Cu, Zn and Fe are crucial micronutrients, at higher levels, they could be harmful to the physiology to the living organisms (Kar et al. 2008; Nair et al. 2010). Surface water is from Helmand River, which runs alongside the city of Lashkergah and is one of the big rivers of Afghanistan. Groundwater is from Lashkergah city four dug wells Water quality checking, and testing is vital for life and environment, this study aims to reveal the correlation analysis of the surface and ground water value with heavy, metal adulteration by the method of heavy metal pollution index (HPI) model.

2. MATERIALS AND METHOD

2.1 Study area

Lashkergah city lies between latitudes 31_35–37_75N and longitudes 64_22–17_80E and 786 m above sea level. Freshwater from Helmand River beside Lashkergah city is one of the big rivers of the country, and it is located beside the Lashkargah city. Lashkergah city is the center of Helmand province, one sample is collected of surface water (Helmand River water) and other five samples from different places of Lashkergah city as; Old Karta-e-lagan 1 (T.W), Helmand University (T.W), Shaheed Ghultan (T.W), Old Karta-e-lagan 2 (S.W) and Helmand River (Sur. W) areas. Its map is showed by a figure no (1).

***Figure – 1**: Map of the study area.*

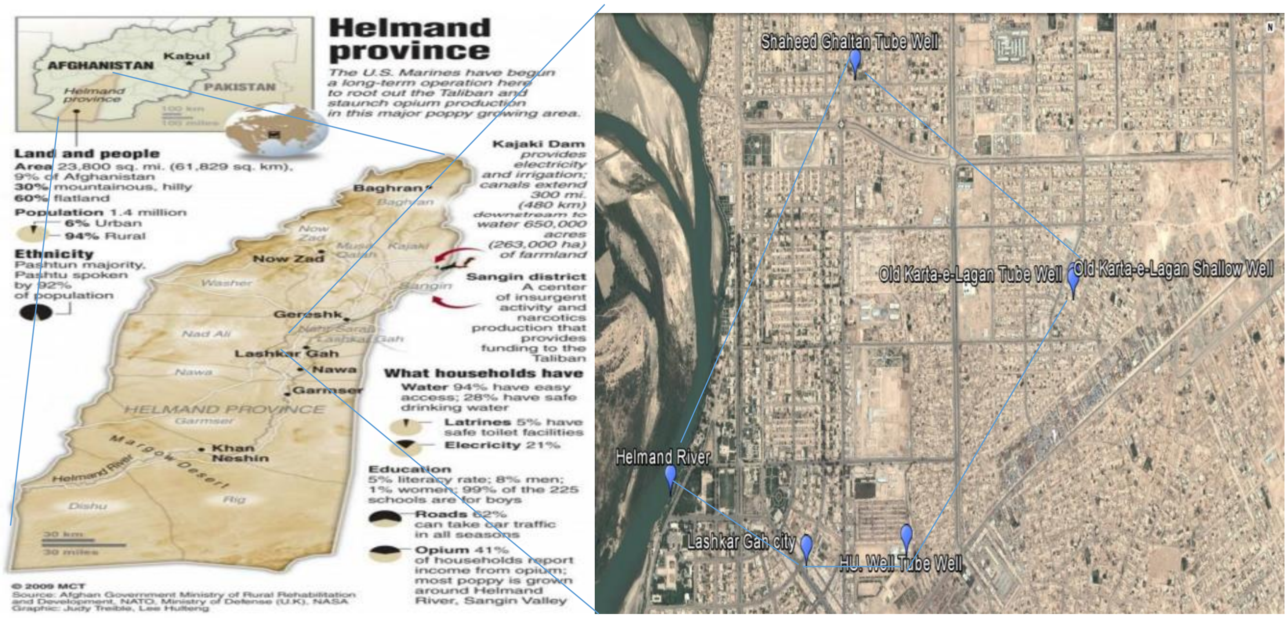

Figure 1 Helmand Province and Lashkragah City Map (Location of study area)
Source: McClatchy-Tribune News, 2009.

2.2 Sampling

One surface water sample from Helmand River beside Lashkergah city and four groundwater samples of Lashkergah city from different places like Lashkargah city, Old Karta-e-lagan 1 (T.W), Helmand University (T.W), Shaheed Ghultan (T.W), Old Karta-e-lagan 2 (S.W) and Helmand River (Sur. W) areas were collected. The locations for the sampling were chosen based on residential areas, various patterns of land use and shown in (Fig. 1). Water samples from those wells collected during October-2014. Water samples of underground and surface water were collected in 100mm bottles (polypropylene) and acidified with Sulfuric acid (H_2SO_4) to minimize precipitation and adsorption on container walls and to preserves the water for longer time. The Plasma Mass Spectrometry Coupled Inductivity (ICPMS) was used to measure the heavy metal (Cr, Mn, Fe, Ni, Cu, Zn, Cd, Hg, Pb, and As) concentration in ground and surface water sample.

2.3 Water Quality Analysis

2.3.1 Heavy metals description

Lead (Pb) is a chemical element and one of the heavy metals present in drinking water, it belongs to the carbon group's atoms, the element lead is widely used in industries; car batteries, pigments, ammunition, radiation protection and in some solders. The decay of lead pipes and the lead (Pb) released from the smelting of machine exhaust fumes (Gowd and Govil 2008). Lead is also present in natural source water; its presence is primarily from the household water system and manufactures of Lead wastes, which are contaminated by Lead atom (WHO 1993).

Cadmium (Cd) is one of the Zinc group's atom; the lead (Pb) is a metal element and naturally present in water and earth's crust. The element is used for stabilizing plastics and also for the steel corrosion-resistant. Cadmium metal and its compounds mostly used in batteries. The environment is obtaining Cadmium from contaminated wastewater, fertilizers, and air pollution. Cadmium contamination drinking water is hazardous and not suitable for health. The Cadmium found in drinking water supplies is usually less than one µg/L. Excess level of Cadmium in potable water can be harmful and toxic, and can effect on human's beings, animals and plants. According to WHO (1993) guideline the maximum permissible amount of Cadmium metal in potable water in 3µg/L. Copper (Cu) is a flexible and soft metallic element which is used in massive quantity and it also used as an electrical conductor such as bronze and brass. Numerous kinds of industries such as plastic, steel and blast furnaces caused by the addition of Copper in water. In potable water, the level of Copper is generally low and has only a few micrograms per liter, but the concentration of copper plumbing considerably increased. Having concentration in a period would reach several milligrams per liter. Copper is one of the vital element, and adsorption from food usually is about 1–3 µg/day. In adults, the retention and absorption rates of Copper depend on the daily consumes. So the overload of Copper is unlikely. According to (WHO 2011) the people using copper above 3 mg/L in drinking water may observe critical gastric irritation problems. In a drinking water the maximum allowable limit of Cu at WHO (2003) guideline value is (2000 µg/l). Zinc (Zn) is also a vital heavy metal element found in all food and potable water in the form of organic complexes and salts. Typically, food is the primary source of Zinc, and besides it, the levels of Zinc in surface and groundwater typically do not exceed 0.01 and 0.05 mg/L. Dissolution of Zinc from pipes would give much higher concentrations. However, Consumers won't accept Zinc containing drinking water at levels above 3 mg/L. The maximum concentration limit of Zinc (Zn) in drinking water is 3,000 µg/L in the guideline WHO (2011).

2.3.2 Indexing approach

The heavy metal pollution index (HPI) is a method of evaluation, which shows the components impact of individual heavy metal and the overall water quality (Sheykhi and Moore 2012). The index for each metal weight (Wi) between 0 and 1 is assigned, and Wi inversely proportional to the recommended standard (Si) for each parameter, Si evaluation is based on the relative importance of individual quality of the metal. Drinking water examined by the determination of water quality index and its correctness (Prasad and Kumari 2008; Mohan et al. 1996; Prasad and Mondal 2008).
The HPI calculation is by the following equation:

$$\text{HPI} = \frac{\sum_{i=1}^{n} Wi\,Qi}{\sum_{i=1}^{n} Wi} \quad \ldots\ldots\ldots\ldots 1$$

In the equation no.1 (Wi) is the unit weight of ith parameters, (Qi) is the sub-index of the ith parameter and (n) is the number of parameters considered. The calculation of the HPI weighted arithmetic index method used. (Wi) unit weight found out using the following formula:
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$$Wi = K/Si \quad \ldots\ldots\ldots\ldots..2$$

In equation no 2, K is proportionally constant, and Si is the standard permissible value of the ith parameter in equation no 2. The sub-index of (Qi) parameter is calculated by the following equation number 3:

$$Qi = \sum_{i=1}^{n} \frac{Mi-Ii}{Si-Ii} \text{x100} \quad \ldots\ldots\ldots\ldots 3$$

In the above equation, Mi is the monitored value of the heavy metal of the ith parameter, Where the (Ii) is the ideal value of the ith parameter, which taken from the WHO drinking water guidelines. Si is the standard value of the ith parameter calculated in ppb (µg/L). Generally, the critical heavy metal pollution index HPI value taken to be 100. In this research, after manipulating and calculation of data, HPI = 96.82 value obtained. So higher HPI value of water would cause more significant damage to human life health.

3. RESULT AND DISCUSSION

Concentration samples (n = 6) one from surface water and five samples from groundwater collected in the autumn session in (2014). Statistics analysis, correlation analysis, and heavy metal pollution index HPI tables and data shown and discussed below

Table 1 *Statistical analysis data of heavy metals concentrations in the groundwater and surface water is (µg/L).*

	N	Minimum	Maximum	Mean	Std. Deviation	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
Cr	6	2.244	27.799	14.58867	9.185058	-.551	1.741
Mn	6	1.714	17.108	5.36317	5.962251	4.531	1.741
Fe	6	187.730	638.572	305.02033	167.373011	5.045	1.741
Ni	6	2.644	3.754	3.24067	.409688	-.821	1.741
Cu	6	2.260	32.354	7.72117	12.080410	5.955	1.741
Zn	6	6.686	50.959	26.74600	17.431121	-1.540	1.741
Cd	6	.001	1.331	.30200	.514615	5.147	1.741
Hg	6	.001	.723	.22767	.276171	1.695	1.741
Pb	6	2.849	9.577	5.39533	2.533017	.024	1.741
As	6	1.116	2.509	1.65100	.506172	.627	1.741
Valid N (list wise)	6						

Ten (10) heavy metals pollution of drinking water analyzed and their basic statistics shown in Table 1. The (n=6) samples, one of them is surface water, and others fives are groundwater samples. Surface water heavy metal concentration obtained from Helmand River water and its concentration is higher than the concentration of groundwater of the city. So heavy metals concentrations are significantly different because of different site locations of samples. Heavy metals dissolved concentrations are considerable and collected in the time of autumn. It means the main source of pollution surface water is waste of landfill. The surface water sample, highest total heavy metal concentrations obtained in autumn session and its order is Fe > Zn > Mn > Pb > Ni > Cu > As > Cr > Cd > Hg. so other five groundwater samples order is a little different in some metals, Fe > Zn > Cr > Pb > Ni > Mn > Cu > As > Hg > Cd. The difference between those two kinds (surface and groundwater samples) is very much between Mn and Cr, and a little difference between Cu, Hg, and Cd. In surface and groundwater, the high content of Fe, Zn, and Ni maybe due to waste of landfill. And also, Lead (Pb) and Arsenic (As) would be a source of lead-acid batteries and environmental wastes. Some amount of Lead (Pb) could make very high contamination in soil, and after making the solution of Pb in soil it would diffuses to surface and groundwater (Hardman et al. 1994). Standard deviation data showed that the highest value of Fe = 167.37301, and the second-highest value of Zn = 17.431121, also Cu deviation value is 12.080410 and Cr deviation value is 9.185058. Others are closer to mean or average values. More spread out from mean or average value is not close to it. In total (n=6) water samples and Ten (10) heavy metals, Fe has the highest deviation value of different concentrations. It means Fe has differences in water samples concentration. Fe, Zn, Mn, and Ni are good for health, but Pb, As, and Cd are toxic and hazardous for health.

Table 2 *Correlation matrix of heavy metals of surface and groundwater.*

	Cr	Mn	Fe	Ni	Cu	Zn	Cd	Hg	Pb	As
Cr	1									
Mn	-0.77826	1								
Fe	-0.75445	0.988553	1							
Ni	-0.49184	0.737467	0.730113	1						
Cu	-0.1311	-0.14867	-0.07845	0.091452	1					
Zn	-0.47059	0.664663	0.696462	0.577733	0.485706	1				
Cd	-0.14225	-0.02364	0.060617	0.204315	0.979338	0.607832	1			
Hg	0.725801	-0.50549	-0.56465	-0.55583	-0.43118	-0.3375	-0.46448	1		
Pb	-0.45091	0.415797	0.474573	0.549466	0.820249	0.864958	0.891239	-0.59119	1	
As	-0.75848	0.922191	0.909246	0.830031	-0.208	0.431604	-0.10388	-0.6509	0.305009	1

Correlation analyzing matrix created for heavy metals of surface and groundwater presented in Table 2. Chromium has a positive correlation with Hg (r = 0.725801) and negative with other heavy metals. Mn has strongly positive correlation with Fe (r = 0.988553) and Arsenic (r = 0.909246), but some correlation with Nickle (r = 0.737467), Zinc (r = 0.664663) and Pb (r = 0.415797). And negative values with Cu, Cd, and Hg. Fe correlation with As (r = 0.909246), Ni (r = 0.730113) and Zn (r = 0.696426), Pb (r = 0.474573) and negative value with Cu, Hg. Ni correlation with As (r = 0.830031), Zn (r = 0.577733) and Pb (r = 5.49466) and negative value with Hg. Cu is correlated with Cd (r = 0.979338), Pb (r = 0.820249) and Zn (r = 0.485706). And negative value with Hg and As. Zn is correlated with Pb (r = 0.864958), Cd (r = 0.607832) and As (r = 0.431604) and negative value with Hg. Cd correlated with Pb (r = 0.891239) and negative value with Hg and As. Hg negatively correlated with Pb and As. Also, Pb is not correlated with As. A negative correlation means there is some difference between 1 and negative value, and they not obtained from the same amount of waste solid or air pollutants. A positive correlation shows that it obtained from the same amount of solid waste and air pollutants.

3. CONCLUSION

In conclusion, the experimental data of heavy metals concentrations and calculation of heavy metal pollution index (HPI) of Lashkargah city from six (n=6) samples, one from surface water and other five samples from groundwater is analyzed, the HPI value for ground and surface water found 96.82 which is near to critical index limit of 100. This overall pollution level of surface and ground water from the side of heavy metal contamination is not useful. Also, the correlation data shows that Hg, As have good correlation, which obtained from the same amount of solid waste, so Hg, As, and Pb are harmful to human beings.

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