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ASSESSMENT OF HEAVY METALS CONCENTRATION IN TOGONA RIVER OF GOBA TOWN, OROMIA REGION, ETHIOPIA

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ABSTRACT

This study is undertaken to assess the heavy metals status of Togona River in Goba town of Bale zone, Oromia region, Ethiopia. For this, a total of 24 river water samples were collected from three locations across the river from upstream, midstream and low stream. All the samples were analyzed for seven heavy metals such as Pb, Zn, Cd, Cu, Cr, Fe, and Mn, using standard procedures and Flame atomic absorption spectrophotometer (FAAS). The heavy metals concentrations in the surface water samples of Togona river decreased in the sequence: Fe > Zn > Cu > Mn > Pb > Cd > Cr. From the results, Iron recorded the highest mean value of 0.30 mg/L while cadmium concentration with mean value of 0.0018 mg/L was the lowest. The results were compared with international standards. All samples contain heavy metals within the maximum permissible limit of WHO and US-EPA.

Key words: Togona River, Heavy metals, FAAS.

INTRODUCTION

Water is essential for life on earth. Because of its importance, the pattern of human settlement through history has often been determined[1]. Next to oxygen, water is the most important substance for human existence. It is an essential nutrient, which also sustains agriculture, allows aquatic life, supports industry, produces hydroelectric power, permits aquatic transport, insures personal hygiene, maintains clean environment, besides its uses in sport as well as recreation.

The preservation and maintenance of the water resources is a very difficult task due to rapid growth of population and increased industrial activities. The quality of water

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resources is deteriorating day by day due to the continuous addition of undesirable chemicals. Moreover, the demand for safe water is increasing continuously due to the increase in population, living standards and industrialization. Among various organic and inorganic water pollutants, metal ions are toxic, dangerous and harmful because of their tissue degradation in nature. Toxic metals are also bio-accumulative and relatively stable, as well as carcinogenic; therefore, require close monitoring[2]. They are easily assimilated and can be bio-accumulated in the protoplasm of aquatic organisms[3]. Increase in concentration of toxic metals beyond toxic limits, results in loss of water quality, making it unfit for drinking, irrigation, aquaculture and recreational purposes[4]. The acute toxicity of metal ions has attracted scientists towards their detection in natural water resources. Among various natural water resources, rivers are highly polluted by toxic metals due to the direct discharge of municipal and industrial effluents into it. Since river water is supplied for domestic purposes in different parts of the world; therefore, the analysis of toxic pollutants in river water has received great attention. Heavy metals are among the most common environmental pollutants, and their occurrence in water is from chemical weathering of minerals, rocks and soil leaching. The anthropogenic sources are associated with industrial and domestic effluents, urban storm, water runoff, and landfill leachate, mining of coal and ore, atmospheric sources and agricultural activities[5-7]. Many of these wastes are toxic and they find their ways into land, water and air. The release of large quantities of heavy metals into the natural environment has resulted into a number of environmental problems. They also cause various diseases and disorders when exceed specific limits. Heavy metals are essential for plant growth in traces or very minute quantities. They are toxic and poisonous in relatively higher concentrations.

The practice of using polluted river water for irrigation and domestic consumption is a common problem in Africa. People living in Goba town on and around the Togona river bank have been utilizing its water for irrigation and domestic purposes. Polluted water has become the main cause of different diseases among poor people in many developing nations. This shows how much serious is the problem of using untreated or polluted water for domestic and irrigation purposes. The present study attempts to assess the level of heavy metals in the Togona river, and to monitor and compare it against standards set by WHO and US-EPA.

EXPERIMENTAL

Materials and methods

Description of the study area

Goba town is located in Bale zone of the Oromia region approximately 446 km south east of Addis Ababa, capital city of Ethiopia. The town has latitude and longitude of 7^{o}N and

39°59 E and an elevation of 2,743 meters above sea level. The town has two kebeles with a population of approximately 32,025. It is gifted with two major rivers, one of which separates the town into two major parts known as Togona River.

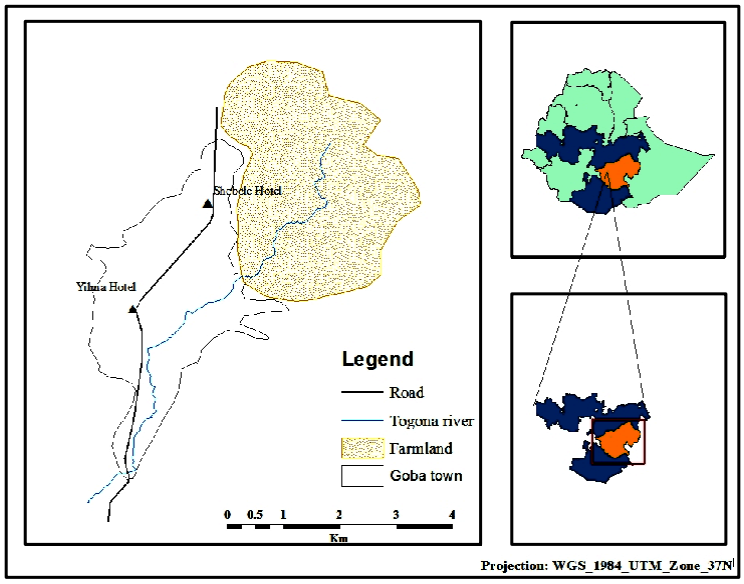

Fig. 1: Location of Goba town in Oromia regional state

Sample collection and preparation

Water samples were collected from three sites across the river at a depth of 10-15 cm in plastic bottles that had been previously soaked in 10% nitric acid overnight and thoroughly rinsed with deionized water. From each sampling sites, samples were taken for four consecutive months (February-May), every fifteen days. The water samples were acidified to pH 2 with nitric acid immediately on arrival to the laboratory and kept at 4°C until analysis. The lower pH is required to suppress adsorption of the metals to suspended solids and the lower temperature serves the aim of inhibiting chemical processes that may alter the form and abundance of the metals[8]. For the analysis of heavy metals, 50 mL of water samples were digested with 10 mL of concentrated HNO_3 at 80°C until the solution became transparent[9]. The concentrations of heavy metals in the water samples were determined using Flame Atomic Absorption Spectrophotometer (Perkin Elmer model 400, USA), fitted with a specific lamp of particular metal using appropriate drift blank. Quality control measures were taken to assess contamination and reliability of data. Blank and drifts standards (Sisco Research Laboratory Pvt. Ltd., India) were run after five readings to calibrate the instrument.

RESULTS AND DISCUSSION

The concentrations of heavy metals Cd, Cr, Cu, Fe, Mn, Pb, and Zn in Togona river water are presented in Tables 1 and 2. Highest heavy metal concentration was found for Iron (0.563 mg/L) and zinc was the second highest heavy metal in terms of concentration in the river. In this study cadmium (Cd) was of the lowest concentration in water sample of the river. The heavy metals concentrations in the river water samples of Togona river decreased in the sequence:

$$Fe > Zn > Cu > Mn > Pb > Cd > Cr$$

Iron

In the present study, Iron concentration was generally very high in the entire sample that had been analyzed. Iron was detected in every site with the following values 0.188 ± 0.02 at upper stream, 0.372 ± 0.012 mid streams and 0.301 ± 0.03 low streams and an average mean concentration of 0.2870 ± 0.0213 which is below the World Health Organization (WHO) and Environmental Protection Agency (US-EPA) recommended value.

Table 1: Range and Means of Heavy Metal concentrations (mg/L) in water across sampling location determined by FAAS

Location	N		Elements and their respective concentration						
			Pb	**Zn**	**Cu**	**Cd**	**Cr**	**Mn**	**Fe**
Up Stream	8	Range	0.014-0.012	0.0576-0.024	0.02–0.10	0.0020-0.0013	0.010-0.004	0.108-0.094	0.364-0.073
		Mean	0.013 ± 0.01	0.053 ± 0.013	0.04 ± 0.012	0.0016 ± 0.05	0.0072 ± 0.02	0.0981 ± 0.01	0.188 ± 0.02
Mid Stream	8	Range	0.021-0.01	0.263-0.0976	0.03–0.12	0.0025-0.001	0.0140-0.007	0.123-0.0854	0.563-0.143
		Mean	0.016 ± 0.02	0.178 ± 0.03	0.06 ± 0.013	0.0023 ± 0.04	0.011 ± 0.025	0.108 ± 0.012	0.372 ± 0.012
Low Stream	8	Range	0.019-0.012	0.087-0.065	0.02-0.07	0.0021-0.001	0.0103-0.004	0.0985-0.0675	0.401-0.121.
		Mean	0.014 ± 0.07	0.072 ± 0.015	0.03 ± 0.010	0.0017± 0.01	0.0060 ± 0.02	0.0921 ±0.03	0.301 ± 0.03

*N = Number of samples

Although, iron is one of the essential elements in human nutrition, however when present at elevated concentration in aquatic ecosystems, serious pollution and health problems could result. According to WHO and US-EPA guideline value and maximum contamination levels, concentration value of 0.30 mg/L iron in water is acceptable[10].

Zinc

The dissolved concentration of zinc in the water samples from river Togona was 0.053 ± 0.013 mg/L at upstream 0.178 ± 0.03 mg/L at mid stream and 0.072 ± 0.015 mg/L at low stream and average of mean of 0.072 ± 0.015 mg/L, which was below the permissible limit recommended by WHO and US-EPA guideline. This high concentration in the water samples could be traced to urban runoff that has been polluted by domestic wastes and dust particulate matter.

Chromium

Analysis of surface water of the river for dissolved chromium gave the values ranging between 0.010 mg/L and 0.004 mg/L at upstream, 0.0140 mg/L and 0.007 mg/L at mid stream and 0.0103 mg/L and 0.004 mg/L at low stream and mean of 0.0081. Both the WHO and the US-EPA guidelines require the maximum concentration of chromium in drinking water to be 0.05 mg/L. The maximum value obtained from this study is below the recommended level. Therefore, chromium could not be a cause of health problem if the water is used for irrigation and household purposes.

Cadmium

The level of dissolved Cadmium in the river water ranged between 0.0025 mg/L and 0.001 mg/L and means average of 0.0019 mg/L. Comparison the current result for the river with WHO and EPA guide line (0.003 mg/L) shows lower values for the river. The level of the metal is within the safe range for household consumption, irrigational use and for protection of aquatic species. The US-EPA for example recommends the maximum level of Cadmium to present in water for household consumption and irrigational use to be 0.3 mg/L and 20 mg/L, respectively.

Manganese

Manganese Concentration in the river water ranged between 0.123 mg/L and 0.0675 mg/L with average value of 0.0970 ± 0.02 mg/L. The value is below the permissible limit recommended by international water quality standards like WHO (0.1 mg/L) and US-EPA

(0.5 mg/L) guide lines. The average Manganese content in the river is nearly equal to the US-EPA guide line value of 0.1 mg/L for water. So, Manganese could be source of health problem in the near future.

Copper

Meanwhile Copper was discovered in every site with the following values 0.04 ± 0.012 from upper stream, 0.06 ± 0.013 midstream and 0.03 ± 0.010 low streams and an average mean concentration of 0.0433 ± 0.013 which is below the WHO (2008) and US-EPA recommended value of, 1 mg/L and 0.05-1.5 mg/L, respectively. In this study, the concentrations of copper was ranging between 0.010 mg/L to 0.06 mg/L are registered.

Lead

In the present study, lead concentration was found in the entire sample that had been analyzed. Lead was detected in every site with the following values 0.013 ± 0.01at upper stream, 0.016 ± 0.02 mid streams and 0.014 ± 0.07 low stream and an average mean concentration of 0.0143 ± 0.013 which is below the permissible level (0.05 and 0.02 mg/L) recommended by WHO (2008) and US-EPA. Lead is higher toxic metal and its concentration in natural water increases mainly through anthropogenic activities. Lead may enter into sewage system through dust, soil erosion, leaching urban waste discharges and runoff from steels and other surfaces. This toxic metal may cause anemia, kidney disease and nervous disorder above the tolerance limits.

A comparison of the concentration values of some of the heavy metals with standard guideline values for drinking water is shown in Table 2.

Table 2: Maximum Permissible Concentrations (mg/L) of Heavy metals in drinking water against average trace metal concentration in Togona river water

Element	WHO	EPA	Togona river
Pb	0.05	0.02	0.0143 ± 0.02
Zn	5	5.0-15.00	0.1515 ± 0.01
Cu	1	0.05-1.50	0.0433 ± 0.04
Cd	0.003	0.003	0.0019 ± 0.03
Cr	0.05	0.05	0.0081 ± 0.01
Mn	0.1	0.5	0.0970 ± 0.02
Fe	0.30	-	0.287 ± 0.04

The result obtained in this study showed that Cadmium, Zinc, Manganese, Copper, Chromium, Iron and lead had maximum values that were less than recommended values by the EPA and WHO. The concentration levels of these metals would markedly impair the potability of the water if it had been greater than the permissible limits. It serves as the main source of household consumption, and irrigation for the various communities settling along its banks and catchment area. As this study indicates that the current status of Togona River in terms of heavy metals concentration is under the permissible limits. Even though its current status is tolerable as recommended by different organization; these heavy metals have the property to accumulate in the sediments, and increase their concentration with time. There is a need, therefore, to constantly monitor the concentration levels of heavy metals in the river as well as mounting comprehensive conservation efforts by relevant organizations.

However the present concentrations of these metals in the river should not be underestimated because there are numerous pollutant sources in urban areas that can affect runoff, such as dust and dirt, vegetation; precipitation; traffic emission; animal faces; agricultural activities; and fertilizers, pesticides, and detergent which can rise these concentrations beyond the permissible limits.

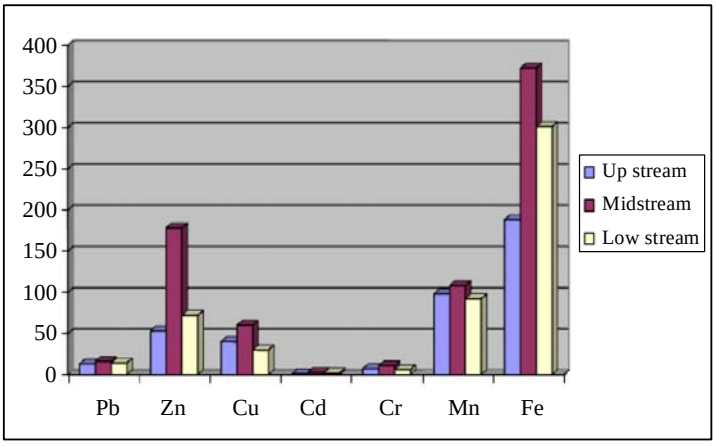

Fig. 2: Chart showing concentrations of metals at different locations in µg/l; from upstream, midstream and low stream

CONCLUSION

The concentrations of dissolved heavy metals (Pb, Cu, Mn, Fe, Cr, Cd and Zn) in Togona River are within the standards set by US-EPA and WHO. Therefore, we can conclude that, keeping the presence of pesticides under question, Togona river water can be used for household consumptions and irrigation purposes as far as the concentrations of

these heavy metals are concerned. Domestic wastes like detergents and particulates materials are responsible for polluting urban runoff and consequently increase the concentrations of heavy metals in the river at the mid-stream.

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