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Heavy Metals Concentration in Effluents of Textile Industry, Tikur Wuha River and Milk of Cows Watering on this Water Source, Hawassa, Southern Ethiopia

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ABSTRACT

Textile industries contribute immensely to surface water deterioration and are categorized among the most polluting in all industrial sectors. For this reason, the heavy metals profiles of Hawassa Textile effluent along with Tikur Wuha River and their accumulation in milk samples collected from cows watered in this water source was assessed in Chafe and Dato Villages, Southern Ethiopia. In the present study, water samples were collected from the textile factory treatment ponds and Tikur Wuha River at different sampling site. Similarly, fresh milk samples were collected from 15 cows watered in textile treatment pond water and Tikur Wuha River, Chafe and 15 cows from Dato, relatively far from textile industry. Metal levels in both water and milk samples were determined using Atomic Absorption Spectrophotometer after wet digestion. The result shows the mean concentrations in water samples collected from site S1, S2, S3 and S4 to be 0.72, 0.652, 0.121 and 0.12 mg L^{-1}, respectively for lead metal, 0.135, 0.05, 0.124 and 0.132 mg L^{-1} for nickel, 0.023, 0.01, 0.014 and 0.02 mg L^{-1} for cadmium. The results further indicated that the mean concentrations of Pb, Ni, Cd and Cr in milk samples collected from Chafe were 0.8, 1.6, 0.2 and 0.2 mg L^{-1}, respectively while in samples from Dato village to be 0.4, 1.4, 0.1 and 0.8 mg L^{-1} in the same order. It was therefore, implicated that textile effluent entering Tikur Wuha River could cause toxic effects on consumers through food chain like via milk consumption and decreases livestock productivity consuming this water source and grazed around this area. It could also cause toxic effects on aquatic species of the river. It was emphasized that using the water for irrigation and water source for livestock in its present state is unsafe.

Key words: Heavy metals, milk, water, permissible limits

INTRODUCTION

The quality of surface water within a region is governed by both natural processes (precipitation, weathering and soil erosion, lithology of basin, atmospheric inputs and climatic conditions) and anthropogenic effects (urbanization, industrialization, agricultural activities and human exploitation of water resource). The input of waste into surface water bodies has a negative impact not only on the aquatic life but also affects the self purification property of the water body. The effluents from industries have a great deal of influence on pollution of water body by altering the physical, chemical and biological nature of receiving water body (Sangodoyin, 1991). This further results in vast degradation of the surface waters and make worse their use for agricultural, drinking, industrial, recreation and other purposes (Simeonov *et al.*, 2003).

Textile dyeing and printing industry has high importance in terms of its environmental impact, since it consumes water and produces highly polluted wastewater in large amounts. Pollutants from textile dyeing and printing industries vary greatly and depend on the chemicals used in various dyeing and printing processes. The receiving water thus becomes brackish. Textile dyes are toxic, highly stable and do not degrade easily and are not removed by conventional wastewater treatment methods. Due to the non degradable nature and long time persistence in the environment the toxic waste often accumulates through tropic level causing a deleterious biological effect (Kannan *et al*., 2005).

A significant portion of inorganic contaminants remain within body fat whereas other insignificant portion is excreted from the body (Reilly, 1991). Certain food items are a regular component of human diet and are essential for growth and development. Milk is considered as a nearly complete food and it is the main constituent of the daily diet since it is a good source of protein, fat and major minerals (Enb *et al*., 2009). Cadmium (Cd) and lead (Pb) are amongst the elements that have caused most concern in terms of adverse effects on human health (Karpel and Peden, 1972). This is because they are readily transferred through food chains and are not known to serve any essential biological function. Children have been shown to be more sensitive to Cd and Pb than adults and the effects are cumulative (Qin *et al*., 2009). Animals that graze on contaminated plants and drink from polluted waters accumulate such metals in their tissues and milk if lactating (Enb *et al*., 2009).

A large amount of these metals taken in by plants and animals subsequently find their way into the food chain. It is therefore necessary to monitor and control their levels in consumed food. The measurement of metal levels is helpful not only in ascertaining risk to human health but also in the assessment of environmental quality (Farid *et al*., 2004).

The majorities of industries in Ethiopia are old and use outdated technology Environmental Protection Authority (EPA., 2003). Despite the fact that their number is few, their impact in terms of pollution is enormous. Moreover, a great majority of these industries discharge their waste in the form of liquid, dust particles and smoke, without any treatment. Likewise, in Ethiopia all of the textile factories have no effluent treatment plants. For example, Hawassa textile industry is one of the industries in Hawassa town that released its waste to Tikur Wuha River. Although, no studies to ascertain the impact on human health resulting from this pollution have been made, it is assumed that there has been human exposure to various diseases.

Inhalation of air borne pollutants, ingestion of contaminated dust, drinking contaminated water and eating food grown over contaminated soils may cause severe health risks among humans and animals.

Tikur Wuha River crosses scattered semi-urban and rural villages. It has been used for domestic animals, washing clothes and for bathing purpose. When domestic animals drink the water, they get sick, lose weight and abort (Desta, 1997). Local farmer were complaining about their cattle death may be due to poisoning from the Hawassa textile factory wastewater. Chronic poisoning resulting from intake of smaller quantities through various routes leads to their accumulation in tissues, bones and milk and is manifested by loss of appetite and body weight, anaemia, reproductive disorders and immunosuppression (Mehennaoui *et al*., 1988). For rural communities losing livestock assets might lead to the collapse into chronic poverty with long-term effects on their livelihoods. An assessment revealing the heavy metals profiles in tissues of animals environmentally exposed to heavy metals is scanty in Ethiopia. Thus, knowledge on toxic metal concentration in livestock in a polluted environment is essentially required for assessing the effects of pollutants on domestic animals as well as human beings.

The main objectives of the study are:

- To assess concentration of heavy metals (Pb, Ni, Cd and Cr) in Hawassa Textile Factory treatment ponds water and Tikur Wuha River
- To determine metal levels in milk from cows watered in biological lagoons of Hawassa Textile factory and Tikur Wuha River
- To study variation of heavy metals concentration in water samples collected from different sampling sites of Tikur Wuha River
- To compare the accumulation of heavy metals in milk samples collected from cows inhabited in a nearby and relatively far from textile industry

MATERIALS AND METHODS

Study area description: The study area is located 275 km south of Addis Ababa and has an elevation ranging from 1692-1742 m.a.s.l. It is characterized as sub-humid climate and has with bimodal rainfall distribution. The main rainy season taking place from July to September while March to October the period for small amount (Fig. 1). The maximum amount of mean annual rainfall goes up to 1150 mm. the study area has mean annual temperature of 19.5°C with March and April (Fig. 2) having the highest and November and December having the lowest Temperature (Tilahun, 2006).

Hawassa Textile Factory was selected as the focus for this study where attempts were made to determine impact of the effluents from the textile industry on Tikur Wuha River and heavy metals accumulation in cows' milk. It is the largest factory around Tikur Wuha River and has a capacity of 24,288 spindles, 124 shuttle rapier looms and a finishing plant with a capacity to dye, print and

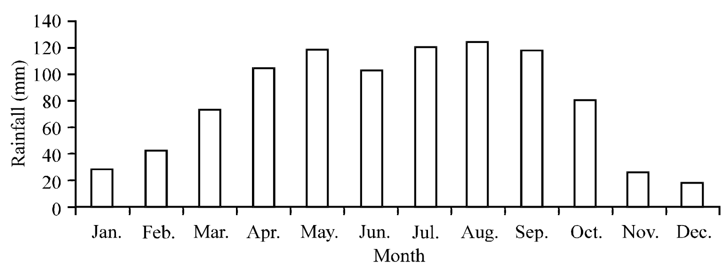

Fig. 1: Mean Monthly precipitation of Hawassa

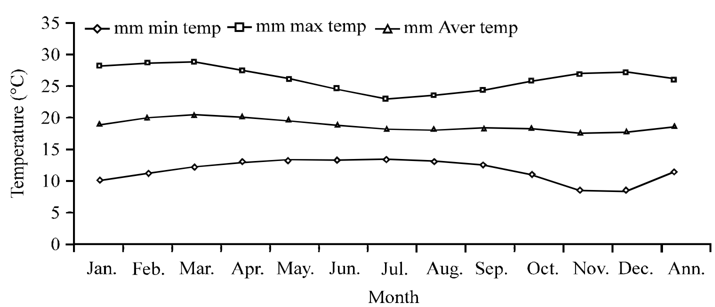

Fig. 2: Mean monthly minimum, maximum and average temperature at Hawassa

finish 36.1 million square meters of fabric per annum. The factory is highly energy, chemical and water intensive. It discharges an average of 50 m^3 of wastewater per hour, rising to 120 m^3 at full capacity (Desta, 1997).

The sampling site, S1 (Fig. 3) was the biological lagoon that receives the effluents of the textile for treatment before discharged to the downstream Tikur Wuha River and it was not fenced and hence accessible for livestock as source of drinking water. The sites from S2 to S4 were used to study downstream pollution profile and the impact of the effluent on the studied heavy metals concentration of cow's milk watered on this river. Site 2 (S2) is the reference site with an altitude of 1710 m.a.s.l. It was selected as reference site to be used as benchmark to compare changes in other sites. Because it was the Point on Tikur Wuha River before joining the waste water released from biological lagoon after treatment. The other two sites (S3 and S4), the main watering points of sampled cows, were selected to assess downstream pollution profile and the impact of the effluent on the studied heavy metals contents of cow's milk in the study area (Fig. 4).

Fig. 3(a-d): Biological lagoons of Hawassa textile factory and livestock grazing and watering around the ponds (Site 1)

Fig. 4: Point where the raw waste from the biological lagoon of the textile factory joins the river (Site 3)

Table 1: Summary of the sampling points in the study area

Sampling sites	Altitude (m)	Description
S1	1730	Place where the raw waste accumulated in the biological lagoon for treatment before it joins Tikur Wuha river
S2	1710	Point on Tikur Wuha River before joining the waste water released from biological lagoon after treatment
S3	1702	Point where the waste water released from biological lagoon joins the river
S4	1692	Downstream, about 4 km meters from S3

Water sample collection: To study the heavy metals profile of textile treatment ponds water and Tikur Wuha river water quality, grab water samples were collected from representative sampling sites where the water was used for watering of livestock. Water samples were collected from December to April, 2013 once a month from the sampling site. The samples were collected directly from the biological lagoon of Hawassa Textile Factory and from different sampling locations along Tikur Wuha River and the sampling points are summarized in the following Table 1.

From each sampling site, triplicate water samples were collected in one liter acid washed polythene bottles. Prior to sampling each bottle was washed with diluted acid and double distilled water and before actual sampling these bottles were rinsed with waste water to be sampled. The samples were filtered through a 0.45 μm (pore size) Millipore membrane filter. Soon after collection, samples were acidified with 10% HNO_3 by adding a few drops of the acid. The samples were labeled carefully and then placed in 4°C. The bottle of water sample were kept in the box during the transportation prior to the laboratory. Samples were transported to Ethiopian Health and Nutrition Research Institute (Pasteur) laboratory for heavy metal analysis (Pb, Ni, Co and Cd).

Water sample digestion and analysis: The method involved the acid digestion of the water sample in a closed vessel device using temperature control microwave heating for the metal determination by spectroscopic methods. After the water sample filtered with 0.45 μm Millipore, 10 mL of water sample was filled into vessels and nitric acid was added to digest the samples.

Each sample was carried out in duplicate. Preparations of the water samples were made in Milestone Microwave Acid Digestion apparatus using 7 mL 65% (v/v) nitric acid and 1 mL 30% (v/v) hydrogen-peroxide according to the instrument manual. Shattering was done by the instructions of MIILESTONE “Microwave Acid Digestion Cookbook” and diluted to volume of 50 mL all along three blank samples were also prepared for comparison.

Distilled water was used throughout the study. All the plastics and glass wares was washed in nitric acid and rinsed with distilled water before use. The standard solutions of each metal were prepared by appropriate dilution of stock solution from commercial chemicals. Heavy metal contents (Pb, Ni, Cr and Cd) of the prepared samples were analyzed by using atomic absorption spectrophotometer.

Milk sample collection: Raw milk samples were taken randomly from two groups of lactating cows. Grouping of cows was based on distance from the textile industry. One sampled groups of cows were those cows watered directly on the biological lagoon of Hawassa Textile Factory and Tikur Wuha River, immediate receiver of effluents from the biological lagoon around Chafe (Village of inhabitants near to the Textile Factory). The other groups of sampled cows were those cows watered on Tikur Wuha River some distance away from the Textile Factory around Dato (Village of inhabitants away from the Textile Factory).

Accordingly, raw milk samples from 15 lactating cows watered directly on the biological lagoon of Hawassa Textile Factory and Tikur Wuha River, immediate receiver of effluents from the biological lagoon around Chafe and 15 Lactating cows watered on a relatively far from the industry around Dato were collected from December to April, 2013. The milking was done in the morning and stored in propylene tubes. They were preserved in coolers packed with ice blocks and transported immediately to Ethiopian Health and Nutrition Research Institute (Pasteur) laboratory for heavy metal analysis (Pb, Ni, Co and Cd).

Milk sample digestion and elemental analysis: Milk sample digestion was carried out using the acid digestion of the sample in a closed vessel device using temperature control microwave heating for the metal determination by spectroscopic methods. Preparations of the samples were made in Milestone Microwave Acid Digestion apparatus using 6 mL 65% (v/v) nitric acid and 2 mL 30% (v/v) hydrogen-peroxide according to the instrument manual. Shattering was done by the instructions of MIILESTONE “Microwave Acid Digestion Cookbook”. Analytical blanks were prepared with each batch of digestion set. All samples were prepared in triplicate run. The digested samples were quantitatively transferred into 50 mL flask, made up to the mark with distilled water and stored in 50 mL propylene bottles. Metal concentration in the digest was determined by Atomic Absorption Spectrophotometer (Specter AA. 20 Plus) supplied by Varian Pty Ltd Australia at Ethiopian Health and Nutrition Research Institute. Hallo cathode lamps of the respected metals were used as a radiation source. Air acetylene gas mixture was used as source of flame. Maximum absorbance was obtained by adjusting the Cathode lamps at specific slit and wave lengths as indicated in Table 2. The standards were prepared from 1000 ppm stock solution.

Table 2: Instrumental conditions for determination of the studied heavy metals

Parameters	Wavelength (nm)	Slit width (nm)	Optimum working range ($\mu g\ mL^{-1}$)
Pb	217.0	1.0	0.1-30
Ni	232.0	0.2	0.1-20
Cd	288.8	0.5	0.02-3
Cr	357.9	0.7	0.05

Statistical analyses: Statistical analysis was carried out with the SPSS version16 program package. Significant tests were performed for heavy metal contents of cow's milk sampled from cows watered the nearby and far from the Textile factory with student t-test. Significance tests were also performed between the heavy metal contents of Tikur Wuha River before and after it joined the effluents released from the biological lagoons of Hawassa Textile Factory. The LSD test were used to determine the significance of differences between group means in an analysis of variance setting, with alpha set at 0.05. The findings were also presented in bar graphs using excel.

RESULTS AND DISCUSSION

Heavy metals in water samples: Average concentration of heavy metals (Pb, Ni, Cd and Cr) in water collected from biological lagoons of the Hawassa textile factory (S1) and Tikur Wuha River at different locations (S2, S3 and S4) are given in Table 3. Both the biological lagoons and Tikur Wuha River were source of drinking water for livestock in the study area. Significant difference was observed among sampling sites as indicated as follows.

Lead (Pb): The average concentration of lead was significantly higher in the water collected from biological lagoon of textile factory (S1) than the water collected from Tikur Wuha River (Site S2, S3 and S4). Lead concentration in water collected from site S3 and S4 was significantly higher than S2 though S2 and S3 did not differ significantly (Table 3). The value in the raw textile effluent was above the maximum permissible limit set by the Environmental Protection Authority (EPA., 2003) even though the values of water samples collected from Tikur Wuha River were below the acceptable ranges of the provisional discharge limits set by the Environmental Protection Authority (EPA., 2003).

Although, the lead concentration in site S3 and S4 was below the acceptable ranges of the provisional discharge limits set by the EPA (2003), it was 3 times higher than the reference value 0.0652 mg L^{-1} at S2 and were above the maximum permissible limits which is 0.05 mg L^{-1} as recommended by the Ministry of Iraqi Health (1988). Lead concentration at S3 and S4 was reduced as compared to the value in textile effluent treatment ponds water. This was probably associated with the dilution effect. Lead concentration in the upstream reference samples was lower than the downstream (Fig. 5) suggesting that lead pollutions were due to point discharges from textile effluent in the area. The mean values in the present study were higher than the previous studies conducted by Gebre-Mariam and Desta (2002). Similar studies on assessment of pollution profiles on Sebeta River by Mammo (2004) reported (0.1±0-2.2±0 mg L^{-1}). It can be concluded that the concentration of lead in the river water could contribute to pollution.

Nickel (Ni): Nickel concentrations in water from site S1, S3 and S4 were significantly ($p<0.05$) higher than water collected from site S2, the upstream reference samples (Fig. 5) and indicated that nickel pollutions were due to point discharges from textile effluent in the area. The levels of nickel in the water did not differ significantly ($p>0.05$) between site S1, S3 and S4 (Table 3). Although, the values obtained were below maximum permissible limit established by the Ethiopian Environmental Protection Authority (EPA., 2003), most of the pollutant concentrations were still very high to meet the provisional discharge limits set by EPA (2003). Nickel concentrations in water collected from S3 and S4 were above the maximum permissible limits which is 0.1 mg L^{-1} as

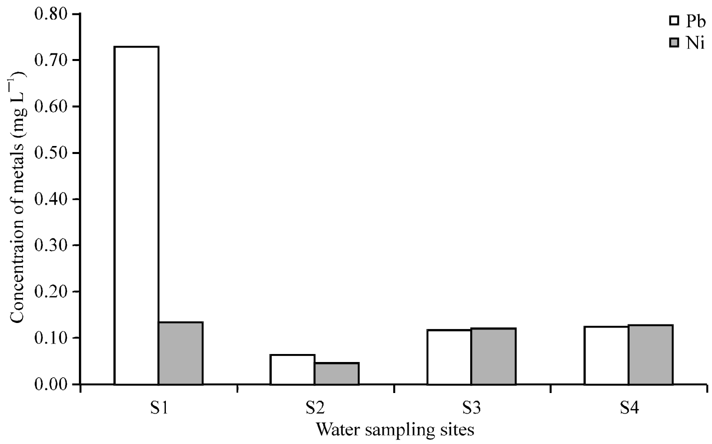

Fig. 5: Distribution of concentration of Lead and Nickel in the Textile Factory treatment ponds water and Tikur-Wuha River

Table 3: Average concentration of heavy metals in Hawassa Textile Factory treatment ponds water and Tikur-Wuha River (Mean± SEM)

Heavy metals	S1	S2	S3	S4
Pb	0.726±0.135[a]	0.0652±0.003[c]	0.1210±0.0032[b]	0.1288±0.0017[b]
Ni	0.135±0.00245[a]	0.050±0.0001[b]	0.1240±0.0025[a]	0.1320±0.002[a]
Cd	0.023±0.0001[a]	0.010±0.0001[b]	0.0140±0.0001[b]	0.0200±0.0001[a]
Cr	0.216±0.005[a]	0.012±0.007[c]	0.1580±0.0037[b]	0.2200±0.007[a]

Values in the same row not followed by the same letter are significantly different

recommended by the Ministry of Iraqi Health (1988). Similar studies on assessment of pollution profiles on Sebeta River by Mammo (2004) reported concentration value of (0.1±0 mg L^{-1}).

Cadmium (Cd): The mean concentration of Cadmium was in water 0.023, 0.01, 0.014 and 0.020 mg L^{-1} at site S1, S2, S3 and S4 (Table 3), respectively. Even though the concentrations were below the acceptable ranges of the provisional discharge limits set by the Environmental Protection Authority (EPA., 2003), the values at S1, S3 and S4 were higher than the reference value 0.01 mg L^{-1} (Fig. 6). Furthermore, the cadmium level in the water collected from S1, S3 and S4 were above the maximum permissible limits which is 0.005 mg L^{-1} as recommended by the Ministry of Iraqi Health (1988). This indicates cadmium is a potential risk for livestock production and consumers as well as aquatic species in the study area. Similar studies on assessment of pollution profiles on Sebeta River (Mammo, 2004) reported concentration value of (0.1±0 mg L^{-1}) which was higher than the values obtained in the present study.

Chromium (Cr): Table 3 compares the variation of chromium concentrations in water collected from biological lagoons of textile effluents and Tikur Wuha River. The results indicated chromium concentrations at site S1, S3 and S4 significantly higher than the natural chromium concentrations in Tikur Wuha River (S2). The results refer to the chromium concentration was within the acceptable limits in the river and biological lagoon of textile water which is 1 mg L^{-1} set by EPA (2003). But as compared to other references, the values 0.216, 0.158 and 0.22 mg L^{-1} for S1, S3 and S4, respectively were above the maximum permissible limits which is 0.05 mg L^{-1} as recommended by the Ministry of Iraqi Health (1988) while chromium concentration in the natural chromium concentrations in Tikur Wuha River (S2) was below this limit. The natural chromium

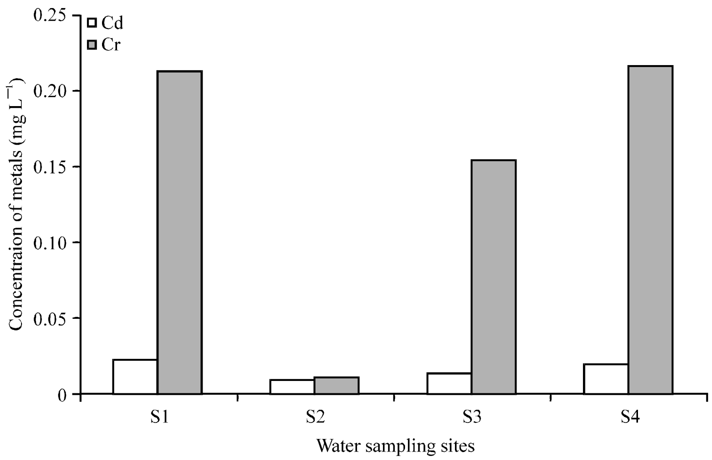

Fig. 6: Distribution of cadmium and chromium concentrations in the Textile Factory treatment ponds water and Tikur-Wuha River

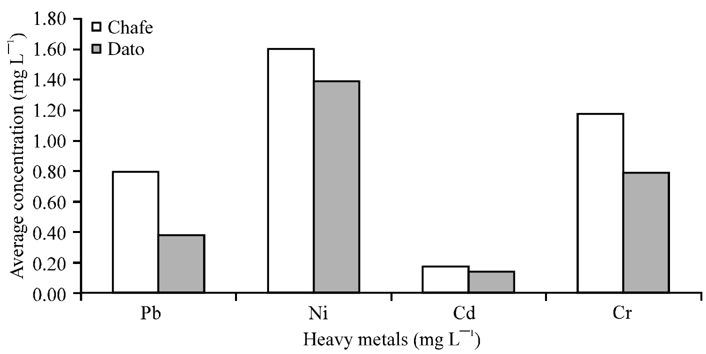

Fig. 7: Distribution of concentration of Pb, Ni, Cd and Cr in fresh cow's milk from Chafe and Dato

Table 4: Average heavy metal concentration (mg L^{-1}) in milk samples collected from Chafe (Industrialized area) and Dato (relatively non-industrialized area)

Heavy metals	Chafe	Dato
Pb	0.8±0.1[a]	0.4±0.1[b]
Ni	1.6±0.3[a]	1.4±0.2[b]
Cd	0.2±0.001[a]	0.1±0.001[a]
Cr	1.2±0.3[a]	0.8±0.2[b]

Values in the same row not followed by the same letter are significantly different

concentrations in Tikur Wuha River (S2) below the standard limits indicated that chromium pollutions in the downstream river were due to point discharges from textile effluent in the area. Similar studies on assessment of pollution profiles on Sebeta River (Mammo, 2004) reported, concentration value of (0.23±0.15 to 0.65±0.21 mg L^{-1}).

Heavy metals in milk samples: The average concentrations of Pb, Ni, Cd and Cr in the cow whole milk from Chafe and Dato villages are shown in Table 4. As indicated in the table, the average concentration of lead, nickel, cadmium and chromium in fresh cow milk collected from Chafe was higher than that in milk collected from Dato (Fig. 7). Significant difference was observed between the two villages except the element cadmium ($p<0.05$).

Lead (Pb): From the present study, the effluents from Hawassa textile factory and Tikur Wuha River, receiver of the effluent, contain lead above the permissible limit (0.5 mg L^{-1}) established by Ethiopia (EPA., 2003). This was a source of drinking water for the sampled cows in Chafe and Dato villages which effects elevated level of lead in milk. Hence, a potential risk for consumers and livestock production around Chafe and Dato villages. Industrial waste water discharge played a vital role in elevated level of heavy metals in water bodies around the factory which ultimately results the bioaccumulation of toxic metals (Sekhar *et al*., 2003). The mean concentrations of lead in this study were higher than those reported in previous studies of Tiecco (2000) and Ogabiela *et al*. (2011) while higher levels were recorded in Ethiopia, as reported by Admasu *et al*. (2005) and Dawd *et al*. (2012). The maximum lead concentration in milk is 0.02 mg L^{-1} (1881/2006/EC). With regard to these limits, the average concentration of lead in milk collected from both Chafe and Dato were higher than the limit which reflects the lead pollution of Tikur Wuha River watered by dairy cows in the study area.

Nickel (Ni): In the present work, the average concentration of nickel was found to be 1.6 and 1.4 mg L^{-1} in cows whole milk collected from Chafe and Dato villages respectively. It was observed that the average concentration of nickel found by us was 12 times higher than that reported by Farid and Baloch (2012). Ogabiela *et al*. (2011) reported higher values in the milk collected from polluted areas than the detected values of Ni in this study. As discussed above the nickel content of the biological lagoon of Hawassa textile factory and the effluent receiver of the downstream, Tikur Wuha River was above the maximum permissible limits set by Ethiopia (EPA., 2003). This polluted water was the source of drinking water for livestock kept by farmers around Chafe and Dato villages and effects elevated level of nickel in milk of cows. Therefore, similar to lead, nickel was also potential threat for consumers and livestock production in the study area.

Cadmium (Cd): In the present study, the average concentration of cadmium in fresh milk collected from Chafe was 0.2 mg L^{-1} (Table 4) while the average concentration of cadmium in fresh milk collected from Dato was 0.1 mg L^{-1}. The average concentration of cadmium in fresh milk from Chafe was higher than that from Dato village. This could be as a result of elevated level of cadmium in biological lagoon and Tikur Wuha River which was a source of drinking water for livestock around Chafe. Significant difference was not observed between the two study sites regarding cadmium content of cow's whole milk ($p<0.05$).

The average concentration of cadmium in milk collected from Chafe was 10 times higher than the maximum permissible limit put by International Dairy Federation (IDF., 1979) at 0.026 mg L^{-1} while Cd accumulation in milk collected from Dato was 5 times higher than this limit. The presence of cadmium above the established limits suggests that there are toxicological risk in the consumption of cow milk from Chafe and Dato. A similar result of cadmium concentration in cow milk above the permissible limit was reported by Admasu *et al*. (2005).

Chromium (Cr): Chromium level of milk in this study was 1.2 mg L^{-1} in Chafe village which is significantly greater ($p<0.05$) than in Dato village where in the concentration, was 0.8 mg L^{-1}. The level of Cr in milk collected from both sampling areas was higher than the maximum permissible levels put by WHO (1973).

The elevated level of chromium in milk samples of these villages was most likely because the livestock farm were exposed to pollution from Hawassa textile factory discharges and hence, effecting the milk supplies. In the present work, drinking water for livestock was highly polluted with effluents from the textile factory, though the chromium concentration in drinking water of livestock was below the maximum limits set by Ethiopia (EPA., 2003). Moreover in these farms some of the feed was provided to the cattle on farms while most of the time the cattle were grazed outside in rural fields which are irrigated with waste water drainage channels. In this way toxic elements inadvertently entered into milk supplies. The concentration of Chromium in this study was higher than that reported by Licata *et al.* (2004) and Alais (2000), except the report by Ogabiela *et al.* (2011). Ogabiela *et al.* (2011) reported that the high concentration of Chromium in cow milk could be attributed to discharges released from tanneries.

CONCLUSION AND RECOMMENDATION

The present study indicated that the effluents from the biological lagoon of Hawassa textile industry that are directly discharged into the Tikur Wuha River elevated the studied heavy metals of water collected from Tikur Wuha River and implies significant pollution of the river. The heavy metals concentrations in the treated effluent were above the maximum permissible limits set by EPA (2003) and indicate inefficient treatment of the waste water. These compounds contaminate the surface water, thereby making it unfit for irrigation and drinking for livestock. The heavy metals in milk samples collected from cows watering on this water source were also elevated and indicated potential risk for consumers and livestock production. Therefore, proper treatment of effluent water and enforcement of pollution control by the regulatory authority on the indiscriminate discharge of textile wastewater into water bodies should be carried out.

Since, farmers were using water from Tikur Wuha River for agricultural purposes, like as source of water for their livestock and irrigation, it is quite unsafe for these purposes. The ecological and human health safety of continual discharge of this treated textile effluents into this river are undoubtedly under threat.

Therefore, proper treatment of waste waters is recommended before discharge into Tikur Wuha River and the local communities should be aware of the potential dangers of using such polluted water for their livestock as well as other Agricultural purposes and also, occasional physic-chemical analyses of the river water are necessary.

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REFERENCES

Admasu, E., B.S. Chandravanshi, T. Wondimu and G. Akalu, 2005. Levels of some nutrients and non-essential metals in cow's whole milk delivered to Addis Ababa, Ethiopia. Addis Ababa University, Chemical Information Centre, Addis Ababa.

Alais, C., 2000. Science of Milk. 3rd Edn., New Techniques, Milan, Italy.

Dawd, A.G., T.B. Gezmu and G.D. Haki, 2012. Essential and toxic metals in cow's whole milk from selected sub-cities in Addis Ababa, Ethiopia. Online Int. J. Food Sci., 1: 12-19.

Desta, Z., 1997. Industrial environmental management the case of Hawassa textile factory, Ethiopia. M.Sc. Thesis, Wageningen Agricultural University, The Netherland.

EPA., 2003. Provisional standards for industrial pollution control in Ethiopia. Ecologically Sustainable Industrial Development (ESID) Project-US/ETH/99/068/Ethiopia, EPA/UNIDO, Addis Ababa, Ethiopia.

Enb, A., M.A. Abou Donia, N.S. Abd-Rabou, A.A.K. Abou-Arab and M.H. El-Senaity, 2009. Chemical composition of raw milk and heavy metals behavior during processing of milk products. Global Vet., 3: 268-275.

Farid, S. and M.K. Baloch, 2012. Heavy metal ions in milk samples collected from animals feed with city effluent irrigated fodder. Greener J. Phys. Sci., 2: 36-43.

Farid, S.M., M.A. Enani and S.A. Wajid, 2004. Determination of trace elements in cow's milk in Saudi Arabia. JKAU: Eng. Sci., 15: 131-140.

Gebre-Mariam, Z. and Z. Desta, 2002. The chemical composition of the effluent from Awassa textile factory and its effects on aquatic biota. SINET: Ethiop. J. Sci., 25: 263-274.

IDF., 1979. International dairy federation bulletin, chemical residues in milk and milk products. International Dairy Federation (IDF), Document, 133.

Kannan, V., R. Ramesh and C. Sasikumar, 2005. Study on ground water characteristics and the effects of discharged effluents from textile units at Karur District. J. Environ. Biol., 26: 269-272.

Karpel, J.T. and V.H. Peden, 1972. Copper deficiency in long-term parenteral nutrition. J. Pediatr., 80: 32-36.

Licata, P., D. Trombetta, M. Cristani, F. Giofre, D. Martino, M. Calo and F. Naccari, 2004. Levels of toxic and essential metals in samples of bovine milk from various dairy farms in Calabria, Italy. Environ. Int., 30: 1-6.

Mammo, D., 2004. An assessment of downstream pollution profile of Sebeta River and its surroundings. M.Sc. Thesis, School of Graduate Studies, Addis Ababa University, Ethiopia.

Mehennaoui, S., E. Charles, B. Joseph-Enriquez, M. Clauw and G.E. Milhaud, 1988. Indicators of lead, zinc and cadmium exposure in cattle: II. Controlled feeding and recovery. Vet. Hum. Toxicol., 30: 550-555.

Ministry of Iraqi Health, 1988. Protection of rivers and public water from pollution no. 25 of 1967. Iraqi Official Gazette, No. 1446 on 16 July 1967, Vol. 2, pp: 108.

Ogabiela, E.E., U.U. Udiba, O.B. Adesina, C. Hammuel and F.A. Ade-Ajayi *et al*., 2011. Assessment of metal levels in fresh milk from cows grazed around Challawa industrial estate of Kano, Nigeria. J. Basic Applied Scient. Res., 1: 533-538.

Qin, L.Q., X.P. Wang, W. Li, X. Tong and W.J. Tong, 2009. The minerals and heavy metals in cow`s milk from China and Japan. J. Health Sci., 55: 300-305.

Reilly, C., 1991. Metal Contamination of Food. 2nd Edn., Elsevier Applied Science, London, UK., pp: 1-20.

Sangodoyin, A.Y., 1991. Groundwater and surface water pollution by open refuse dump in Ibadan, Nigeria. J. Discov. Innovations, 3: 24-31.

Sekhar, K.C., N.S. Chary, C.T. Kamala, J.V. Rao, V. Balaram and Y. Anjaneyulu, 2003. Risk assessment and pathway study of arsenic in industrially contaminated sites of hyderabad: A case study. Environ. Int., 29: 601-611.

Simeonov, V., J.A. Stratis, C. Samara, G. Zachariadis and D. Voutsa *et al.*, 2003. Assessment of the surface water quality in Northern Greece. Water Res., 37: 4119-4124.

Tiecco, G., 2000. [Inspection of food of animal origin]. Bologna, Ed. Edagricole.

Tilahun, N., 2006. Numerical Ground-Water Flow Modeling of the Awassa Catchment. Addis Ababa University, Awassa, Ethiopia.

WHO., 1973. Evaluation of certain food additives and contaminant: Hg, Pb, Cd. WHO Technical Report Series, No. 51, Sixteenth Reoort of Expert Committee, Geneva, Switzerland.