Metals Concentration in Textile and Tannery Effluents, Associated Soils and Ground Water

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Abstract: An investigation has been made to ascertain the metals concentration in the effluents and associated soil and groundwater samples collected from textile and tannery industries located near Haridwar. The physico-chemical analysis for metallic parameters was conducted by using Atomic absorption spectrometer (AAS) and spectrophotometer. The results showed that all metals such as Cr, Fe, Mn, Cu, Pb and Cd exceeded the standard limits in effluents of textile and tannery industries and associated soil samples, while Cr contamination in groundwater samples was observed only in samples collected from nearby areas of tannery. The findings also indicate that the Cr contamination was more than other metals. The estimated metal levels in the water and soil were compared with the safe limits laid down by World Health Organization (WHO). [New York Science Journal 2010;3(4):82-89]. (ISSN: 1554-0200).

Key words: Heavy metals, Atomic absorption spectrometry, textile and tannery effluents

1. Introduction

Heavy metals are important for proper functioning of biological systems but their deficiency or excess could lead to a number of disorders (Ward, 1995). Industrial effluents which discharged from the textile and tannery contains a higher amount of metals especially chromium, copper and cadmium. These effluents released on the land as well as dumped in to the surface water which ultimately leaches to ground water and lead to contamination due to accumulation of toxic metallic components and resulted in a series of well documented problems in living beings because they cannot be completely degraded (Malarkodi et. al. 2007). Hence, industrial effluents offer a wide scope of environmental problems and health hazards are becoming more complex and critical not only in developing countries like India but also in developed countries

In the present context of study, particular emphasis is placed on the status of metals in effluents of textile and tannery industries. All these metals in effluents cause serious health hazards due to unsafe disposal on soil and into water. To keep this view in mind that textile and tannery industries are the major source of pollution and contributors of metals to the environment, a systematic study was required to ascertain the status of metals in textile and tannery effluents and associated soil and groundwater.

2. Experimental

2.1 Description of the Study Area

Textile and tannery industries, situated in Haridwar district of Uttarakhand state were selected to evaluate the metal concentration in effluents and their effects on surrounding soils and ground water samples. The samples for analysis of textile and tannery effluents, associated ground water and soils were collected from the Rishabh Valvaleen, a textile industry situated at Delhi-Dehradun highway, near Bahadarabad, Haridwar and a local tannery, situated at Sansarpur village at Roorkee town.

2.2 Sample Collection and Analysis

The study was carried out by systematic collection of effluents, soils and ground water samples from textile and tannery industries around Haridwar. The samples were taken during the study period of 2005 to 2007.Eighteen samples for each component i.e effluent, soil and ground water were collected from the vecinity of both industries and all the collected samples were analyzed for chromium (VI), iron, manganese, copper, lead, cadmium and nickel. Standard methods were used for collection and analysis of effluents, ground water (Jain and Bhatia, 1987; APHA, 1998) and soils samples (Berrow and Mitchell, 1993; Buckley and Cranston, 1993). Effluent and ground water samples were collected and stored in a clean polythene bottles that had been pre-washed with 10% nitric acid and thoroughly rinsed with de-ionized water. Soil samples were collected in fresh polythene bags.

2.2.1 Metals in Effluent and Ground Water

Suitable volume of sample was taken, filtered through Whatman 42 filter paper and then acidified with concentrated HNO_3 to bring down the pH up to 2.0. 100 ml of sample was taken and added 5 ml concentrated HNO_3, and then digested in a closed chamber, within 30 minutes digestion was completed and make up the volume to 100 ml with distilled water. Digested samples were analyzed for metal concentrations by atomic absorption spectrophotometer (Perkin Elmer 3110). The Cr (VI) concentrations in samples were determined colorimetrically by using spectrophotometer at 540 nm by diphenyl carbazide (DPC) method (APHA, 1998).

2.2.2 Metals in Soil

0.25 gm soil was digested with 10 ml HF acid and 1 ml aquaregia i.e. HCl and HNO_3 in a ratio of 3:1 in a flask. Thereafter, 5.0 ml of $HClO_4$ was added and again heated on heating plate up to dryness and double distilled water was added to make up the volume to 100 ml and filtered through Whatman no. 42 filter paper. Digested soil sample were analyzed for metal concentrations by atomic absorption spectrophotometer (Berrow and Mitchell, 1993; Buckley and Cranston, 1993).

3. Results and Discussion

The results obtained for this study to examine the status of metals in textile and tannery industries effluents and their contamination in associated soil and ground water. Generally concentrations of heavy metals in environment occur due to continuous disposal of untreated industrial effluents generated during operational phase of industries. Among various industries, textile and tannery industries are major producer of metals like hexavalent chromium, iron, manganese, copper, lead, cadmium and nickel etc. Hence, all the collected samples were analyzed for chromium (VI), iron, manganese, copper, lead, cadmium and nickel. Of the total analyzed samples, six metals were detected in each sample, except nickel which was not detected in all the studied samples of effluents, sols and ground water.

3.1 Metals in Effluents

The data of metal concentration in textile and tannery effluents are furnished in Table 1-2 & Figure 1. Analytical results revealed that the average concentration of chromium in effluents of textile and tannery industries were recorded 2.38 and 7.21 mg/l, respectively (Table 1-2). Chromium metal was found 89.30% higher, against the lower value of 0.255 mg/l reported for textile industries effluent in Lagos metropolis, Nigeria (Ugoji and Aboaba, 2004). Whereas in tannery industry effluent, chromium (VI) was found 7.21 mg/l, which was 9.89% lower as compared to the value of 9.0 mg/l reported for tannery effluent (Dikshit and Shukla, 1989). Chromium can cause allergic reactions in the skin, damage the lungs, and asthma attacks (ATSDR, 2005).

Effluents of textile and tannery industries were found to contain the average concentration of 1.70 and 0.75 mg/l, respectively for iron, while in a similar study, 0.45 to 2.14 mg/l of iron was reported in textile industry effluent in Nigeria (Yusuff and Sonibare, 2004). However, a lower value of iron metal (0.351 mg/l) was reported in effluent released from tanneries in India and abroad (Tariq et. al. 2006; Kaushik, 2003). Higher iron content may produce undesirable effects such as astringent taste, discoloration, turbidity, deposits, and growth of iron bacteria in pipes affecting the acceptability of water for domestic use (Das and Borah, 1983).

Present study reflects that the average concentration of manganese was 0.570 mg/l in effluents of textile industry (Table 1). On the contrary, higher value of 1.65 mg/l of manganese was reported by some workers in effluent of textile industries in Nigeria, which was 65.46% higher, as compared to the value of present study (Yusuff and Sonibare, 2004). The concentration of manganese was reported 0.988 mg/l for tannery effluent (Table 2). Depending upon the exposure route, manganese may be among the least toxic of the trace elements if ingested (USEPA, 1988) but if inhaled, can enter the brain in two ways: by olfactory (nasal airway) that provide a direct path to brain tissue, and by lung uptake that could provide a source of continuing exposure (Weiss, 2006).

In case of textile industry effluent, average concentration of copper was found 0.011 mg/l. On the other hand, higher concentrations of 5.14 mg/l and 4.0 mg/l of copper were reported earlier (Aslam et. al. 2004; Yusuff and Sonibare, 2004), which showed a rise of 99.79% and 99.73%, respectively as compare to the aforesaid values of present study. Copper content was reported 0.022 mg/l in waste water samples of tannery industry (Figure 1). Copper is an essential element in mammalian nutrition as a component of metallo-enzymes in which it acts as an electron donor or acceptor. Conversely, exposure to high levels of copper can result in a number of adverse health effects (Bremner, 1998).

As revealed by analytical results (Table 1& Figure 1) cadmium content of textile industry effluent was 0.018 mg/l, which showed a fall of 10%, in comparison to the value of 0.02 mg/l for cadmium in dye house effluent (Dubey et. al. 2003). The average concentration was recorded 0.076 mg/l, in tannery effluent for cadmium (Figure 1). In an other study, average value of cadmium was found 73.91% lower as compared to the value of 0.076 mg/l was observed in Peshawar, Pakistan for tannery effluent [(11)]. Long-term exposure to lower levels of cadmium in air, food, or water leads to a build up of cadmium in the kidneys and possible kidney disease. Other potential long-term effects are lung damage and fragile bones (ATSDR, 2005).

The values of lead were below the detectable level in textile effluent, while lower values of 0.18 to 0.59 mg/l were observed in the effluent of textile industry, Panipat, Haryana (Dubey et. al. 2003). Average value of lead was reported 0.06 mg/l in tannery effluent (Figure 1). On the other hand, 0.646 mg/l and 0.289 mg/l of lead were noted in waste water samples of tannery industry (Tariq et. al. 2006; Kaushik, 2003). These values were 90.71% higher and 51.02% lower as compared to the values reported for the present study (Table 2). In excess amount, lead affects central nervous system, particularly in children and also damages kidneys and the immune system.

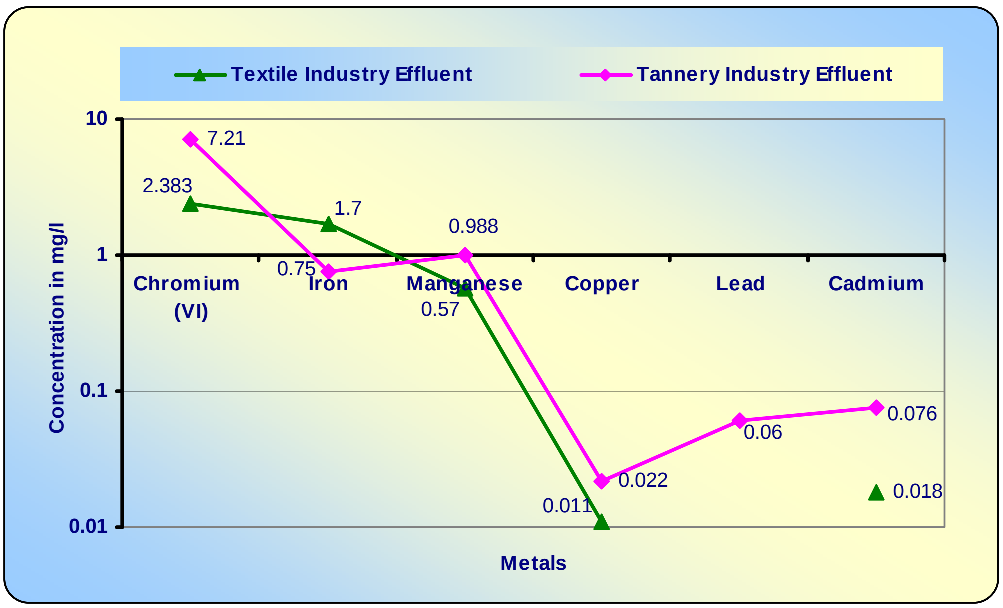

Figure 1 Average value of metals in effluents

3.2 Metals in Soils

The average metal concentration in soil samples of textile and tannery industry are recorded and pooled in Table 1-2 and Figure 2. The average values of chromium recorded in soil samples of textile industry and tannery were 568.0µg/gm and 743.80µg/gm, respectively. Chromium contents were 23.63% lower in textile effluent contaminated soil, as compared to tannery effluent contaminated soil (Figure 2). Chromium values were reported 55.4-180.5 mg/kg in the soils contaminated with textile effluent in Tamil Nadu (Malarkodi, 2007). Cr (IV) was reported in tannery waste contaminated soil of Vellore district of Tamil Nadu, ranged from 154.5 to 568.0µg/l, respectively (Mahimairaja, 2000). The effluent released on land particularly at high concentration (100%) increased chromium content in soil (Mariappan and Rajan, 2004). Both trivalent and hexavalent chromium ions are toxic to plant life (Alvarez-Bernal et. al. 2006).

The present study recites that the value of iron was 308.40µg/gm in soil contaminated with textile industry effluent, which showed a rise of 87.78%, as compared to the value of 37.70µg/gm for tannery industry soil (Table 1-2). On the other hand, higher values of iron ranged from 4837–6311 mg/kg were noted in tannery effluent affected soil in Mexico (Alvarez-Bernal et. al. 2006).

Table 1. Average metals concentration in industrial effluents of textile industry and its associated soils and ground water (2005-07) (All values are Mean ±SD and range for four observations each, expressed in mg/l, otherwise stated).

S.No.	Metals	Textile Industry		
		Effluents	Soils (µg/gm)	Ground Water
1.	Chromium	2.38 ± 0.005 (2.37 - 2.38)	568.00±4.163 (562 - 572)	ND
2.	Iron	1.70 ± 0.017 (1.65 – 1.74)	308.40±3.02 (298 - 332.12)	2.95 ± 0.15 (2.80 – 3.10)
3.	Manganese	0.57 ± 0.005 (0.56 – 0.57)	668.80±0.559 (668.43-669.09)	0.70 ± 0.02 (0.68 – 0.72)
4.	Copper	0.01 ± 0.004 (0.007 – 0.015)	109.54±0.315 (109.12-109.85)	0.05 ± 0.02 (0.04 – 0.07)
5.	Lead	ND	191.25±19.35 (175 – 208)	ND
6.	Cadmium	0.018 ± 4.472 (0.012 – 0.022)	83.62±0.119 (83.48-83.75)	0.04 ± 0.02 (0.02 – 0.06)
7.	Nickel	ND	ND	ND

Table 2. Average metals concentration in industrial effluents of tannery and its associated soils and ground water (2005-07) (All values are Mean ±SD and range for four observations each, expressed in mg/l, otherwise stated).

S.No.	Metals	Tannery Industry		
		Effluents	Soils (µg/gm)	Ground Water
1.	Chromium	7.21 ± 2.09 (5.32- 9.45)	743.80 ± 98.955 (630.85 – 815.25)	0.93±0.113 (0.68-0.1.15)
2.	Iron	0.75 ± 0.017 (0.67 – 0.83)	37.70±0.25 (37.45 – 37.95)	0.84 ± 0.09 (0.75 – 0.92)
3.	Manganese	0.98 ± 0.018 (0.97 – 1.008)	0.97 ± 0.011 (0.96 – 0.99)	0.02 ± 0.007 (0.02 – 0.03)
4.	Copper	0.02± 0.004 (0.018 – 0.026)	0.04 ± 0.015 (0.03 – 0.05)	ND
5.	Lead	0.06 ± 0.03 (0.02-0.10)	ND	ND
6.	Cadmium	0.076 ± 0.006 (0.070 – 0.082)	0.04 ± 0.008 (0.03 – 0.05)	0.007 ± 0.005 (0.002 – 0.012)
7.	Nickel	ND	ND	ND

The observed concentration of manganese was 668.80µg/gm in soil samples collected from the nearby areas of textile industry. The manganese value showed a rise of 99.85%, as compared to the value of 0.973 µg/gm reported for tannery industry soil (Table 2). In other study, manganese was reported 382.4 mg/kg for textile industry soil and 218.0–577.0 mg/kg for tannery industry soil in the vicinity of industries in Bangladesh (Kashem and Singh, 1999).

The analytical results revealed that the average value of copper was reported 109.54µg/gm in soil samples of textile industry. The highest amount of 148.96 mg/l for copper was reported from the soil of textile dying industrial area in Bangladesh (Kashem and Singh, 1999). The average value of copper was found 0.038µg/gm in tannery effluent affected soil (Figure 2). However, copper was ranged from 7.2-20.5 mg/kg in soil of Leon, Mexico (Alvarez-Bernal et. al. 2006).

During the study, average concentration of lead was noted 191.25µg/gm in soil samples contaminated with textile industry effluent (Table 1), while, lead was not detected in soil samples of tannery industry. Although lead was below detectable limits in effluents of both industries. But a possible reason of the presence of lead in soil is that other airborne lead released by automobiles and other industries in the area. This airborne lead can be deposited on soil and water, thus reaching humans via the food chain (Jarup, 2003).

In the present study, average value of cadmium was 83.62µg/gm in textile industry soil samples (Figure 2). In a similar study of textile industry soil in Bangladesh, cadmium concentration was reported 0.48 mg/kg (Kashem and Singh, 1999). Present study shows that the value of cadmium was 0.040µg/gm in tannery industry soil (Table 2), which was 99.96% less, as compared to the value noted for textile industry soil. Cadmium values were reported 0.2-5.8 mg/kg^{-1} in the soils contaminated with textile effluent in Tamil Nadu (Malarkodi et. al. 2007).

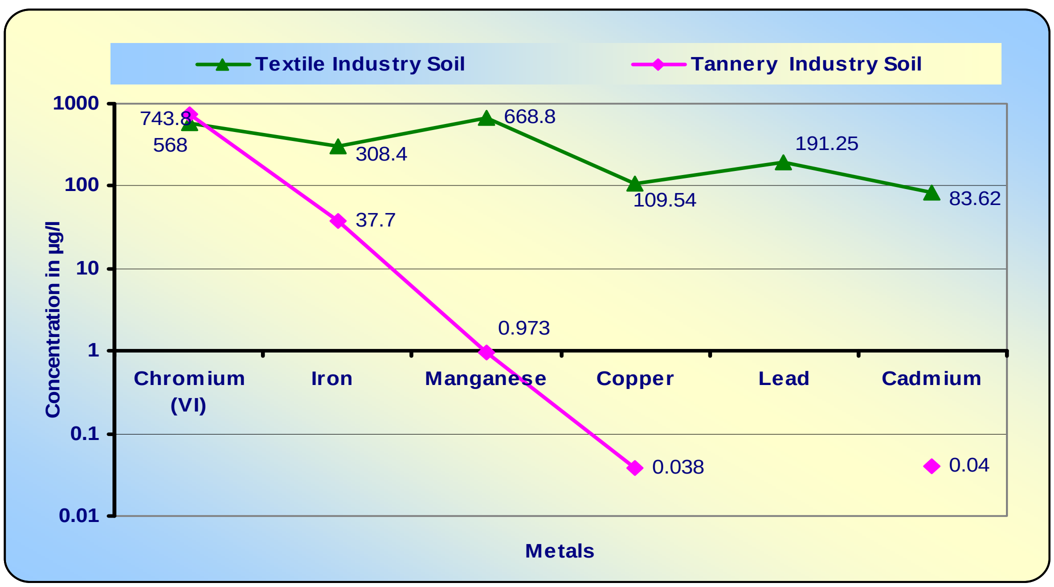

Figure 2 Average values of metals in soils

3.3 Metals in Ground Water

Observed average concentrations of metals in ground water samples collected from textile and tannery industry are pooled in Table 1 and Figure 3. In the present study, hexavalent chromium was not found in textile industry ground water; while 0.05 ppm of chromium was observed in ground water samples contaminated with effluent of dyeing units at Karur district, Tamil Nadu (Kannan et. al. 2005). While, average chromium concentration was observed 0.93 mg/l in ground water samples of tannery (Table 2 & Figure 3). However, permissible limit for Chromium in drinking water 0.05 mg/L (De, 2002). Skin contact can cause skin ulcers, allergic reactions and swelling of the skin (Martin and Griswold, 2009).

Results recites that the iron was in higher concentrations of 2.95 mg/l in textile industry ground water (Table 1). It was 89.83% higher than the set limit of 0.3 mg/l by IS (1991). For ground water samples of tannery, 0.84 mg/l of iron was noted (Figure 3). While, desirable limit of iron is 0.3–1.0 mg/l (ISI, 1991). Beyond this limits taste and appearance are affected, has adverse effect on domestic uses and water supply structures and promotes iron bacteria. Iron values were reported 0.003 to 1.097 mg/l of in ground water of tannery at Peshawar (Tariq et. al. 2006).

For the textile industry ground water, 0.70 mg/l of manganese was noted which was above the permissible levels of 0.1 mg/l (ISI, 1991). Traces of Manganese were found in all the ground water samples of Karur district, Tamil Nadu (Kannan et. al. 2005). The mean value of manganese was reported 0.02 mg/l in tannery ground water (Table 2). Manganese concentrations were ranged from 0.001-0.740 mg/l in ground water samples[11]. Taste and appearance may be affected due to high manganese concentration above 0.3 mg/l in ground water (ISI, 1991).

The study revealed that the copper concentration was found 0.05 mg/l in ground water samples of textile industry (Figure 3), which was noted maximum from the desirable limit of copper set by IS limits (ISI, 1991). Higher concentration of 0.75 mg/l was also reported in the ground water samples collected from the neighboring area of textile units at Sanganer, Jaipur (Sharma et. al. 1999). Although, copper was absent in ground water samples of tannery. If present in higher amount (above 0.05 mg/l) it gives astringent taste to water and causes discoloration and corrosion of pipes, fitting and utensils (ISI, 1991). Prescribed limit for copper is between 1.0-1.5 mg/l (WHO, 1958).

During the present study, lead was not found in ground water samples of textile and tannery industries. Whereas, 0.24 - 0.45 mg/l of lead was reported in ground water samples at Panipat, Haryana (Dubey et. al. 2003). Desirable limit for lead is 0.05 mg/l, beyond this limit water becomes toxic (Martin and Griswold, 2009)

Ground water of textile industry contained 0.04 mg/l of cadmium (Table 1), which was higher than the standard limits (0.04 mg/l) of WHO (1958). Due to higher cadmium concentration water becomes toxic but there are a few recorded instances of Cd poisoning in human beings following consumption of contaminated fishes (Moore and Ramamoorthy, 1984). While, cadmium was reported 0.29 ppm in ground water samples of Panipat (Dubey et. al. 2003) that was also higher than the standard limits (ISI, 1991). The mean value of cadmium was noted 0.007 mg/l in tannery ground water (Figure 3). The values were with in the prescribed limits of ISI (1991). However, cadmium was observed 0.003 to 0.043 mg/l in ground water samples (Tariq et. al. 2006).

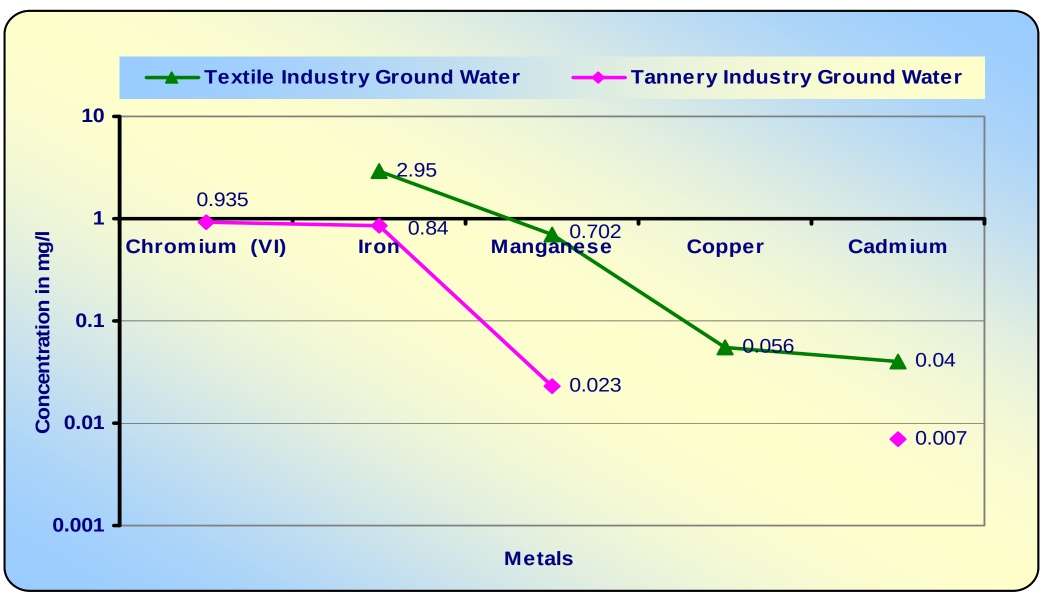

Figure 3 Average values of metals in ground water

5. Conclusions

On the behalf of the above results and discussions it is concluded that the soil and ground water samples showed the presence of high level of metal contamination due to receiving of industrial effluent from textile and tannery industries. Further, it is clear that the effluent is far from the prescribed limits, toxic in nature and requires treatment before disposal on land as well as water because many components are too higher than the prescribed limits and not safe for final release.

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