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ASSESSMENT OF HEAVY METALS POLLUTANTS IN TEXTILE INDUSTRIAL EFFLUENTS FROM PANCHAGANGA RIVER, ICHALKARANJI, M.H., (INDIA)

J. P. Sarwade[1] and S. J. Mankar[2]*

[1]P.G.Department of Zoology, Arts, Science, and Commerce College, Indapur, Dist-Pune– 413 106, Maharashtra, India.
[2]Department of Zoology, Modern College of Arts, Science and Commerce, Ganeshkhind, Pune – 411 053, Maharashtra, India.

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***Corresponding Author**
S. J. Mankar
Department of Zoology, Modern College of Arts, Science and Commerce, Ganeshkhind, Pune – 411 053, Maharashtra, India.
saritahupare24@gmail.com,

ABSTRACT

The pollution of water bodies is a worldwide concern nowadays. The textile industrial effluent water is responsible for freshwater pollution. This paper mainly included the analysis of heavy metal like Chromium(Cr), Cadmium(Cd), Iron(Fe), Lead(Pb), Nickel(Ni), Zinc(Zn), Cobalt(Co) from pre-confluence(site 1), at confluence(site 2) and post confluence site(site 3) on river Panchaganga of Ichalkaranji. The contents of heavy metal analysis were determined using Atomic Absorption Spectrophotometer (APHA2009).The results indicate that concentrations of heavy metals in studied water samples recorded higher than the standards proposed by WHO(2011) and the Indian Standards (2012).In this study, the concentration of each of the metal varies in all the samples. The average concentration of Lead recorded at three sites was (site 1=0.0059 mg/L, site 2=0.38mg/L, site 3=0.26mg/L) and chromium (site 1=0.041mg/L, site2=0. 24mg /L, site 3=0.094mg/L) were found to be high. The concentration of Zn in a water sample collected at three sites (site 1=0.02mg/L, site 2=0.23mg/L, site 3=0.01mg/L) was found to be lowest indicated that zinc was not causing pollution at these sites. Remaining metals showed variations in their concentrations. It was concluded that the effluent samples of textile industries discharge causes pollution to the Panchaganga river water and become problematic for a biological environment and human being. Therefore, the effluent water to be discharged by these industries must be sufficiently treated before release.

KEYWORDS: Atomic Absorption Spectrophotometer, Heavy metals, Water pollution, Textile industrial effluent, Panchaganga.

INTRODUCTION

The increasing industrialization and urbanization lead to environmental pollution (Nazir, et al., 2015). Moreover, the pollution of the aquatic environment causes extremely serious environmental damage and consequently negatively affecting living organisms. The effluent generated by the industries is one of the sources of pollution (S.Ali, et al., 2019).Contaminated soil, air, and water by effluents from the industries are associated with various disease problems (WHO, 2002) and this could be part of the reasons for the current shorter life probability in the country (WHO, 2003). The discharge of toxic effluents from different industries adversely affects water resources, aquatic organisms, soil fertility, and ecosystem integrity(Nazir, et al., 2015). Textile industries are one of the largest water consumers and polluters resulting in high wastewater generation (Nemerow, 1978; Ghoreishi and Haghighi, 2003).Textile processing industries largely employ dyes and discharge a large volume of wastewater after the dyeing process. These dyes are aromatic hydrocarbons, derivatives of benzene, toluene, naphthalene, phenol and aniline (Drumond Chequer, et al., 2013) and the use of dyes in textile processing industries releases organic and inorganic pollutants in the environment. Textile dyes in the effluent are toxic, highly stable and contained heavy metals that are carcinogenic (Tamburlini, et al. 2002). Heavy metal pollution is an ever-increasing problem of our rivers, lake, and ocean. These heavy metals showed a remarkable effect on the aquatic plants and animals which through bio-magnification enters the food chain and eventually affects human beings (Ram, et al., 2011). Worldwide occurrence of heavy metal accumulation in oysters, fish, sediments and other components of aquatic ecosystems have been reported. (A.Aghor, 2007 and Singare, et al., 2010).These toxic heavy metals entering in fresh water environment are adsorbed onto particulate matter, even though they can form free metal ions and soluble complexes that are available for uptake by biological organisms(Singare, et.al., 2010).

According to various research studies, it was confirmed that heavy metals such as Pb, Cd, Zn, and Ni have shown a toxic or carcinogenic effects on human and environment (Frascasso, et al., 2002; and Frenzilli, et al.,2009) have shown the genotoxicity of heavy metals on aquatic organisms. Heavy metals caused deadlier diseases like a tumor, congestion of pharynx and nasal mucous membranes, edema of eyelids, stuffiness of the head and gastrointestinal, reproductive, muscular, genetic and neurological malfunctions have been documented (Abbasi, et al. 1998; Johnson 1998; Tsuji and Karagatzides, 2001).Heavy metals like Mercury, Cadmium, Arsenic, Molybdenum, and Chromium causes water as well as soil pollution (Sim, et al., 2016).It was studied that, after the industrial revolution heavy metals cause a serious impact on the environment which is adverse effects on aquatic animals, plants as well as humans. Along with these problems textile effluent might change the physicochemical properties like pH, dissolved oxygen level and electric conductivity, etc. of the water bodies.(Monika das, et.al.,2011).

In the present context, the study area consists of three sites on the Panchaganga river. The effluents from most of the textile industries get discharged in the Panchaganga river through a Chandur nallah of Industrial Estate Area. The nallah confluence with the Panchaganga river which mainly impacts on the life of peoples and aquatic animals like fishes. The Chandur nallah originates from hills near Hatkanangale, it flows by the textile industries and then falls in the Panchaganga river. The locations for collection of water samples from this nallah are selected in such a way that the first sample shows the heavy metal analysis of water at the pre confluence site. The second sample shows the heavy metal analysis of a water sample where the nallah confluence with the Panchaganga river. The third sample shows heavy metal analysis from the water sample after the confluence site.

Today, due to the presence of heavy metals like Cu, Zn, Ni, Pb, Cd, and Cr into various sources of drinking water pose a great threat to public health (D.Shankar et al., 2014). Heavy metals are among the most common environmental contaminants and become problematic for environmental concern (A.Papafilippaki, et al., 2007). Therefore, heavy metal pollution study in river water became important considering receiving water is used on paddy field irrigation, affecting food crops quality, freshwater fishes which eventually would be consumed by humans. Therefore, the objectives of this research were to create a heavy metal pollution profiles and determine the tendency of those heavy metal content in river water after receiving the main textile industrial effluent, which is important for the safety assessment of the environment and its biodiversity.

MATERIALS AND METHODS

Study Site

Ichalkaranji is located at 16.7°N 74.47°E. Ichalkaranji has an average elevation of 538 meters (1768 ft.). Ichalkaranji (Hatkanangale T.; 16° 40' N; 74° 25' E; p. 27,423; an 8.7 square miles), lies in the Panchaganga valley about eighteen miles (29 km), east of Kolhapur and half a mile north of the river. The Ichalkaranji is the Manchester city of India which is located 10 km southeast of the railway station of Hatkanangale tahsil in Kolhapur district of Maharashtra state.

Sampling Programme

The study was carried out on the Panchaganga river. Three sites on the river were selected for the collection of water samples. Three sites represented as site 1, located 1 km upstream of confluence site i.e. pre confluence site, site 2 where the textile industrial effluent from Chandur nallah confluence in Panchaganga river and site 3, located 2 km downstream from confluence site i.e. post confluence site along the river were selected. During the survey, all points of three sampling sites were noted on the bank of the river. Details about the sampling sites are as follows: site 1 where the water sample was collected at a point upstream. This sample represents a point in the river before effluent from textile industries released in the river. The water sample collected at site 2 where effluent from textile industries are discharged into the Panchaganga river through Chandur nallah. Site 3 where water sample was collected at 2 km downstream to the confluence site.

Industrial Waste Water Sampling and Sample Preparation

The samples were collected every alternate month from August 2018 to December 2019. For the sampling, polyethylene bottles first cleaned by washing in non-ionic detergent, rinsed with deionized water before use and then samples were collected in them.

Heavy metal analysis

Heavy metals like Lead (Pb), Chromium (Cr), Nickel (Ni), Cobalt (Co), Iron (Fe), Cadmium (Cd), and Zinc (Zn) were analyzed in effluent samples by Atomic Absorption Spectrophotometer. Atomize the samples and determine their absorbance. Two hundred milliliters (200 ml) of the water sample was digested with 5 ml of a di-acid mixture (nitric acid: perchloric acid) of 9:4 ratio v/v on a hot plate and then filtered by Whatman filter paper No. 42 and made up to mark in a 50 ml volumetric flask by double distilled water for analysis of heavy metals using atomic absorption spectrophotometry (APHA 2009).

The analysis begins with selection and adjustments of various units of the Atomic Absorption Spectrophotometer (i.e. lamp selection, flame adjustment, wavelength selection, slit adjustment) and the Atomic Absorption Spectrophotometer was standardized by aspirating distilled water to get zero absorbance. Standard solutions of 1000 mg L -1 for all the metals were prepared, and from them working solutions (with concentrations within the range of 0-5 mg L-1) were prepared by serial dilution (APHA 2009). After digestion, the solutions were taken to Atomic Absorption Spectrophotometer and the absorbance value read and recorded. Graphs of absorbance v/s.

concentration was plotted. After that, the absorbance of the sample was recorded. The concentration (in mg L-1) was obtained by extrapolating the values of absorbance from the calibration curve. The same procedure was used for all water samples. The concentrations obtained were compared with the European Commission WHO, 2011 and IS 2012.

RESULTS AND DISCUSSION

In this study, samples collected from three study sites of river Panchaganga were analyzed for heavy metals between the gap of one month (Table 1). Metals like Chromium (Cr), Cadmium (Cd), Iron (Fe), Lead (Pb), Nickel (Ni), Zinc (Zn) and Cobalt (Co) were analyzed by Atomic Absorption Spectrometry and results (in mg/L) are represented by statistical means. The monthly average values of heavy metal content in mg/L for 3 sites are graphically represented in Figure 1.

For the production of color pigments of textile dyes, heavy metals such as Lead (Pb), Chromium (Cr), Copper (Cu) and cadmium (Cd) are widely used (Vipul Bhardwaj et al., 2014). Lead is known to interfere with several body functions and it is primarily affecting the central nervous, hematopoietic, renal and hepatic system producing serious disorders (Kalia and Flora, 2005). Generally, the most important source of lead in the freshwaters is atmospheric fallout (A.Paar, 1998). In the present investigation, it was observed that the maximum monthly average concentration of Pb was 0.38 mg/L in water samples collected at the confluence site where textile industrial effluent mixed with river water. The average concentration of lead 0.26 mg/L was found in the corresponding water sample at the Post confluence site. The minimum concentration (0.0059mg/L) of Pb was found in the water samples collected from a Pre influence site. However, in all the cases the concentration of toxic Pb in effluent samples was found to be above the permissible limit set by the (WHO, 2011 and Indian water standards, 2012). Acute toxicity of Pb in invertebrates is reported at a concentration of 0.1–10 mg/L (A.Paar, 1998). Higher levels pose an eventual threat to fisheries resources (Ram. et al., 2011).

The monthly average Cr content in wastewater samples was found to be a minimum of 0.0414 mg/L in samples collected from Pre confluence site and a maximum of 0.242 mg/L in water samples collected at confluence sites whereas it showed 0.0942 mg/L at Post confluence site. This was very much higher than the permissible limit of 0.05 mg/L set by (WHO, 2011). Cr compounds are used as pigments, mordents and dyes in the textiles and as a tanning agent in the leather(Ram. et al., 2011). The experimental data indicate that textile industries are the major source for the release of toxic Cr metal in the surrounding aquatic environment (Ram. et al., 2011). Acute toxicity of Cr to invertebrates is highly variable, depending upon species(A.Paar., 1998). Cr is generally more toxic at higher temperatures and its compounds are known to cause cancer in humans(A.K.De., 2002).

The monthly average Ni content was found to be minimum of 0.050 mg/L in the water samples collected at Pre confluence sampling site, while higher concentration of 0.29 mg/L was found in the water samples collected at confluence sampling site which causes the source for contribution of toxic Ni metal in the surrounding aquatic environment. The results show that Ni content in the water samples collected at Post confluence was 0.23 mg/L. The overall average concentration of Ni in water samples collected from different sampling sites were very much higher than the maximum limit of 0.02 mg/L set by (WHO, 2011).Nickel is identified as a nephrotoxic, immunotoxic, genotoxic, neurotoxic, pulmonary toxic, reproductive toxic, haematotoxic, hepatotoxic and carcinogen (Das K.K. et al., 2008). The carcinogenic action of nickel carbonyl on rat was reported earlier by (Sunderman., 1959 and P.S.Sindhu., 2002). Ni magnification along in the food chain is not confirmed but it can accumulate in aquatic life(Ram. et al., 2011). Nickel- induced toxicity and carcinogenicity, with an emphasis on the generation and role of reactive oxygen species, are reviewed(Das K.Ket al., 2008).

The monthly average minimum concentration of Co in water samples collected at Pre confluence site 1 was 0.042 mg/L. While the maximum concentration of 0.26 mg/L was found at confluence site2. The concentration of Co in a water sample collected at Post confluence site 3 was 0.083 mg/L. The permissible limit of Co is not specified by (Indian standards, 2012and WHO, 2011) for drinking water. The high Cobalt concentrations were observed in the water sample collected at site 2. Cobalt particles deposited in the upper and lower respiratory tract due to inhalation, where they can be absorbed or retained into the blood after dissolution or swallowing and automatically transferred by mucociliary action to the gastrointestinal tract. Inhalation and dermal exposure to cobalt in humans can result in sensitization (J.BalaChennaiahab, et al.,2014). Interstitial lung disease such as hard metal lung diseaseis an occupational lung disease caused by metallic cobalt-containing particles. Mortality studies of the hard metal industry suggest an increase in lung cancer mortality(Singare, et al.,2010).

In the present study, the maximum monthly average concentrations of Fe were 0.70 mg/L in the water samples collected at confluence site 2 which is effluent mixed river site. The concentration of Fe at site 3 was found to be 0.43mg/L. The minimum concentration of Fe (0.23 mg/L) was found in the water samples from site 1.However, it was observed that the concentration of toxic Fe in effluent samples collected from site 2 and site 3 was higher than the permissible limit of mg/L. Iron toxicity is also led to arrhythmia, joint disease (arthropathy), increased atherosclerosis risk, heart failure, and increases in the risk of, breast, liver, gastrointestinal and hematologic cancers (Vipul Bhardwaj et al., 2014). The risk of pathogenic organisms may increase due to the presence of a high concentration of Fe; since most of these organisms require Fe for their growth (Ram. et al., 2011).

Cadmium accumulates in the human body affecting negatively several organs: liver, kidney, lung, bones, placenta, brain and the central nervous system (Rajaram, T., and, A., 2008). Cadmium toxicity is responsible for kidney tubular damage and osteomalacia. If cadmium, manganese, and zinc are present in sufficient concentrations, affection regulation (Howells.,1990). The monthly average Cd content in water samples was found to be minimum of 0.015mg/L and 0.09 mg/L in the effluent samples collected from site 1 and site 3 respectively, while maximum Cd content was found to be 0.13 mg/L in the water sample collected from site 2.The experimental values indicate that the release of toxic Cd in the surrounding water bodies causes water pollution. The values obtained were found to be higher than the permissible limit of 0.01 mg/L set by (WHO, 2011) standards. Cadmium is less toxic to plants than Cu, like in toxicity to Pb and Cr. It is equally toxic to invertebrates and fishes (A.Paar., 1998).

In the present study, the monthly average concentration of Zn was maximum (0.23mg/L) in water samples collected from site 2,while the minimum concentration of 0.011 mg/L was found in water samples collected from site 3.The concentration of Zn in a water sample collected at site 1 was 0.019 mg/L. However, the Zn concentrations from studied sites were below the (Indian standards, 2012 and WHO, 2011) which implies that textile industries not causing the Zn pollution at these sites.

Table 1: Heavy Metal Content (mg/L) in Water Samples Collected at three sites (Pre confluence, Confluence, and Post confluence) from River Panchaganga, Ichalkaranji, (2018-2019).

Collection Period		Aug	Oct	Dec	Feb	April	June	Aug	Oct	Dec	Mean	S.D	S.E.	WHO Std	Indian Std
Pb	**SITE I**	0.001	0	0	0.001	0.001	0	0	0.03	0.02	0.0059	0.0111	0.0042	0.05	0.05
	SITE II	0.31	0.15	0.34	0.21	0.39	0.12	0.27	0.98	0.68	0.3833	0.2779	0.1051	0.05	0.05
	SITE III	0.26	0.1	0.08	0.18	0.26	0.09	0.21	0.575	0.653	0.2676	0.2089	0.0789	0.05	0.05
Cr	**SITE I**	0.002	0.06	0.005	0.15	0.013	0.002	0.001	0.123	0.017	0.0414	0.0573	0.0217	0.05	0.05
	SITE II	0.34	0.13	0.25	0.26	0.67	0.11	0.3	0.024	0.102	0.2429	0.1916	0.0724	0.05	0.05
	SITE III	0.23	0.09	0.007	0.2	0.026	0.08	0.18	0.01	0.025	0.0942	0.0876	0.0331	0.05	0.05
Ni	**SITE I**	0.092	0.038	0.067	0.011	0.006	0.06	ND	0.085	0.0458	0.0506	0.0316	0.0119	0.02	0.02
	SITE II	0.2	0.017	0.001	0.016	0.088	0.001	0.1	0.664	1.561	0.2942	0.5192	0.1963	0.02	0.02
	SITE III	0.1	0.06	0.13	0.013	0.011	0.05	0.07	0.757	0.923	0.2349	0.3476	0.1314	0.02	0.02
Co	**SITE I**	0.003	0.05	0.006	0.009	0.009	0.07	0.04	0.098	0.096	0.0423	0.0386	0.0146	-	-
	SITE II	0.94	0.024	0.18	0.022	0.02	0.01	0.91	0.116	0.127	0.2610	0.3811	0.1441	-	-
	SITE III	0.032	0.21	0.09	0.015	0.017	0.04	0.16	0.079	0.106	0.0832	0.0672	0.0254	-	-
Fe	**SITE I**	0.12	0.064	0.52	0.39	0.31	0.4	0.11	0.183	0.001	0.2331	0.1781	0.0673	0.3	0.3
	SITE II	1.2	0.92	0.59	0.84	0.87	0.35	0.8	0.732	0.019	0.7023	0.3457	0.1307	0.3	0.3
	SITE III	0.56	0.52	0.45	0.64	0.7	0.41	0.47	0.105	0.034	0.4321	0.2255	0.0852	0.3	0.3
Cd	**SITE I**	0.01	0.007	0.02	0.003	0.013	0.004	0.002	0.017	0.062	0.0153	0.0186	0.0070	0.05	0.01
	SITE II	0.35	0.052	0.076	0.1	0.21	0.02	0.28	0.047	0.087	0.1358	0.1160	0.0439	0.05	0.01
	SITE III	0.21	0.048	0.041	0.083	0.17	0.04	0.12	0.061	0.047	0.0911	0.0623	0.0236	0.05	0.01
Zn	**SITE I**	0.023	0.001	0.029	0.014	0.06	0.002	ND	0.011	0.016	0.0195	0.0189	0.0072	3	5
	SITE II	0.91	0.11	0.17	0.13	0.068	0.04	0.62	0.004	0.023	0.2306	0.3160	0.1194	3	5
	SITE III	0.022	0.008	0.011	0.014	0.001	0.003	0.021	0.009	0.018	0.0119	0.0075	0.0028	3	5

Site 1: Pre Confluence site, Site 2: Confluence site and Site 3: Post confluence site

Table 2: Monthly average variation in Heavy metal content (mg/L) in water samples at three representative sites from river Panchaganga, Ichalkaranji for the Assessment years 2018-19.

SITE	Pb	Cr	Ni	Co	Fe	Cd	Zn
SITE I	0.0059	0.04	0.05	0.04	0.23	0.02	0.02
SITE II	0.38	0.24	0.29	0.26	0.70	0.14	0.23
SITE III	0.27	0.09	0.23	0.08	0.43	0.09	0.01

Figure 1. Graphical representation of monthly average variation in Heavy metal content (mg/L) in water samples at three representative sites from river Panchaganga Ichalkaranji for the Assessment years, 2018-19.

CONCLUSION

Textile industries a major economic zone of India. The majority of the population depends upon the textile industries. But textile industries became more problematic as they consider the most polluting industries. The toxic heavy metal concentration damages the aquatic system mainly. The maximum level of heavy metals concentration in water will be a serious impact on the environment. The discharge of textile industrial effluent water into the Panchaganga river invariably results in the presence of high concentrations of heavy metals in the water. Water samples from mainly two sites (sites 2 and 3) have also been found to be containing almost all toxic heavy metals above permissible limits. Pb was found to be present in concentrations higher than the standards from all studied sites. The Cr is present in concentrations higher than the WHO(2011) in the site 2 and 3 of the river and site 1 showed lower concentration than standard as it is upstream to confluence site. The concentrations of Cd, Ni, Co, Fe were found to be high at confluence site due to the discharge of effluent in the river. Zn was found to be present in concentrations lower than (WHO, 2011) in all studied sites of the river which showed the water to be safe from Zn toxicity. As shown in figure 1 the confluence and post confluence site happened to be more polluted than the pre confluence site. Overall findings indicated that the textile effluent mixed river water of the study sites was not better and should not be used for irrigation without prior treatments. This result reveals that Ichalkaranji faces water and heavy metal pollution as such, they are rendered not good for human use without adequate treatment. Thus there is a need for proper management to minimize the toxic level of these metals.

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