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RESEARCH ARTICLE

HEAVY METAL CONTAMINATION IN THE RIVER BHADRA NEAR KUDREMUKH MINING AREA IN SOUTH INDIA

[1]Anil N. Patel and [2]Shankarmurthy*, K.

[1]Department of Environmental Science, Gulbarga University, Gulbarga- 585106, Karnataka, India
[2]Department of Botany and Biotechnology, Directorate of Distance Education, Kuvempu University, Shankaraghatta- 577 451, Karnataka, India

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ABSTRACT

Mining of metals creates a potential source of heavy metal contamination in the environment. Mining activity in Kudremukh area of Western Ghats region is the main source for iron deposits in Bhadra River water. To evaluate water contamination risk increased by heavy metals from mining activities, samples were collected from different areas in different seasons (station I – uncontaminated perennial source of water, Satation II to Station V- contaminated water). The heavy metals like Fe, Mn, Cu, Zn, Ni, Cd Pb, Hg, Cr, Al were analyzed. Iron and Manganese found to be less in uncontaminated water samples. The least concentration of Iron & Manganese in uncontaminated water found to be 0.75 ± 0.03 & 0.25 ± 0.01 respectively but it showed highest in contaminated water that is, 1.8 ± 0.04 & 0.9 ± 0.0 respectively at different seasons.

INTRODUCTION

Kudremukh is a well-known region for iron ore and a mining industry is situated near Kalasa, Mudigere taluk of Chikmagalure district, Karnataka State. The ore has been excavated through open cast mining, which includes blasting of debris, mechanical removal and so on. Due to this there is a large amount of degradation in natural resources like land, water, forest, air and various kinds of flora and fauna. Destruction of the environment is often an unfortunate consequence of mining. With increase in iron ore mining in Kudremukh region of Western Ghats there has been scant attention paid, so far on surface water and sediment quality of Bhadra River, which originates near Kudremukh mining area called Gangamoola, then flows towards N.R. Pura. The surface water quality of this region is being over stressed in order to meet the increase in demand for fresh water, due to over pollution of surface water bodies. Water leached out from mine waste/tailing/dumps also carried various dissolved metallic/non metallic chemical compounds. Such contaminated water, mixed up with surface water that polluted the latter.

This may lead to depletion of water resources and increase in concentration of physico-chemical parameters. Heavy metals include all metals with atomic numbers greater than 23 and specific gravity more than $5g/cm^3$. Their use in industries in vast quantities gives them considerable pollution. Essential metals always function in combination with organic molecules and most commonly with proteins either tightly bound in metallo proteins are more commonly with proteins.

***Corresponding author:** shankaraaanil@gmail.com

If their level gets beyond the required trace concentration in the system in the whole aquatic environment gets deteriorated. The metal pollution load both from natural and anthropogenic sources is posing a serious threat to the environment. Recent research carried out in some Rivers of Rio Grande does Sul, the southernmost Brazilian state, showed significant loads of heavy metals transported by their waters (Edison, 2001). Mining involves the production of large quantities of waste, in some cases contributing significantly to a nation's total waste output. Iron mining is less wasteful, with approximately 60 percent of the ore extracted processed as waste (Da Rosa, 1997 and Sampat, 2003). Disposing of such large quantities of waste poses tremendous challenges for the mining industry and may significantly impact the environment.

The impacts are often more pronounced for open-pit mines than for underground mines, which tend to produce less waste. Degradation of aquatic ecosystems and receiving water bodies, often involving substantial reductions in water quality, can be among the most severe potential impacts of metals extraction. Pollution of water bodies results from three primary factors *viz.*, sedimentation, acid drainage and metals deposition. The chemical effects of mining and mineral processing might be less obvious than the disturbance of land but are often more dangerous and long-lasting (Ghose, 2004). Mines waste heaps and processing plants release toxic substances into the environment. Smelters emit gases into the atmosphere, which cause acid rain and contribute to the green-house effect. New mining technologies as well as recycling and the substitution of mineral products by other materials help to reduce the impact of mining on the environment (Sinha, 1998). In the present study the concentration of heavy metals such as Iron, Manganese, Cadmium, Mercury, Lead Zinc, Copper, Nickel, Chromium, and Aluminium. in the River water have been recorded and discussed. The study is a consorted effort towards the understanding of the various natural and anthropogenic processes influencing the water quality of Bhadra River starting from Gangamoola to Narasimha Raja Pura, Chikamagalure district, Karnataka state (South India) and to suggest effective management strategies for the future. The present investigation addresses a few parameters of water quality emphasizing on their occurrence, concentration levels and distribution. While a complete understanding of every aspect of water quality of the study area is unrealistic. Hence, a concerted effort with the following objectives will significantly reduce the uncertainties in predicting future consequences of current trends. A few important aspects that have been focused in the context of local changes in environmental and their regional implications are, to assess the quality of Bhadra River water in the mining area of Kudremukh region with respect to heavy metals and to estimate the distribution and temporal variation in concentration of toxic heavy metals which are pollutants in water in order to highlight the current status of heavy metal pollution in water system of this study area.

MATERIALS AND METHODS

Sampling design of the River water has been made in order to pursue the quality control for making forecasts and to determine of the extent of damage due to pollution (Allen *et al*., 1978). For developing a sampling design, a due attention has been paid to the sampling unit, source and size of the sample, parameters of interest, budgetary constraint and sampling procedures. As there are several sample designs available, only one such design has been chosen for the study area such that for a given budgetary constraint will have a smaller sampling error. For present investigation probability sampling design was selected. Probability sampling design, which is also known as random sampling or chance sampling, has an equal chance of inclusion of every item of an object in the sample. Random sampling (Bisht, 1978) ensures the law of statistical regularity, which states that if on an average the sample chosen is a random one, the sample will have the same composition and characteristics as the object under consideration. This may be the reason why random sampling is considered as the best technique of selecting a representative sample.

Sampling locations on the River Bhadra in Kudremukh area of the Western Ghats region have made using random grid or spatial network method on the basis of geographical ground map of Bhadra River. Based on the topography, nature of environment and human interference, five sampling stations were selected in Bhadra River (Gangamoola to N.R.Pura) for the present investigation. As the network technique has been used for many years for a scientific data generation, the same technique is followed in the present study for generation of analytical data, which can be used as baseline data for many years to this region. It is important to note that a selection of site be chosen not because of convenient access, but because of representative sample sake. The use of few strategic locations and enough samples define the results in terms of statistical significance is usually more reliable than using many locations. The details of sampling locations have been shown in Fig- 1. In the present study water samples from five different stations along the River stretch of Bhadra from Kudremukh area of the Western Ghats region were collected and analyzed for pre-monsoon, monsoon and post-monsoon seasons during the year 2002 – 2003 and 2003 – 2004. The pre-monsoon season includes March, April and may, monsoon season comprises of July, August and September and post monsoon season commences from November, December and ends in the month of January. Water and sediment sampling locations on the River Bhadra of Kudremukh area of the Western Ghats region are

1. Station I – Gangamoola in Kudremukh National Mark
2. Station II – Catchment area near Lakya Dam
3. Station III – Nellibeedu
4. Station IV – Kalasa
5. Station V – Narasimha Raja Pura (down stream of Bhadra River)

Water samples from different locations were collected as per the guidelines of random sample technique. Sample cans were flushed with water before samples were collected. As water is dynamic in nature and during sampling it enters the new environment from its natural environment, its chemical composition may not remain same but may tend to adjust itself according to its new environment (Sawyer, 1978) and its content alters at very different rates particularly with organic materials. The Sample collection, fiitration, treatment and analysis for dissolved heavy metals such as iron, manganese, zinc, lead, mercury, cadmium, copper, aluminium and chromium characteristics were studied with a view to determine the changes in quality of water in the pre monsoon, monsoon and post monsoon seasons, and were carried out according to protocols established for heavy metal analysis in the laboratory as described by Standard methods (Trivedy *et al*., 1986; APHA, 1995).

RESULTS AND DISCUSSION

Water is an essential commodity for the sustenance of life. The heavy metal alters the natural status of the water resulting in the alteration of the water chemistry causing harmful effects on water dependent organisms. Hence, the present investigation was undertaken to know the status of the Bhadra River that has received considerable amount of heavy metals due to Kudremukh Iron Ore Company Limited (KIOCL). A continuous exchange in metals between water and sediments and transport to food chain of higher animals through bio-accumulation by aquatic micro-organisms. The impact of a particular metal species may be more important than the total metal concentration (Forstner and Wittman, 1993). Iron is found in nature in two oxidation states as Fe^{2+} and Fe^{3+}. The ferric oxides found by weathering are very fine grained and as a result are carried by Rivers. Mining operations and metallurgical processes also contribute to the aquatic environments. The main source of iron to the Bhadra River from Kudremukh mining area are lithogenic, runoff from excavation and transportation. In the present study the iron content ranged from a minimum average of 0.45mg/L in Station I during pre-monsoon season (Table 1) to a maximum average of 1.8 in Stations II and III during monsoon season (Table 2) could be attributed to the continuous runoff from mining area.

Table 1. Average values of heavy metal concentration in Bhadra River water during pre-monsoon season (2002 – 04)

Sl. No.	Parameters	Station I	Station II	Station III	Station IV	Station V
		Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd
	Iron	0.45 ± 0.02	1.5 ± 0.03	1.7 ± 0.03	1.4 ± 0.02	1.0 ±0.01
	Manganese	0.25 ± 0.01	0.8 ± 0.03	0.8 ± 0.03	0.6 ± 0.02	0.3 ±0.01
	Copper	BDL	0.02 ± 0.0	0.01 ± 0.0	0.01 ± 0.0	BDL
	Zinc	BDL	0.01 ± 0.0	0.02 ± 0.0	0.01 ± 0.0	BDL
	Nickel	BDL	0.002 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	BDL
	Cadmium	BDL	BDL	BDL	BDL	BDL
	Lead	BDL	0.001 ± 0.0	0.002 ± 0.0	0.001 ± 0.0	BDL
	Mercury	BDL	BDL	BDL	BDL	BDL
	Chromium	BDL	0.002 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	BDL
	Aluminum	BDL	0.001 ± 0.0	0.002 ± 0.0	0.001 ± 0.0	BDL

Note: All the parameters were expressed in µg/L, BDL : Below Detection Level

Table 2. Average values of heavy metal concentration in Bhadra River water during monsoon season (2002 – 04)

Sl. No.	Parameters	Station I	Station II	Station III	Station IV	Station V
		Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd
	Iron	0.75 ± 0.03	1.8 ± 0.04	1.8 ± 0.03	1.5 ± 0.01	1.1 ±0.01
	Manganese	0.25 ± 0.01	0.9 ± 0.0	0.85 ± 0.03	0.65 ± 0.02	0.35 ±0.01
	Copper	BDL	0.02 ± 0.0	0.01 ± 0.0	0.01 ± 0.0	BDL
	Zinc	BDL	0.01 ± 0.0	0.02 ± 0.0	0.01 ± 0.0	BDL
	Nickel	BDL	0.002 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	BDL
	Cadmium	BDL	BDL	BDL	BDL	BDL
	Lead	BDL	0.001 ± 0.0	0.002 ± 0.0	0.001 ± 0.0	BDL
	Mercury	BDL	BDL	BDL	BDL	BDL
	Chromium	BDL	0.002 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	BDL
	Aluminum	BDL	0.001 ± 0.0	0.002 ± 0.0	0.001 ± 0.0	BDL

Note: All the parameters were expressed in mµg/L, BDL : Below Detection Level

Table 3. Average values of heavy metal concentration in Bhadra River water during post-monsoon season (2002 – 04)

Sl. No.	Parameters	Station I	Station II	Station III	Station IV	Station V
		Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd
	Iron	0.55 ± 0.02	1.55 ± 0.03	1.75 ± 0.03	1.5 ± 0.02	1.0 ±0.01
	Manganese	0.3 ± 0.01	0.75 ± 0.03	0.8 ± 0.03	0.65 ± 0.02	0.35 ±0.01
	Copper	BDL	0.02 ± 0.0	0.01 ± 0.0	0.01 ± 0.0	BDL
	Zinc	BDL	0.01 ± 0.0	0.02 ± 0.0	0.01 ± 0.0	BDL
	Nickel	BDL	0.002 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	BDL
	Cadmium	BDL	BDL	BDL	BDL	BDL
	Lead	BDL	0.001 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	BDL
	Mercury	BDL	BDL	BDL	BDL	BDL
	Chromium	BDL	0.001 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	BDL
	Aluminum	BDL	0.001 ± 0.0	0.001 ± 0.0	0.001 ± 0.0	BDL

Note: All the parameters were expressed in µg/L, BDL : Below Detection Level

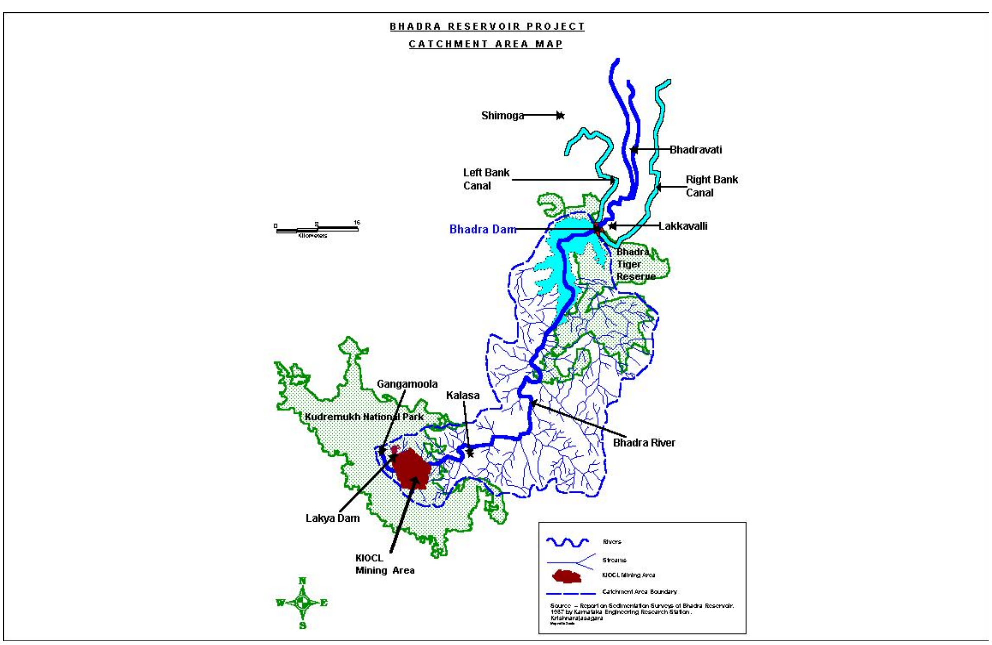
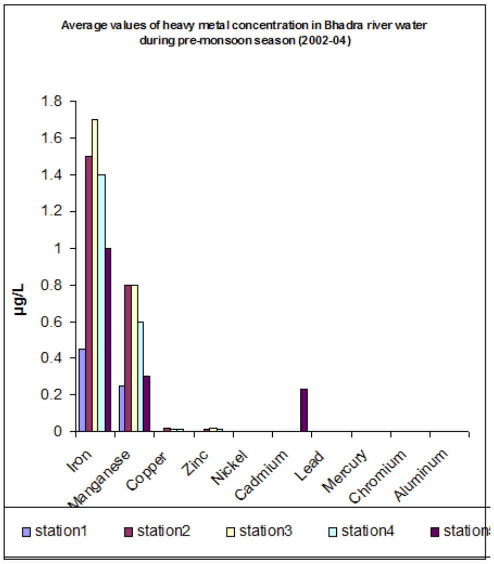
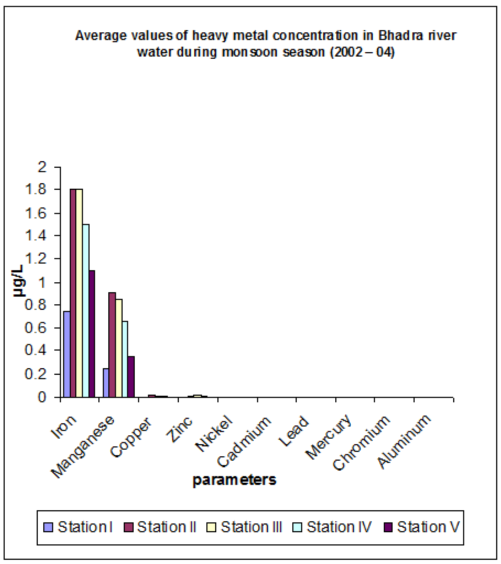


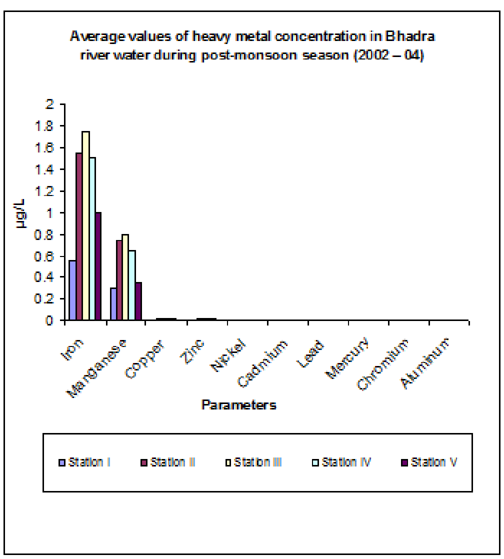
Figure 1. Map showing water and sediment sampling locations in Bhadra River



Graph-1



Graph-2



Graph-3

According to Mitra (1998) while working on discharge of iron mining wastes to the Damodar River, have recorded the high value of iron (1.8mg/L) and attributed to the runoff from the mining area. Seasonally the iron content was found to be high during monsoon and low during pre-monsoon season (Table 1). Our observation is in partial agreements with the findings made by Dwivedi (1996) who have studied iron concentration in Hindon River. The values of iron recorded in the Bhadra River at Station II, III and IV are above the permissible limits of Bureau of Indian Standards for drinking water quality. The main source of manganese in Bhadra River are lithogenic and the runoff from the mining area. The average manganese content in River water varied from a minimum of 0.25mg/L in Station I during pre-monsoon (Table 1) and monsoon seasons (Table 2) and maximum value was 0.9mg/L recorded in Station II during monsoon season (Table 2). Khurshid, (1999) have recorded high (2.4mg/L) content of manganese while working on Hindon River basin, which receives oxides of iron ore nearby mining area. They attributed that the higher concentration of manganese is due to runoff from the mining area. In the present investigation high values of manganese at Station II, III and IV are due to runoff from the mining area.

The average copper content in River water varied from a minimum of 0.01mg/L in Station III and IV in all the seasons and maximum value was 0.02mg/L recorded in Station II in all the seasons (Table 1, 2 and 3), where as in Station I and IV the copper concentration was below detectable level (Table 1, 2 and 3). The average zinc concentration in River water varied from a minimum of 0.01mg/L in Station II and IV in all the seasons (Table 1, 2 and 3) and maximum value was 0.02mg/L recorded in Station III in all the seasons (Table 1, 2 and 3), where as in Station I and V the zinc concentration was below detectable level. The cadmium concentration in the study area in all the stations was below detectable level. The average lead content in River water varied from a minimum of 0.01mg/L in Station III and IV in all the seasons (Table 1, 2 and 3) and maximum value was 0.02mg/L recorded in Station II in all the seasons (Table 1, 2 and 3) where as in Station I and V the lead concentration was below detectable level. The mercury concentration in the study area in all the stations was below detectable level.

The average chromium content in River water varied from a minimum of 0.001mg/L in Station III and IV in all the seasons (Table 1, 2 and 3) and maximum value was 0.002mg/L recorded in Station II in all the seasons (Table 1, 2 and 3), where as in Station I and V the chromium concentration was below detectable level. The average aluminum content in River water varied from a minimum of 0.001mg/L in Station II and IV in all the seasons (Table 1, 2 and 3) and maximum value was 0.002mg/L recorded in Station III in all the seasons (Table 1, 2 and 3), where as in Station I and V the aluminum concentration was below detectable level. Figure 1. showing water and sediment sampling locations in Bhadra River Large amounts of heavy metals were found to be related to mining activities (Baisch, 1994; Laybauer, 1995,1998;Laybauer & Bidone, 1999). Average values of heavy metal concentration in Bhadra River water during Pre-monsoon season, Monsoon season and Post monsoon season are shown in the graph 1, graph 2 and graph 3 respectively. The aim of this work which formed an integral part of environmental impact assessment due to mining in the Kudremukh region led to investigate the biogeo chemical processes controlling heavy metals in the mixing zone of River Bhadra. A detailed sampling approach over two year period (2002-04) indicated a seasonal pattern in the distribution and intensity of heavy metal concentration in the River water. This study also focused on estimation of annual Riverine dissolved heavy metal fluxes from the Bhadra River system. As a result low pH (7.15 ± 0.338) and high heavy metal concentration have been observed in Bhadra River.

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