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Research Paper Chemistry

Water chemistry
A study of dissolved heavy metals in Sabarmati River, Gujarat, India

Tushar Kumar Gandhi

Field of education, Gujarat, India

ABSTRACT

The purpose of this study was to investigate five heavy metals (Cu, Zn, Cd, Pb and Cr) in the surface water of the Sabarmati river, one of the most important river in Gujarat, India. In the selected research area, the Sabarmati River is receiving the domestic, industrial and municipal wastewaters/effluents all along its course. All in all, the ascendancy of the analyzed heavy metals in the surface water of Sabarmati followed the sequence: Zn>Pb>Cu>Cd>Cr.

KEYWORDS: Cu, Zn, Cd, Pb, Cr, River

Introduction

Rapid urbanization and industrial development during last decade have provoked some serious concerns for the environment. Heavy metals contamination in river is one of the major quality issues in many fast growing cities, because maintenance of water quality and sanitation infrastructure did not increased along with population and urbanization growth especially for the developing countries

The anthropogenic sources are associated mainly with industrial and domestic effluents, urban storm, water runoff, landfill leachate, mining of coal and ore, atmospheric sources and inputs rural areas. (Kabata – Pendias and Pendias, 1992; Biney *et al.,*1994; Zarazua *et al.,* 2006). Water pollution by trace metals is an important factor in both geochemical cycling of metals and in enviromental health (Kabata –Pendias and Pendias, 1992). The existence of heavy metals in aquatic environments has led to serious concerns about their influence on plant and animal life. Metal nutritional requirements (Cu, Zn etc.) differ substantially between species or elements, and optimum ranges of concentrations are generally narrow severe unbalances on metal proportions caused by exposure to elevated concentrations can cause death for organisms. Other elements (Pb, Cd etc.)

All heavy metals exist in surface waters in colloidal, particulate, and dissolved phases (Osmond *et al.,* 1995). Rivers are a dominant pathway for metals transport (Miller *et al.,* 2003) and trace metals may become significant pollutants of many small riverine systems (Dassenakis *et al.,* 1998). The behaviour of metals in natural waters is a function of the substrate sediment composition, the suspended sediment composition, and the water chemistry (Osmond *et al.,* 1995). During their transport, the trace metals undergo numerous changes in their speciation due to dissolution, precipitation, sorption and complexation phenomena (Dassenakis *et al.,* 1997; Akcay *et al.,* 2003) which affect their behaviour and bioavailability.

Trace elements are easily influenced by environmental factors such as surface runoff, groundwater, dissolution from sediment, deposition from the atmosphere and anthropogenic pollutants. Hence, trace metals may be sensitive indicators for monitoring changes in the water environment. There are many reports on temporal changes, especially seasonal variations, in heavy metal concentrations in river waters (Iwashita and Shimamura, 2003).

The purpose of this study was to estimate dissolved Cu, Zn, Cd, Pb and Cr between the wet and warm period in the Sabarmati river system and their correlations with pH, water temperature and electrical conductivity in both periods.

Materials and methods

Study area

The Sabarmati River is a river in western India and one of the biggest rivers of north Gujarat. River Sabarmati is one of the major West flowing river of Gujarat which originates from Dhebar lake in Aravalli Range of the Udaipur District of Rajasthan and meets the Gulf of Cambay of Arabian Sea after travelling 371 Km. from the origin. The Sabarmati basin has a maximum length of 300 Km. and maximum width of 105 Km. The total catchment area of the basin is 21.674 Sq.km. out of which, 4124 Sq.km. lies in Rajasthan State and the remaining 18550 sq. km. in Gujarat State. It rises in the Aravalli hills at north latitude of 24° 40′ and an east longitude of 73° 20′ in the Rajasthan state at an elevation of 762 meters near the popular shrine of Amba Bhavani.

Sampling and analysis

The surface water samples were colloected at 7 sampling sites in the Sabarmati river system

Seven sampling campaigns were carried out in each site in a 1-year period, during July 2010 to June 2011. The four sampling campaigns were realised at the warm period and the other three were carried out during the wet period . Water samples were collected in an acid-cleaned polyethylene bucket, after that, water samples were transferred in 2 l polypropylene bottles, and they were immediately transported in a portable refrigerator, to the laboratory at ± 4 °C. Water temperature was measured at the sampling sites. Hydrogen ion activity (pH) and electrical conductivity (EC) values were measured by a portable pH meter and conductometer, respectively.

For the heavy metal analysis, a 200-ml water sample was immediately filtered through a 0.45- µm membrane using a vacuum pumping system and transferred into an acid-cleaned 250-ml polypropylene bottle, and then 2 ml of high-purity nitric acid was added to give a pH of ~1 (Cenci and Martin, 2004). Heavy metal concentrations were determined directly in the acidified filtrates by Atomic Absorption Spectrometry (Perkin Elmer, AAnalyst 700). Zinc was analyzed by Flame Atomic Absorption Spectrometry. Copper, lead, cadmium and chromium were determined by graphite furnace Atomic Absorption Spectrometry. All water samples were treated in duplicate. The relative standard deviations of the methods and each run were <3.5%. In all cases, standards and blank were treated in the same way as the real samples to minimize matrix interferences during analysis.

RESULTS AND DISCUSSION

The values of the physicochemical parameters in Sabarmati river water during two different periods are given in Table 1. The water temperatures were higher in the warm period from March to June due to meteorological conditions. The water pH was lower in the warm period than in the wet period. In general the pH of Sabarmati river water was alkaline. The values of the electric conductivity showed no significant variations between warm and wet period at the most of the sampling sites.

Table 1. **Physicochemical parameters in warm and wet period in the Sabarmati river water**

Period	Parameter	Min	Max	Average
Summer	Temperature (oC)	29	35	32
Summer	PH	7.3	8.4	8.1
Summer	E.C. (µS cm-1)	250	1350	578
Monsoon	Temperature (oC)	25.4	28.1	26.4
Monsoon	PH	7.1	7.8	7.4
Monsoon	E.C. (µS cm-1)	261	1376	567

The studied dissolved metal concentrations in the Sabarmati' river during warm and wet period and their variation percentage are given in Table 2. The variation percentage was evaluated from the average values of the dissolved metal concentrations.

Table 2. **Dissolved metal concentrations (µg l-1) and variation percentage (%) in the Sabarmati river**

Period	Element	Min	Max	Average
Summer	Cu	3.78	14.2	6.72
Summer	Zn	17	146	40
Summer	Cd	0.019	0.042	0.019
Summer	Pb	0.036	11.65	2.73
Summer	Cr	2.41	4.98	3.57
Monsoon	Cu	0.7	1.55	0.91
Monsoon	Zn	05	11	4
Monsoon	Cd	0.005	0.018	0.005
Monsoon	Pb	0.30	1.18	0.29
Monsoon	Cr	1.01	2.45	1.67

According to the variation percentage, the maximum seasonal decrease observed for Zn and the minimum for Cr. The relative variability of the studied dissolved metals of the Sabarmati river. followed the order: Zn>Pb>Cu>Cd>Cr.

The solubility of trace metals in surface water is predominately controlled by the water pH

(Osmond *et al.,* 1995), water temperature (Iwashita and Shimamura, 2003), the river flow (Neal *et al.,* 2000b; Iwashita and Shimamura, 2003; Olías *et al.,* 2004) and the redox environment of the river system (Osmond *et al.,* 1995; Iwashita and Shimamura, 2003). A lower pH increases the competition between metal and hydrogen ions for binding sites. A decrease in pH may also dissolve metal-carbonate complexes, releasing free metal ions into the water column (Osmond *et al.,* 1995). Although the pH decrease was low in the Sabarmati river.

it may play a significant role in the dissolved metal increase in the warm period. A decreased redox potential, as is often seen under oxygen deficient conditions, will change the composition of metal complexes and release the metal ions into the overlying water (Osmond *et al.,* 1995).

Temperature impacts the rates of metabolism and growth of aquatic organisms, rate of plants' photosynthesis, solubility of oxygen in river water, and organisms' sensitivity to disease, parasites, and toxic materials. At a higher temperature, plants grow and die faster, leaving behind matter that requires oxygen for decomposition. Trace elements where are accumulated to phytoplankton may become soluble during the decay of plants (Kabata – Pendias and Pendias, 1992). The seasonal variation of the water temperature in the Sabarmati River may influence the variability of the studied metals indirectly via biological activity (decay of phytoplankton) or due to possible decrease of dissolved oxygen which related to redox potential decrease. In wet period the intense rains cause an increase in the river flow, producing a dilution of the contaminants. During the mixing of large volumes of non contaminated runoff water, the pH increases and the sulphate and metal content decrease. When the river flow decreases during the warm period, the concentrations of contaminants begin to recover, reaching maxima in the summer due to sulphide-oxidising bacterial activity increasing with the temperature, and simultaneously, a concentrating effect of the dissolved pollutants occurs in the water due to water evaporation (Olías *et al.,* 2004).

Temperature, pH and electric conductivity affect the contaminants fate in the river, control their speciation and thus their distribution within the dissolved or particulate fractions . In this study investigated the linear relationships between the studied physicochemical parameters and the dissolved metals of the sampling site of the Sabarmati river water on warm and wet period.

CONCLUSIONS

This study investigated the seasonal variation of Cu, Zn, Cd, Pb and Cr in the Sabarmati river, one of the most important river in Gujarat – India. Significant variations were found between warm and wet period for the studied metals. The relative variability followed the order Zn>Pb>Cu>Cd>Cr. The seasonal variation of the studied metals maybe related to the variations of water pH, river flow, water temperature and redox conditions.

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