# Heavy Metals distribution in Sediment and Water of Phrinkaruh River in East Khasi Hills, Meghalaya

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## Abstract

Anthropogenic factors mainly local people's activities and catchments runoff may influence the index of nutrients in river water and may alter the physico-chemical characteristics and also the whole water quality. Physico-chemical parameters play an important role into system restoration maintenance and self-regulation of water quality. Location variation in Heavy Metals concentration of the river was studied with special reference to physico-chemical parameters in the river water and sediment.

The present study deals with the preliminary physico-chemical characteristics and Heavy Metals of the river water and exhibits the status of natural quality of water with minimum anthropogenic activities, which contribute in pollution load of an aquatic system. Heavy Metals were found almost nil or in very low concentrations at selected site.

**Key words:** Water Quality, Pollution status, Transfer factor, Heavy Metals, river sediment

### Introduction

Water quality characteristic of aquatic environment arise from a multitude of physical, biological and chemical interactions (Dezuane, 1979). The water bodies, lakes, rivers, dams and estuaries are continuously subject to a dynamic state of change with respect to the geological age and geochemical characteristics. This is demonstrated by continuous circulation, transformation and accumulation of energy and matter through the medium of living thing and their activities (Adefemi, 2007). The present study deals with the characteristics the water nutrient chemistry, influenced by anthropogenic activity & quarrying of the geologically sediment environments and to determine the nature and degree of anthropogenic impacts on qualitative and quantitative variations occurred in nutrients in relation to physico-chemical parameters and Heavy Metals of river water and sediment.

Adequate understanding of the North-East regional streams is extremely important for the development of a realistic program for utilizing the potential of water that exist in the form of hidden water resource in the area. The impact of anthropogenic pollution from industrial, agricultural, sources, quarrying and tourists activity on water quality has concerned environmentalists and scientists for the past three decades. Ecological, geo-chemical and hydrological research has been carried out in various ecosystems to understand the factors controlling the chemistry of natural water (Baron & Bricker, 1990; Malik and Bharti, 2005a). Many of such studies have been under taken during the last two decades to understand the processes that control the hydrochemistry of alpine and

sub-alpine systems of North America and Europe (William *et al.* 1993 and Psenner, 1989).

The present study reveals to characteristics the water nutrient chemistry, influenced by anthropogenic activity & quarrying of the geologically sediment environments and to determine the nature and degree of anthropogenic impacts on qualitative and quantitative variations occurred in Heavy Metals in relation to physico-chemical parameters of river water and sediment.

***Study area:***

The Meghalaya has been surrounded by the natural beauties with lovely trees and cool climate, which is not only a pleasant place to live in but relaxing for holiday also. This is not only a popular state but also valuable or important place for tourism. Shillong is the capital of Meghalaya state. Mowlong Cherra Cement Ltd and Lafarge Umaim Mining Ltd are the major industries of the region. The all seven states of North East India are quite famous as Seven Sisters. Meghalaya is very well known for the record of rainfall, the state consists of the two places namely Cherrepunjee and Mawsinram for maximum rainfall throughout the year. So, the maximum water resources are depending chiefly on total precipitations of the region.

Population of the region is completely depending upon the river water for drinking, bathing, and other activities. *Meteorologically*, region has a cool & pleasant climate. *Geologically*, North-east hills are enriched with various minerals and the hills near Bangladesh are rich in limestone. *Geographically*, the study area is situated in the globe on a Latitude 25° 11' 5.8" N & Longitude 91° 37' 26.1" E for Upstream site and Latitude 25° 10' 51.9" N & Longitude 91° 37' 22.5" E for Downstream site.

## Materials and methods

The water samples were collected from Phrinkaruh River upstream (U/S sampling site A) near Phrinkaruh Village and downstream (D/S sampling site B) near Bangladesh border according to the analytical requirement in morning period 9:00 Hrs. to 10:00 Hrs. along with the water samples, sediment samples was also collected from the river bed with the help of Eckmen Dredge sediment sampler.

The water samples for physico-chemical parameters and Heavy Metals were collected by using rinsed Borosil glassware, and analyzed with the help of the procedure described by APHA (1995) and Trivedi and Goel (1984). Colour, odour, turbidity, velocity, temperature and Dissolved oxygen were analyzed on sampling sites. Samples were collected from selected sites and immediately preserved in ice boxes, and transfer to the lab for further analysis. Water and sediment samples were digested and Heavy Metals were detected using Atomic absorption spectrophotometer. Transfer Factor (TF) was calculated according to Bharti (2007) to assess the status of Heavy Metals transfer from river water to river sediment of Phrinkaruh river. Geo-accumulation factor ($I_{geo}$) and Enrichment factor (EF) were calculated according to Bharti (2007).

## Results & Discussion

Phrinkaruh river is flowing throughout a valley of North-east hills chain near the Bangladesh Border, enriched with limestone and lignite rocks, which affect the water quality of river according to the locations. Nutrients concentration, Heavy Metals and related physico-chemical parameters from selected sites are depicted in tables.

Phrinkaruh river has the spatial variations of water temperature, which plays a significant role in all physico-biochemical reactions and self-purification power of aquatic system (Badola & Singh, 1981). Higher value of temperature was found 17 °C in summer at downstream and minimum 12 °C in winter season at upstream. Turbidity is striking characteristic of the physical status of the water bodies. Although in Phrinkaruh river water is clear because there is no more pollution, siltation was the main source of turbidity in tributaries. Detritus and other non-organic material being added to water mass due to rainfall and anthropogenic activities (Camron, 1996). Maximum turbidity was recorded 8 NTU during rainy season at downstream and minimum 1 NTU in summer season at upstream. The maximum depth of photic zone provides the better biological production for all aquatic organisms (Malik and Bharti, 2005b).

Total dissolved solids were found in the range of 118 mg/l in summer to 148 mg/l in monsoon season, due to the gradual increases in velocity of river which favoured effective sedimentation (Subramanian, 1979). Chemical oxygen demand was found 5 mg/l to 8 mg/l during the study period. Chemical oxygen demand represents chemically oxidizable organic matter load in water, while biochemical oxygen demand is only biodegradable materials (Malik and Bharti, 2005c). In the present study the values observed during monsoon months may be attributed maximum biological activities and high temperature, stimulate the growth of microorganisms (William et al., 1993).

The pH of natural water was controlled in a great extent by the interaction of hydroxyl ions arising from the hydrolysis of bicarbonate (Sharma, 1986). The pH of Phrinkaruh river was recorded alkaline (7.5-8.4). Total hardness is mainly due to percentage of calcium and magnesium salts of bicarbonates, carbonates, sulphates and chlorides, while the value of alkalinity occured due to presence of bicarbonates. The concentration of hardness was analyzed 97-128 mg/l during the study. Alkalinity was also found 81-133 mg/l with a small fluctuation. A positive relationship between hardness and alkalinity was recorded in river Ganga at Rishikesh (Chopra and Patric, 1994). Maximum chloride concentration was recorded maximum (6 mg/l) in winter and minimum in summer (2 mg/l). Chloride and hardness showed a positive relationship to one another (Chopra and Patric, 1994). Chloride was found in the form of chloride ion, and one of the major inorganic anion present in natural water (Malik and Bharti, 2009).

Calcium and magnesium the dominant cations, and these represent the main weathering products, but significant hydro-chemical differences between the two sampling sites associated with the bedrock geology exist (Jenkins *et al.*, 1995). Calcium is one of the essential nutrients, which plays an important role in biological system. Maximum calcium concentration was recorded (48 mg/l) in monsoon and minimum in winter (26 mg/l). Positive relationship between, calcium and temperature was also reported by Khanna and Singh (2000) in river Suswa, Dehradun. Magnesium is also an essential element but it is toxic at higher concentration. The concentration of magnesium in Phrinkaruh river was found maximum (14 mg/l) and minimum (3 mg/l) and it was very low in comparison to Hill-streams of Uttarakhand (Bharti, 2004). During the summer season nutrients concentration in rivers and hill-streams became more. Miller *et al.* (1997) described the nutrients availability in selected

environmental settings of the Potomac River and Cameron (1996) showed the similar type of fluctuation in Fraser river of British Columbia. Bond (1979) described similar nutrients concentration pattern in a stream draining a mountain ecosystem in Utah. The concentrations of Calcium were observed in similar range in Phrinkaruh river water at upstream as well as downstream in comparison to rivers and hill-streams of North India, while magnesium was found in low range. Dissolved oxygen was found 8.1 to 9.8 mg/l at upstream and downstream during the study period. Heavy Metals were found almost nil or in very low concentrations at both selected site.

Heavy Metals like Cadmium, copper, iron, manganese, lead and zinc were not found in high concentration at both sites during any season. Cadmium, copper and manganese were absolutely absent in all seasons, while Lead, Zinz and Iron concentrations were also found below detection limit in maximum samples. The concentration of iron was maximum observed 0.06 mg/l during winter season. Lead was found 0.01 mg/l in winter season at upstream site and Zinc concentration was 0.02 mg/l in summer and monsoon season. Malik *et al*., (2009) described the role of Heavy Metals in the surface water of north India. The results of Bharti *et al*., (2010) were also indicated the relation of Heavy Metals and phytoplankton in a north Indian water body.

The physico-chemical characteristics of Phrinkaruh river sediment were found quite natural. It was found in silty sand category with 74% sand and 25% silt. Moisture, Ca, Mg and chlorides were found 6.1, 5.2, 0.6 and 0.3 % by mass respectively, while conductivity was observed 89 µmho/cm. Physico-chemical parameters of river sediments are also depicted in table-4.

Transfer factors from river water to sediment for all metals were found quite irregular. Transfer factor for cadmium was found 0, while it was found constant for copper in all seasons. It was found 93333.3, 46666.7 and 70000 in winter, summer and monsoon seasons respectively for Iron. Transfer factor was calculated 74000 in winter, summer and monsoon seasons for manganese. For Lead, transfer factor was calculated constant 6000. For zinc, transfer factor was calculated from 5700 to 22800. All results of transfer factors are depicted in Table-5.

Values for Igeo and EF for river sediment are given in table -6. The geo-accumulation index rating was not found positive for almost all metals. Igeo rating for lead was found 0.0, while rating was found with negative value. Besides Igeo index rating, metal value was not found more than 1.0. Enrichment factor was observed 0.0, 7.1, 1000, 10.7, 132.1 and 40.7 for Cd, Cu, Fe, Pb, Mn and Zn respectively.

The present results conclude that significant differences in river water nutrient concentrations exist among different environmental settings within the two subunits. Absence or low concentration of Heavy Metals shows that the water is still industrial pollution free. However, the Indian standards are not so strict (Bharti, 2007b), but Heavy Metals never cross the limits during the study period. On the basis of physico-chemical parameters and Heavy Metals, the water may be considered for drinking and other purposes.

**TABLE 1: Physical characteristics of Phrinkaruh river water**

| S.N. | Parameters | Unit | Phrinkaruh Upstream | | | Phrinkaruh Downstream | | | Desirable Limit |
|---|---|---|---|---|---|---|---|---|---|
| | | | Winter | Summer | Monsoon | Winter | Summer | Monsoon | |
| 1. | Temperature | °C | 12 | 16 | 15 | 12 | 17 | 16 | - |
| 2. | Colour | - | Clear | Clear | Clear | Clear | Clear | Clear | - |
| 3. | Odour | - | Nil | Nil | Nil | Nil | Nil | Nil | - |
| 4. | Turbidity | NTU | 1 | 4 | 7 | 1 | 5 | 8 | 5 |
| 5. | Velocity | m/s | 0.3 | 0.3 | 0.4 | 0.2 | 0.3 | 0.4 | - |
| 6. | TDS | Mg/l | 120 | 118 | 148 | 125 | 120 | 155 | 500 |

**TABLE 2: Chemical characteristics of Phrinkaruh river water**

| S.N. | Parameters | Unit | Phrinkaruh Upstream | | | Phrinkaruh Downstream | | | Desirable Limit |
|---|---|---|---|---|---|---|---|---|---|
| | | | Winter | Summer | Monsoon | Winter | Summer | Monsoon | |
| 1. | pH | - | 7.6 | 8.4 | 7.6 | 7.7 | 8.3 | 7.5 | 6.5-8.5 |
| 2. | Alkalinity | Mg/l | 92 | 81 | 133 | 96 | 85 | 130 | 200 |
| 3. | Total Hardness | Mg/l | 107 | 97 | 128 | 109 | 101 | 128 | 300 |
| 4. | Calcium | Mg/l | 38 | 34 | 48 | 26 | 34 | 38 | 75 |
| 5. | Magnesium | Mg/l | 3 | 7 | 12 | 4 | 11 | 14 | 30 |
| 6. | Chlorides | Mg/l | 5 | 2 | 5 | 6 | 4 | 5 | 250 |
| 7. | DO | Mg/l | 9.6 | 9.8 | 8.1 | 8.6 | 9.0 | 8.6 | - |
| 8. | BOD | Mg/l | Nil | 1 | Nil | Nil | Nil | Nil | - |
| 9. | COD | Mg/l | 6 | 8 | 5 | 5 | 6 | 6 | - |

**TABLE 3: Heavy Metals in Phrinkaruh river water and sediment**

| S.N. | Parameters | Unit | Phrinkaruh Upstream | | | Phrinkaruh Downstream | | | Phalankaruh Sediment mg/kg |
|---|---|---|---|---|---|---|---|---|---|
| | | | Winter | Summer | Monsoon | Winter | Summer | Monsoon | |
| 1. | Cadmium | Mg/l | BDL | BDL | BDL | BDL | BDL | BDL | BDL |
| 2. | Copper | Mg/l | BDL | BDL | BDL | BDL | BDL | BDL | 20 |
| 3. | Iron | Mg/l | 0.06 | 0.02 | BDL | 0.03 | 0.06 | 0.04 | 2800 |
| 4. | Lead | Mg/l | 0.01 | BDL | BDL | BDL | BDL | BDL | 30 |
| 5. | Manganese | Mg/l | BDL | BDL | BDL | BDL | BDL | BDL | 370 |
| 6. | Zinc | Mg/l | BDL | 0.02 | BDL | BDL | 0.02 | 0.02 | 114 |

BDL= Below Detection Limit

**TABLE 4: Physico-chemical characteristics of Phrinkaruh river sediment**

| S.N. | Parameters | Unit | Phrinkaruh Sediment | Method |
|---|---|---|---|---|
| 1. | Texture | - | Silty sand | IS: 2720 p-4 |
| 2. | Grain size analysis<br>Sand<br>Silt<br>Clay | % by mass | <br>74<br>25<br>1 | IS: 2720 p-17 |
| 3. | Moisture Content | % by mass | 6.1 | IS: 2720 p-2 |
| 4. | pH | - | 5.4 | IS: 2720 p-26 |
| 5. | Conductivity | µmho/cm | 89 | Conductivity meter |
| 6. | Calcium | % by mass | 5.2 | APHA (1998) |
| 7. | Magnesium | % by mass | 0.6 | APHA (1998) |
| 8. | Chlorides | % by mass | 0.3 | Volhard's method |

**TABLE 5: Transfer factor of Heavy Metals from Phrinkaruh river water to sediment**

| S.N. | Heavy Metals | Transfer factor | | |
|---|---|---|---|---|
| | | Winter | Summer | Monsoon |
| 1. | Cadmium | 0.0 | 0.0 | 0.0 |
| 2. | Copper | 4000.0 | 4000.0 | 4000.0 |
| 3. | Iron | 93333.3 | 46666.7 | 70000.0 |
| 4. | Lead | 6000.0 | 6000.0 | 6000.0 |
| 5. | Manganese | 74000.0 | 74000.0 | 74000.0 |
| 6. | Zinc | 22800.0 | 5700.0 | 5700.0 |

**TABLE 6: Geo-accumulation Index and Enrichment factor for Heavy Metals**

| S.N. | Heavy Metals | Geo-accumulation Index | | Enrichment factor |
|---|---|---|---|---|
| | | Value | Igeo | - |
| 1. | Cadmium | 0.01 | -6.49 | 0.0 |
| 2. | Copper | 0.30 | -1.75 | 7.1 |
| 3. | Iron | 0.04 | -4.66 | 1000.0 |
| 4. | Lead | 1.00 | 0.00 | 10.7 |
| 5. | Manganese | 0.29 | -1.78 | 132.1 |
| 6. | Zinc | 0.80 | -0.32 | 40.7 |

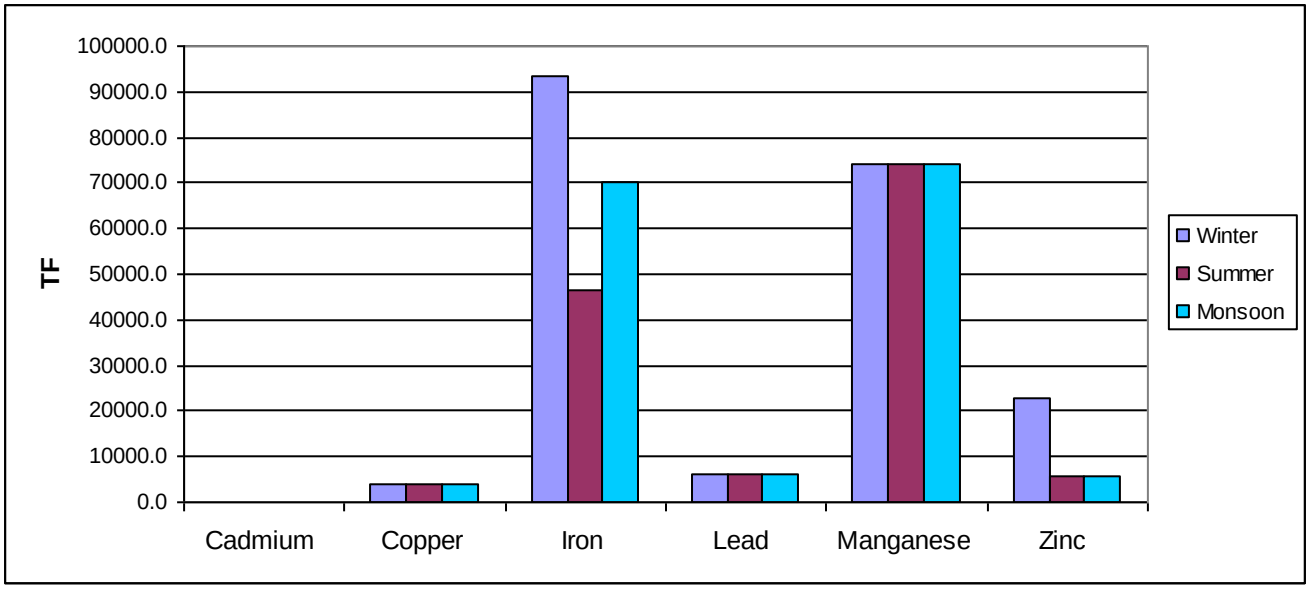


**Fig-1: Showing the Transfer factor for Heavy Metals in Phrinkaruh river water to sediment**

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