ABSTRACT
ION TRANSPORT BY THE RIVER SIANG (ARUNACHAL PRADESH) WITH SPECIAL REFERENCE TO DISTRIBUTION OF HEAVY METALS IN WATER AND SEDIMENTS

The river Siang, which is one of the major river systems of Arunachal Pradesh, has its origin in the Chama-Yung-Dung Glacier in Tibet at the Kailas range of the Himalayas. The river Siang is known as Tsangpo in its upper course in Tibet, which has given the districts of East, West and Upper Siang their names. After the river breaks through mountain ranges along the international border and makes its way into Indian territory east of Gelling in Upper Siang district, it flows south-south east until it takes a southerly turn. At Pangin, the river has bent towards the south east and has run up to Pasighat where it again sharply turns due south. Finally, the Siang descends down into the plains of Assam and meets the combined flow of the Dibang and the Lohit near Kobo in Jonai sub-division of Assam and becomes the mighty Brahmaputra River.

Pasighat, a small town on the banks of the river Siang (upper course of the river Brahmaputra) in Arunachal Pradesh, was a neat and clean town a few years back, but has been rapidly converted into a fast-growing urban center with large quantity of municipal garbage and domestic waste produced and dumped every day. The wastes ultimately find their way to the river Siang affecting the pristine quality of the river water. Moreover, the hilly terrain through which the river Siang flows down contains rich mineral deposits such as limestone, sulphides, ferrous minerals, etc. Weathering process may continually bring down the ions constituting these minerals into the river. Toxic heavy metals may also find their way to the aquatic environment from agricultural runoff, from leaching of metals from garbage and solid waste dumps and from animal and human excretion. Unabated deforestation along the banks of the river and soil erosion is changing the characteristics of the river continuously. The people residing downstream depend on the water of this river for all type of activities from drinking to vehicle washing. The turbulent nature of the river, particularly during the high-flood season, is responsible for flushed out the contaminants to the river.
Brahmaputra. During the lean flow period, when the river is tranquil, the contaminants grow in concentration, accumulate and get stored in accumulation the bed sediments. The sediment-water equilibrium may have important influences on the physical and chemical characteristics of the river water, and thus affect the people downstream.

Distribution and transport of heavy metals in aquatic environment is an important area of study. Last few decades witnessed a tremendous increase in the study of distribution of heavy metals in the major river systems in India. But Arunachal Pradesh is totally untouched in this regard though it has a web of rivers. The present study is an attempt to characterize the bed sediments and the overlying water with respect to the Siang river system. A number of physical and chemical parameters were measured for the bed sediment and the overlying water at nine different sites and for three feeder streams.

The sediments act as a valuable sink for a large number of pollutants. The study of sediment-water interactions help in computing the fluxes of heavy metals and the nutrients through the river systems and for understanding the mobility and bioavailability of these elements entering the aquatic system through pollutant discharges. Depending on the physico-chemical environment, the contaminants trapped in the sediment can leach out to the overlying water and therefore, such processes have to be taken into account in water management planning and in various sediment clean-up programmes.

The ion transport characteristics of the River Siang are thus investigated in this work with the following objectives:

➢ To determine the ion transport properties of the river Siang with respect to major cations and anions, and thus to find the ionic load carried by the river to the Brahmaputra
➢ To investigate the relationship, if any, between ion transport and general stability characteristics of the river, including stability, weathering behaviour and erosion properties.
➢ To evaluate the river geochemically by analyzing the heavy metals in different grain-size fractions of bed and suspended sediments.
To determine the chemical speciation of the important heavy metals in the sediments to ascertain their association with various fractions.

To investigate the competitive adsorption properties of important heavy metals on sediments in relation to their clay content, etc.


Chapter 1. The importance of heavy metal studies of the river basins at international and national levels is reviewed in Chapter 1. Starting with the interactions between a river and the environment, an attempt has been made to discuss the pollution in inland water bodies, ion transport by Rivers, mobility of dissolved trace metals, effects of contaminants in hydrological regime, etc., in the light of similar works on the rivers of the world.

Chapter 2. gives a general description of the study area with some geographical and geological features along with a brief idea of soil type and climatic condition of the study area. The various methods adopted for the analysis of water and sediments in the field and laboratory for the present study are described in brief along with the sample preservation techniques. The methods related to the analysis of total metals in water/sediment systems are presented along with the experimental conditions for the atomic absorption spectrophotometer are also presented here. The procedure for chemical speciation, adsorption/desorption study and the granulometric study of the sediments are also given in this chapter.

Chapter 3. Water chemistry of the Siang river water is discussed in the chapter 3. The water quality parameters such as pH, DO, TDS, EC, TS, hardness and temperature of the river water are tabulated and interpreted in this chapter to establish the river water characteristics. The major cations Na+, K+, Ca+2, Mg+2, Fe +3 and Al+3 and major anions such as Cl-, HCO3-, SO4-2, PO4-3, F- and dissolved silica as well as heavy metals such as Cu, Co, Cr, Cd, Mn, Ni, Pb, Hg, V, Zn were determined and the values of these parameters were found to be within the tolerance limit. From the dissolved ion concentration of the major cations and anions, carbonate
weathering is found to play a dominant role followed by silicate weathering in determining the water chemistry. The silicate and carbonate equilibrium diagrams are used to evaluate the weathering pattern within the river system. The correlations amongst the different pairs of parameters and their variation with time and space are also discussed. The linear relationships existing between pairs of variables were evaluated to show their inter-dependence for the river water.

Chapter 4. In this chapter, sediment chemistry of the river has been discussed. Geochemical characteristics of the river sediment were evaluated by analyzing a few important physico-chemical parameters such as pH, EC, organic matter content of the sediments, bulk density and texture of the sediments, heavy metal content and clay minerals present in the sediments. The heavy metal contents associated with different grain size fractions of the sediments were determined and were found to increase with the decreasing grain size. The metal contents of the sediments show a slightly downward decreasing tendency particularly in pre and post monsoon periods in the study area.

The bioavailability of the toxic heavy metals was determined by chemical speciation studies with respect to nine heavy metals. The distribution of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn in the five chemically distinguishable fractions, viz., the exchangeable phase (F1), the carbonate phase (F2), the reducible phase (iron and manganese oxides) (F3), the organic matter and sulphide phase (F4) and the residual or lattice phase (F5), has been presented with explanation of the significance. On the basis of the speciation results, the possible impact of the heavy metals in the surrounding ecosystem is described. Excepting Pb, the other heavy metals were found to be associated with the non-labile residual fraction while Pb was also found substantially to be associated with the labile fractions.

This chapter also contains the results of adsorption/desorption experiments carried out with the sediment with respect to Zn+2, Cu+2, Cr+6 and Pb+2. The adsorption behaviour was studied with variation of pH, contact time and different amount which have significant influence on the adsorption of the metal ions on the sediments. The mechanistic behaviour of heavy metal adsorption on sediments was worked out by applying adsorption isotherms and adsorption kinetics to the experimental results.
Chapter 5. In this chapter, the quality of the sediment was assessed by applying different statistical methods. Background values of heavy metal contents for World Rivers were compared with the geometric mean values of heavy metal concentrations obtained in the present work. The enrichment factors, PLI and SPI, were determined and their significances were discussed. Geoaccumulation indices (Igeo) were determined and the impact of heavy metal contents of the river basin was highlighted by differentiating between lithogenic and anthropogenic contributions.

Chapter 6 summarizes the results obtained in the present work by presenting a few conclusions and also a few suggestions for further work.

The thesis concludes with a complete list of references, consulted and found useful with reference to the present study.