CHAPTER 6

SUMMARY AND CONCLUSIONS

Keeping with its highly seasonal flow, the major ion chemistry of the Brahmaputra reveals dilution in the rainy season and a subsequent increase in ionic concentration during dry season. The water chemistry reflects a rock as well as precipitation dominance over the basin. Bicarbonates, and chloride are the major anions and calcium, magnesium, sodium and potassium are the major cations. Silicate weathering followed by carbonate weathering control the water chemistry of Brahmaputra.

Greater part of the suspended load in Brahmaputra is carried as medium to fine sands. Concentrations of suspended sediment increase downstream due to addition of newly derived materials through sediment laden tributary waters of the lower basin. A corresponding increase in clay size particles in the suspended load is reflected by the relative increase in concentrations of clay minerals. While quartz and feldspar dominate both bedload and suspended load, kaolinite and illite are the important clay minerals, montmorillonites being almost conspicuously absent. The individual signatures of tributary inputs to the mainchannel are not clearly noticeable due to the river's great width and relatively shallow depth which makes lateral mixing a slow process.

Factors that control the chemical composition of suspended matter in the Brahmaputra river are:
1) Weathering processes in different climates: although physical weathering processes are predominant in the basin, chemical weathering becomes stronger downstream in warm subtropical climate. This results in pronounced leaching of highly mobile elements such as Na and Ca, with relative accumulation (enrichment) of poorly mobile elements such as Fe, Al and heavy metals on suspended matter.

2) Geochemical characteristics of elements, i.e., the resistance to weathering.

3) Geological background level.

4) Anthropogenic activity over the basin.

Particulate organic carbon concentrations generally follow the respective sediment distributions, starting with the lowest concentrations upstream and gradually increasing with higher suspended load downriver. Pre-monsoon concentration of POC is almost double of that of monsoon. POC constitutes between 1% to 3% of the total suspended sediments. This is equivalent to concentrations from 1 mg C/l to 15 mg C/l. Seasonal fluctuations which are similar to that of the suspended sediments, depicts maximum values at rising and high water period.

The POC level in suspended matter is relatively higher in the lower reaches. The C/N ratios of the suspended matter show identical range though absolute concentrations of POC and PN over the basin is variable. Some of the tributaries draining the Himalayas contribute higher POC and PN to the main channel compared to those joining from the south.

Comparison of concentrations of the different forms of P between
suspended and bed sediments indicates decreases of organic-P and total-P after deposition and also a distinct drop in Fe bound P. Changes in P distribution upon transfer from suspended to bottom sediment are perhaps due to simple grain size difference, particularly in case of detrital P.

Apatite P (AP) forms a significant part of the suspended sediment P during high flow period, particularly in the upstream region. Only at locations where agricultural, industrial and/or municipal loads are large does the % AP relatively decreases due to inputs of materials rich in NAIP and OP. In Brahmaputra, Organic P (OP) content is variable and usually higher than AP towards downstream.

Because of uncertainties inherent in selective extraction, it is difficult to clearly establish the possible association of P with Fe, Al, Mn and Ca directly on dried sediment. Results show that in river suspended sediment, there is strong correlation between Fe and P which agrees with the present finding of abundant CDB extractable Fe-P in the same samples.

Factors that control heavy metal distribution and mobility in the Brahmaputra river are linked to weathering processes. This is indicated by the following observations:

- Except the organic fraction, non residual contents of metals are relatively lower than other Indian rivers. The same applies to N/T (non-residual/total concentration) ratio as a whole for both mainchannel and tributaries.
- The N/T ratio for upstream locations (1,2, 3) are comparatively lower.
- The mobility of heavy metals is in the order Fe > Mn > Zn > Ni > Cr > Cu > Pb > Cd.
Heavy metal averages in the suspended particulate sediments are lower than world averages; however, local pollution, though minor, do exist. The contemporary deposition of metallic forms in sediments on the river bed cannot be clearly distinguished from the record of metal concentrations in the core sediment profile alone. Variation in metal concentrations with depth is not significant.

Observations show an approximately fifteen to eighty fold increase of the suspended sediment concentration between the first and the last location (over a distance of about 750 Km). The concentration of metals on suspended particulates increase approximately three fold within the river. The increase is mostly due to the increase of clay size fractions in the suspended load.

The ratio of metal concentration in suspended and bed sediments are generally not high (<1.5) in monsoon samples (as the size distribution is not much different). However, in pre-monsoon samples the metal concentration in suspended load is about double of that of bed sediment. The clay fractions of both bed and suspended loads show similar metal contents.

The pattern of metal partitioning in sediments was similar to those reported for fluvial sediments elsewhere. The general trend in decreasing order is: Residual > Organic > Fe-Mn oxide > Carbonate > Exchangeable. A large part of the copper was organically bound, much of the zinc was contained in the residual (mineral) fraction while for lead the residual and Fe-Mn oxide and for Ni carbonate and Fe-Mn oxide forms predominated.
Bed sediments are contaminated to a limited extent with lead, copper, iron and cadmium near urban conglomerations. Remaining metals are well within background concentrations irrespective of increased concentration along downstream.

Esser and Kohlmaier (1991) identify five categories of anthropogenic activities leading to the release of biogeochemical elements to rivers, notably carbon, nitrogen and phosphorous:

i) Fossil fuel emission
ii) Food and feed production
iii) Fertilizer production
iv) Detergent production
v) Tropical deforestation

Anthropogenic impact upon rivers is principally felt by the aquatic biota (Degens et al., 1991). Additions of nitrate and phosphates stimulate photosynthesis while infiltration of pesticides and metals deteriorates environmental quality of rivers. Apparently, an isolated study of some major elements is not sufficient to the understanding of the riverine system of a large river such as Brahmaputra. Instead, an integrated, well-planned effort across a larger time frame involving all biogeochemical elements critical to life seems to be mandatory.