CHAPTER - VI
SUMMARY
CHAPTER - VI

SUMMARY

Pulp and paper mill effluent is a major pollutant of some streams and lakes. Waste discharge from the paper mill, if present in high enough concentrations, can be toxic to aquatic organisms (Walden, 1976; Roberts, 1977; Gore, 1981). As a consequence, benthic macro invertebrate and fish communities in recipient lakes and streams often have fewer species, lower densities, and altered taxonomic composition (Kelso, 1977; Vander Wai, 1977; Mayack & Waterhouse, 1983). In addition to lethal effects, pulp and paper mill effluent has been shown to have many sub lethal effects on fish. These include liver dysfunction (Oikari & Nakari, 1982), tainting of fish tissues, reduced growth rates (Whittle & Flood, 1977), and avoidance of polluted waters (Kelso, 1977).

The major concerns are with the ecotoxicological impacts in the receiving water bodies because large volume of wastewater are generated by pulp and paper mills and freshwater, estuarine, and marine ecosystem affecting aquatic biota and having negative effect on human health (Lacorte et al., 2003; Pokhrel, 2004).

The Nagaon Paper Mill, a unit of Hindustan Paper Corporation Limited situated at Kagajnagar in the Morigaon district of Assam, at the intersection of 92°47' East longitude and 21°2' North latitude was established in 1970 and started its commercial production from 1985. The present investigation was taken up to study the effect of paper mill effluent on the terrestrial and aquatic ecology and possible effect of contaminants on fish and earthworm.

To study the effect on aquatic system the Taranga beel that has been receiving waste water since 1985, was taken for detailed study. Certain water quality parameters, effect on fish diversity, trace elements in fish muscle and ultra-structural changes in gill and skin were studied similarly the adjacent agricultural land of Taranga beel was taken for studying terrestrial pollution. Soil quality parameters and concentration of trace elements in soil and earthworm was studied. Non industrial site 60 km away from the paper mill was taken as a control site (Tolibor beel).

The major findings of the investigation are presented below.
6.1 Assessment of aquatic pollution due to Paper mill effluent

A. Diversity of fish fauna.

The Taranga beel has been receiving waste water of paper mill since 1985. The diversity of fish was studied in the Taranga beel (Experimental area) and compared with Tolibor beel (non-industrial area) so as to ascertain whether there is any effect of treated paper mill waste water on the Ichthyofauna of the adjoining water body. The non-industrial pond is located about 60km away from the experimental site where no industrial unit is present in the neighbourhood. Eleven species of fishes belonging to eight genera, seven families, four orders and one division has been recorded from the study area (Site 1- Taranga beel, Jagiroad, Morigaon, Assam.) Among them six species are not evaluated (NE), four species is least concerned (LC), and one species falls under the category of Data deficient (DD) (IUCN, 2013.2). Most of the species are air breathing species adapted to hypoxic condition as well as tolerant to pollution.

Twenty-two species of fishes belonging to sixteen genera, ten families, six orders and one division have been recorded from the unpolluted beel (Tolibor beel, Site 2- away from industrial area). All the species of fishes recorded are riverine in nature, among them 19 species can have natural growth and development in stagnant water and 12 species among them can be regarded as pollution tolerant species. Out of the twenty-two species of fishes thirteen species is Least concerned (LC), six species is not evaluated (NE), Two species are near threatened (NT) and one species falls under the category of Data deficient (DD) as stated by IUCN status 2013.2.

B. Analysis of certain abiotic parameters of water and soil.

A detailed description on the study of certain physico-chemical parameters of the Taranga beel covering all seasons has been included. Certain water quality parameters such as Air temperature, Water temperature, pH, Turbidity, Dissolved oxygen, free carbon dioxide and Total alkalinity were studied. Water temperature ranged from 12.7 to 33.8 °C and air temperature ranges from 14.0 to 36.8 °C. pH of the beel water was found to lie in the range of 8.07 to 8.95. Turbidity of the beel water increased during monsoon period (June, July and August). Maximum
value (220 NTU) was recorded in the month of July. In the studied beel it has been observed that Dissolved oxygen content varied from 0.94 mg/l to 1.45 mg/l. The concentration of free carbon dioxide (FCO₂) in the beel fluctuates between 11.87 mg/l to 21.97mg/l. Total alkalinity (T.A) of the beel was found to lie between 110.6 mg/l to 159.8 mg/l. Lower values of alkalinity was recorded during monsoon and retreating monsoon and higher values were during winter and pre-monsoon.

C. Trace element Concentration in water and fish muscles.

The waste water and the water from the Taranga beel were analyzed for nine different trace elements; they are Cr, Ni, Cd, Mn, Se, Cu, Zn, Pb and Fe. The concentration of all the trace elements are within the permissible limit of EPA-1996, and BIS (1982) except Se, which have a concentration of 2.11ppm in bleached waste water collected from the drain and the water from the Taranga beel shows the concentration of Se, as 0.1ppm, while according to EPA-1996 and BIS (1982) the permissible limit in surface water is 0.05ppm.

For detecting bioconcentration factor the elements analyzed were Cu, Cr, Zn, Fe, Ca, Mn, Pb and Ni. The bioconcentration factor (BCF) of trace elements in fishes muscle was found in the order of: Fe(172)>Mn(145.67)> Zn(110.67) the other elements like Cu, Cr, Ca, Pb and Ni analyzed were not detected.

E. Effect of effluent on aquatic fauna.

Rivers, estuaries and beels are commonly repositories for large amounts of domestic and industrial waste. The majority of chemicals interact with the aquatic organisms have been found in waste water, effluents and in untreated industrial and domestic waste. Thus, fish living in these rivers, estuaries and beels environments can be considered as sentinel species for assessing the impact of pollution on the environment.

Fish gills are an efficient indicator of water quality (Kirk and lewis, 2013). Fish gills from experimental site and unpolluted site were studied. Fishes from Taranga beel exhibited major pollution induced changes in the gills of *A.testudineus* and *C.striatus*. Surface morphology of skin also showed degenerative modifications.
Skin of the healthy fish appears smooth with widespread of mucous gland opening. Fine accumulation of mucous secreting particles all over the skin surface was seen in the *Anabas testudineus* from the unpolluted area. However, the fish from the experimental area revealed erosion of skin surface associated with disruption of mucous gland and lesions. In the present study *A. testudineus* gill showed (fig: 7A & 7B) Epithelial cell lifting, epithelial hypertrophy, slight deformations of the lamellae, and fusion of adjacent lamellae. These aberrations were more prevalent and more pronounced in effluent exposed fishes than in the fishes from non-industrial area.

6.2 ASSESSMENT OF LAND POLLUTION DUE TO PAPER MILL EFFLUENT

A. Trace element accumulation in soil

In the present study, the concentration of trace elements in soil was in the order of: Fe>Mn>Zn>Cr>Ca>Cu>Ni>Pb. Among the trace elements, the maximum concentration was shown by Fe (12.87 – 17.94) while the minimum by Pb (0.008 – 0.084) in the soil samples where irrigation with paper mill effluent is done, metals such as Cr, Fe, Mn and Ni were found beyond the permissible limit of WHO (1998), the other trace metals like Cu, Zn and Pb were within the safe limits.

The inter-metallic correlation was found to be positive between Mn and Pb (P<0.05) (Table-10) in the top soil samples at different distance from Taranga beel. Positive correlation was found between Cu and Mn, Cu and Ni, Mn and Ni (P<0.01), while positive correlation is found between Cr and Pb (P<0.05) (Table-11) in the treated waste water irrigated soil. The correlation between the physico-chemical properties and trace elements shows Cu and Mn has positive correlation with pH (P<0.01) and Ni with pH and O.C (P<0.05) (Table-12).

B. Trace element accumulation in earthworm

Trace elements like Cr, Se and Pb was higher than the permissible limit of BIS (1982) and the elements like Cd, Cu, Zn and Fe were within the tolerance limit. The concentration of all the elements in the earthworm was found in the order of Se>Fe>Mn, Ni, Cd and Pb have the same concentration (0.01ppm) while Cr, Cu and Zn was below detection limit.
For detecting bioconcentration factor (BCF) the elements analyzed were Cd, Cu, Cr, Zn, Fe, Se, Mn, Pb and Ni. In experimental earthworm the bioconcentration factor of trace elements was found in the order of Se(0.809)> Cd(0.714)>Pb(0.5)> Ni(0.043)>Mn(0.009)> Fe(0.008) while Cr, Cu and Zn was not detected. Cd and Se were in higher range though the value was within permissible limit.

C. Physico-chemical analysis of soil

The analysis of top soil samples within the twenty feet distance shows the pH value ranges from 4.9 – 5.3, organic carbon ranges from 1.97 – 2.89, the soil nutrients N, P and K ranges from 137.37 – 174.23, 32.39 – 55.19 and 217.03 – 259.53 respectively. All the values are higher than the values from non-industrial area. While studying the impacts of paper mill effluents on characteristics of soil in Assam, Kumar et al., (2010) has reported that the effluent is rich in some plant nutrients and affected the physico-chemical characteristics of the soil as well. The present study reveals that the treated waste water from the pulp and paper mill can be used as alternative to fresh water irrigation and as a source of fertilizers, since it has high contents of both organic matter and nutrients (N, P and K) which are essential for crop production.

A comparison of trace element concentration of agricultural soil waste water released Taranga beel, Earthworm and fish allows us to summarize that the concentration of different elements in the agricultural soil was found in the order of Fe>Mn>Zn>Se>Cr>Cu>Ni>Pb>Cd. The order of concentration of different element in water of Taranga beel was Fe>Pb>Se>Cd, Zn, Mn and Ni shows the same concentration of 0.03ppm while Cr and Cu was below detection limit. The result of different elements for unpolluted soil was in the order of Fe>Mn>Cr>Se>Zn>Cu>Pb, while the Ni and Cd was below detection limit. The concentration of Fe was abundant in agricultural soil, beel water and unpolluted soil, Fe was followed by Mn in earthworm, agriculture soil and unpolluted soil. All the concentrations were within MPL (WHO, 1998 and EPA, 1996) though the values of Fe, Se, and Mn were higher than the Control values.