ABSTRACT

Impact of a textile mill on soil and water quality: a case study at Rangia, Assam (India)

Soil is the natural covering of most of the earth's land surface. It is the part where plants grow, ice lands, lava flows, dune moves, rock mountain stands. Soils are used to grow most of the world's food and much of its fiber. Soil is normally considered as a three-phase system - solid, liquid and gaseous, the liquid and gaseous matter occluded in the pores. When completely dry or frozen, soil becomes a two-phase system, the liquid phase being either absent or a part of the solid phase, but the soil pores still contain some gaseous matter. The three phases of the soil system have definite roles to play. The solid phase provides mechanical support and nutrients to the plants. The liquid phase supplies water and along with it, dissolved nutrients to plant roots. The aeration need of plants is satisfied by the gaseous phase. The soil's responsibility to sustain plant growth is thus shared complementarily by its three phases.

Since soil is a very specific component of the biosphere, it is not only a geochemical sink for contaminants but also acts as a natural buffer controlling the transport of chemical elements and substances to the atmosphere, hydrosphere and biota. Soil is generally contaminated by industrial wastes and effluents, domestic and municipal wastes and also by vehicular traffic.

Synthetic dyestuffs are extensively used in textile, paper, printing industries and dye houses. The textile industry utilizes about 10,000 different dyes and pigments in the world. Dyes are an abundant class of coloured organic compounds that present an increasing environmental danger. Many dyes are difficult to decolourise due to their complex structure and synthetic origin. There are many structural varieties, such as, acidic, basic, disperse, azo, diazo, anthroquinone based and metal complex dyes. The textile industry produces large quantities of highly coloured effluents, which are generally toxic and resistant to destruction by biological treatment methods. Textile wastewater, being mostly non-biodegradable under both natural and sewage treatment plant conditions, is a potential nuisance to the environment. The runoff comprises of

substances, used as auxiliary products in textile production and treatment. These polar organic pollutants in give rise to problems non-biodegradability and persistence.

APOL (Assam Polyester Co-operative Society Limited) is Assam's only textile mill near Rangia town in the district of Kamrup, Assam, just 50 kilometers north of Guwahati (26.11W, 91.47E). The plant covering an area of 38.02 acres of agricultural land was opened in June 1988 and started commercial production of spinning yarn of 5000 kg/day from November 1988, weaving and processing from November 1991. The installed capacity of the weaving unit was 8000 m/day and that of the processing unit was 20,000 m/day. The mill is producing yarn and cloths, especially viscose, polyester and acrylic fibre. In addition to this, to meet the growing demand of the local weavers, it has started manufacturing polyester mixed cotton yarn of variety of shades, blended with 'Eri' and 'Muga' yarn. The mill has its own dyeing unit with a capacity of 1500-2000 kg/day.

The northern and southern boundaries of the Mill are covered by scattered residential accommodation while the vast western side is open agricultural land. The effluent of the mill is released through this agricultural land. There is a historical earthen dam at a distance of about 125 meters from the boundary wall of the mill along the western direction. King Baidyadev built it during the period of 1138-1145 and the dam is about 6.4 km long and 6-8 meter wide. This dam divides the area into two sides (A and B), the side A is between the Mill and the dam, and the side B from the dam and beyond. The side A experiences more effluent load in comparison to side B.

The present work was designed to evaluate the impact of the textile mill effluents and other wastes on quality of soil and water of the surrounding areas. The principal objectives were:

- To monitor the quality of soil, particularly from the area receiving the Mill effluent, with respect to important physico-chemical properties, and compare the same with that of unpolluted or 'Control' soil from no-impact zone.
- To study the quality of water that keeps the agricultural land near the textile mill in a submerged condition.

- To study the quality of water from different sources (pond, dug well, tube well) in the impact zone to find out if there is any infiltration of the textile mill effluent.
- To investigate if the rice grain and husk have accumulated a few heavy metals that is found in the Mill effluent.

This thesis, reporting the results of the investigation, is organized into four-chapter viz. (1) Introduction (2) The Study area and Methodology (3) Results and Discussion and (4) Conclusion

Chapter 1 (Introduction) starts with a brief definition of soil and its composition. It also gives the outline of some of the soil contaminants and uptake of these contaminants by the crop plants, particularly heavy metals. The impacts of industrial effluent on drinking and surface water quality in and around an industry are also described in brief. A review of the relevant literature is also given.

Chapter 2 (The Study area and Methodology) gives a general description of Rangia with reference to the study area. The Mill and its activities are also briefly described. The sampling sites for collection of soil, water (surface as well as ground) and rice grain and husk collection and the sampling frequencies are described in detail. Samples for analysis were collected in two seasons, viz. (i) pre-monsoon (April – May) and (ii) post-monsoon (October – November) during three consecutive years. In total, 175 soil samples, 35 drinking water samples, 32 surface water samples and 5 rice grain samples were collected, analysed and compared with those of "Control" samples. The physico-chemical parameters selected for monitoring and their measurement methodology were also discussed.

Chapter 3 (Results and Discussion) **present the experimental data obtained from the measurements and a parameter wise discussion for different types of samples was included along with data tables and graphs. The results were discussed with respect to the distance of the sampling site from the Mill, the values obtained for the**

'Control' samples and wherever available, with WHO and other standards, and maximum permissible limits.

Important changes were observed with respect to the soil pH, which was from 2.5 – 7.0 for the study area. The soil samples were attaining almost normal pH values of Assam soil (5.5 – 6.5) as the distance from the Mill increased in any direction. The values were found less in the post-monsoon season than the pre-monsoon season. The soil samples in the study area were very rich in ionic content and more so in Side A. The EC values range from 0.02 – 3.51 mS/cm. The bulk density values were from 0.72 – 1.59 g/cm^3 and the soil samples in north, northwest and west directions were found to have gathered more organic matter compared to the soil in the other directions. The samples in Side B, away from the Mill, had less organic load in comparison to Side A, but the values exhibited the same trends as in Side A with distance. The water holding capacity of the soil samples was in the range of 51.1 – 81.0 %, and the mean values for all the batches were very similar. It was observed that the values obtained were lower during the post-monsoon season than the pre-monsoon values. The soil, which remained soaked with runoff during the rainy season, had been found to lose some capacity to retain water. The hydraulic conductivity values were from 0.19- 0.46 cm/min. The high values of hydraulic conductivity around the Mill in side A are consistent with the observation that the large amount of hydrophobic organic wastes dumped by the Mill in its vicinity has led to a loss of capacity of the soil to retain water. The predominantly sandy nature of the soil near the Mill has also led to increased hydraulic conductivity. In the Side B also, the hydraulic conductivity values decreased with distance indicating that away from the Mill, the water's capacity to retain water had improved.

The soil texture reflects sand 54- 74.7 %, silt 9.8 – 26.6 % and clay 10.6 – 26.3 %. The organic matter was present 0.61-4.96 % with high accumulation of organic matter in some samples of side A indicating release of organic matter from the Mill along with the effluent. As distance increased from the mill, the organic matter in the soil decreased showing that the Mill had a certain area of influence beyond which the organic matter content was not dependent on the contributions from the Mill. The soil did not contain much oil and grease although in some cases, the values may be quite high, e.g. 100 mg/kg. The total nitrogen was 0.02- 0.262% and the soil samples in north, northwest and west directions of Side A have comparatively more nitrogen than the other two directions (northeast and southwest). The nitrogen content was comparatively less in the Side B than in the side A. The available phosphorus was found from 0.09 – 3.4 mg/kg in Side A and B. In all the directions, soil samples away from the Mill had lower phosphorous content with a few exceptions. Among the common metals, calcium was present from 7.2 -86.1 meq/kg, which were likely to have influenced the study area soil composition. In side B, all the soil samples had much lower values of calcium in comparison to Side A. The soil had magnesium from 0.2 – 34.4 meq/kg and no distinct variation of the values could be seen in a particular direction and season. Sodium and potassium were found in the study area soil within the range of 0.24 – 6.36 meq/100 g and 0.05 – 0.82 meq/100 g respectively. In both the cases, the samples from Side B have more contents than the Side A samples. With respect to the trace metals, As and Hg could not be detected in samples mostly from the Side B and the overall ranges were As: BDL – 21.78 μg/kg Hg: BDL– 20.6 mg/kg. Both Al and Fe were present in large amounts, the ranges being Al: 1 6- 89 g/kg and Fe: 1- 30 g/kg. Substantial amounts of Cd (range 0.9 – 26.3 mg/kg), Cr (range 24.7 – 298.8 mg/kg) and Cu (range 46 – 1203 mg/kg) were observed in all the soil samples. Though Cd was obtained more in Side B, all the three metals had a decreasing trend away from the Mill. Mn content (range 13.2 – 162.7 mg/kg) was lower than the world average, but large amounts of Ni (range 21.5 – 101.0 mg/kg), Pb (range 12 – 71.4 mg/kg) and Zn (range 156 – 1872 mg/kg) were observed in all the soil samples.

The results of analysis of the drinking water samples from the study area were compared with the WHO guideline values. pH was within the range of 6.1 – 8.4. The electrical conductivity was from 0.13 – 0.64 cm/mS, which indicated entry of considerable load of dissolved salts into water. Total alkalinity was from 61 – 603 mg/L, and some samples recorded alkalinity values almost in the higher range of the permissible limit. This shows that continuous discharge of effluents by the mill may raise the total alkalinity of the water in the area above the permissible limit.

In case of total solids (range 202 – 1464 mg/L), distinct seasonal variation was observed. Total dissolve solids was within the range of 168- 984 mg/L. The total hardness (range 60- 195 mg/L) values were comparatively higher in the water samples collected during the post-monsoon season. Phenol was below detection level in most of the samples but a few samples had phenol in the range of 0.08 – 0.61 mg/L, which were much above the EPA permissible limit.

Chloride (range 20.7– 85.2 mg/L), sulphate (range BDL – 48 mg/L) and nitrate (range BDL – 5.9 mg/L) were within the WHO permissible limits for drinking water. The values for fluoride were in the range of 0.8 - 1.67 mg/L and some of the sources had fluoride in excess of the WHO guideline value for drinking water quality. Most of the water samples had phosphate (range BDL – 0.7 mg/L) more than the USPHS limit (0.1 mg/L). Calcium (range 10.4 – 43.9 mg/L), magnesium (8.74 – 25.38 mg/L), sodium (range 5.8 – 60.8 mg/L) and potassium (range 2.2 – 12.8 mg/L) were found in the drinking water samples within the desirable limits. Among the metals, Al (range 1.85 – 9.60 mg/L), Cd (range 0.20 – 0.53 mg/L), Cr (range 0.21– 2.70 mg/L), Fe (range 0.36 – 7.36 mg/L), Ni (range BDL – 0.5 mg/L) and Pb (range BDL – 0.72 mg/L) were measured in different ranges some of which were quite high. As (BDL – 0.008 μg/mg), Cu (0.001– 0.962 mg/L), Hg (BDL – 0.004 mg/L), Mn (0.07 – 0.96 mg/L) and Zn (0.08 – 1.32 mg/L) were within the permissible limits.

For the surface water samples, pH was from 3.4 – 8.0. EC (range 0.12- 3.01 cm/mS) and total alkalinity (range 61 – 1250 mg/L) contents were high in the surface water. Total hardness was within the range of 60.0 – 221.0 mg/L whereas substantial amounts of total solids (range 530 – 8340 mg/L) and total dissolved solids (range 260 – 3380 mg/L) were available in the surface water. Chloride (range 17.8 – 326.6 mg/L) , fluoride (range 0.2 – 6.9 mg/L), sulphate (range 18.0 – 203.0 mg/L) and phosphate (range BDL – 1.6 mg/L) were also found to be high in the study. Substantial amounts of phenol (range BDL – 1.8 mg/L) and oil and grease (range BDL – 333.89 mg/L) in the surface water of the area gave a clear indication of the industrial effluent having definite impact on the surface water quality.

The presence of nitrate (range BDL – 9.0 mg/L), Ca (range 12.0 – 72.0 mg/L), Mg (range 3.0 – 29.0 mg/L) and K (range 2.0 – 24.4 mg/L) was not considerably high. Na content was within the range of 10.7 – 288.5 mg/L. The ranges of values for other metals present in the surface water were Al: 4.7 – 71.4 mg/L, As: BDL – 0.0018 μg/mg, Cd: 0.01 – 0.32 mg/L, Cr: 0.02 – 1.98 mg/L, Cu: 0.021 – 2.13 mg/L, Fe: 0.5 – 13.5 mg/L, Hg:

BDL – 0.045 mg/L, Mn: 0.05 – 9.07 mg/L, Ni: BDL – 3.9 mg/L, Pb: BDL – 0.23 mg/L, Zn: 0.1 – 4.21 mg/L.

In the rice grains, no As and Hg could be detected. However, the grains contained other metals in the ranges of Al: 30.23 – 110.5 mg/kg, Cd: 0.67 – 1.66 mg/kg, Cr: 1.4 – 2.4 mg/kg, Cu: 4.3 – 10.2 mg/kg, Fe: 36.0 – 59.0 mg/kg, Mn: 38.1 – 60.0 mg/kg, Ni: 0.93 – 3.1 mg/kg, Pb: 1.6 – 8.82 mg/kg, Zn: 18.77 – 61.6 mg/kg. The rice husks were found to contain more of the different metals than the rice grains from the study area a few exceptions.

The results have been discussed with reference to similar works of other workers and the variation as well as the distribution patterns for various parameters was presented in details.

Chapter 4 (Conclusion) gives a summary of the results and the conclusions drawn on the basis of the investigation about the impacts of the Textile Mill on the quality of soil and water in the study area. Suggestions for further work have also been formulated.

The thesis concludes with a complete list of References consulted during the present work for discussing the results.