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Original Article

The Effect of Pulp and Paper Industry Effluent on the Biological and Bacteriological Parameters of River Hindon

Asha Mishra[1], Rakesh Kumar Pande[2]

[1]Department of Zoology, H.R.P.G College Khalilabad, Sant Kabir Nagar, Uttar Pradesh, India, [2]Vice-chancellor, Dr. C. V. Raman University, Vaishali, Bihar, India

Abstract

The effluent from the industries may cause water pollution and result in the altered growth of zooplankton and phytoplankton. The identification and characterization of these species may help in determining the pollution caused by industrial effluent merging into the river. The pulp and paper mill (Star Paper Mill, Saharanpur) discharging effluents directly into the river Hindon were analyzed in the present study. The effluents from the pulp and paper mill were discharged through a canal into the Hindon river. The investigations were carried out from 2002 to 2003, in all the three seasons to assess the influence of effluent, on planktonic abundance and diversity in different seasons.

Key words: Bacteriological, Biological, Effluent, Pulp and paper mill and ETP, River Hindon

INTRODUCTION

In the western district of Uttar Pradesh, mainly Saharanpur, Muzzafarnagar, Meerut, and Bulandshar, a large number of lotic, lentic, and perennial water resources are present, which are used mainly for irrigation, fish catch, to procure fish seed, and fingerlings. The same water resources are also utilized for the disposal of the industrial wastes of about more than 20 different industries. The main water resources of this region are river Hindon, Kalinadi, Krishna, Ganga, and Jamuna with their respective tributaries and four canals. Since the rives are an important natural source of water, maintaining water quality in them is indeed vital for all life because most of the rivers of the country suffer from pollution on one stretch or the other. According to the ministry of water resources, polluted and less polluted stretches of some major rivers have been identified.[1] Hindon, a stretch between Saharanpur to the confluence with the Yamuna has been identified as highly polluted and this stretch has been categorized in Class E (as per the primary water quality criteria of CPCB, 1984) with a critical situation of DO, BOD, and the toxic substances dissolved in it.[2]

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United States Public Health Service (USPHS) 1996 laid down that sample of water from approved areas shall not show the most probable number (MPN) of coliform in excess of 70 in 100 ml.[3] More than this, the areas should be classified as glossy polluted.[4] *Escherichia coli* and *Entrococci* are considered logical indicators of fecal pollution.[4] Hindon water can be placed under the category of glossy polluted as these bacterial counts are very high up to 10,000/100 ml.[5] Algae and ciliates have also been suggested as indicators of pollution.[6,7] Changing patterns of plankton composition have also been proposed as an indicator of water pollution.[8-11]

Many Indian rivers are studied in the last three decades on the algal taxonomy.[12-14]

The determination of algal and other biological agents is a good indicator of the pollution level of the river. In the present study, the biological and bacteriological parameters have been studied under the stress of the pulp and paper

Corresponding Author: Asha Mishra, Department of Zoology, H.R.P.G College Khalilabad, Sant Kabir Nagar, Uttar Pradesh, India.

industry (Star paper Mill, Saharanpur) effluent. The effect of this effluent has also been studied on the water quality of the river Hindan.

MATERIALS AND METHODS

Water samples were collected from five sites that comprise of pre-discharge point, discharge point, and post-discharge point of the effluent from the Star paper mill, Saharanpur. A total of five samples were collected from different locations. During sampling, all precautions were taken, as suggested according to the standard methods for the "examination of water and waste water sewage." Samples were collected at five sites: Effluent treatment plant (EFT) (I), effluent at 1 km away EFT (II), pre-discharge point (III), discharge point (IV), and post-discharge point (V). Total coliform was determined by the multiple tube fermentation technique. Fecal coliform was detected by the fecal coliform membrane filter procedure. Plankton study was made by collecting 100 L of water and filtering it through a bolting silk net, and the concentrate was preserved in 5% formalin solution. Plankton count was made with Sedgwick-Rafter counting cell under a research binocular microscope. Effluent and water samples for bacteriological analysis were collected in sterile bottles of 500 ml capacity and were brought into the laboratory in an icebox, and incubation was made within 6 h of collection. Bacteriological examination for *E. coli* and Enterococci was done according to the method suggested by APHA.[15]

RESULTS AND DISCUSSION

Bacteriological Characteristics

Biological characteristics happen to be the indicators of the water quality which also represents the extent of organic contamination. The total coliform ranged between 72 and 279/100 ml at ETP and 1 km away ETP, whereas, at Site III, it ranged between (16 and 49/100 ml), whereas, Sites – IV and V, it ranged between 89 and 324/100 ml. Based on these parameters, samples collected at the pre-discharge areas were not polluted and those collected at site III and site IV can be considered as moderately polluted. In the present investigation, the fecal coliforms have been found positive in all three seasons and at all the five sites. As the growing number of bacteria is indicative of a measure of organic pollution, it indicates that the water is polluted with organic matter. Two hundred meters downstream at site number five reflect that the self-purification process has begun. This process has been reported before in other studies.[16,17] Table 1 summarizes the bacteriological characteristics of the river water at different sites of sample collection.

Table 1: Comparative bacteriological characteristics of the effluent of pulp and paper mill and Hindon river at effluent sites. The river water samples were collected in 2002–2003. Season is summer, rainy, and winter

Biological parameters	Site I	Site II	Site III	Site IV	Site V
Total coliform	203	244	29	270	188
(MPN/100 ml)	72	86	16	108	89
	231	279	49	324	192
Fecal coliform	+ve	+ve	+ve	+ve	+ve
	+ve	+ve	+ve	+ve	+ve
	+ve	+ve	+ve	+ve	+ve

Phytoplankton

The phytoplanktons in river Hindon have a diverse assemblage of major taxonomic groups. Many of these forms have different physiological and environmental requirements depending on the number, type, and distribution of these organisms present in any aquatic environmental factors interact to provide conditions for the growth of planktons, both specialty and seasonally. Table 2 summarizes the main phytoplankton observed in this study.

The group *Chlorophyceae* are indicative of progress in recovery and regeneration of polluted water, as most representatives of the group do not thrive in the deoxygenated waters. Many algal species grow nicely in the river water with a good amount of dissolved oxygen. *Chlorophyceae* were represented by genera *Cosmarium, Closterium, Scenedesmus Pediastrum, Spirogyra, Volvox, Oedogonium,* and *Zygnema* in this study. Maximum genera (5) were observed at Site – III.

The periodicity of Myxophyceae has been well studied in various aquatic systems and there are mainly three factors that influence Myxophyceae populations. They include temperature, organic matter, and dissolved oxygen. In the present study, they were represented by the genera *Spirulina*, *Nostoc*, *Microcystis, Oscillatoria Anabaena,* and *Phormidium*. The maximum of three genera was recorded at Site – III. The enrichment of water with high nitrogen and phosphorus is associated with high temperature which enhances the growth of *Microcystis.*

Zooplanktons

Like phytoplankton species, a few zooplankton species are also considered by many ecologists as indicators of organic pollution; thus, protozoans as an indicator of organic pollution have been described by few studies[18-20]. Unlike phytoplankton, most of the zooplanktons show the reverse relationship with the pollution except protozoans and insects. In polluted stretch, the protozoans and insects occur in quite large numbers which indicate the polluted condition of the water [Table 3].

Table 2: Comparative phytoplankton's characteristics of the effluent of pulp and paper mill and Hindon river. Season is summer, rainy, and winter

Biological parameters	Season	Site I	Site II	Site III	Site IV	Site V
Chlorophyceae	S	Cosmarium-3	Cosmarium-2 Cosmarium-1	Pediastrum-2 Closterium-2 Spirogyra-2	Pediastrum-3 Closterium-3 Spirogyra-3	Pediastrum-3 Spirogyra-1
	R		Scenedesmus-2	Spirogyra-3 Volvox-4 Oedogonium-1 Cosmarium-2 Zygnema-1	Spirogyra-4 Volvox-4 Zygnema-2	Spirogyra-6 Volvox-5 Zygnema-2
	W	Cosmarium-2	Cosmarium-1 Closterium-3 Scenedesmus-2	Volvox-5 Closterium-3 Cosmarium-1 Scenedesmus-1	Zygnema-2 Scenedesmus-3 Cosmarium-1 Volvox-4	Zygnema-3 Scenedesmus-3 Cosmarium-2 Volvox-4
Myxophyceae	S	Spirulina-2	Spirulina-3	Spirulina-1 Microcystis-2 Oscillatoria-1	Microcystis-1 Anabaena-1 Phormidum-1	Microcystis-3 Phormidium-2
	R		Nostoc-1	Oscillatoria-2 Nostoc-2 Microcystis-1	Anabaena-2 Nostoc-13	Phormidium-2 Nostoc-6
	W			Nostoc-3 Oscillatoria-3 Microcystis-4	Nostoc-1	Nostoc-4

Table 3: Comparative biological zooplankton characteristics of effluent of pulp and paper mill and Hindon river at effluents. Season is summer(S), rainy (R), and winter (W)

Biological parameters	Season	Site I	Site II	Site III	Site IV	Site V
Protozoa	S		Euglena-3 Paramecium-2	Euglena 12 Paramecium-5 Difflugia-2	Euglena-6 Arcella-1 Centropyxis-2 Epistylis-1	Euglena-5 Arcella-1 Centropyxis-1
	R		paramecium-2	Nebela-1 paramecium-6 Epistylis-2	Nebela-1 paramecium-7	paramecium-7 Nebela-2
	W		Nebela-1 Euglena-3	Nebela-1 Euglena-2	Phacus-2 Difflugia-2 Euglena-5	Nebela-1 Euglena-4
Rotifera	S		Monostyla-1 Distyla-1	Distyla-1 Rotaria-2	Distyla-1 Rotaria-2 Monostyla-4 Brachionus-1	Distyla-1 Rotaria-2
	R		Distyla-1	Euchlonis-2 Distyla-1	Euchlonis-6 Brachionus-4 Distyla-1	Euchlonis-3 Brachionus-1
	W		Distyla	Rotaria-1 Distyla-2 Monostyla-1	Rotaria-6 Distyla-4 Brachionus-2	Rotaria-2 Brachionus-3

The protozoan group was represented by *Englen, Paramecium, Nebela, Difflugia, Epistyls, Arcella, Centrophyis*, *and Phacus.* The total protozoan population was highest at Sites – III and IV, indicating water was polluted at these sites. Entomostraca group also shows an uneven distribution. At Sites – III and IV, around 3-4 genera were present, whereas, at Sites – I and II, they are absent, perhaps due to the intense pollution. *Copepoda, Cladocera,* and *Ostrocoda are* the main groups from the class Entomostraca, which are represented in the present investigation. In general, the representatives of Entomostraca do not occur in polluted or toxic waters. It has been shown that the impact of pollutants in marine tropical coastal water the results indicate an increase in the nutrient levels of pulp wastewater (eutrophication), which causes an enhancement of the reproductive rate of copepods and a decrease in density of other zooplankton taxa and ichthyoplankton. The rotifers formed the most important group of zooplanktons. In the present study, the main genera observed were *Distyla, Monostyla, Euchlonis, Roteria, and Brachionus.* At Site – III,

(7) genera were recorded, and at Site – IV, (6) genera were recorded, whereas, at Site – V, (4) genera were present. At the site I, Rotifera are absent, however, at site II, they are represented by two genera.

CONCLUSION

The chemical substances resulting from pulp and paper mill effluent can cause long-term effects on zooplankton and phytoplankton. Among these chemicals, there are fibers and other settleable solids, substances that stimulate algal growth. These can also cause the eutrophication, and accumulation of these chemicals result in chronic-toxicity to the zooplankton and phytoplankton.

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