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IMPACT OF PULP AND PAPER MILL EFFLUENTS ON THE DIVERSITY OF MACRO-INVERTEBRATE FAUNA OF GANGA RIVER AT BIJNOR, U.P., INDIA

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ABSTRACT

Impact of pulp and paper mill effluents on the diversity of benthic macroinvertebrate in Ganga river at Bijnor, UP, India was investigated from four selected sites July, 2007 to June, 2009. A total of 13 genera of benthic fauna belonging to 6 orders viz. ephemeroptera (4 genera, 30.7%), plecoptera (2 genera, 15.3%), diptera (3 genera, 23%), odonata (2 genera, 15.3%), leptostraca (I genus, 7.6%) and decapoda (1 genus, 7.6%) were recorded where Ephemeroptera was reported as the most abundant order at all the sites. It has been observed that as the site-II is the discharge point of the effluents, minimum diversity was recorded, while site-III has the maximum generic diversity which was 500 mts away from the discharge point which is clearly documenting the harmful effects of industrial effluents on the benthic fauna. Diversity index was also recorded maximum at site-IV with value of H' as 0.557 while it was found to be minimum at site-II as 0.248. Benthic density was reported to be higher during winter months.

KEYWORDS: Benthic Fauna, Pulp and Paper, Diversity, U.P. Macro-Invertebrate

INTRODUCTION

Pulp and paper products are made from three major types of fibres: wood, recycled fibres, and non-wood fibres, however most pulp and paper products are wood-based. The pulp and paper industry, because of its diverse nature, can release a wide range of compounds into the aquatic environment. Pulp and paper effluents have implicated fibre and suspended solids, colour and turbidity, and organic and nutrient enrichment loads as the three pollutant factors with adverse environmental consequences (Owens, 1991). Pulp mill effluents have been associated with various impacts on water quality and aquatic biotic system in the receiving water bodies. While most research on pulp and paper mill effluent has focused on the effects on fish and fisheries resources, studies that have investigated the effects on benthic assemblages have reported an increase in abundance, together with some combination of increases, decreases, or no change in taxon richness, depending on the degree of eutrophication (Sprague and McLeese 1968; Marier 1973; Shumway and Palensky 1973; Culp *et al*. 2000). The chemical composition of each effluent varies drastically, making the assessment of their environmental impact a difficult task. Moreover, the complexity and natural variability of biological systems make it difficult to provide definitive answers with regard to the environmental impacts of effluents (Kovacs et al., 1995). Other studies have revealed uptake of contaminants by benthic fauna in areas exposed to pulp and paper mill effluents (Etiégni *et al*. 2007; Meriläinen and Oikari 2008). Because of their abundance and position in the aquatic food chain, benthos plays a critical role in the natural flow of energy and nutrients.

As benthos die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain. Unlike fish, benthos cannot move around as much, so they are less able to escape the effects of sediment and other pollutants that diminish water quality. Therefore, benthos can give reliable information on stream and lake water quality. Their long life cycles allow studies conducted by aquatic ecologists to determine any decline in environmental quality. Results from these studies show that the evaluation of biotic communities offers a comprehensive alternative to the

use of physicochemical parameters when assessing the impact of pulp and paper mill effluents on the aquatic environment. The purpose of this study was to investigate the impact of pulp and paper mill effluents on the hydrography and biology macroinvertebrate assemblages in relation to changes in water quality arising from discharges from a pulp and paper mill effluents. Such information is necessary in assessing, monitoring, and managing the river and other similar water bodies.

MATERIAL AND METHODS

Benthos were collected at four selected sites on Ganga river viz. site-I (control), site-II (discharge point), site-III (500 mts from the discharge point) and site-IV (1000 mts from discharge point) by enclosing one square meter area of bottom. The bottom stones, gravels and sand were unturn to dislodge the benthic life. Each animal was collected with the help of forceps and brushes and were preserved in 5% formalin for identification. For the identification of benthic fauna the standard references like Pennack (1978), Ward and Wipple (1992) and APHA (1998). Species composition was calculated from ach sites and quantitative analysis were done as per formula

N= O x 10000/AS

Where, N = Number of benthos in one square meter

O = Number of benthos actually counted

A = Transverse area

RESULTS

During the period of investigation, a total of 13 genera of benthic fauna belonging to 6 orders viz. ephemeroptera (4 genera, 30.7%), plecoptera (2 genera, 15.3%), diptera (3 genera, 23%), odonata (2 genera, 15.3%), leptostraca (I genus, 7.6%) and decapoda (1 genus, 7.6%) were recorded.

Ephemeroptera was reported as the most abundant order with 4 genera and percentage composition as 36.3% followed by odonata (2 genera, 18.1%), diptera (2 genera, 18.1%), plecoptera (2 genera, 18.1%) and leptostraca **(**1 genus, 9 %) at site-I (**Table 1 Figure 1)**. Among ephemeroptera, *Ephemerella* (Nymph*)* and *Chironomus* (Nymph) and *Tendipestentans* (Larva) Among diptera were the dominant genera **(Table 1)**. At site-II, 8 genera belonging to 4 orders with ephemeroptera (4 genera, 50%) as the most abundant order were reported followed by diptera (2 genera, 25%), plecoptera (1 genus, 12.5%) and leptostraca (1 genus, 3%) (Fig.2). Site-III was reported to be the most diverse site with a total of 13 genera belonging to 6 orders (Fig.3) The most abundant order reporteted again was ephemeroptera (4 genera, 30.7%) followed by diptera (3 genera, 23%) **(Table 1)**. At site-IV, 11 genera belonging to 6 orders of benthic fauna were recorded. The maximum number of genera was recorded from order ephemeroptera (4 genera, 36.3%) followed by odonata (2 genera, 18.1%), diptera (2 genera, 18.1%), plecoptera (1 genus,9 %), leptostraca (1 genus, 9%) and decapoda (1 genus, 9%) (Figure 4).Among ephemeroptera, adult Mayfly, *Baetis* (Nymph), *Stenonema* (Nymph) and *Ephemerella* (Nymph) were recorded throughout the period of investigation while among among odonata, *Lestes* (Nymph) and *Macromia* (Nymph*)* were recorded frequently. It has been observed that as the site-II is the discharge point of the effluents, minimum diversity was recorded, while site-III has the maximum generic diversity which was 500 mts away from the discharge point which is clearly documenting the harmful effects of industrial effluents on the benthic fauna.

Diversity index (**Table 1)** was recorded maximum at site-IV with value of H' as 0.557 while it was found to be minimum at site-II as 0.248. Density of benthos (**Table 1**) recorded per sq.mt was ranged between 0 – 9 organisms at

site- I, 0-11 organisms at site- II, 0 - 10 organisms at site- III and 0 – 9 organisms at site- IV. Density was reported to be higher during winter months.

DISCUSSIONS

The taxa recorded at the upstream site mainly belonged to the pollution sensitive Ephemeroptera (Raburu et al. 2009). As a consequence of the effect of the effluent discharges on water quality, the sensitive taxa were replaced by tolerant *Chironomus* sp., *Pedicia* sp., *Tabanus* sp. (Diptera), which have been found to be tolerant to high organic loads from industrial discharges (Raburu and Tonderskii 2004). This can be confirmed by the fact that the Ephemeroptera taxa recorded at the upstream site (e.g. *Baetis* sp., *Philopotamus* sp., and *Caenis* sp.), are among the most tolerant groups to eutrophication (Thorne and Williams 1997), Findings in this study are in agreement with results from studies elsewhere on the effects of pulp mill effluent on benthic assemblages in mesocosms in which the composition of benthic invertebrates was significantly altered (Culp *et al*. 2003).

These factors include substrate, suspended sediment, gradient, water temperature, and stream order and width. Sharma *et al.,* (2000) investigated the concentration of heavy metals in benthic macroinvertebrates in the western Yamuna canal, New Delhi and observed that heavy metals were high in the upstream except lead. They stated that western Yamuna canal was getting polluted due to addition of different pollutants from anthropogenic sources. Rumana (2001) investigated benthic biodiversity of streams of western Himalayas and identified 32 genera of benthos out of which ephemeroptera (13 species) reported maximum genera as observed during the present investigation. He also found maximum benthos abundance in the post monsoon and winter season. Duran and Suizmez (2007) observed benthic macroinvertebrates with high species richness in stream Cererek of Turkey dominated by ephemeroptera, plecoptera and trichoptera. They noticed that *Planaria, Canies, Capnia, Similium, Philopotamus* and *Hydropsyche* were major indicators of pollution and the *Asellus, Lymnea, Planorbis* and *Baetis* sp. were dominant and frequent in weakly polluted water.

Varadharajan *et al*., (2010) observed the seasonal abundance of macro- benthic composition and diversity in the five different coastal areas of India. They observed that polychaetes were the dominating group followed by decapods, bivalves, gastropods, amphipods and isopods. Nesemann *et al*., (2011) recorded 95 invertebrate taxa in the river Ganga in the endangered Gangatic dolphin habitat. They found benthic sediment fauna rich in diversity and high in abundance.

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APPENDICES

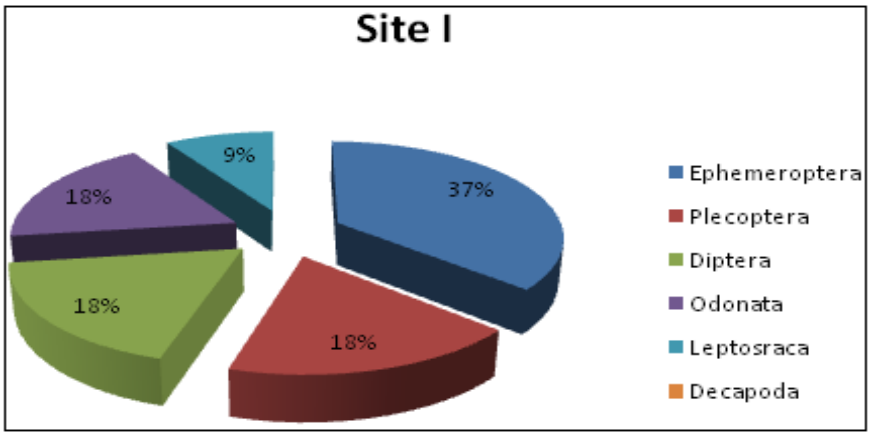

Figure 1: Percentage Composition of Benthic Fauna Recorded during July, 2007-June, 2009 at Site- I

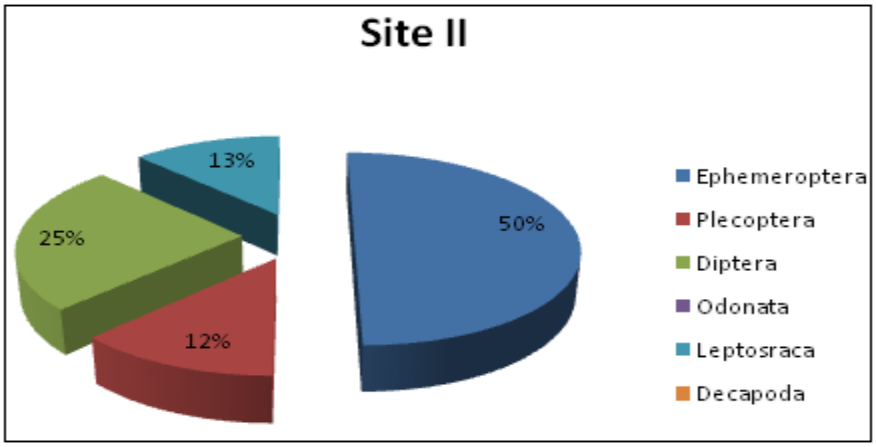

Figure 2: Percentage Composition of Benthic Fauna Recorded during July, 2007-June, 2009 at Site- II

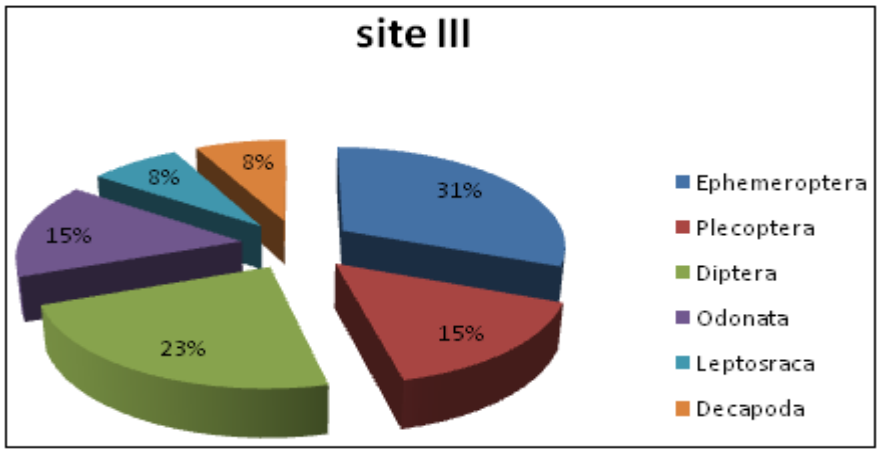

Figure 3: Percentage Composition of Benthic Fauna Recorded during July, 2007-June, 2009 at Site III

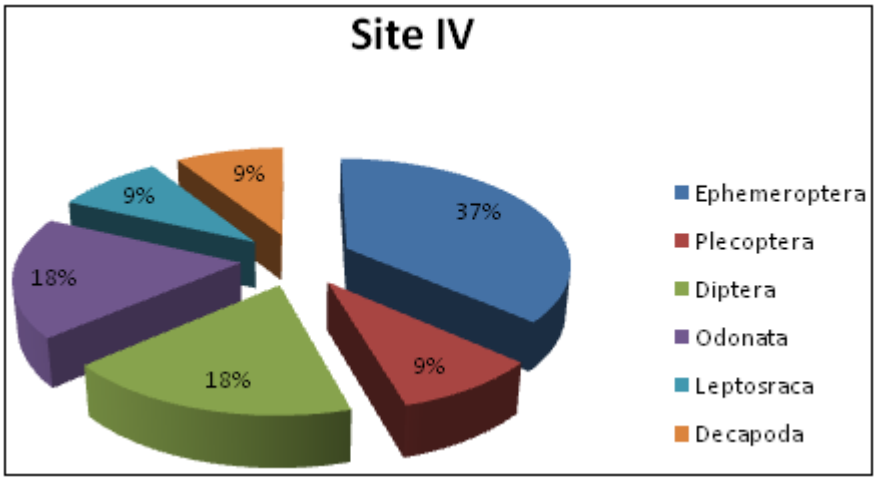

Figure 4: Percentage Composition of Benthic Fauna Recorded during July, 2007-June, 2009 at Site- IV

Table 1: Species Composition, Percentage Composition, Diversity Index and Density of Benthic Fauna from Ganga River at Bijnor

	Site-I	**Site-II**	**Site-III**	**Site-IV**	**Total Genera/ Percentage Composition**
Ephemeroptera	Adult Mayfly	Adult Mayfly	Adult Mayfly	Adult Mayfly	4 genera
	Baetis (N)	*Baetis* (N)	*Baetis* (N)	*Baetis* (N)	
	Stenonema(N)	*Stenonema*(N)	*Stenonema*(N)	*Stenonema*(N)	
	Ephemerella (N)	Ephemerella (N)	Ephemerella (N)	Ephemerella (N)	
Percentage composition	36.3%	50%	30.7%	36.3%	30.7%
Plecoptera	*Isoperla* (N)	*Isoperla* (N)	*Isoperla* (N)	*Isoperla* (N)	2 genera
	Pteronarcus (N)	----------	*Pteronarcus* (N)	----------	
Percentage composition	18.1%	12.5%	15.3%	9.0%	15.3%
Diptera	*Chironomus* (N)	*Chironomus* (N)	*Chironomus* (N)	*Chironomus* (N)	3 genera
	Tendipestentans (L)	*Tendipestentans* (L)	*Tendipestentans* (L)	*Tendipestentans* (L)	
	----------	----------	Musca (L)	----------	
Percentage composition	18.1%	25.0%	23.0%	18.1%	23.0%
Odonata	*Lestes*(N)	----------	*Lestes*(N)	*Lestes*(N)	2 genera
	Macromia(N)	----------	*Macromia*(N)	*Macromia*(N)	
Percentage composition	18.1%	----------	15.3%	18.1%	15.3%
Leptosraca	*Asellus*	*Asellus*	*Asellus*	*Asellus*	1 genus
Percentage composition	9.0%	12.5%	7.6%	9.0%	7.6%
Decapoda	----------	----------	Cambarus	*Cambarus*	1 genus
Percentage composition	----------	----------	7.6%	9.0%	7.6%
Total genera	11	8	13	11	13 genera
Diversity Index(H')	0.000-0.258	0.000-0.248	0.000-289	0.000-0.557	
Density (organisms/sq.mt.)	0-9	0-11	0-10	0-9	