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IMPACT OF THE POLLUTION OF RIVER BURHI GANDAK ON PLANKTON AND MAICOFAUNA AT MEHSI, NORTH BIHAR CAUSED BY SUGAR MILLS AND MOTHER OF PEARL BUTTON INDUSTRIES

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INTRODUCTION

River Burhi Gandak, constitutes an important freshwater resource of North Bihar passing through several districts like Champaran, Muzaffarpur, Darbhanga and Begusarai and is a part of the major riverine system of the region-the Kosi-Gandak Because of the availability of bivalve shells in huge quantities in the river, several important mother of pearl button and lime cottage industrial centres have developed alongside the river. Besides the belt has several sugar mills. These industries discharge their untreated effluents and wastes directly into the river. With the result, certain stretches of the river got polluted.

Although some reports are available on the pollution of main river Ganga and some other tributaries like Daha in North Bihar, particularly by Sugar and distillery wastes (David and Ray, 1966, Sahay *et al*., 1994), practically no information is available on the pollution and its impact on the biota in the tributaries of Gandak -Kosi river system. An earlier report (Datta Munshi and Datta Munshi, 1991) on the ecology of the rivers of this system gives only a general idea of their physiography With this in mind, the present studies were undertaken to assess the impact of pollution on the diversity and density of plankton and molluscan fauna of this river near polluted sites in Mehsi block of East Champaran district. Mehsi Township (Fig 1) is an important centre for the mother of pearl button and lime industries. Besides, there are three sugar mills also located in the area. These discharge their wastes into the river causing pollution of the river in the vicinity of the township.

DESCRIPTION OF THE STUDY AREA

The impact of the pollution on the biota of the river was studied by fixing following stations/ sites as shown schematically in Fig. 1.

Zoological Survey of India, Kolkata-700 020.

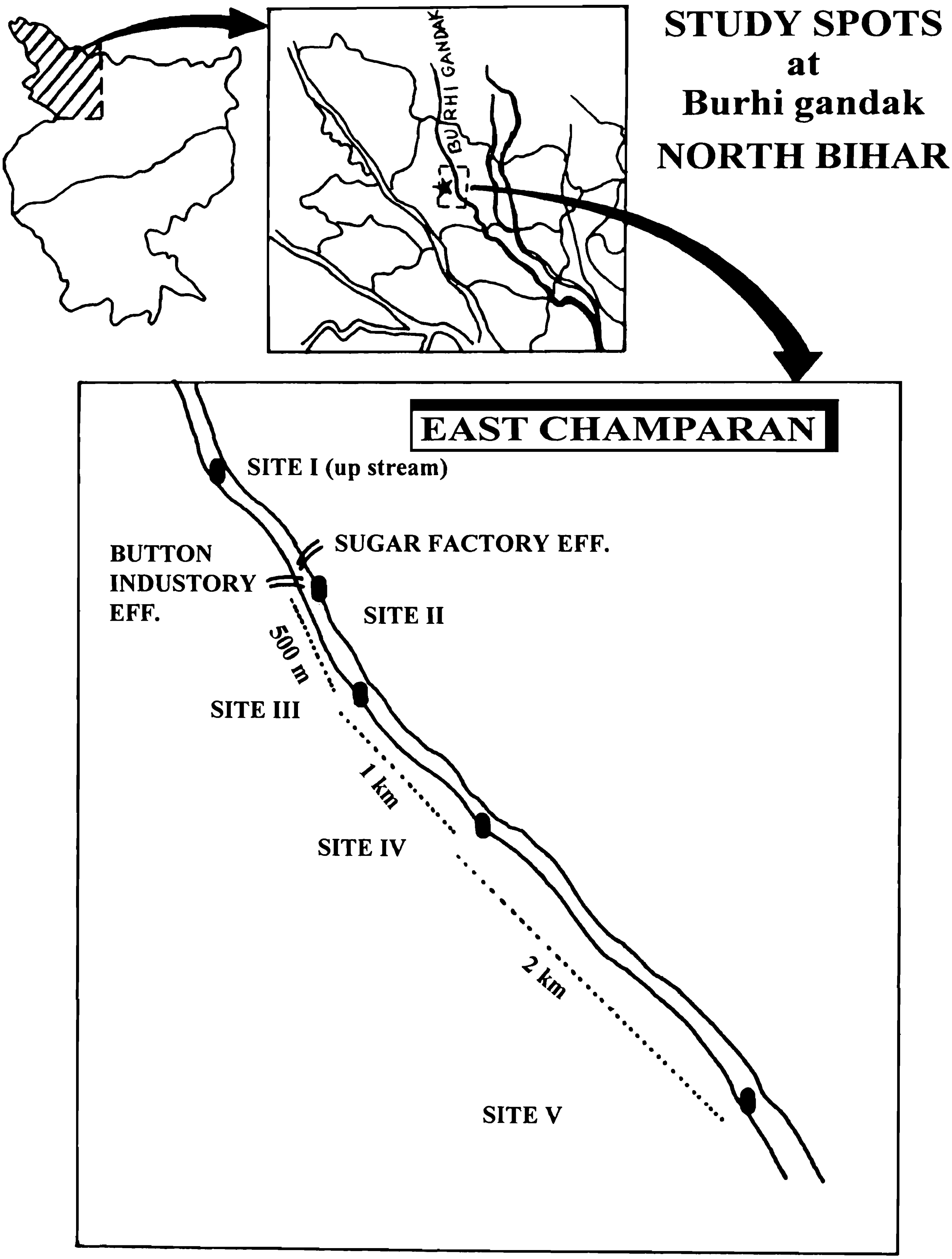


Fig. 1. Study spots at Burhi gandak, North Bihar.

Site I. **above outfall.** This site was fixed nearly 1 km above Mehsi Town where no industrial effluents were discharged. This has been considered as standard unpolluted site.

Site II. **Outfall.** The station was situated near Mehsi Town ship where the solid and liquid wastes are discharged into the river.

Site III. **Approximately 500 m below the outfall.** This site was situated nearly 500 m from the Mehsi Town

Site IV. **Approximately 1.5 km below the outfall.**

Site V. **Approximately 2 km below the outfall**

MATERIAL AND METHODS

Surface water samples for physico-chemical analysis were collected from atleast three places at each site. The analysis of temperature, pH, dissolved oxygen and hardness were done in the field itself and samples for B.O.D., C.O.D., Silicate and Ca^{++} were brought to the laboratory. Standard Methods (A.P.H.A., 1991) were followed for the analysis. Only those parameters which showed significant impact are included here.

Phytoplankton samples were collected by filtering I-2 lit of water through Whatman filter paper No. 4 and preserved in Lugol's solution. Zooplankton samples were collected with the help of plankton net made of bolting nylon No. 20 (mesh size 0.075 mm). For relative composition and qualitative studies samples were collected randomly from several places by throwing and towing the net from the shore. The filtered zooplankton were preserved in 4% formalin. The quantitative molluscan fauna for the determination of density were collected with the help of a wooden quadrate net (area 0.25 sqm, height of the frame 3"), attached with a bag of fine meshed mosquito net cloth. For bottom fauna, the quadrate was placed on the bottom of littoral zone and all shells live and dead alongwith the mud /sand upto the depth of 2" was collected. There after the quadrate was pulled up slowly collecting all the macrophytes falling with the quadrate. For qualitative studies, thorough search of the bottom of littoral zones and macrophytes were done and specimens were collected. Dead shells were discarded and live ones preserved in 6% formalin.

Although studies were carried out for all the seasons, summer (March-June) monsoon (July-October) and winter (November-February), the data collected during winter and summer are anlysed and presented. Due to heavy rains and flooding of the river during monsoon months, location of the stations were disturbed and sampling was also difficult. Further due to considerable dilution the impact was also not visible.

RESULTS

1. Physico-chemical properties of water

The physico-chemical condition around outfall at different sites during winter and summer are shown in Table 1. There was a sudden alteration in almost all parameters studied except water temperature at Site-II, (outfall) as compared to Site-I (above outfall). The conditions started improving soon after outfall. The most important effect was on the pH, which dropped considerably near the outfall in both seasons. During summer, the dissolved oxygen concentration dropped from 7.2 mg/l at site-I to 2.4 mg/l at Site-2. Although recovery started immediately from site-III onwards, its rate was comparatively slower. While the recovery in respect of B.O.D. was comparatively faster, C.O.D. decreased gradually. The recovery of hardness was very slow and even at Site-V, the values were much higher than those of Site-I. Silicate and Ca++ also showed the initial increase that was followed by considerable recovery at sites-III and IV and the values returned to normal at Site-V Almost similar trends were noticed during winter season.

Table 1. Physico-chemical conditions of river water at different sites around outfall.

	WINTER					SUMMER				
Paramters	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
	I	II	III	IV	V	I	II	III	IV	V
Water Temperature °C	23.2	23.4	22.8	22.7	23.3	31.5	31.9	31.8	31.6	32
pH	5.8	5	5.5	5.7	5.9	6	5.2	5.8	5.9	6.1
Dissolved oxygen mg/l	8.4	2.8	3.6	6.5	8.4	7.3	2.4	3.2	3.9	8.2
B. O. D. mg/l	10	105	63	49	25	328	446	413	392	327
C. O. D. mg/l	250	1102	593	301	228	1709	2430	2329	2190	1805
Total hardness mg/l	102	239	231	209	117	104	328	309	283	178
Silicate (mg/l)	12	16.5	15.8	14.6	12.7	12.2	34.3	27	21.9	12.8
Ca^{++} mg/l	37.5	59.6	51.2	37.2	38	17.5	24	22.5	21.6	18

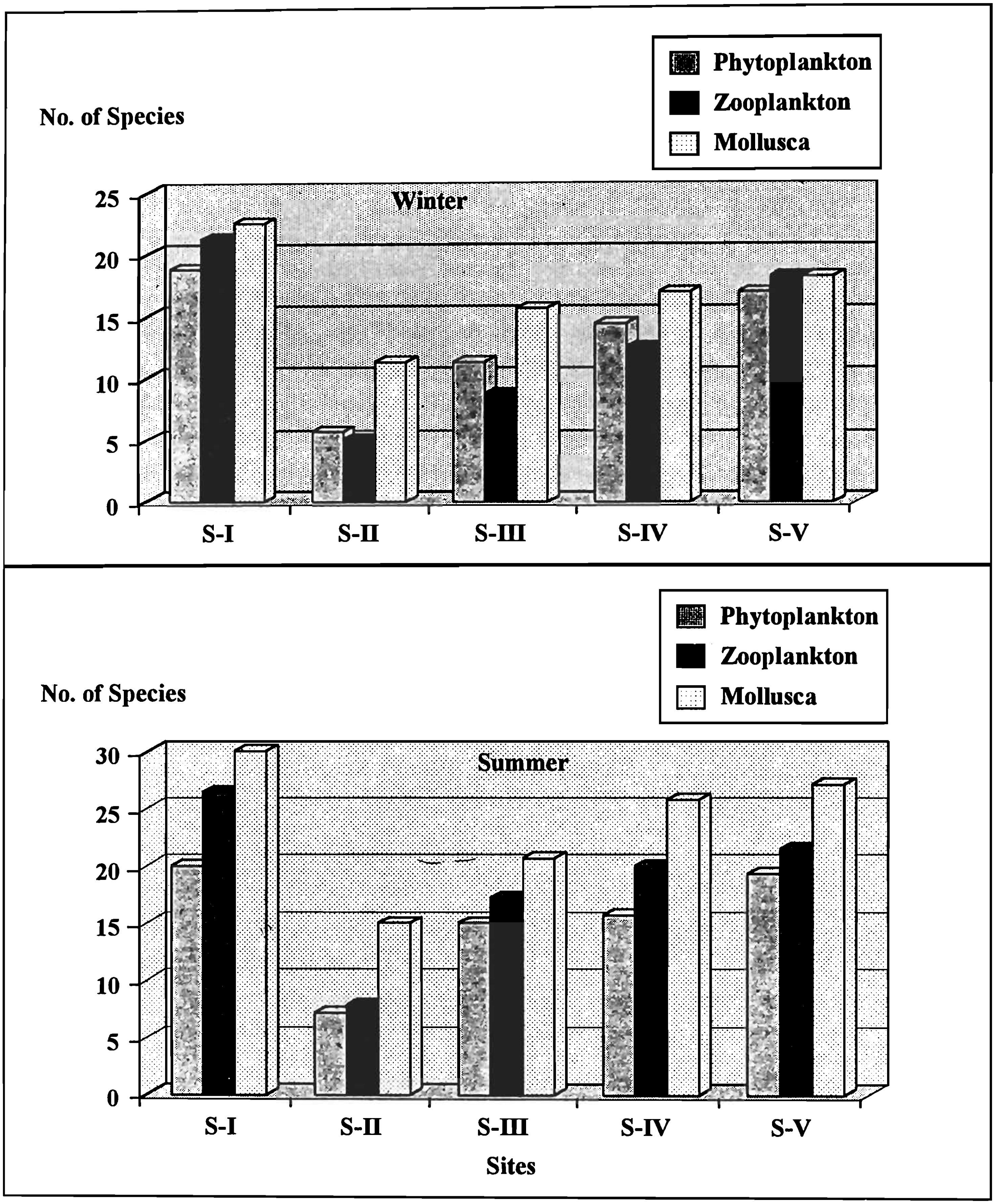
2. Plankton

Impact on species richness and abundance of both phyto and zooplankton was severe near the outfall. The number of phytoplankton taxa during summer dropped from 20 to 8 between Sites-I and II (Table 2, Fig. 2) revealing a reduction of 60% (Table 3). Similarly number of species of zooplankton also decreased from 26 above the outfall to 9 at the outfall, exhibiting a reduction of 65% (Fig. 2). However recovery in both cases was rapid as station 3 harboured 15 and 17 species of phyto and zooplankton showing an improvement of 75.0 and 65.33 percent respectively.

The decrease and increase in the numerical density of both phytoplankton and zooplankton at different sites was almost similar to the species richness (Table 2, Fig 3) However, the rate of reduction between Sites-I and II was of slightly lesser magnitude than the species richness. In case of phytoplankton the reduction between Sites I and II was about 52% but the recovery between sites II and III was rapid (87.12%). Similarly the reduction in zooplankton density between Sites-I and II was of the order of 63.55% and recovery between Sites I and III was 77.02% (Table 3). The conditions returned to almost normal at site-V, both for phytoplankton and zooplankton. Not much variation in the pattern was observed during winter season.

Table 2. Species richness and density of phytoplankton, zooplankton and malacofauna at different sites.

	WINTER					SUMMER				
	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
	above outfall	outfall	500 m below outfall	1 km below outfall	2 km below outfall	above outfall	outfall	500 m below outfall	1 km below outfall	2 km below outfall
No. of Phyto-plankton species	19	6	12	14	17	20	8	15	16	19
Density of Phyto-plankton (no/l)	3648	1382	2402	2554	3179	4015	1925	3489	5667	3894
No. of Zooplan-kton species	21	5	8	12	19	26	9	17	20	22
Density of Zoo-plankton (no/l)	229	66	189	207	219	557	203	429	468	499
No. of Molluscan species	22	12	16	17	19	30	15	21	26	27
Density of Mollu-sca (no/sqm)	538	177	485	487	491	616	413	529	541	558



S-I–above outfal, S-II–outfall, S-III–500 m below outfall, S-IV–1 km below outfall, S-V–2 km below outall.

Fig. 2. Species richness of phytoplankton, zooplankton and malacofauna at different sites during summer and winter.

Table 3. Percentage of reduction (between sites I and II) and recovery (between sites I and III) of biotic components around outfall.

	WINTER					SUMMER				
PARAMETGERS	Site-I above outfall	Site-II outfall	Percent reduc-tion	Site-IV 500 m below outfall	Percent reco-very	Site-I above outfall	Site-II outfall	Percent reduc-tion	Site-IV 500 m below outfall	Percent reco-very
Species Richness										
Phytoplankton	19	6	68.42	12	63.15	20	8	60	15	75
Zooplankton	21	5	76.2	8	57.14	26	9	65.3	17	65.3
Gastropoda	10	7	30	9	90	15	9	40	10	66.66
Bivalvia	12	5	58.33	7	58.33	15	6	60	11	73.33
Total Mollusca	22	12	44.5	16	72.72	30	15	50	21	73.33
Density										
Phytoplankton	3648	1382	62.1	2404	63.15	4015	1925	52.05	3489	87.12
Zooplankton	229	66	71.12	189	82.53	557	203	63.55	429	77.02
Gastropoda	250	120	52	265	106	280	201	28.21	255	91.07
Bivalvia	288	57	80.2	220	76.39	336	112	66.66	274	81.55
Total Mollusca	538	177	67.1	485	90.14	661	313	52.64	529	80.03

3. Mollusca

Species richness **:** Detailed studies were carried on the impact of pollution on the diversity, density and composition of molluscan fauna. A total of 31 species was recorded from the unpolluted Site-I, which included 16 species of gastropods and 15 species of bivalves (Table 4). The number reduced drastically at site-II, near the outfall where only half of the number of species was present as compared to unpolluted Site-I during summer. However, 21 species were recorded from site-III and 28 from site-IV showing quick recovery (Table 2, Fig 2). This was also evident from the analysis of the reduction and recovery rates (Table 3). The reduction in species richness between Sites I and II was 52%. The recovery was very quick as nearly 80% of the species reappeared at Site-3. During winter also only 12 species were at site-II as compared to 22 at site-I exhibiting a reduction of 44.5%. The immediate recovery (72.72%) was significant.

Table 4. Species richness and density of gastropods and bivalves at different sites.

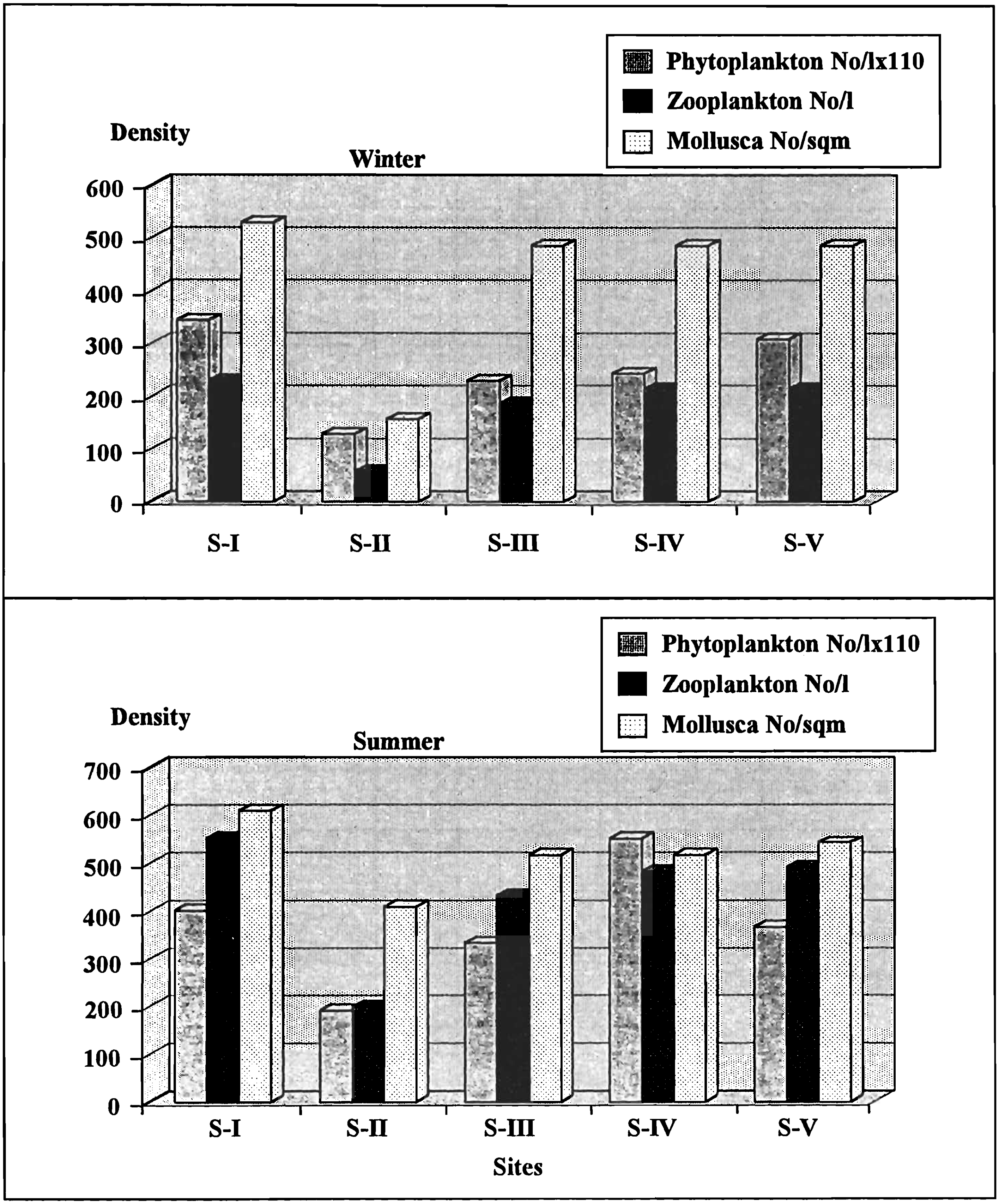
	WINTER					SUMMER				
	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
	above outfall	outfall	500 m below outfall	1 km below outfall	2 km below outfall	above outfall	outfall	500 m below outfall	1 km below outfall	2 km below outfall
No of Gastropod species	10	7	9	9	10	15	9	11	14	14
Number of bivalve species	12	5	7	8	9	15	6	10	12	13
Density of gastropods (no/sqm)	250	120	265	250	230	280	230	255	260	235
Density of bivalves (no/sqm)	288	57	220	237	261	336	183	274	281	323

Abundance : The total molluscan density at site-I during summer was 616/sqm, which was reduced to 413/sqm at the outfall site-II. Like species diversity the recovery in case of density was also quick and the mean density at site-III was 529/sqm. (Table 2, Fig. 3). This resulted in the reduction of 52.64% between sites-I and II and recovery of 80% at site-III (Table 3). During winter the reduction between sites II and I and recovery between Sites II and III were 67.10 and 90.14% respectively showing comparatively lesser impact during the season.

Composition : Table 5 and Fig. 3 show the relative impact of pollution on the species richness and density of the two major molluscan groups viz. gastropods and bivalves. It is abundantly clear that bivalves were much more affected than gastropods. During summer at unpolluted site-I, there were 30 species of mollusca, 15 of gastropods and 15 of bivalve. At the outfall, Site-II, only 6 species of bivalves were present as compared to 9 of gastropods. This resulted in a decrease of only 28.21% in case of gastropods between sites-I and II but the reduction in case of bivalves was of the magnitude of 66.66%. The recovery between sites-I and III was also slower in case of bivalves (Table 3) than gastropods.

DISCUSSION

From the results, it is quite clear that the river Burhi Gandak near Mehsi was polluted as evident from generally altered conditions of both physicochemical and biological characteristics of the water around the outfall region. The lower value of pH near the outfall was probably due



S-I–above outfal, S-II–outfall, S-III–500 m below outfall, S-IV–1 km below outfall, S-V–2 km below outall.

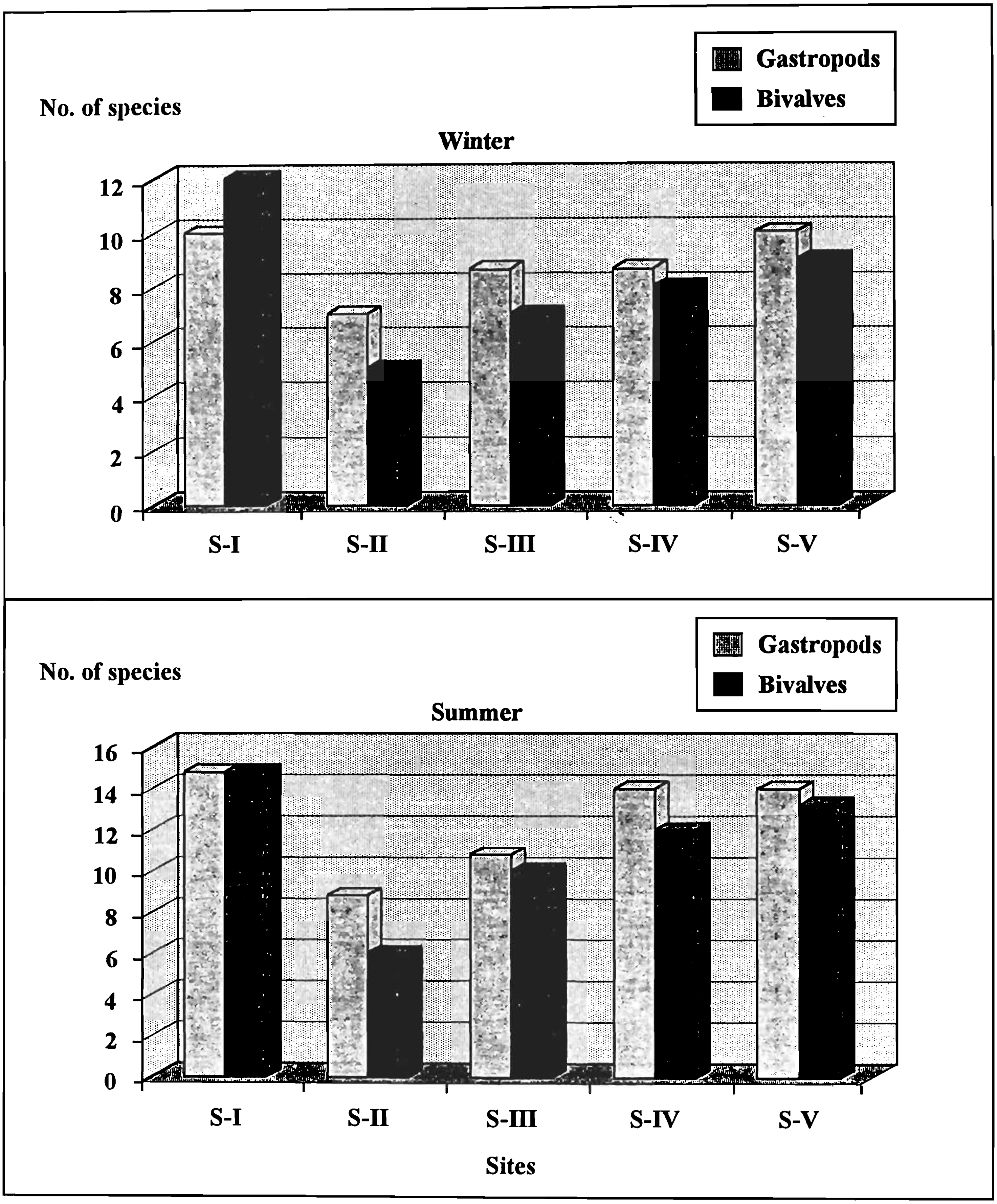
Fig. 3. Density of phytoplankton, zooplankton and malacofauna at different sites during summer and monsoon.

Table 5. Occurrence of molluscan species at different sites around outfall during winter and summer.

Species	WINTER					SUMMER				
Gastropoda	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
Family : **Viviparidae**										
Bellamya bengelensis (Lamarck)	+	+	+	+	+	+	+	+	+	+
Bellamya crassa (Benson)	–	–	–	–	–	+	+	+	+	+
Bellamya dissimilis (Mueller)	–	–	–	–	–	+	–	–	+	+
Family : **Pilidae**										
Pila globosa (Swainson)	+	–	+	+	+	+	–	+	+	+
Family : **Bithyniidae**										
Gabbia orcula (Frauenfeld)	+	+	+	+	+	+	+	+	+	+
Digoniostoma ceraneeo-poma (Benson)	+	–	+	+	+	+	–	–	–	–
Digoniostoma pulchella (Benson)	–	–	–	–	–	+	–	–	+	+
Family : **Thiaridae**										
Thiara (Thiara) scabra (Muller)	+	+	+	+	+	–	–	–	–	–
Thiara (Thiara) lineata (Gray)	–	–	–	–	–	+	+	+	+	+
Thiara (Melanoides) tuberculata (Mueller)	+	+	+	+	+	+	+	+	+	+
Bortia (Antimelania) co. Costula Rafinesque	+	–	–	–	+	+	–	+	+	+
Family : **Lymnaeidae**										
Lymnaea (Pseudosuccinea) acuminata (Lamarck)	+	+	+	+	+	+	–	–	+	+
Lymnaea (P) lt (P) lufeola (Lamarck)	–	–	–	–	–	+	+	+	+	+
Family : **Planorbidae**										
Indoplanorbis exustus (Deshayes)	+	+	+	+	+	+	+	+	+	+
Gyraulus convexlusculus (Hutton)	+	+	+	+	+	+	+	+	+	+
Gyarulus tabiatus (Benson)	–	–	–	–	–	+	+	+	+	+

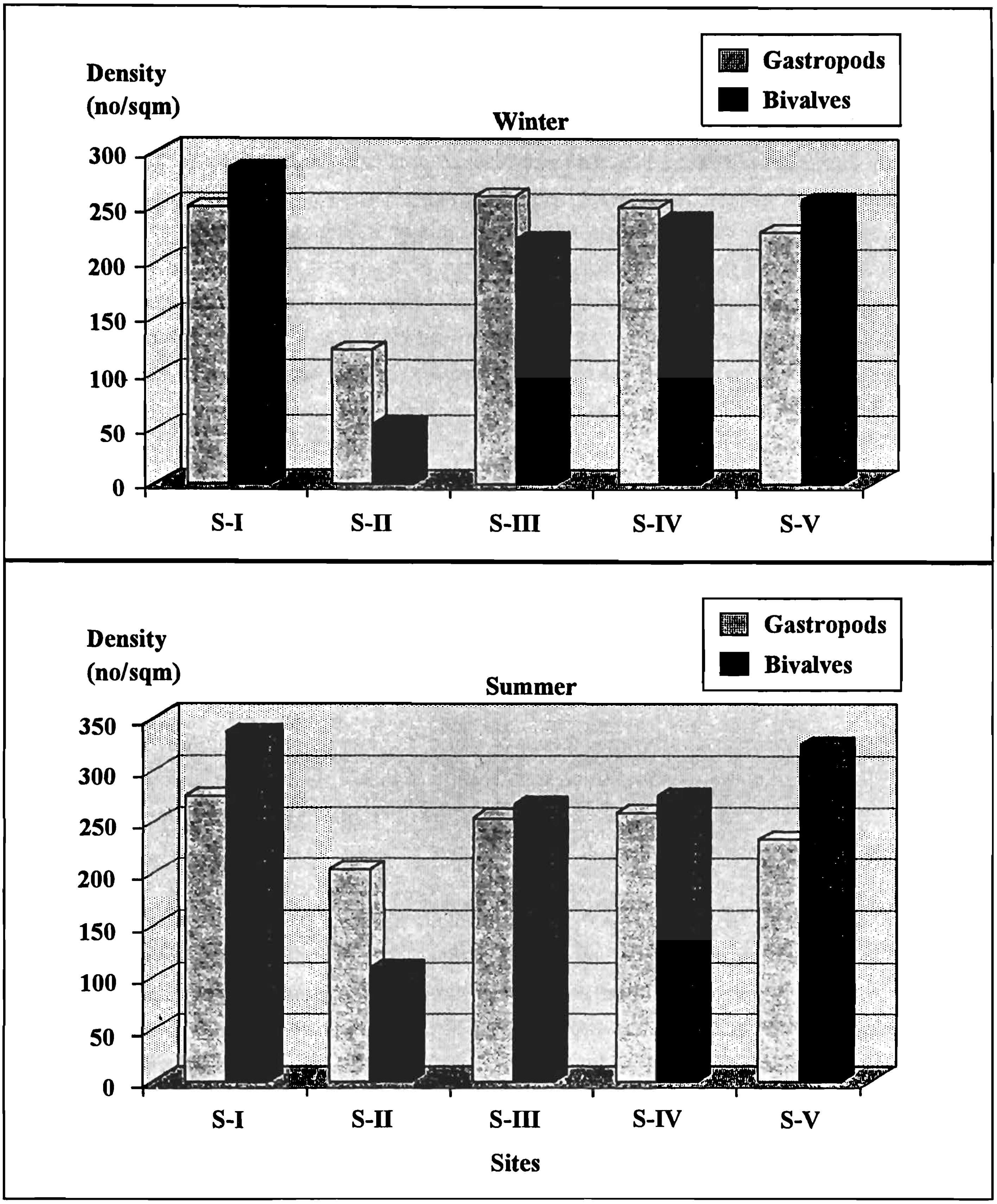
Table 5. *Cont'd.*

Species	**WINTER**					**SUMMER**				
Gastropoda	Site-I	Site-II	Site-III	Site-IV	Site-V	Site-I	Site-II	Site-III	Site-IV	Site-V
Class : **Bivalvia** Family : **Unionidae**										
Lemellidens corrianus (Lea)	+	+	+	+	+	+	+	+	+	+
Lammellidens jenisianus (Benson)	–	–	–	–	–	+	–	–	+	+
Lammellidens marginalis (Lamarck)	–	–	–	–	–	+	–	+	+	+
Family : **Amblemidae**										
Parreysia (Parreysia) corrugata (Mueller)	+	+	+	+	+	+	+	+	+	+
Parreysia (P.) favidens (Benson)	+	+	+	+	+	+	+	+	+	+
P. (P.) favidens assamensis Preston	+	–	+	+	+	+	+	+	+	+
P. (P.) favidens chrysis (Benson)	+	–	+	+	+	+	–	+	+	+
P. (P.) favidens deltae (Benson)	–	–	–	–	–	+	–	–	+	+
P. (P.) virdula (Benson)	+	–	–	–	–	+	–	–	+	+
P. (P.) triembolus (Benson)	+	–	–	–	–	+	–	–	+	+
Parreysia (Radiatula) andersoniane (Nevill)	+	+	+	+	+	+	–	+	+	+
P. (R.) caerulea (Lea)	+	–	–	–	+	+	–	–	+	+
P. (R.) lima (Simpson)										
Family : **Corbiculidae**										
Corbicula bensoni (Deshayes)										
Family : **Pisidiidae**										
Pisidium (Afropisidium) clarkeanum (G & H Nevill)										
NUMBER OF SPECIES	**22**	**12**	**16**	**17**	**19**	**30**	**15**	**21**	**26**	**27**



S-I–above outfal, S-II–outfall, S-III–500 m below outfall, S-IV–1 km below outfall, S-V–2 km below outall.

Fig. 4. Relative species richness of gastropods and bivalves at different sites during summer and winter.



S-I–above outfal, S-II–outfall, S-III–500 m below outfall, S-IV–1 km below outfall, S-V–2 km below outall.

Fig. 5. Density (no/sqm) of gastrodods and bivalves at different sites summer and winter.

to acidic nature of the organic wastes. The organic nature of some of the pollutants was also visible from increased load of B.O.D and rapid decrease in dissolved oxygen contents at the outfall. At the same time sudden increase in C.O.D, hardness, silicates and Ca^{++} at the outfall region also indicate the inorganic nature of some pollutants. Although no detailed studies on the nature of effluents from different discharge sources were made, it can be assumed that the effluents discharged by sugar mills were of highly organic nature. The increase in hardness, silicate and Ca++ was probably due to the mother of pearl button and lime manufacturing activities. The analysis further revealed that the impact of pollution was restricted only to a short distance near the outfall and conditions started improving rapidly from Site-III onwards. The impact of pollution on physico-chemical nature of water was almost invisible at site-V, nearly 2 km downstream. Even during summer months when dilution ratio was low due to comparatively reduced flow of water, the impact on the physicochemical quality of the water was not severe at site-V This revealed a limited nature of the physico-chemical impact of pollution on the river. It is well known that the impact of pollution on running waters is mostly governed by the nature and amount of pollutants added and inflow of freshwater from upstream. At Mehsi, the flow of the river was moderate which brought sufficient amount of water needed for dilution. Further the nature of wastewater generated by neither the sugar mills nor by button industries were toxic and therefore their impact was also not severe. Generally in case of organic pollution created by food/ beverage industries the recovery is rapid because of quick decomposition of organic matter. Similarly coarse sized suspended inorganic particles also settle quickly.

As compared to the physico-chemical nature of water, the impact of pollution was much severe on the biota. Although conditions improved significantly at Site V, neither the species richness nor numerical abundance of different groups, excepting the sudden abundance of phytoplankton at Site-3 during summer returned to their original numbers recorded from unpolluted upstream Site-I, showing that the recovery was still underway. The sudden increase of the phytoplankton at Site-IV was probably due to increased availability of nutrients liberated by the decomposition of huge quantity of organic matter as observed by Khan (1995) in case of the discharge from a paper and pulp mill in the Hugly river. The slower recovery of biota as compared to physico-chemical nature of water pointed out towards the long lasting impact of pollution on living material. This confirms the viewpoints expressed by a number of workers (Cook, 1976) that the physico-chemical parameters of water indicate the impact of pollution as long as pollutants remain in the particular area. Once flushed, these parameters do not indicate the deterioration of the quality in the past. Contrary to this, the biota once affected, take a long time to recover and return to their normal biological activities.

Among the three groups of biota studied, phytoplankton, zooplankton and malacofauna, only the last groups was either sessile or very slow moving and could not escape from the impact of changing condition of environment quickly by moving elsewhere. Due to this reason, benthic/

macrophytes associated sessile or slow moving animals have been considered as most reliable indicator of the impact of pollution. (Wilhms, 1970, Chandler, 1970, Cook, 1976).

Among the two molluscan groups, the bivalves appeared to be considerably more sensitive to pollution than gastropods. The reduction in both species number and density of bivalves at outfall was much higher than gastropods. While several species of gastropods like *Bellamya bengalensis, Gabbia orcula, Thiara tuberculata, Indoplanorbis exxustus and Gyraulus convexiusculus* were remained almost unaffected near the outfall, none of the bivalve species were comfortable at this site and a few species which occurred, had their densities greatly reduced.

SUMMARY

The present studies were undertaken to assess the impact of pollution on the physico-chemical nature of water and diversity and density of phytoplankton, zooplankton and molluscan fauna of river Burhi Gandak near polluted sites in Mehsi block of East Champaran district. Mehsi Township (Fig 1) is an important centre for the mother of pearl button and lime industries. Besides, there are three sugar mills also located in the area which discharge their wastes into the river causing pollution in the vicinity of the outfall. The impact of the pollution was studied by fixing 5 sites (sites I-V), starting from nearly one km above the outfall to nearly 2 km below the outfall.

There was a sudden alteration in almost all the physico-chemical parameters studied near the outfall but conditions started improving soon after and the recovery was nearly complete within a short distance of 2 km. Impact on species richness and abundance of both phytoplankton and zooplankton was severe near the outfall. Species richness near the outfall (as compared to site above the outfall) decreased by 60% and 65% in case of phytoplankton and zooplankton respectively. However recovery in both cases was rapid as the site-III (500 m below the outfall) showed improvement of 75.0 % and 65.33 % for phyto and zooplankton respectively. The pattern of reduction and recovery for their densities was almost similar to that of species richness.

Although similar pattern of impact was noticed on the diversity and density of molluscan fauna, the recovery was comparatively slower and neither species richness nor density recovered completely at site V, which indicated the greater impact of pollution on these organisms. Bivalves were found to be more affected than gastropods.

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