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THE IMPACT OF EFFLUENTS FROM HARIHAR POLYFIBRE AND GWALIOR RAYON FACTORIES ON THE AQUATIC LIFE IN THE RIVER TUNGABHADRA NEAR HARIHAR IN KARNATAKA

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THE IMPACT OF EFFLUENTS FROM HARIHAR POLYFIBRE AND GWALIOR RAYON FACTORIES ON THE AQUATIC LIFE IN THE RIVER TUNGABHADRA NEAR HARIHAR IN KARNATAKA — A REPORT

By

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FOREWORD

Environmental degredation continues to be a pressing problem consequent to the developmental needs of an escalating population. Contamination of air, water and soil by the wastes arising from growing agricultural and industrial activities and the unscientific exploitation of natural resources are some of the recognized problems that need immediate attention.

Despite advancements made in the science of environmental management, certain degree of adverse environmental impact may be unavoidable in a progressive materialistic society. Nevertheless, frequent threat to natural systems occurs chiefly due to the licentiousness of man towards a healthy environment.

The large-scale fish kill in the stretch of river Tungabhadra at Harihar in Karnataka due to the effluent discharge from Harihar Polyfibre and Gwalior Rayon factories is one of such several examples. At the instance of the Karnataka State Pollution Control Board, Central Inland Capture Fisheries Research Institute conducted investigations in this stretch to assess the impact of these factory effluents on the water quality and aquatic life. I am glad to place on record that these studies carried out by two scientists of this Institute, Dr. H.C. Joshi and Shri P.K. Sukumaran unravelled information on the extent of damage caused to the aquatic ecosystem as well as on the impact of the effluents of the two factories on the physiology of the aquatic fauna, especially the fishes. The report also puts forward a few recommendations to minimise the pollution hazards in river systems in general and the river Tungabhadra in particular.

It is sincerely anticipated that all the agencies concerned will give adequate attention to the recommendations and take up necessary measures for abating the pollution towards maintaining a healthy environment.

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THE IMPACT OF EFFLUENTS FROM HARIHAR POLYFIBRE (HPF) AND GWALIOR RAYON (GR) FACTORIES ON THE AQUATIC LIFE IN THE RIVER TUNGABHADRA NEAR HARIHAR IN KARNATAKA - REPORT

INTRODUCTION

In india many of our rivers are facing the threat of pollution due to ever increasing urban, industrial and agricultural activities along their banks. In the small rivers, the problem of pullution is further compounded by lean flow in the rivers during summer . The river Tungabhadra, which traverses the long drought-prone regions of Karnataka is one such example.

Harihar Polyfibre (HPF) Factory, producing 170 tonnes of rayon grade pulp every day and Gwalior Rayon (GR) Factory producing 800 tonnes of grasiline fibre per month generate 33,000 and 11,000 m^3/day of waste waters respectively and discharge them into the river Tungabhadra at two points, 150 metre apart, near Harihar town in Karnataka. The fish mortality on 14th Feb., 1984 is of vital significance with respect to deteriorating water quality in this river due to continuous discharge of these effluents. On the behest of Karnataka State Pollution Control Board (KSPCB), Bangalore, the Madras Centre of CIFRI conducted two survey along this river during Nov., 1984 and Feb., 1985 and submitted its report to them. Again on instance of KSPCB, further detailed investigations were carried out on the effects of these effluents on the water quality and aquatic life in the river Tungabhadra, downstream of the Harihar town. The results of these studies and the conclusions drawn are presented in the following pages.

A few recommendations for abatement of pollution in the river Tungabhadra have also been suggested.

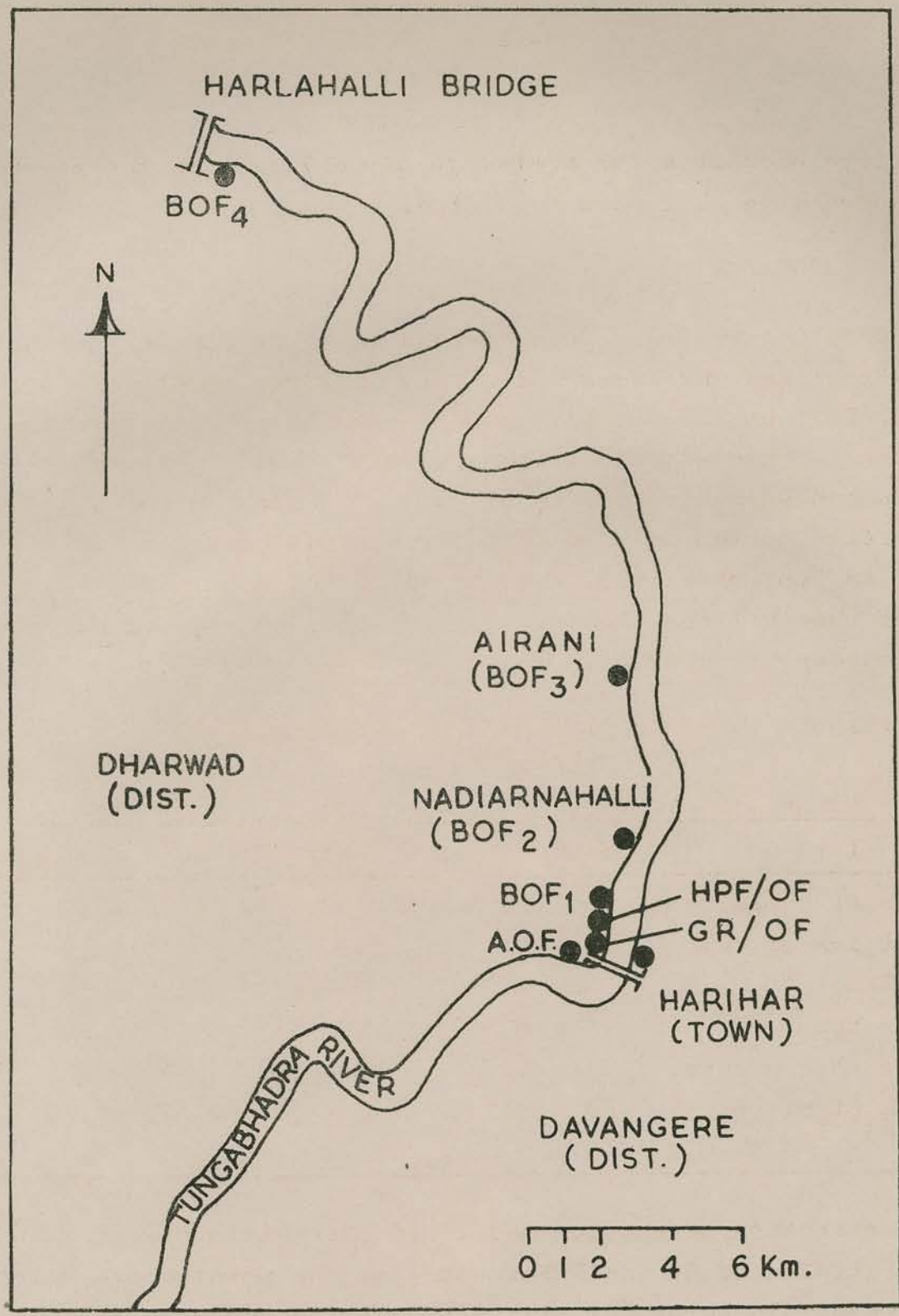
SAMPLING PROGRAMME

Sampling programme was formulated after discussions with the Chairman and the Member Secretary, KSPCB, Bangalore and the Regional Officer, KSPCB, Davangere. With their collaboration studies on physico-chemical changes in the water quality in the river Tungabhadra, downstream of HPF and GR factories, vis a vis their effect on the aquatic life were initiated. The site was visited in September 1985, February 1986 and June 1986. The dates of observations along with corresponding weather and river conditions are presented in Table 1.

Table 1 : River flow and weather conditions during sampling.

Parameters	Sept. '85	Feb. '86	June '86
1. Dates of sampling	20 - 22	19 - 21	2 - 3
2. Condition of sky	clear	clear	cloudy
3. Air Temp. ^{o}C	30 - 32	33 - 35	30 - 32
4. Water temp. ^{o}C	26 - 29	31 - 33	25 - 27
5. River flow $m^3/sec.$	50 - 55	8.3 - 8.4	30 - 32
6. Width of river meters	60 - 130	30 - 60	50 - 100

Collection of samples and field observations were made at the outfalls of GR and HPF factories, one point above outfall and three points below outfall. In June '86 one more point, 55 km below outfall near Harlahalli bridge, was included. The locations are illustrated in Fig. 1 and the details are summa-



MAP OF RIVER TUNGABHADRA SHOWING DIFFERENT SAMPLING CENTRES NEAR HARIHAR TOWN

rized in Table 2. At all these locations, temperature and oxygen (DO) were estimated at the site, on both the banks of the river. pH, hardness, alkalinity and specific conductivity were determined at the regional laboratory of KSPCB, at Davangere. Estimations for metal content of water, soil and fish were carrried out on Atomic Absorption Spectrophotometer at CIFRI, Barrackpore. Extraction for metals in soil and fish was carried out with redistilled concentrated nitric acid. Mercury was analysed by cold vapour method on AAS.

Cast net operations were made in the upstream at AOF, between GR/HPF outfall and BOF_1, and at BOF_2 and BOF_3 for examining fish fauna at these points. Plankton samples and bottom fauna were also collected from these locations. Local fishermen's catches were also examined for their general condition and growth trends. Detailed examination of fishes and estimation of plankton and benthic populations was carried out at the Bangalore Centre of CIFRI. Toxicity tests on Oreochromis mossambicus, using different dilutions of GR and HPF effluents, were carried out at Barrackpore.

IMPACT OF POLLUTION ON WATER QUALITY

Physico-chemical characteristics of water including zinc and mercury in the sediments are summarized in Tables 3 and 4. A brownish tinge is noticed on the river bank where the GR and HPF factories are located till 10 km downstream at Airani, (Table 2). Marked depletion in the dissolved oxygen at the outfalls of GR and HPF factories is noticed which continues till Airani, as is evident from the respective DO values on the opposite bank (Table 4). During Feb. '86, when the flow in the

Table 2 : Description of different locations on the banks of Tungabhadra river near Harihar.

S.No.	Location	Brief description	Morphological features		
			Factory side		Opposite side
1.	A.O.F.	500 meter upstream of outfall of Grashim Rayon	River bed	- gravelly and rocky	gravelly
			Water	- Colourless	Colourless
2.	GR/OF	Effluent from Grashim Rayon meets the river at this point	River bed	- Full of sludge, black in colour	Gravelly
			Water	- Steel grey colour	Colourless
3.	HPF/OF	Effluent of Harihar Polyfibre factory enter the river at this point. It is about 150 m downstream of GR/OF.	River bed	- Covered with thick sludge	gravelly
			Water	- Dark brown-black colour	Colourless
4.	HPF/BOF$_1$	500 meter downstream of HPF/OF	River bed	- Covered with mat of sludge, banks slippery, dense pockets of aquatic vegetation mainly Eichhornia crassipes & Potemogeton sp.	gravelly no vegetation
			Water	- dark brown coffee colour	Colourless
5.	HPF/BOF$_2$	3 km downstream of HPF access - Nadiarnahalhalli village	Bed	- gravelly covered with thin mat of brownish sediments	gravelly
			Water	- Brown coffee colour	Colourless
6.	HPF/BOF$_3$	10 km downstream of HPF access - Airani village	Bed	- gravelly covered with silt	
			Water	- slightly brownish	Slightly brownish
7.	HPF/BOF$_4$	55 km downstream HPF	Bed	- Sandy with thin mat of silt	Sandy
			Water	- Colourless	Colourless

Table 3 : Physico-chemical characteristics of water at different locations on the factory side in Tungabhadra river.

S.No.	Parameters	A.O.F. Harihar	GR/OF Harihar	HPF/OF Harihar	HPF/BOF$_1$ Harihar (500 m)	HPF/BOF$_2$ Nadiarna-halhalli	HPF/BOF$_3$ Airani	HPF/BOF$_4$ Harla-
1.	pH	8.0	8.6	8.6	8.3	8.2	8.2	7.8
2.	D.O.(mg/l)	7.0	1.2	0.8	2.8	4.72	6.48	7.56
3.	Alkalinity)mg/l)	140	153	397	312	208	191	160
4.	Hardness	142	461	465	290	185	173	-
5.	Sp. conductivity µmhos/cm	27.4	179.5	174.5	102.2	45.3	36.3	29.0
6.	B.O.D.(mg/l)	1.0	48	29	12	6.8	4.0	2.0
7.	C.O.D.(mg/l)	24.0	296.0	570.0	276.0	115.0	68.0	49.0
8.	Zinc in water (mg/l)	0.07	3.26	1.46	0.66	0.36	0.26	0.10
9.	Mercury in water (µg/l)	nd	nd	0.5	nd	nd	nd	nd
10.	Zinc in sediments (µg/g dry soil)	43.3	1003	600	167	143	76	56
11.	Mercury in sedi-ments (µg/g dry soil)	0.004	0.096	0.26	0.066	0.046	0.032	0.030

Table 4 : Physico-chemical characteristics of water at different locations on the opposite side of HPF/GR factories in Tungabhadra river.

S.No.	Parameter	A.O.F. Harihar	GR/OF Harihar	HPF/OF Harihar	HPF/BOF$_1$ Harihar	HPF/BOF$_2$ Nadiarna-halhalli	HPF/BOF$_3$ Airani	HPF/BOF$_4$ Harlahalli
1.	pH	8.0	-	8.0	7.9	8.0	8.0	8.1
2.	D.O.(mg/l)	6.8	-	7.2	7.0	7.4	7.6	8.4
3.	Alkalinity (mg/l $CaCO_3$)	138	-	145	144	162	162	136
4.	Hardness (mg/l $CaCO_3$)	144	-	150	153	169	163	100
5.	Specific conductivity (µmhos/cm)	28.2	-	27.5	27.8	29.0	30.5	27.0
6.	Zinc in water (mg/l)	nd	-	0.08	0.05	0.07	0.10	0.09
7.	Mercury in water (µg/l)	nd	-	nd	nd	nd	nd	nd
8.	Zinc in sediment (µg/g dry soil)	40	-	39	43	50	57	48
9.	Mercury in sediment (µg/g dry soil)	0.008	-	0.01	0.012	0.012	0.02	0.022

river was only 8 m^3/sec., D.O. was completely absent at the outfall of GR. The chemical parameters such as hardness, alkalinity and specific conductivity increase considerably in the outfall region and remain high even upto 3 km downstream. These values tend to approach normal values (as observed above outfall) near Airani, thus indicating recovery in water quality. A comparison of Table 3 and 4 reveals that the opposite bank of the river upto 10 km downstream is affected only marginally by the septic conditions prevailing on the factory side.

The average zinc level at the outfall of GR is 3.26 mg/l which is very high. In Feb. '86 it was as high as 4.85 mg/l. It declines considerably to 1.46 mg/l near HPF outfall and 0.66 mg/l at 500 m downstream, and at Harlahalli, the concentration goes down to 0.1 mg/l. It is evident from the corresponding zinc levels in sediments that most of the zinc in solution settles down as a result of chemical precipitation and adsorption on settleable suspended matter. Mercury in water could not be detected in most of the locations but significantly high value (0.26/µg/g) was recorded in the sediments near HPF outfall. It is difficult to trace out the source of mercury other than the use of organomercurials for preservation of wood by HPF. Copper and chromium in water were below detectable levels.

IMPACT OF POLLUTION ON BIOTIC COMMUNITIES

Fish :

Twenty one species of fishes belonging to 6 families (Table 5) were recorded in Tungabhadra river right from Harihar bridge (above effluent discharge) to Airani village below

Table 5 : List of fishes collected with numbers and size range in mm (in parentheses) from different zones in Tungabhadra river near Harihar.

Species of fish	Collection zones in the river stretch		
	Above effluent discharge	Nadiaharnahalli	Airani
Family: CYPRINIDAE			
Puntius pulchellus*	12 (110 - 180)	10 (55 - 140)	20 (110 - 195)
Puntius phutunio	9 (40 - 50)	7 (50 - 55)	13 (40 - 58)
Puntius ticto	20 (55 - 60)	- -	10 (50 - 62)
Puntius puckeli	13 (55 - 78)	11 (60 - 82)	12 (72 - 90)
Puntius kolus *	12 (150 - 192)	- -	8 (162 - 208)
Cirrhinus reba*	18 (60 - 170)	14 (75 - 97)	13 (180 - 200)
Chela atpar	12 (72 - 89)	12 (108 - 125)	- -
Chela laubuca	20 (60 - 85)	- -	- -
[illegible]	- -	- -	18 (170 - 200)
Rohtee vigorsii	- -	- -	6 (95 - 162)
Barilius bendelisis	10 (58 - 110)	15 (68 - 74)	13 (60 - 114)
Schismatorhynchus mukta	3 (52 - 65)	11 (50 - 69)	14 (49-200) [illegible]
Rasbora daniconius	4 (59 - 72)	12 (60 - 70)	6 (62 - 70)
Garra notyla	19 (54 - 67)	- -	35 (57 - 110)
Family: BAGRIDAE			
Mystus vittatus*	- -	8 (120 - 138)	9 (110 - 149)
Mystus cavasius*	- -	6 (185 - 200)	10 (195 - 210)
Family: SILURIDAE			
Ompok bimaculatus*	- -	- -	8 (190 - 240)
Family: AMBASSIDAE			
Ambassis ranga	13 (42 - 55)	12 (45 - 59)	13 (42 - 56)
Ambassis nama	9 (43 - 50)	5 (42 - 52)	11 (40 - 55)
Family: CICHLIDAE			
Etroplus maculatus	6 (54 - 68)	1 (only one)	- -
Family: GOBIDAE			
Glossogobius giuris	- -	1 (")	4 (56 - 68)

* Economically important species.

the effluent discharge zone in cast net collections during the course of investigations. Of these, 7 species attaining large size are of economic value. No fishes were caught in cast net operations one km stretch below the discharge point. Large number of economically important fishes viz. Puntius pulchellus, Tor khudrea, Wallago attu, Mystus seenghala etc. and a few other less important fishes, both young and adult, were caught in the lower stretches of the river (12 km below the effluent discharge point) by local fishermen.

The fishes caught had a slight discoloration and foul odour. However, no external injury could be noticed but choking of gills was evident. Examination of digestive organs of the specimens collected from the lower stretches indicated mainly empty stomachs and the blood vessels lining the digestive organs and the adjoining body musculature within the abdominal cavity appeared congested and swollen. In several fishes the liver had become discolored and pulpy to touch. Microscopic examination revealed that fatty digestion had set in. The condition was more pronounced in bottom feeding fishes. In Labeo spp., Schismatorhynchus spp., C. reba, P. kolus and Garra spp. which are more or less bottom feeders pathological conditions were more severe than the surface and column feeders like P. phutunio and R. vigorsii. The growth of these fishes seems to have been adversely affected due to the continuous discharge of effluents and the prevailing adverse conditions in the large stretch of the river downstream of Harihar.

Zinc and mercury levels in muscles, liver and kidneys of fishes have been presented in Table 6. Zinc levels are higher in the fishes collected from BOF_2 (Nadiaharnahalli) as compared to those collected from AOF and BOF_3. Accumulation

Table 6 : Heavy metals (Zn & Hg) in fishes collected from different locations in the river Tungabhadra near Harihar.

Fish (Nos)	Zinc (ug/g wet wt)			Mercury (ug/g wet wt)		
	Muscle	Liver	Kidney	Mus.	Liver	Kidney
1. At Nadiaharnahalli						
Puntius pulchellus (5)	18.2	72.0	118.8	-	-	-
Cirrihina reba (5)	16.1	77.5	151.0	-	-	-
Puntius puckeli (5)	18.1	89.7	142.8	-	-	-
Channa marulius (1)	16.0	66.0	173.9	0.18	0.74	0.71
2. At Harihar, AOF						
Puntius pulchellus	4.6	-	-	-	-	-
Puntius kolus (2)	5.6	-	-	nd	-	-
3. At Airani, BOF_3						
Puntius pulchellus (2)	6.8	-	-	0.056	-	-
Puntius kolus (2)	10.0	-	-	0.020	-	-

of zinc is maximum in kidneys followed by liver and muscles. Mercury level in C. marulius is markedly high, however appreciable levels of mercury have been detected in other fishes also.

Toxicity experiments on O. mossambicus revealed that the fishes survived for 96 hrs. in the HPF effluent at 50% dilution. GR effluent was found to be considerably toxic as the LC_{50} 96 hrs was 5%, which means that GR effluents at 5% concentration (v/v) caused 50% mortality in fishes during 96 hours exposure.

Plankton and benthos :

A total of 9 phyto-and 6 zooplankton organisms were identified from the different stretches of the Tungabhadra river (Table 7).

Diatoms, showed comparatively equitable distribution. In September 1985 and February 1986 their density was higher (above 82 to 349/litre) at Airani. Navicula spp., Fragilaria sp., Diatoma sp., Nitzschia sp., Gyrosigma sp. and Synedra sp. were the most common forms. The plankton population was maximum in samples collected from Airani, followed by Nadiaharnahalli. The pollutants thus appear to have a fertilising effect in the water in the recovery zone.

As a group, protozoans were almost unrecorded at all the centres except in Nadiaharnahalli during 1986. Rotifers (Brachionus spp., 2/1) were present in Airani in September 85 and at the effluent side in June 1986 (Lecane spp. 4/1). Diaptomus spp., Cyclops spp. and their nauplii were present in negligible numbers at Nadiaharnahalli and Airani. Plankton was completely

Table 7 : Data on plankton (number per litre) in different zones

Species	Above effluent discharge	Nadiaharna-halli	Airani
PHYTOPLANKTON			
CHLOROPHYCEAE :			
Spirogyra	9	59	13
BACILLARIOPHYCEAE :			
Staurnneis	-	2	2
Diatoma	50	112	7
Navicula	19	34	320
Fragilaria	6	4	1
Nitzschia	-	-	1
Gyrosigma	-	-	1
Synedra	-	1	4
ZOOPLANKTON			
PROTOZOA :			
Arcella	-	2	-
ROTIFERA :			
Brachionus	9	-	2
Lecane	-	4	-
CLADOCERA :			
Macrothrix	3	-	-
COPEPODA :			
Diaptomus	-	4	-
Cyclops	-	-	4
Nauplii	-	2	-

Table 8 : Bottom biota and littoral fauna in different zones of Tungabhadra river near Harihar.

Species	Above effluent discharge	Nadiaharna-halli	Airani
	(Number/Sq. m in parentheses)		
LITTORAL FAUNA :			
Fish fry	-	4 (2)	6 (3)
BOTTOM FAUNA :			
Chironomid larvae	-	-	17 (755)
Lamellidens marginalis	4 (177)	-	-
Lamellidens corrianus	6 (267)	5 (222)	4 (177)
Malania striatella tuberculata	7 (311)	4 (177)	6 (267)
Corbicula regularia	3 (133)	5 (222)	4 (177)
Viviparus bengalensis	1 (44)	2 (89)	2 (89)
Pila globosa	1 (44)	-	1 (44)
Gyralus	3 (133)	-	2 (89)

absent in the outfall region of GR/HPF except in Sept. '85 when 16 no/L of Diatoma sp. was recorded.

The collections of bottom and littoral fauna showed 2 species of bivalves and 6 species of gastropods in freshly dead condition downstream of the discharge point (Table 8). Dead shells of gastropods and bivalves in large numbers were noticed in the river below the effluent discharge point. Benthic population was completely absent between GR/HPF and BOF_1. Chironomid larvae were also present in Airani ($755/m^2$) in February 1986.

CONCLUSIONS

The river Tungabhadra is severely polluted near the outfall of the HPF and GR factories and this condition of the river continues upto 500 meters downstream. Aquatic life is completely absent in this stretch. In the region between 0.5 - 1 km downstream number of patches of aquatic weeds mainly Eichhornia crassipes and Potamogeton sp. grow on the factory side during the lean flow period from Dec.-June.

Opposite bank of the river remains unaffected which helps in sustenance of aquatic life in the river as it provides sufficient space for the fish to migrate.

Average zinc level in water at the outfall of GR is very high. Eventhough, most of the zinc settles down, its presence in the sediments at such high levels, as observed here is not desirable. During the lean flow periods in the river, dilution to safer limits is not complete even upto 10 km downstream. Zinc accumulation in different tissues, organs of fishes, particularly in kidneys is very high.

Although presence of mercury in water is not detectable, its significant presence in sediments around HPF outfall and farther downstream suggests occassional discharge of mercury into the river. Accumulation of mercury in the muscles, liver and kidney of Channa marulius upto 0.17, 0.74 and 0.71 µg/g wet wt., respectively, is alarming and signifies its biomagnification in the aquatic food chain in the river.

At many occassions between Sept. '85 and June '86 the flow in the river had receded below 1 m^3/sec, which is too low to bear the load of 44,000 m^3/day of effluents from the two factories. Bioassay toxicity tests with GR effluents have shown that 5% v/v concentration of the effluent causes 50% mortality in exposed fishes (O. mossambicus) within 96 hours. This implies that if the effluent discharge from GR continues even during the lean flow, approximately below 2.5 m^3/sec, the likelihood of heavy fish mortality in the downstream cannot be ruled out.

Summation of observations on fishes collected by cast net operations at different locations facilitates comparison of the availability of fishes in the different stretches of the river (Table 9). Condition of fishes particularly in the BOF_2 near Nadiaharnahalli is not satisfactory.

Due to adverse environmental conditions and non-availability of proper food, the growth of fish is hampered. Poor condition of fish is evident from just by seeing it. Hence, merely their presence does not indicate that the environment in this stretch of the river is congenial for fish. Fishes come there in search of food and inhabit the changed conditions.

Table 9 : Collection of fishes from different locations in Tungabhadra river.

Parameters	AOF Harihar	GR/HPF Outfall	BOF_2 N.halli	BOF_3 Airani
1. No. of observations	3	3	3	3
2. Total no. of cast net operations	36	30	60	60
3. No. of fish species caught	15	nil	14	18
4. Total no. of fishes caught	180	nil	125	225
5. Catch per unit effort	50	nil	20	40

Plankton and benthic fauna is completely absent in the outfall region. Only during Sept. 85, when the river flow was 50 m^3/sec., Diatoma sp. were available in this stretch. Shells of dead gastropods and bivalves are found in large numbers. This indicates that organisms carried by upstream water succumb to adverse conditions prevailing in this stretch, along HPF/GR outfall. Abundance of plankton near Airani shows recovery in water quality as is also reflected by physico-chemical observations.

RECOMMENDATIONS

1. Gwalior Rayon and Harihar Polyfibre factories should be asked to scrupulously follow the ISI/MINAS standards for the disposal of their effluents into the river Tungabhadra. Monitoring of these standards may be done from time to time.

2. Zinc content in GR effluent is very high. To minimise zinc content, the effluents of GR may be combined with the effluents of HPF before their discharge into the river and retained in a separate tank. Lagooning associated with introduction of water hyacinth will reduce the zinc content in water. This treated waste water may be discharged into the river through an elongated zigzag shaped channel. This will also help in checking the entry of mercury into the river.

3. As a short term measure the discharge of effluents from the two factories can be stopped during the lean flow period in the river. The Gwalior Rayon should be asked to discontinue its discharge into the river, as and when the flow in the river recedes below 5 m^3/sec and HPF should also stop its discharge when the river flow is below 1 m^3/sec, so that the chances of fish mortality in the downstream water may be avoided. KSPCB should insure that the above measures are strictly followed.

4. Fish catch in the upstream of Harihar and downstream at Nadiaharnahalli, Airani and Harlahalli should be regularly monitored by the state Fisheries Department in order to assess the exact losses due to deteriorating water quality in the Tungabhadra river, downstream of Harihar and remedial measures taken for the same.

5. Monitoring of zinc and mercury in sediments and fish should be included in the routine water quality monitoring programme of KSPCB.

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