Policy Paper
No - 1

RIVERINE HEALTH AND IMPACT ON FISHERIES IN INDIA

भाकृअनुप
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Policy Paper No. 01

RIVERINE HEALTH AND IMPACT ON FISHERIES IN INDIA

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1. River Systems and Fishery potential

There are 14 major rivers in India (Ganga, Brahmaputra, Brahmani, Cauvery, Godavari, Indus, Krishna, Mahanadi, Mahi, Narmada, Periyar, Sabarmati, Subarnarekha, Tapti) covering 83% of the drainage basin and account for 85% of the surface flow. Brahmaputra, Ganga, Indus and Godavari basin cover more then 50% of the country's surface flow. Apart from this there are 44 medium and 55 minor rivers which mostly originate from the coastal mountains. Only 4 out of 14 major rivers are perennial. These are Brahmaputra, Ganga, Mahanadi and Brahmani. The Cauvery, Mahi, Sabarmati and Periyar passes through low rainfall areas. The major rivers with a catchment area of more than 10 M.ha each are the Indus (32.1 M.ha), Godavari (31.3 M.ha), Krishna (25.9 M.ha) and the Mahanadi (14.2 M.ha). The total catchment area of medium rivers is about 25 M.ha and Subarnarekha with a 1.9 M.ha catchment area, is the largest river amongst the medium rivers in the country.(IINC,2004)

The diverse river system in India harbour one of the richest fish genetic resources in the world. The gangetic system alone harbours around 265 species of fish. The Brahmaputra system126 species and the peninsular rivers are reported to bear around 76 fish species. Rivers exhibit a complex mix of artisanal, subsistence and traditional fisheries with a highly dispersed and unorganized marketing system making collection of regular data on fish yield difficult. Based on the data on fish yield collected by CIFRI the average fish production from these riverine resources in India is only 300g/km.

The catch statistics over the years indicate some disturbing trends in the riverine sector; the biologically and economically desirable species the Indian major carps is being replaced by low value miscellaneous fish species, the total average fish landing in the Ganga River system declined from 85.21 tones during 1959 to 62.48 tones during 2004 Similarly the fish spawn availability of IMC has also declined drastically. (Jhingran 1991; Fish Statistics FAO 1958-76; Handbook of Fisheries Statistics, Govt. of India 1981-2000, Das, 2007)

2. Environmental concerns and conservation

Rapid urbanization, industrialization, and intensification of agriculture have all affected the rivers in different ways in India. Most Indian rivers, at present, are highly regulated (Agrawal and Chak 1991).Hundreds of multi-purpose reservoirs for water supply, irrigation, hydropower and fisheries have been constructed, as well as numerous barrages for water diversion. Many floodplains have been cut out from rivers by embankments and the remaining riparian lands are under intensive agriculture and grazing pressure. Human settlements, deforestation, mining and other activities have degraded the river catchments and increased sediment loads of all rivers. Also, during the past few decades, rivers have received increasingly large discharges of industrial effluents, fertilizers and pesticides from agricultural practices and domestic wastes (CPCB 1996). All this affected riverine biota. Fish species composition has changed and many species have nearly disappeared. It is pertinent to mention that out of the 30 world river basins marked as global level priorities for the protection of aquatic biodiversity by Groombridge and Jenkins (1998), nine are from India. These basins include Cauvery, Ganges-Brahmaputra, Godavari, Indus, Krishna, Mahanadi, Narmada, Pennar and Tapi.

Conservation and restoration of rivers have become vital for the overall sustainable development of the country. However, until recently, this "conservation" has been limited to "cleaning" of rivers by treatment of wastewater, occassional symbolic removal of garbage and enforcing the treatment of industrial effluents (Gopal and Chauhan 2003). For the conservation and restoration of river Ganga the Central Ganga Authority redesignated as the National River Conservation Directorate (NRCD) was established in 1985. NRCD coordinates the implementation of the schemes under the Ganga and other Action Plans. The main objective of the Ganga Action Plan was to improve the river water quality to the 'Bathing Class'. According to the CPCB survey report, the total municipal sewage generated in the identified 25 towns in 1985 was of the order of 1340 million litres per day (mld). Out of this, works corresponding to 873 mld were taken up under the first phase of GAP The Action Plan primarily addressed to the interception and diversion for treatment of the targeted municipal sewage of 873 mld. Schemes for the abatement of pollution from grossly polluting industries has been monitored and controlled under the existing Environmental Laws. With the completion of 256 schemes, the water quality of Ganga has shown improvement over the pre-GAP period quality in terms of both the bio-chemical oxygen demand (BOD) and dissolved oxygen, the two important parameters to assess the river water quality. To arrest river pollution in Yamuna, certain measures of cleaning river have been taken by the Ministry of Environment and Forests of the Government of India in 12 towns of Haryana, 8 towns of Uttar Pradesh, and Delhi under Yamuna Action Plan which is being implemented since 1993 by NRCD. Under Gomti river Action Plan pollution abatement works are being taken up along the Gomti river in Lucknow, Sultanpur and Jaunpur in Uttar Pradesh. About 269 mld of sewage is targeted to be intercepted, diverted and treated under this action plan.

So far, these efforts have indicated localised improvements. Overall, there has been limited appreciation of the nature of rivers as ecosystems whose ecological integrity depends upon their physical, chemical, biological characteristics and interactions with their catchment. The evaluation of the condition of rivers and lakes relative to their original or desired state is essential to conservation and rehabilitation. With the outlook for fisheries shifting from increasing yield to increasing profitability the approach for fisheries development is to ensure sustainability and reduce environmental impacts. (Ayyappan *et al*, 2007). Thus knowledge of the relative state of any water-body is essential in negotiations with other users of the resource.

3. Sources of Riverine Degradation

Domestic waste Domestic and municipal effluents are estimated to constitute 75% of India's wastewater by volume (Ministry of Environment & Forest, 1992). The enormity of sewage pollution is reflected in the river Ganga in which more than 70% of the total pollutional load is contributed by the sewage (Chaudhury, 1985). Municipal sewage is very often accompanied by trade waste synthetic detergents, heavy metals and (MBAS) from small scale industries sprawling around thickly urban areas.

The CPCB systematically collects data on industrial waste water and domestic waste water generation from big cities.

Basin-wise wastewater generation in class I cities

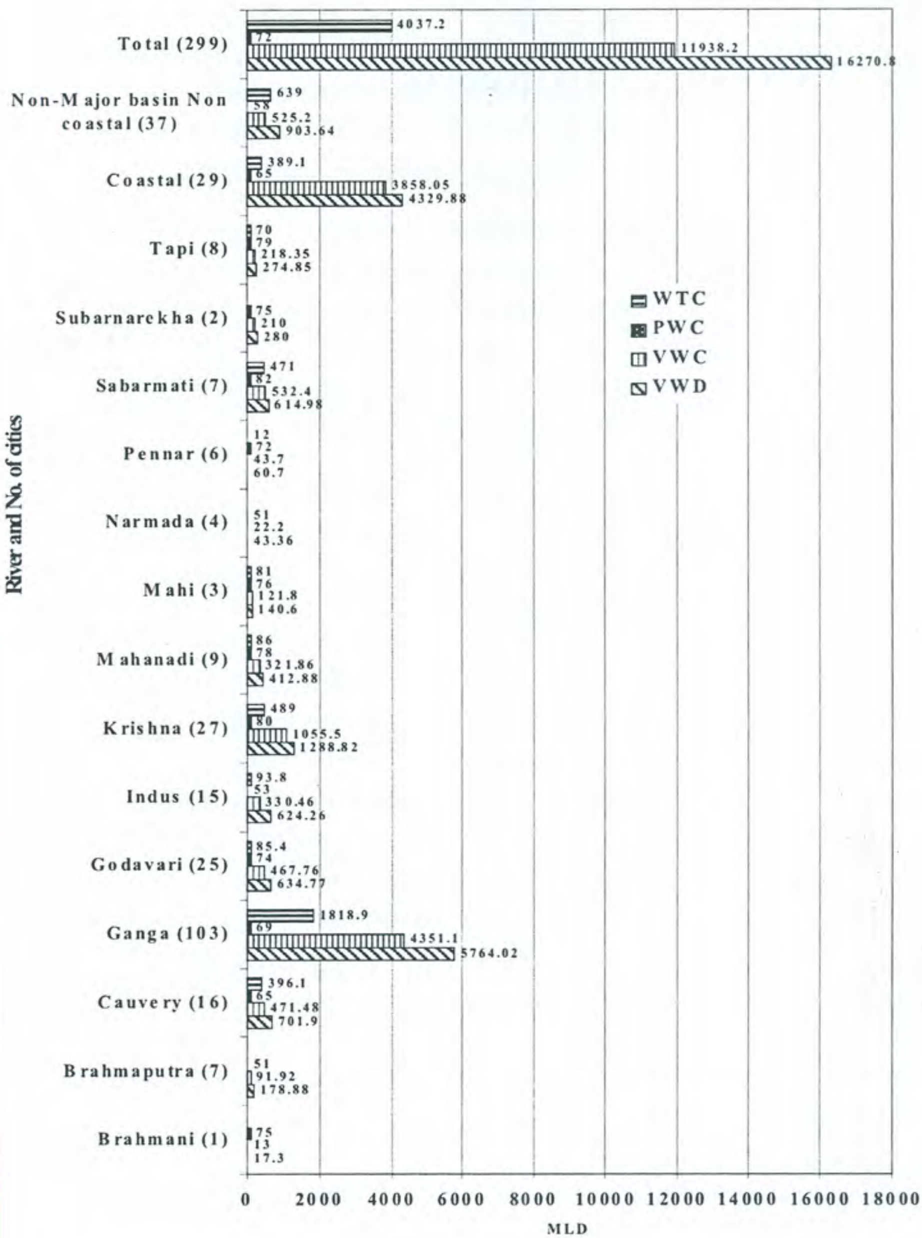


Fig. 1

Source: CPCB (2000)

299 class one cities in India generate about 1.66 million MLD of wastewater, where as capacity to treat only 4037 MLD exists in these cities. CPCB (2000). The basin wise waste water scenario of class one cities are given in Fig. 1 & 2.

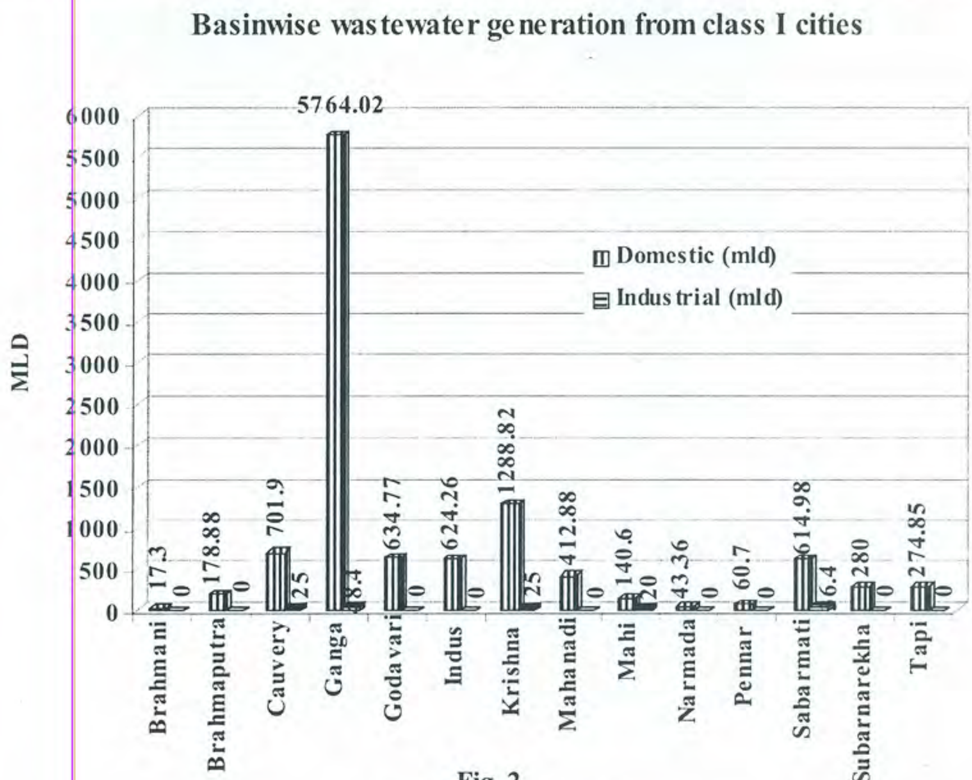


Fig. 2

Source: CPCB (2000)

Industrial waste: About 35.30% of the over 3 million small-scale industrial units (SSIUs) are of polluting nature. In case of large water polluting industrial units discharging effluents into the rivers and lakes, only 29% have adequate effluent treatment plants (Ministry of Environment & Forests, 1997). CPCB has identified 17 categories as highly polluting industries for priority action like sugar sector followed by pharmaceutical, distillery, cement and fertilizer.

According to the 1996 figures, 229 class I cities in India generate about 16662 MLD of waste water whereas the capacity to treat only 4037 MLD exists. 345 Class II towns generate about 1650 MLD of waste water whereas capacity to treat only 61.5 MLD exists, (CPCB, 2000). Estimates for the waste water generated by the rural households are not available. The current practices adopted for disposal of industrial wastewater includes discharge into public sewers, rivers, reservoirs or seas through creeks and estuaries with little or no treatment.

Agricultural runoff: Agricultural activities are one of the important causes of environmental degradations. The problem of water pollution becomes more severe as the magnitude of agricultural runoff is very vast .The fertilizer ($N+P_2O_5+K_2O$) consumption in India has increased from 7.7 million tonnes in 1984 to 17.54 million tonnes in 2000-01 (Ministry of Chemicals & Fertilizers, 2003). Use of pesticides also increased from 24,305 tonnes in 1971 to 61,357 tonnes in 1994-95. The pesticide use however, decreased to 47,020 tonnes in 2001. It is interesting to note that only 25-30% of total cultivated area is under pesticide cover. Yet the pesticides and their residues have polluted agricultural produce and different components of environment. This is mainly due to improper handling, wrong use schedule, non-awareness about chemicals and their residue behaviour.

Water abstraction: The projected water requirement of India for irrigation and other uses from the different watercourse as estimated during 2025 is approximately 1100 billion cubic meter (Sunderesan, 1982). According to the Ministry of Water Resources (MoWR) 80% of India's utilizable water is devoted to agriculture in the form of irrigation. Demand for domestic sector has remained low and accounts for only 5% of the annual fresh water withdrawals in India. According to MoWR, industrial water use in India stands at about 40 billion cubic meters or nearly 6% of the total fresh water abstraction. According to Central Pollution Control Board (CPCB), in 2000, India's annual freshwater withdrawals were about 500 billion cubic metre and the Indian industry consumed about 10 billion cubic meter of water as process water and 30 billion cubic meter as cooling water. This accounts for 8% consumption by the industry. The large scale abstraction alters the water quality by reducing the load bearing capacity of down stream water. Although water abstracted for the various needs are drained back into the water system, but it is contaminated by a variety of substances detrimental to aquatic life. The dams, barrages, rivers and other hydraulic structures constructed on riverine ecosystem disturb the river continuity. The discharge downstream is reduced leading to habitat destruction both downstream and upstream. The migratory pathways of fishes are obstructed. As flood control measures various forms of river training viz. guide, banks, spruce and river revetments have been constructed in our country. One of the direct impacts of river embankment is the increase in the water current velocity at particular sites of the river upsetting the life habits of aquatic organisms

Siltation: Nearly 5334 million tons of soil is eroded annually from the cultivable land and forests of India. On cropland, the erosion can range from less than 3 to more than 50t $acre^{-1}yr^{-1}$. The country's rivers carry approximately 2050 million tons of soil of which nearly 480 million tons is deposited in the reservoirs and 1572 million tons is washed into the sea every year. The loss of storage capacity of reservoir due to silting is by far the most serious problem created by soil erosion (Gupta, 1975). The sediment load of the river Ganga and Brahmaputra are the highest in the country with 586 million t to 470 million t respectively. Of the major river basins studied in the country more than one third carry sediment loads of 100 million t or more (Jhingran,1991)

Climate change: The climate of the earth in the past few decades is showing perceptible changes both in global and regional scale manifested by increase in atmospheric and water temperature. Historical data shows an increase in temperature by 0.3°C to 0.6°C between1890 to 1990 and projections by the end of the century show a range of 2-4.5 °C increase (IPCC,2007).As global warming continues to increase the atmosphere temperature, it will lead to a continuous shift of zero temperature line (snow line) toward higher altitude. Thus glaciers will receive more liquid precipitation and less monsoonal solid precipitation. Shift in snowline will result in lesser input to glacier mass balance during summer periods. Therefore, higher atmospheric temperature and more liquid precipitation at higher altitude in the Himalayas will lead to rapid retreat of glaciers and downstream flooding in the coming future (Hasnain 2002, Kadota *et al.* 1993). Its impact will be felt in the rivers and associated ecosystems. This alteration in the hydrologic pattern of the rivers and associated wetlands will definitely impact inland fisheries (Das *et al,* 2007a) .In West Bengal for example the mean minimum and mean maximum air temperature increased in the range 0.19 °C - 0.67 °C and 0.09 °C - 0.37 °C in four districts during 1985 to 2006. The mean maximum and mean minimum water temperature during the fish breeding season (March-September) also increased by 1.66°C and 0.31°C respectively during the same time period in district North 24 (Prgs). This enhanced temperature is one of the prime reason for the advanced breeding by 1-2 months of the Indian Major Carps in all the districts since last twenty years in West Bengal. (Das *et al*, 2007b).

Reports of fish kill

The degraded rivers in specific stretches have recorded total loss in aquatic life including fishes. The severe impacts of industrial effluents disposed into our river systems have resulted in fish kills, which have been reported from time to time.

Table 1. Fish kill reports from Indian rivers

Place	Year	Cause	Source
River Gomti, Lucknow	1983, 1984, 1986	Distillery waste	Joshi, 1994.
River Chahar, Alwage	1974	Pesticide	Joshi, 1994.
River Tungabhadra, Harihar	1984 1994	Poly fiber, rayon effluents	Murthy, 1984.
River Ganga, Monghyr, Bihar	1968	Oil refinery effluents	Sunderesan *et al.* 1983
River Adyar, Madras	1981-82	Tannery effluents	Joshi, 1994.
River Gomti, Tripura	1988	Epizootic ulcerative syndrome (EUS)	Das and Das, 1993.
River Shella, Meghalaya	1988	EUS	Das and Das, 1993.
River Churni, West Bengal	1993 1997	Sugar mill effluents	Ghosh & Konar, 1993. Konar, 1997.
River Yamuna, Haryana	1999	Sudden increase in turbidity due to sugar factory discharge	Anon, 1999.
River Bhavani Tamil Nadu	1999	Untreated effluent of South India Viscose	Bhavani River Protection Council
River Burhi Gandak, Bihar	2000	Effluent from sugar mill	Alam *et al.* 2001.
River Sutlej	2001	Probably effluents of NFL and Punjab Alkalis and Chemicals Ltd.	The Tribune, Chandigarh. 24th November, 2001.
River Gomti Lucknow	2003	Effluent from sugar mill, paper mill, Sugar mill and distilleries, upstream of Sitapur and Lakhimpur-Kheri	India-ej News,13th July.2003
River Gedilam Tamil Nadu.	2005	Sugar mill effluents of Nellikuppam,	The Hindu, 11th May 2005

All these reports indicate the laxity of our pollution monitoring system.

4. Detailed Case Studies

Ganga River System

4.1 General features **:** The length of mainstream of the river is 2525 km. It originates from the icepacks of Gangotri in Uttar Kashi District of U.P. at 7100 m MSL. Its total basin area is 0.861 million km^2 with a geographic location 37° 3' – 85° 58' E and 25° 25 – 31° 30' N covering 8 states. Its main tributaries are the Yamuna, Ramganga, Gomti, Tons, Ghagra, Gandak, Burhi Gandak, Son, Bagmati and Kosi. A total of 1, 42,637 million m^3 of water is abstracted out of which the break up is for Irrigation - 85,000 million m^3; Storage under reservoir projects- 33,476 million m^3; and for other purposes (Industries. Collieries. power plants. etc.) - 24,161 million m^3. The major water abstraction points on the main Ganga are: The Upper Ganga Canal at Haridwar; the Lower Ganga Canal at Narora; the pumped canals -Dalmau, Bhoupali and Zamanie and the Farakka Barrage.

Among the northern tributaries, Ramganga, Ghagra and Sarda have diversion points. The Tribeni Canal taking off from the Gandak, Madhuban and Lalbakhuja canals and the recent projects on Gandak and Kosi are the diversion points on the eastern group of tributaries. In the southern sector, the Chambal projects consisting of three dams and the barrage at Kota have a live storage of 8500 m cu m. The Eastern and Western Yamuna Canals provide irrigation to the fertile Yamuna Ganga tract where 75% of the land is cultivable. There are a number of projects contemplated by Bihar on the tributaries of Son like the Kanhar, North Koel etc.

The State of Uttar Pradesh has the maximum impoundment of Ganga waters (17,271.9 m cu m).This includes the largest storage reservoir of the Ganga basin *viz.,* the Rihand which holds 8971 m cu m of water. Gandhisagar in Madhya Pradesh has an overall capacity of 6.911 m.cu.m. Farakka barrage is the only hydraulic structure on the main river which obstructs the flow of river just before its bifurcation into Bhagirathi and Padma. Commissioned in 1975. The barrage serves a vital purpose of flushing the Hooghly during the dry months. Water impounded behind the barrage is regulated to flow into the main river Padma that flows into Bangladesh and to Bhagirathi in India through a feeder channel.

4.2 Water and nutrient quality: Along the banks of Ganges, over 29 cities, 70 towns, and thousands of villages are situated. Nearly all of their sewage - over 1.3 billion litres per day - goes directly into the river. Another 260 million litres of industrial waste are added to this by hundreds of factories along the river's banks. Municipal sewage constitutes 80 per cent by volume of the total waste dumped into the Ganges, and industries contribute about 15 percent. The majority of the Ganges pollution is organic waste, sewage, trash food, and human and animal remains. Recent water samples collected in Varanasi revealed fecal-coliform counts of about 50,000 bacteria per 100 ml of water, 10,000% higher than the government standard for safe river bathing.

The major polluting industries on the Ganga are the leather industries, especially near Kanpur, which use large amounts of chromium and other toxic chemical waste, and much of it finds its way into the meager flow of the Ganga. From the plains to the sea, pharmaceutical companies, electronics plants, textile and paper industries, tanneries, fertilizer manufacturers and oil refineries discharge effluent into the river. This hazardous waste includes hydrochloric acid, heavy metals, bleaches, dyes and pesticides. Damming the river or diverting its water, mainly for irrigation purposes, also adds to the pollution crisis.

The water quality data of the National River Conservation Directorate clearly showed that the Ganga has deteriorated over the period 1993-1999. During 1999 BOD exceeded the permissible limit at 10 out of 27 sampling stations, as against only at 1 sampling station, viz. Kanpur down stream in 1993. The coliform levels also exceeded in many places during 1999. The poor condition of the river Ganga is reflected in various reports of CIFRI cited in succeeding pages. The physico-chemical parameters of water exhibited poor condition at the out fall (OF) and below out fall (BOF) zones of the major effluent discharge sites. Dissolved oxygen was critically low (<4 mgl^{-1} and even nil) at the OF sites. At many OF sites the phosphate and nitrate contents was also high. Organic load in the sediments (organic carbon %) was also noticed high at the major effluent discharge sites.

Though the water quality of river Ganga is optimum for fisheries is some stretches but pollution from the domestic sewage and industries have in general affected fish species abundance and composition in some stretches.

4.3 Pesticide residue status in water, sediment and fish: Studies indicate that the residues of organochlorine pesticides including HCH, DDT, endosulfan and their metabolites are commonly occurring substances in water of the river and its estuary. Unusual content of the pesticides was reported by Nayak et al. (1995) in the middle stretch (Varanasi) of the river (Table -2). Moderate content of HCH compounds were recorded in the studies of Kumari and Sinha (2001). DDT and its analogues was noticed moderate by Ray (1992) and Halder *et al.* (1989). Ray (1992) also reported moderate content of endosulfan compounds. Comparison of the data with the US EPA permissible limits for aquatic organisms or their consumers clearly indicates that the river water is contaminated with the residues of organochlorine pesticides, the content of which often cross thousands of times over the permissible limits.

Table :2 Organochlorine pesticide residues (ng l^{-1} or ppt) in water of river Ganga

Water resource	HCH	DDT	Aldrin	Endosulfan	Heptachlor	Chlordane	Reference
Ganga River	1 – 971	0 – 1240		0 – 2890			Ray, 1992
Ganga River	0 – 5808						Singh, 1992
Ganga River	0 – 1119	0 – 832	0 – 120	0 – 232	0 – 412		Agnihotri, 1993
Ganga River	105–99517	69 – 143226		83 – 66516			Nayak *et al.*, 1995
Ganga River	189 – 2597	19 – 1663	0–800	0–862			Kumari & Sinha, 2001
Hooghly Estuary	1–400	2–500					Thakar, 1986
Hooghly Estuary		6–4000		0–97			Halder *et al*, 1989
Hooghly Estuary	1.5	6.2				0.180	Anbu, 2002

Only limited studies available on the sediment phase of the river indicate low levels. Senthilkumar *et al.* (1999) reported HCH <0.1 – 8.1, DDT 0.1 – 36 and chlordane <0.1 – 49 ppb in the river while Joshi (1986a,b) observed DDT 17 – 89 ppb in the estuary.

In the fishes of river Ganga,(Table-3) significant accumulation of DDT (60 – 3700 ppb) was noticed by Senthilkumar *et al.* (1999). In the studies of Kumari *et al.* (2001) observed pesticide levels in fishes were: HCH

(55 – 1207 ppb) and DDT (14 – 1666 ppb). Aldrin and endosulfan were relatively low of 0 – 225 and 0 – 175 ppb respectively. In the estuary zone the reported levels were relatively low (Joshi, 1986 a & b and Samanta, 2006). Thus, it may be concluded that the Ganga river fishes sometimes cross the limits for HCH (Kumari *et al.,* 2001) and endosulfan (Kumari *et al.,* 2001). Although in majority of the cases, the observed residues of DDT in fish samples were much more than that of HCH or endosulfan, the permissible limit is not exceeded. Probably the dilution effect in the estuary is protecting the fishes from accumulating these persistent compounds.

Table -3: Organochlorine pesticide residues (ng g^{-1} or ppb) in fish and molluscs of river Ganga

	HCH	DDT	Aldrin	Dieldrin	Endosulfan	Reference
Fish	77	160	2.7	2.9		Kannan *et al.,* 1993
Fish	28 – 110	60 – 3700				Senthilkumar *et al.,* 1999
Fish	55 – 1207	14 – 1666	0 – 225		0 – 175	Kumari *et al.,* 2001
Hooghly estuary Fish Molluscs		 31 – 460 66 – 953				Joshi, 1986 a & b
Hooghly estuary fish	0.1 – 9.0	1.4 – 73.4	0 – 0.7		0 – 4.2	Samanta, 2006
Safe limits for human						
US FDA		5000	300	300		FAO, 1983
FAO	100 lindane	5000	200	200	100	
Thailand	500 lindane	5000	100	300		

In India, permissible limits of the organochlorine pesticides for aquatic organisms or their consumers have not yet been developed. Thus the US EPA limits (EPA, 2002, 2006)are considered for comparison. It is very clear that all the surface water resources are contaminated with the residues of organochlorine pesticides, the levels of which often cross thousands of times over the permissible limits. However, the residues in fish flesh are below harmful level for human consumption except in a few cases.

4.4 Heavy metals in water, sediment and fish: Metal contamination in the river Ganga has been reported by several workers (Table-4). The upper most stretch is relatively free from different metals. The middle stretch, receiving different effluents, is found heavily polluted. Although a significant stretch of the estuarine zone is heavily industrialized and receive effluents regularly, due to greater dilution the metal contents were found lower than that of the middle stretch. In majority of the cases the reported levels are found much higher than the US EPA permissible limits for the aquatic organisms. All the effluents were found contaminated with metals and sometimes it goes to unusually high values as was observed by Prasad *et al.,* (1989), Joshi (1991) and Ghosh *et al* (1983).

Metal content in sediment of river Ganga has been studied by many workers (Table 4). In the upper stretch, as per expectation, contents were found relatively low except Cd (Saikia *et al.,* 1988). Since the area is free from human activities, the metal contents were attributed to the geochemical sources. In the middle stretch (Rishikesh to Ramghat near Bulandshahr), highest content of the metals was recorded in the Ghaziabad stretch receiving industrial discharges. Although the Kanpur stretch of the river is reported to be heavily polluted, these are not reflected in the sediment metal content due to huge sediment load of the river and fresh deposition is protecting the system from the accumulation of the same. As a whole the river is found moderately polluted.

Joshi (1991) studied metal content in fish in the Rishikesh to Kolkata stretch of river Ganga. The highest values recorded are given in the Table -5. Like sediment, the content of Cr, Cu, Pb and Zn was found high in the fish samples collected from middle stretch of the river while Hg was high in the estuarine samples. Kaviraj (1989) reported relatively high content of Zn (135.6 $\mu g\ g^{-1}$) in *Penaeus indicus*. Among the studied fishes, *Mastacembelus pancalus* accumulated more amount of Zn (108.2 $\mu g\ g^{-1}$). As per the US FDA limit for human consumption, the Pb and Cr are found to cross the limits in some occasions.

Sinha *et al.* (2007) reported mercury concentration in different samples of the Ganga river in various seasons (water: 0.00037-.00032; sediment: 0.08-0.106; benthos; 0.108-0.144; fish: 0.205-4.369; floodplain soil: 0.095-0.126; vegetation: 0.098 – 0.254)

The high pH level (> 7.5) also facilitates metal precipitation in the Ganga river system in addition with the heavy silt load. Since fresh silt is also deposited every year, the cumulative impact of metal accumulation on sediments is not observed.

Table 4 . Heavy metals in sediment ($\mu g\ g^{-1}$) of river Ganga

River	Cd	Cr	Cu	Mn	Ni	Pb	Zn	Reference
Ganga (upstream)	0.8 - 29.4		4.1 - 17.9	107.3 - 226.1	4.9 – 11.8		26.3 - 48.3	Saikia *et al.*, 1988
Ganga (midstream)	0.0 - 1.2	3.0 – 51.0	2.5 - 45.0	70.9 - 511.0	4.5 – 49.0	1.2 - 16.0	125.0 - 259.0	Israili, 1991
Ganga (midstream)		8.4 – 13.0					60.0 – 84.0	Singh and Mahaver, 1997
Ganga (midstream)	2.1 – 9.9		10.2 – 128.1			30.5 – 47.1	50 - 249	Vass *et al.*, 1998
Ganga (midstream)	0.4 – 1.0	12.8 – 20.9				1.9 - 22.0		Khan *et al.*, 2003
Ganga	3.5	83.2	95.0	470.0	28.8	21.8		Mohammad *et al.*, 1987
Hooghly Estuary			4.0 - 53.0	250.0 – 800.0		12.0 – 115.0	12.0 – 611.0	Subramanian, 1985
Hooghly Estuary mouth			7.9 – 32.2	53.6 – 286.0	9.1 – 39.0	3.0 - 27.4	21.1 - 147.7	Mitra *et al.*, 1996
Hooghly Estuary	2.5 – 7.7		35.5 – 52.5			24.0 – 36.4	145.8 – 165.6	Vass *et al.*, 1998
Hooghly Estuary mouth	0.4 (0.1 - 0.7)	61.5 (24.9 – 96.6)			37.5 (16.9 – 58.3)	10.5 (6.8 - 14.2)	64.4 (27.2 - 95.2)	Ramesh *et al.*, 1999
Hooghly & Haldi	2.0 (0.4 – 4.4)		26.0 (3.9 – 80.4)	298.5 (34.4– 539.6)		36.0 (0.5 – 79.4)	77.0 (25.0– 363.4)	Samanta *et al.*, 2007
US EPA limit Not polluted Moderate pollution Heavy pollution	 - - > 6	 < 25 25 – 75 > 75	 < 25 25 – 50 > 50	 - - -	 < 20 20 – 50 > 50	 < 40 40 – 60 > 60	 < 90 90 – 200 > 200	Nichols *et al.*, 1991

Metal is a point source pollutant and since it gets adsorbed or precipitated very quickly on particulate matters, the effect is not clearly observed zone wise. Although the estuarine zone of river Ganga is heavily industrialised, the high tidal flushing activity is not allowing the metals to accumulate at alarmingly high levels.

5. Comparative Contamination of Inland Waters

5.1 Metal contamination

In general, metal pollution was found more in the rivers since these have become the discharge sites of the effluents which are mostly untreated. Studies are relatively less, in the reservoirs, since these are mostly located in the upstreams of the river and the huge water volume is protecting these water bodies from pollution. Some of the reservoirs receiving effluents are reported to be heavily polluted. Floodplain wetlands are also reported to have heavy metal contamination. The levels of heavy metal in various water bodies are given in (Table- 5)

Heavy metal contamination has been a problem for fisheries only in the rivers especially at the point source of pollution

5.2 Pesticide contamination

Majority of the studies on the pesticide residues in the inland aquatic systems in India were conducted in the rivers. In some cases the observed levels in water are enormously high as has been reported in Table 6.

If we generalize the rest of the data generated from the Indian rivers, the observed range for HCH was 0 – 5000 ppt of which the 1000 – 5000 ppt were detected near the pollutant receiving areas. In case of DDT also, rivers exhibited similar levels (0 – 5000 ppt) and trend. Aldrin was not recorded in all the cases. Its reported range was 0 – 200 ppt. Dieldrin was recorded in still less number of cases. Abundance of endosulfan was however, noticed, in the range of 0 – 3000 ppt. Heptachlor was reported 0 – 412 ppt in river Ganga (Agnihotri, 1993). Chlordane was found in traces (Anbu, 2002).

Studies in reservoirs are meager. Very high accumulation of the organochlorine pesticides are reported from the reservoirs of Rajasthan. Rajendra Babu *et al.* (1983) observed 1000 – 10000 ppt HCH in the Aranyar reservoir of Andhra Pradesh. These published values are unusually high and detected in only isolated cases. Modern instrumental technique like GC-MS

Table- 5 Table trace metals in water (ppb) of the Inland water bodies

Water bodies	Cd	Cr	Cu	Ni	Pb	Zn	Reference
Ganga (upstream)	0 - 11	0	7 - 17	12 - 50	0	72 - 157	Saikia *et al.,* 1988 Israili, 1991,
Ganga (midstream)	0 - 28	3 - 119	3 - 170	1 - 10	1 - 680	1 - 311	Singh and Mahaver, 1997 Vass *et al.,* 1998
Hooghly Estuary	2-14	-	5-19	-	17-41	22-37	Samanta et. Al,2005
Yamuna	0 - 0.38	0 - 1.32	(2.3 -18.0)		(0.8 - 6.9)	(22 - 54.7)	Jhingran & Joshi 1987
Yamuna (Allahabad)		(2.2-2.4)				(28-30)	Singh & Mahaver 1997
Hindon	(1.5 - 6.75)**	(12.5-210)	(16.5- 175)**	(9.75- 21.25)*	(10-14)**	(13-23.5)	Mukhopadhya 2003
Kali	(2 - 4)**	(6 - 17)	(15-28)**	(12 - 20)	(17 - 55)	(112- 167)**	Krishnamurti & Bharat 1994
Subarnarekha		150 - 250	127 - 182		200 - 420	205 - 292	Datta Munshi and Singh, 1990
Motijhel Surajkhand Ranital Reservoirs (MP)	(9-10)	20-48	(17-34)	(1-4)	(2-9)	(65-120)	Koushik *et al* 1999
Byramangala Reservior (Banglore)	0 - 15	0	28 - 52		16 - 22	87 - 130	Joshi 1990
Byramangala Reservior (Banglore)	nd	nd-15.0	(22-23)		(18-22)	(102-123)	CIFRI Report
Hussain Sagar (Hydrabad)	4.6	68	141		361		Khan *et al*,1986
Wyra, Moosi, Nagarjun Sagar Reservoirs (Karnataka)	0 - 30		0 - 20		0	(20-30)	CIFRI Report
Suguna & Bansdah Wetlands	0 - 2		0 - 10		0	(10 - 60)	CIFRI Repor

** indicating above permissible level & * indicating bellow permissible level could validate such observations. Joshi (1990) detected the isomers of HCH and DDT in water of Rihand reservoir.

In some ponds and floodplain wetlands of West Bengal relatively high content of endosulfan (670 – 8350 ppt) was reported by Chowdhary, *et al.* (1994).

Although the observed residue levels are many a times high, the tropical climate of the country is protecting the water phase from the worst state of pollution even after a huge consumption of these compounds in the past. It is clear that all the surface water resources are contaminated with the residues of organochlorine pesticides, the content of which often cross thousands of times over the permissible limits of US EPA and the aquatic organisms or their consumers are at a risk due to these pesticide residues.

Only a few attempts have been made to study the residues of organophosphorus pesticide in the river waters in India. Malathion, methyl parathion and dimethoate were detected in many water samples of river Ganga, ethion was also found occasionally (Ray 1992). In the same river however, Agnihotri (1993) observed very low concentrations of these insecticides.

In some pond and floodplain wetland of West Bengal, unusually high content of methyl parathion (85000 – 2113000 ppt) and monocrotophos (535000 – 4410000 ppt) were detected (Chowdhary, *et al.,* 1994). Although the water sources were near the paddy fields receiving these pesticides, more such study can strengthen the findings.

Studies on the residues in sediments of organochlorine pesticides are relatively less than that of the water phase. For HCH, the reported range is 0 – 250 ppb except river Gomti (0.1 – 1650 ppb). DDT and aldrin were found to be present in the range of 0 – 1000 ppb. In only one report the levels of DDT and aldrin were high of 690 – 4850 and 0 – 17000 ppb respectively (UNEP, 2002). Dieldrin was also detected in many cases, observed range 0 – 500 ppb. Endosulfan was reported in the sediments of river Gomti (0 – 72.6 ppb) (Singh *et al.,* 2005).

Scattered reports on the residue content in fish are available. In the fish from river Yamuna, huge residues of DDT (59 – 7575 ppb) were observed (Pillai and Agarwal, 1979). In the fish samples of river Gomti, higher content of DDT (0 – 1658 ppb) and moderate amount of HCH (4 – 410 ppb) were reported by Kaphalia *et al.* (1986).

Application of fertilizers and pesticides are responsible for their higher residues in the fishes of the floodplain wetlands. Very limited study was undertaken to measure the pesticide residues in such environments. The residues of endosulfan were found high (490 – 2390 ppb) in the fishes from pond and floodplain wetlands of West Bengal.

A few studies on the residue of organophosphorus pesticides in fish are available. Very high accumulation of methyl parathion (10250 – 10850 ppb) and monocrotophos (320000 – 523500 ppb) in the fishes from pond and floodplain wetlands of West Bengal was observed (Chowdhury et al., 1994). Agricultural applications were the source behind such unusual accumulation

Table- 6 Organochlorine peticide residues (ng /l or ppt) in the surface water of India

Water Resource	HCH	DDT	Aldrin	Dieldrin	Endosulfan	Heptchlor	Chlordane	Reference
Ganga River	1-971	0-1240			0-2890			Ray 1992
Ganga River		0-5808						Singh 1992
Ganga River	0-1119	0-832	0-120		0-232	0-412		Agnihotri,1993
Ganga River	105-99517	69-143226			83-66516			Nayak, *et al* 1995
Ganga River	189-2597	19-1663	0-800		0-862			Kumari & Sinha 2001
Yamuna River		40-3400						Agrawal *et al*,1986
Yamuna River	0-939	0-1444	0-58	0-129				CPCB 2000
Yamuna River(Delhi)	120	660					<0.008	Anbu,2002
Cooum River(Chennai)	1.6	250					1	Anbu,2002
Ulsoor River(Banglore)	3.1	13					0.54	Anbu,2002
Gomoti River		0-53165	0-627					Singh,1996
Gomoti River	0-4846	0-4578	0-205		0-1372			Singh *et al* 2005
Vellar River	26-3900	1-5						Ramesh *et al* 1990a
Tammileru/Kolleru River	upto 2637	upto 95			upto 18			Veeraiah and Prasad,1996
Rivers of Northeastern State	6-214	13-218			0-7			Pathak *et al* 1992
Kshipra River	272000	21900						Kulshrestha 1989
Chambal River		14470						Kulshrestha 1989
Tributaries of Ganga	4-26	9-72			2			Sarkar *et al* 2003
Hooghly Estuary	1-400	2-560						Thakar 1986
Hooghly Estuary		6-4000			0-97			Halder *et al* 1989
Hooghly Estuary(Kolkata)	1.5	6.2					0.18	Anbu,2002
Lake(Lucknow)	1450	121						Nigam *et al* 1998
Jalmahal reservoir(Rajasthan)	10-4600	40-4700						Kumar *et al* 1988
Mahalal reservoir(Rajasthan)	0-46530	70-33630	110-25040			0-1560		Bakre *et al*, 1990
Aranyar reservoir (AP)	1000-10000							Rajendra Babu *et al* 1983
Bheri (Kolkata)	59	53	0	6	2			Samanta *et al*, 2005
Floodplain Wetland (WB)	9	41	2	5	13			Samanta *et al*, 2005
Pond Floodplain Wetland(WB)					670-8350			Chowdhury *et al* 1994

Pesticide contamination of fishes has not been a major problem for fishes in our inland water bodies as indicated by the reports.

6. Impact of Stressed Environment

6.1 Hydraulics

6.1.1 Salinity: In river Hooghly river course modifications have played their part in estuarine fisheries. There has been a overall decline in the salinity of Hooghly-Matla estuary after commissioning of Farrakka barrage (Sinha et al, 1996) with gradient and marine zones pushed down towards sea. This has brought about distinct change in the species composition of fishes caught, with freshwater species making their appearance in tidal zone and a few neritic species disappearing.

The likely impact of taming of river Narmada on its estuarine fishery is an example. In a desk review (Anon, 1994) of the likely impact of Narmada Sagar and Sardar Sarobar on the fisheries downstream, carried out by CIFRI for Narmada Control Authority, it has been pointed out that as per the report of the Narmada Water Dispute Tribunal (Anon,1978) there would be 72.71 % reduction in water availability down stream at 30 years of commencement of construction.It may not change the salinity regime during non-monsoon months by the annual event of dilution during months shall not be maintained.This shall effect the migratory fauna, particularly *Tenualosa ilisha* and *Macrobrachium rosenbergi*, and accordingly the fish yield downstream will decline. Stage attained at 45 years from the commencement of construction of construction, when freshwater release from Sardar Sarovar shall cease, will be very critical as it shall be associated with steep hike in salinity and in absence of compromising factor (Freshwater flow) the tidal ingress shall be more towards river side. It is more likely that the whole estuary shall undergo a transformation into a biotope characterized by hypersaline condition with salinity tongue further invading inland. Fishery shall drastically change. With the present height of 80.3m attained by Sardar Sarovar Dam, impact of impoundment are already visible in the down stream.

In river Krishna changes due to salinity are discernible. Recent investigations conducted by CIFRI in river Krishna estuary in Andhra Pradesh, revealed that the establishment of upper Krishna projects in Maharashtra, and Karnataka involving reservoirs viz., Srisailam and Nagarjunasagar, the water availability in the river downstream of Prakasam Barrage has dwindled. Further, the requirement of water for irrigation and the Vijayawada Thermal Power Station, the gates of Prakasam Barrage remain closed resulting in complete drying up of the upper estuary bed. The seawater incursion into the riverine stretch has resulted in ground water becoming saline. The increase in salinity is due to reduction of freshwater river flows. Present investigations revealed the salinity amplitude in Krishna estuary to range from 20 to 35 ppt, a hyper-saline condition. During high tide the seawater reaches up to Nadakudu covering about 90% of the tidal stretch. Only during monsoon the rainwater and discharges from Prakasam Barrage on account of attainment of full storage level, lowers the estuarine salinity. Thus the Krishna estuary at present is wholly a tide-fed, polyhaline estuary threatened by the absence of freshwater from the main river. Thus Mullets are dominant in catches (80%) represented by *Mugil cephalus, Liza parsia, Liza* spp. Clupeids, perches, sciaenids, catfishes, penaeid prawns and mud crabs *(Scylla serrata)* form the other groups. The marine catch includes mackerels, sardines and pomfrets etc.

6.1.2 Siltation: Land use patterns in a watershed influence runoff, river hydrography and sediment load. Deforestation is a reason for the excessive silt load in most of the Himalyan river tributaries, a load which has increased rates of siltation downstream in oxbow lakes, floodplain sloughs & backwaters (Natarajan1989). Reduction in forest cover has led to a great increase in both the dissolved and particulate solids in Ganga river system Rao (1979). The sediment loads of the Ganga and Brahmaputra are the highest in the country with 586 million tones and 470 million tones respectively. Of the major basins studied in the country more than one third carry sediment loads of 100 million tones or more which is very high. In Chilka lagoon (Banerjee et al, 1996) regulated decreased discharges in coming rivers have made considerable negative impact on its fishery. Siltation of lagoon bed and its connecting channel with sea, profuse weed infestation, decrease in salinity and qualitative and quantitative decline in the fishery of this lagoon has been observed.

6.1.3 Recruitment: The impact of water abstraction is very obvious in river Ganga. Water abstraction and consequent reduced stream flow has affected the breeding and recruitment of fishes. The fish spawn availability index in river Ganga declined from 2984 ml in the 1960s to 27 ml in recent years (1994-2004) (Natarajan 1984, CIFRI Annual Report 1971-2004). It also showed a continuing deterioration of Indian major carps seed with decreasing percentage of major carps seed (78.62% in 1961-1965 to 34.48% in 2000-04) whereas minor carps (from 20.68% in 1961-65 to 52.95% in 1991-95) and other fish seed (from 0.7% in 1961-65 to 47.8% in 2000-04) showed an increasing percentage in total seed collection.

In the Ganga basin approximately 85 billion m^3 of water is diverted by canal project and by hydro-electric and storage reservoir for irrigation, power and flood control. Canal projects accounted for a little over 60% of the impounded water (Natarajan, 1989). The construction of flood control dykes and levees in flood prone low lying areas has deprived the major carps of their extensive breeding habitats, previously available in network of interlaced channels connected with the Kosi river (David,1959) and the flood plains of the Kosi, Gandak, Rapti, Sarju and other tributaries. Canal projects and flood control measures are the two major factors that are specially responsible for destruction of breeding habitat for major carps (Natarajan1989). The spawning grounds of Indian major carps are situated in the flood plains which are inundated during the monsoon. It is believed that a flood level between 5-8 m helps the fish to migrate upto the breeding grounds & a moderate current (0.35 to 1.6km/hr) help the spawn to shift down. Breeding and recruitment are seriously hampered when the water level in the streams do not reach the spawning ground due to inadequate discharge rate. Flood levels have a close relationship with the spawn availability of major carps (Jhingran, 1989)

The oxbow laks, deep pools and other lentic water bodies associated with the river act as sanctuaries for the brooders which get connected to the mainstream during the monsoon, when the discharge rate become inadequate, these water bodies fail to get connected and the brooders get isolated.

6.2 Dams and Fish passes

Hilsa: Hilsa is a classical example of anadromous fishes being affected due to obstruction of their migratory pathways by dams. The natural migratory range of these fishes in 1500 km from the Hooghly estuary to Allahabad on the Ganga. The 1975 construction of the Farrakka barrage at the head of the Bhagirathi and Padma tributaries of the Ganga, some 470 km from the river mouth, has not affected the hilsa fishing in the tidal stretch of the delta.However; the barrage has nearly dominated the riverine fishery upstream of Farrakka on the main stream of the Ganga, a fishery whish was based on runs of both Padma & Hooghly stocks. (Natarajan, 1989). Similarly hilsa ceased to migrate up to Damodar River, a tributary of the Hooghly after construction of dams (DVC), a barrage (Durgapur), and a weir (Anderson weir).The migration of fish is also restricted to 40km in the Rupnarayan River (Pantulu *et.al.* 1966).

The dams in the upper stretches of the river obstruct migration of mahseers (*Tor* spp) that move from low land to upland reachs for breeding. Shetty & Malhotra(1983) reported decline of *Tor tor* along with other fishes following construction of a barrage at Tribeni on the Gandhak river, Barrage at Son, Okhla and Farrakka are also known to impede major carp migration for breeding. For example the yield of major carps are reported to have been reduced about 50% of the 1964 level in the lower Ganga following construction of Farrakka (Jhingran & Ghosh 1978)

Fish pass: Major irrigation structures on rivers such as dams, weirs and barrages form solid obstruction to the migratory path of fish for spawning or feeding. Majority of these hydraulic structures in India have no provisions of fish pass resulting in significant reduction of fish species and yield. Fish passes are key elements for the restoration of free passage for fish and other aquatic species in rivers. The few fish passes built in India are on the Mahanadi barrage, Naraj barrage on river Mahanadi, the Hathnikund barrage on river Jamuna and Farakka barrage on river Ganga. The fish passes in the barrages on river Mahanadi are of the Denil type and in Farakka barrage on river Ganga it is Fish lock. These passes were constructed to take care of the migratory requirement of the Indian major carps, *Macrobrachium rosenbergi* and *Tenualosa ilisha.* Unfortunately these requirements has been partially fulfilled. Most of these structures had some drawbacks. This can be overcome by intensive research on the hydraulic design of fish passes for structures of varying heights and on migration behavior of the migratory fishes of India. CIFRI is conducting research on this important aspect and has designed pool type fish passes for some upcoming dams in the rivers of north eastern India. This environmental requirement of constructing fish passes for maintaining fish population in the entire stretch of the river for sustainable fisheries development needs due importance.

6.3 Contamination

6.3.1 Water quality: Sewage pollution is the major source of water quality deterioration of our rivers and floodplain wetlands. The major adverse impacts of sewage pollution are deoxygenation, high BOD load, rapid eutrophication and accumulation of heavy metals in the environment. Sharp fall in dissolved oxygen in water puts the biotic communities under severe stress. While some species can tolerate a wide range of dissolved oxygen, many communities are highly sensitive to this parameter. . For instance, complete absence of zooplankton during January to August and its reappearance in September represented by *Keratella* sp. have been observed in the downstream of sewage effluent outfall on the Ganga and Yamuna.

Bacterial population in river water and river bed gives a direct indication of the organic waste load. The mean concentration of total coliform organisms in Ganga water shows considerable seasonal and sectoral variations. The count is low in the sectors from Rishikesh to Kanauj (normally less than 2,400 MPN/ lOO m!) and higher concentrations are noticed at Uluberia, Dakshineswar, Palta. Kalyani, and Darbhanga Ghat (Patna). It is estimated that domestic wastewater contains 100 million coliform per 100 ml and 7000 viral particles per 100 ml. Synthetic detergents being absorbed into the body system of fish impair their growth and reproduction capacity. Detergents mixed with oil may be 60 times more toxic than oil alone. Synergistic action of detergents with insecticides has also been recorded. Its sub-lethal concentration causes thinning and elongation of respiratory epithelial cells. (Jhingran 1989)

Observation in river Kali (Qasim and Siddiqui, 1960) revealed deterioration of water quality by sugar mill effluent. It increases the BOD which depletes a great deal of DO in the river water and very often fish mortality occurred.

6.3.2 Toxicants: *Paper and pulp mill effluent*: Impact of toxic discharge from Triveni paper and pulp mill is reflected in erratic movement and mortality of fishes spreading over an area of 50 sq. m.(Das et.al). The fishes affected were *Mystus vittatus, Puntius sophore, Esomus danricus, Rita rita.* Bleaching powder present in the effluents release free chlorine which is highly poisonous with corrosive properties and is responsible for fish mortality.

Suspended solids: Exposure of fishes in river Damoder to fly ash produced from thermal power plants cause respiratory distress. This is due to deposition of coal dust particles and fine silt on the gills. Damages occur in the primary and secondary gill lamellae with swollen tips (.Banerjee *et. el*, 1998)

Heavy metals : Fishes in the industrial effluent outfall area in river Haldi at Haldia are exposed to an average metal concentration(μl^{-1}) of Cd (2-14), Cu (5-19), Mn (8-88), Pb (17-41) and Zn (22-37).The levels of Cd, Pb and Pb were alarming (Samanta *et al* 2005)

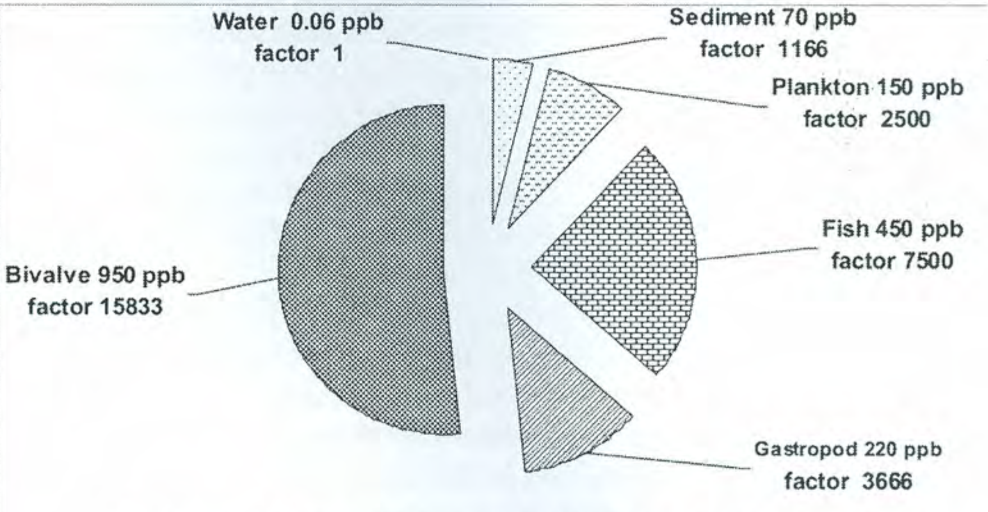
Biopsy of the gills, liver and kidney of fish *A. gagora, A. aor* and *P. pama* showed gill hyperplasia and swelling. Necrotic hemopoitic tissue and renal tubular degeneration is evident.

Investigations conducted in 110 Km stretch of river Hooghly passing through a densely industrialised zone indicated the levels of metals and pesticides to be within permissible limits. However fish abundance and richness declined in the downstream sites of this stretch. This is because of sandification of the river with frequent sand extraction from the river bed and point source pollution. (Das and Samanta, 2006)

6.3.3 Bio-magnification

In the Hooghly estuary, studies were conducted to determine the bio-concentration factor of DDT. The observed levels of DDT in different components of the food chain and bio-magnification factors are given in the Figure (3). The bio-concentration factor of 7500 for fish and 15833 for bivalves are indicating risk associated with the terrestrial consumers including human being.

Fig. 3



Biomagnification of DDT in aquatic food chain in Hooghly estuary

The ecological malady afflicting the inland aquatic resources and the consequent decline in fisheries can be traced to the anthropogenic activities associated with population growth in the river basins. Irrigation projects, flood control measures have nearly destroyed floodplains, sloughs, inundation zones, and oxbow lakes, all of which are breeding habitats of the major carps. The impairment of recruitment in these fishes has set into motion changes and readjustments of fish populations at the second and third trophic levels. The Major carp populations are now declining, while minor carps and other less economic species are increasing in relative abundance. The impact of irrigation project on fisheries is compounded by land use practices, pollution, exploitation, and fishing. Hydraulic structures have all eliminated the fishery for anadromous fishes *Tenualosa ilisha*

7. Existing Policy support

For inland fisheries and its beneficiaries as stake holder the significance of water lies in the fact that water in the river, reservoir or lake serve as habitat for fish unlike other stakeholders. For suggesting any policy for inland fisheries development it is essential to understand the structure and mechanism of water quality govermence in India. Basically it has three aspects; policy frame work to deal with water quality issues, a legal framework for violators of the policy and institutional framework to implement the policies

7.1 Policy Framework

The policy framework of Government of India for management of water resources in India are elucidated in National Water Policy (2002) (Box-1); National Conservation Strategy and Policy Statement on Environment and Development (1992); Policy statement for Abatement of Pollution (1992) and Draft National Environment Policy (2004) (Box-2). The policy statements and strategies advocated are technological measures like use of clean technologies and water pollution control systems; zoning strategy like setting up of source specific and area wise water quality standards and time bound plans to prevent and control pollution; fiscal incentives for environmentally clean technologies, recycling and reuse of wastes and conservation of natural resources, operationalization of polluter pays principle and command control like enforcement of pollution control norms, environmental audit, EIA and clearance of projects by MOEF above certain size.

Box-1
National Water Policy

1 Water is a prime natural resource, a basic human need and a precious national asset. Planning, development and management of water resources need to be governed by national perspectives
2 Water is part of a larger ecological system. Realising the importance and scarcity attached to the fresh water, it has to be treated as an essential environment for sustaining all life forms
3 Water resources available to the country should be brought within the category of utilizable resources to the maximum possible extent.
4 Water resources development and management will have to be planned for a hydrological unit such as drainage basin as a whole or for a sub-basin, multi-sectorally, taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental considerations.
5 Watershed management through extensive soil conservation, catchment-area treatment, preservation of forests and increasing the forest cover and the construction of check-dams should be promoted.
6 With a view to give effect to the planning, development and management of the water resources on a hydrological unit basis, along with a multi-sectoral, multi-disciplinary and participatory approach as well as integrating quality, quantity and the environmental aspects, the existing institutions at various levels under the water resources sector will have to be appropriately reoriented / reorganised and even created, wherever necessary.
7 In the planning and operation of systems, water allocation priorities should be broadly as follows:
Drinking water
Irrigation
Hydro-power
Ecology ?
Agro-industries and non-agricultural industries
Navigation and other uses.
However, the priorities could be modified or added if warranted by the area / region specific considerations.

8 There should be a close integration of water-use and land-use policies

9 Management of the water resources for diverse uses should incorporate a participatory approach; by involving not only the various governmental agencies but also the users and other stakeholders, in an effective and decisive manner, in various aspects of planning, design, development and management of the water resources schemes.

10 Both surface water and ground water should be regularly monitored for quality. A phased programme should be undertaken for improvements in water quality.

11 Effluents should be treated to acceptable levels and standards before discharging them into natural streams.

12 Minimum flow should be ensured in the perennial streams for maintaining ecology and social considerations.

13 Principle of 'polluter pays' should be followed in management of polluted water.

14 Necessary legislation is to be made for preservation of existing water bodies by preventing encroachment and deterioration of water quality.

15 While physical flood protection works like embankments and dykes will continue to be necessary, increased emphasis should be laid on non-structural measures such as flood forecasting and warning, flood plain zoning and flood proofing for the minimisation of losses and to reduce the recurring expenditure on flood relief.

16. The erosion of land, whether by the sea in coastal areas or by river waters inland, should be minimised by suitable cost-effective measures.

Box-2 National Environment Policy

The *National Environment Policy* (NEP, 2004) is a response to our national commitment to a clean environment, mandated in the Constitution in Articles 48 A and 51 A (g), strengthened by judicial interpretation of Article 21. It is recognised that maintaining a healthy environment is not the state's responsibility alone, but also that of every citizen.

Objectives of NEP 2004

The principal objectives of this policy are enumerated below.

i. Conservation of Critical Environmental Resources:

To protect and conserve critical ecological systems and resources, and invaluable natural and man-made heritage which are essential for life support, livelihoods, economic growth, and a broad conception of human well-being .

ii. Intra-generational Equity: Livelihood Security for the Poor:

To ensure equitable access to environmental resources and quality for all sections of society, and in particular, to ensure that poor communities, which are most dependent on environmental resources for their livelihoods, are assured secure access to these resources.

iii. Inter-generational Equity:

To ensure judicious use of environmental resources to meet the needs and aspirations of present and future generations.

iv. Integration of Environmental Concerns in Economic and Social Development:

To integrate environmental concerns into policies, plans, programmes, and projects for economic and social development.

v. Efficiency in Environmental Resource Use:

To ensure efficient use of environmental resources in the sense of reduction in their use per unit of economic output, to minimize adverse environmental impacts.

vi. Environmental Governance:

To apply the principles of good governance (transparency, rationality, accountability, reduction in time and costs, and participation) to the management and regulation of use of environmental resources.

vii. Enhancement of Resources for Environmental Conservation:

To ensure higher resource flows, comprising finance, technology, management skills, traditional knowledge, and social capital, for environmental conservation through mutually beneficial multi stakeholder partnerships between local communities, public agencies, and investors.

Under this objective the proposed action plan for Freshwater Resources viz., river systems is

a) Promote integrated approaches to management of river basins by the concerned river authorities, considering upstream and downstream inflows and withdrawals by season, pollution loads and natural regeneration capacities, to ensure maintenance of adequate flows and adherence to water quality standards throughout their course in all seasons.

b) Consider and mitigate the impacts on river flora and fauna, and the resulting change in the resource base for livelihoods, of multipurpose river valley projects, power plants, and industries.

c) Consider mandating the installation of water saving closets and taps in the building byelaws of urban centres.

And for Wetlands it is

a) Set up a legally enforceable regulatory mechanism for identified valuable wetlands to prevent their degradation and enhance their conservation. Develop a national inventory of such wetlands.

b) Formulate conservation and prudent use strategies for each significant catalogued wetland, with participation of local communities, and other relevant stakeholders.

c) Formulate and implement eco-tourism strategies for identified wetlands through multistakeholder partnerships involving public agencies, local communities, and investors.

d) Take explicit account of impacts on wetlands of significant development projects during the environmental appraisal of such projects; in particular, the reduction in economic value of wetland environmental services should be explicitly factored into cost-benefit analyses.

e) Consider particular unique wetlands as entities with "Incomparable Values", in developing strategies for their protection.

7.2 Legal Framework

Some of the environmental laws of importance are

(a) The Water (Prevention and Control of Pollution) Act, 1974 : It created the Central and State Pollution Control Boards (CPCB and SPCBs)

(b) The Water Cess Act, 1977: It was amended in 2003 and its main attention is to enhance the finance of the CPCB and SPCBs by imposing a levy (cess) on water consumed by certain industries and by local authorities.

(c) The Environmental (Protection) Act, 1986: It empowers the Central Government to decide emission standards, restricting industrial sites, laying down procedures and safeguards for accident prevention and handling of hazardous waste investigation and research on pollution issues.

(d) The Environment Impact Assessment introduced in 1994, empowered Central Government to impose restrictions and prohibitions on installation expansions or modernization of 30 types of activities unless an environmental clearance is granted.

Environment standards**:** The prevailing aim of environment standards is to reduce potential damage to: human society in terms of health damages (morbidity and mortality); to sensitive ecosystems, resource conservation (fish) is also one of the aims.

Environment Management System (EMS): Such as ISO 14001 requires adoption of standardized environment management practices, documentation and third party verification. Adoption of EMS could significantly ease the burden of monitoring by PCBs.

Ecolabeling: Ecolabels address the preference of environmentally conscious consumers, rather than ensuring adherence to environmental standards. Labeling schemes may involve review of the entire product cycle from sourcing raw material to final disposal of the project.

7.3 Institutional Framework

At present, states generally plan, design and execute water supply schemes. Water supply and sanitation is a state responsibility under the Constitution of India. The states may give the responsibility and powers to the Panchayati Raj institutions (PRIs) and Urban Local Bodies (ULBs). In addition, a variety of different government institutions at the centre have a role in the management of declining of water supply.

Ministries of Water Resources, industry, power, agriculture, environment and forests, rural development, urban development are some of the major stakeholder's ministries that have a mandate in water resource management. Other important institutions that have a major role in water resource/quality management are Central Water Commission, Central Groundwater Board/ Authority, Central Water Quality Authority, Central and State Pollution Control Boards.

7.4 Are the Interests of Fisheries Covered in the Above Policies

The National Water policy (NWP) of India stipulates (Clause 14.3) that "Minimum water flow should be ensured in the perennial streams for maintaining ecology and social considerations". However, the NWP also places environment in the fourth order of priority for allocation of water. The sequence of priority is drinking water, irrigation, hydropower, and then environment.

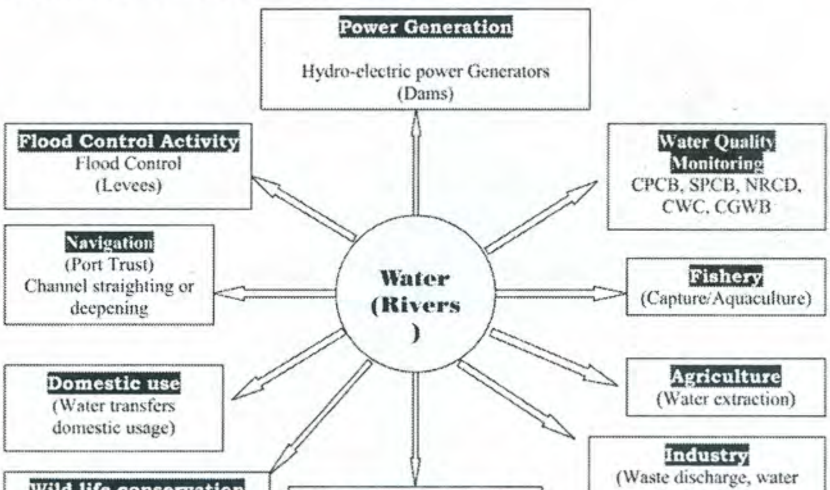
This means that at any particular location, the available water after supplying the requirements of drinking, irrigation and hydropower requirement, the requirement of environment will be fulfilled. On the other hand, the concept of a minimum flow in the river stipulates that a certain quantity of water is to be first allocated to maintain this minimum flow, and all other requirements are to be supplied only from the balance if any. This upgrades the environment requirements at priority one. Thus it is seen that placing of environment at fourth priority in the NWP creates a conflict with the concept of minimum flows or EFR.

Riverine and coastal biodiversity has not been adequately recognised in the conservation challenges of NEP, nor the fisheries sector as such. It may be noted that exotics fishes have been introduced into the inland waters bodies and riverine systems without effective mechanisms to examine ecological consequences, particularly on biodiversity and aquatic life. One major concern demanding the attention of policy makers is the question of water allocations for maintaining ecological services. Also as an environmental issue, the difficult problem of land- water linkage is not being addressed in the present water or land policies.

The pressing problems of conservation and management of Inland fisheries are not being addressed in the policy document. For the aquatic organisms like fish water serve as a habitat If we take the example of irrigation and flood management which has relevance to fish and fisheries interesting set of supply side and demand side option come out. For adaptation to the increased demand of water for irrigation, the supply side option aims at increasing supply. Increasing the water source for irrigation is expensive and has potential environmental impact. The demand side options aims at reducing demand. They include increase use efficiency through improved technology and high price for water and changes in cropping pattern by switching to crops that require less or even no irrigation.

For flood management, supply side option include flood protection with levees and reservoirs, these are expensive and have potential environment impact. Another supply side option is to use catchment source controls to reduce peak flows; these are more effective for small floods. Demand side options include improvement in flood warning and information and to curb floodplain development. So a variety of options are available; influences on fish and fisheries depend on the details of such choices. The demand side options would appear in most cases to be better choice for those interested in fish and fisheries as opined by Arnell et al. (2001).

Graphic picture of water stakeholders



8. Recommendations

1. Only 30% of the industries on the Ganga river system adopt any control measure. Fly ash, coal particles, agro-industrial organic wastes and settleable sewage have diminished benthic productivity. While sewage is taken care off to a certain extent through the Ganga action plan programmes, the industrial wastes need effective control measures.
2. Siltation being one of the chief reasons for low productivity of river stretches, it is necessary to promote aforestation along the catchment areas of the river and its tributaries. Planting a 10-15 m wide strip of land bordering the river with herbaceous plants, shrubs and small trees can act as a buffer zone.
3. Gravel and sand extraction from river beds should be restricted wherever possible. Extractions should be confined to catchment areas where there is already a high sand sediment input to streams.
4. Hydraulic structure, embankments or levees should be restricted to allow free entry of fish into their known breeding grounds like oxbow lake, flood plains, low lying areas and back waters.
5. Critical water levels required for effective breeding of major carps and maintenance of a minimum level of water downstream during the dry season should be considered as a criterion while determining the quantum of water to be released from dams and barrages.
6. The migratory habits and behaviour of riverine fishes and prawns are to be understood well, and any future river valley project on the river system should incorporate in the plan the construction of effective fish passes. Experience so far indicates that effectiveness of fish passes constructed in India are far from satisfactory. The appropriate technology for fish pass /locks based on the biological requirement of the migratory species need be developed.
7. Fish along with other aquatic fauna and flora are natural claimants of water. But their requirements of water have always been overlooked while designing any project concerning modification of water courses. Care need be taken not to abstract or spoil the quantum and quality of water beyond their tolerance limit. Controlling the harmful effects of

these man-made interference would require the cooperation of various agencies, such as fishery scientist, irrigation and flood control authorities, pollution control boards and general public. Fisheries scientists should be involved in clearance of all development projects concerning inland waters.

8. Programmes aimed at restoring the quality of river water and abating pollution should urgently evolve viable standards for various water quality and biological parameters stretch-wise and to ensure that the standards are strictly adhered to by the agencies concerned. viz. industries, municipalities etc. There is also a need for a holistic bio-indicator approach using fish for evaluation of the ecological integrity of aquatic ecosystems in India.

There are conflicting interests of various users of inland waters. Common property nature of resource with open access creates problems for management. In case of rivers flowing through more than one state, the exploitation policies are at variance, with none caring for conservation or development of fisheries. A well-defined national riverine policy needs to be evolved for optimum utilization and conservation of fisheries resources. A coordinated mechanism may be evolved between the littoral states, fishery departments, water authorities and research institutions for formulation of a rational and ecologically sound development and exploitation policy for fisheries of such rivers. A reorientation of the water demand strategies is needed laying emphasis on a) Public participation and awareness creation and b) Participation of all stakeholders in decision- making at local, regional, state and national level.

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