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Impact of aquatic pollution and its effect on fisheries in Bangladesh

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Abstract : Bangladesh is uniquely endowed with vast water resources. The near-shore sea, estuaries, mangroves, rivers, lakes, and pond all taken together, offer tremendous opportunities for farming of fish and shell fishes. The effect of heavy metal on the aquatic environments was reviewed, localized anthropogenic sources of heavy metals in Bangladesh show evidently the future deleterious effects on the aquaculture environment that eventually cause the decline of fish production. Degradation of the environment through natural and anthropogenic interventions has been identified as the primary causes for the decline in open water capture fishery production. Due to rapid industrial development of the country, industrial pollution may, in time, become a threat to the aquatic environment. No systematic studies have been done so far on the impact of industrial pollution on aquatic life. Industrial effluents specially the discharge of fertilizer, petrochemical, tanneries, pulp and paper mills, distilleries and thermal power plants might have adverse effects on the aquatic life. It is also anticipated that indiscriminate use of pesticides for crop production may partially responsible for hydrological degradation of rivers leading to the decline of fish production in open water of Bangladesh. In recent years, the impact of aquatic pollution on human and animal life has become a matter of special concern of ecologists in general, and aquaculturists in particular.

1. Introduction

Bangladesh is located in South Asia between lat 20° 34″ and 26° 38″ N and long 88° 01″ and 92° 41″ E(Fig. 1) and is surrounded by the Bay of Bengal, the Gangetic plains fo India and the forest of Myanmar. It is primarily a low lying plain of about 148,000 km^2 criss-crossed by innumerable water courses including the mighty rivers Padma, Jamuna, Meghna and Karnaphuli. Other important rivers include the Teesta, old Brahmaputra, Karatoa, Surma, Shitalakhy, etc. During peak periods, these rivers and their tributaries discharge a total of about 5 million cubic feet per second into the Bay of Bengal. Water resources are one of the most critical and valuable components of the natural resources of Bangladesh. Its rich soils and humid climate also have brought about some of the most fertile agricultural land in the world (JICA, 1997). Bangladesh has a tropical monsoon climate. The country has mainly four seasons : winter (December-February), summer (March-May), monsoon (June-September), and autumn (October-November).

Aquaculture, as a major component of agriculture in Bangladesh, is practiced either as a primary or secondary source of income. The contribution of agriculture to the country's gross domestic product is 45%, of which 6% comes from fisheries. In the agriculture-based economy, fish and fisheries play an important role in nutrition, income, employment, poverty alleviation and foreign exchange earnings, contributing 73% to national animal protein intake and 10% to export earnings, in addition to providing full-time employment to 1.4 million people and part-time employment to another 11 million (MAZID and ALAM, 1995). An estimated 73% of rural households are involved in rural fishing.

The production of fish in 1993-94 has been

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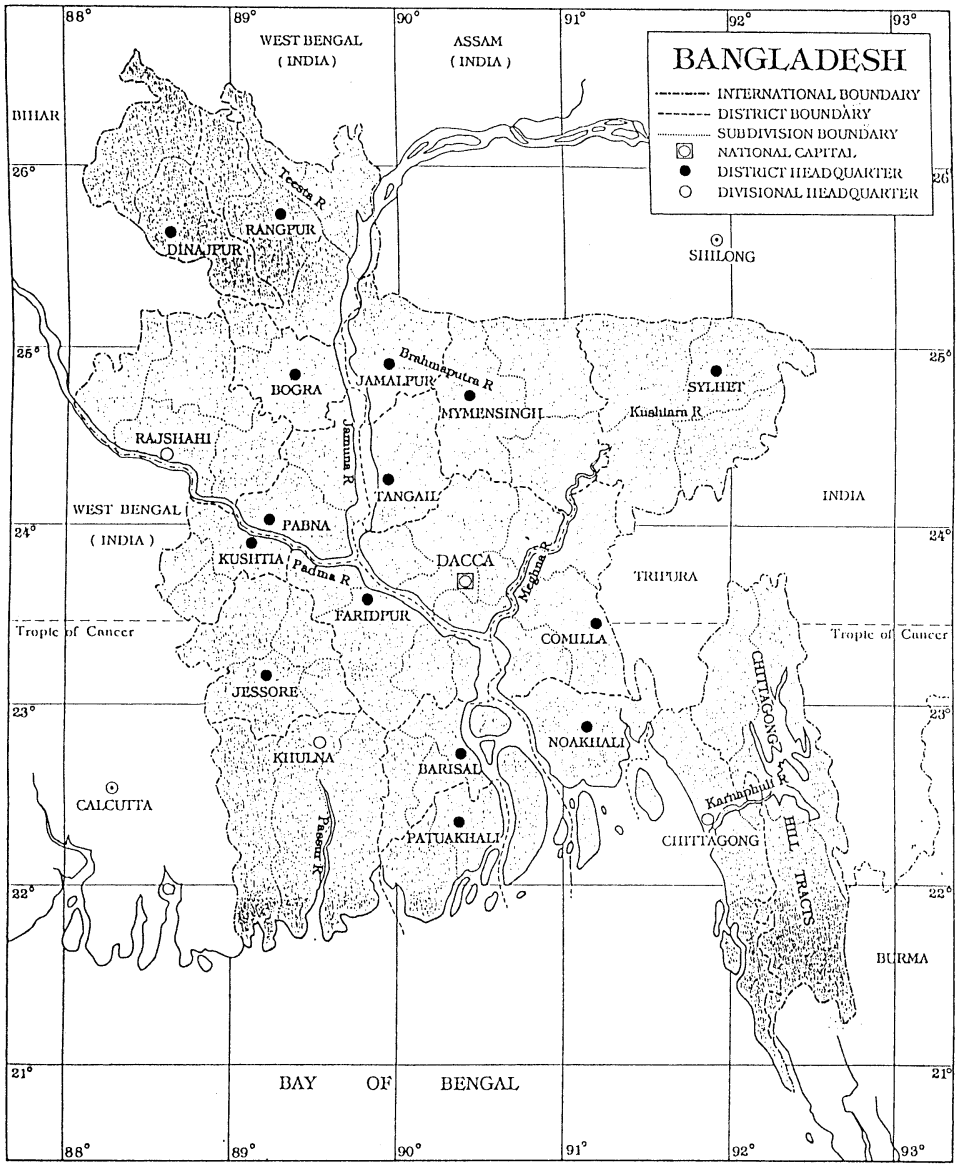

Fig. 1. Map of Bangladesh.

estimated to have been about 1.08 million metric tons. Of this total, inland open water fisheries contribute 51%, inland fresh and brackish water aquaculture 25%, and marine capture fisheries 24%. Current annual consumption fish per caput is about 25.0 g up from 20.5 g in 1989 -90. However, to achieve the recommended consumption rate 38.0g caput^{-1} day^{-1}, the country needs to produce about 1.9 million metric tons of fish. Vast potential water resources exist to achieve this production through sustainable development of aquaculture and resource management. The role of fisheries in nutrition and the economy of Bangladesh is shown in Table 1.

1.1. Inland aquatic environment In Bangladesh

Bangladesh has altogether 230 rivers, big and small. Of these, 54 are shared with the upper

Table 1. The role of fisheries in nutrition and economy in Bangladesh.

Fisheries contribution	: 4.0% of GDP
(1993-94)	10.0% of export earnings
	(Tk.13,000 million=US $ 325 million in 94-95)
	6.0% of total protein intake
	73.0% of animal protein intake
Employment	: 7.0% of total employment
Population engaged in fisheries activities	: Full time 1.4 million
	: Part time 11.0 million
Recommended daily per caput fish intake	: 38.0 g
Average daily per caput fish intake	: 25.0 g
Average yearly per caput intake	: 9.13 kg
Recommended per caput protein intake	: 45.0 g
Recommended per caput animal protein intake	: 15.0 g
Average per caput animal protein intake	: 11.0 g
Average per caput fish protein intake	: 7.56 g

riparian country, India. These rivers have extensive flood plains i.e., low-lying land along both banks of the river courses. The flood plains remain submerged for 4 to 5 months during the monsoon season. Many of the rivers in the south western region of the country had, in the process of changing courses, left behind ox bow bends which became disconnected from the main rivers thereby turning the bends into isolated reservoirs known as oxbow lakes or locally termed *baors*. An artificial large reservoir of economic importance is Kaptai Lake, the largest man-made freshwater reservoir in Bangladesh as well as in Southeast Asia (FERNANDO, 1980). Kaptai Lake was impounded in 1961 by damming the Karnaphuli River near Kaptai primarily for hydroelectric power generation, but it also paved the way for substantial contributions to the national economy through freshwater fish production, navigation, irrigation and flood control. It has an average area of 68,800 hectare with an average water reserve of 5.2×10^9 m^3. In addition, man made ponds are also scattered all over the country.

The waters are fresh in nature in the inland waters except in the southern region, where the sea influences the rivers. There are estuaries in the southern region with a variable range of salinity. Tidally submersible lands in the south are also used for saltwater shrimp aquaculture. From the fish habitat point of view, the inland water areas can be divided into two broad categories : (a) open-water habitats and (b) closed-water habitats. Inland open-water habitats are rivers (including estuaries), canals, flood plains and *beels* (deep depressions). All of these habitats become components of a single, integrated fishery-production system during the monsoon season. The open water is either flowing (lotic) or standing (lentic). In the rivers and flood plains of Bangladesh, both lotic and lentic conditions are interconnected.

The patterns of movement and migration of riverine fishes and prawns is controlled by the seasonal flooding in the monsoon season. Fish movement and migration in the rivers are upstream or downstream during the greater part of the year and laterally out onto the inundated flood plains during the flood season. The inundated flood plains provide a wide range of habitats for fish reproduction, early development, and growth (DOF, 1986). The flood plains enormously enhance fish productivity in the riverine systems and the *beels*. They also provide habitats for breeding of fish normally resident in stagnant water bodies as well as feeding grounds for their offspring after birth. The estuarine environment, with varying degrees of salinity, is another component of the open inland water fish production system.

1.2. Commercially important fishes and shrimps in Bangladesh

A total of 256 species of fishes have so far

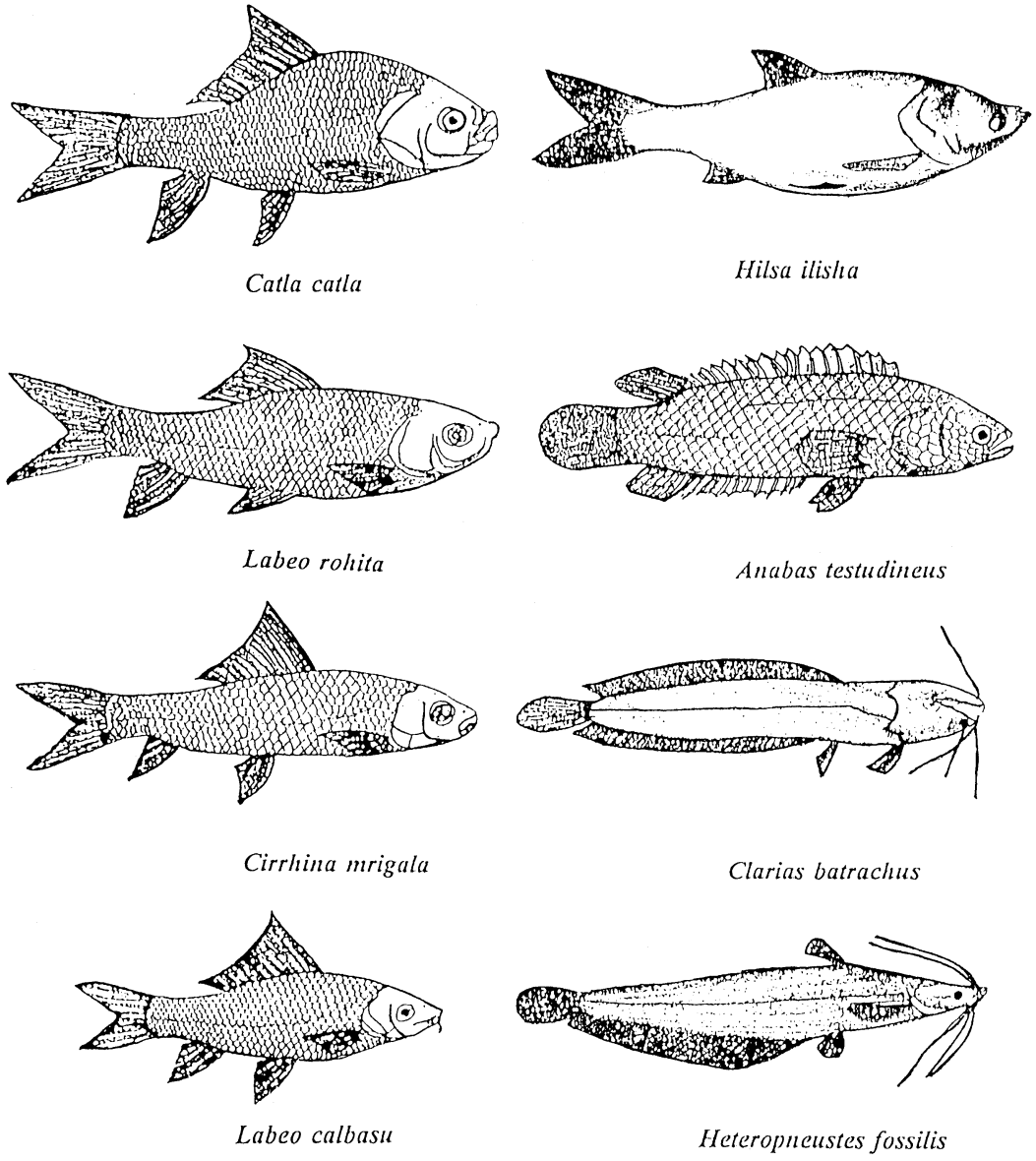

Fig. 2. Commercially important freshwater fishes of Bangladesh.

been recorded from freshwaters in Bangladesh (RAHMAN, 1989). However, it is estimated that about 200 species are truly freshwater culturable forms and the rest are estuarine and marine forms that enter rivers and other freshwater areas during certain periods of their lives. Out of the 200 freshwater species, about 69 species belonging to 23 different families are commercially important. Most of those are carps and catfishes. Some commercially important fresh water fishes and shrimps are shown in Table 2 and Fig. 2. However, at present only major carps, such as *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* and *Labeo calbasu*, are commonly cultured in a polyculture system in ponds and tanks. Hilsa (*Hilsa ilisa*, family clupeidae and English name shad) is one of the most commercially important species and the largest single fishery in Bangladesh, constituting about 30 to 40% of

Table 2. Commercially important freshwater fishes of Bangladesh.

Family	Fish species	English name	Popular name
Clupeidae	*Hilsa ilisha*	Shad	Ilish
Cyprinidae	*Labeo rohita*	Rohu	Rui
	Catla catla	Catla	Catla
	Cirrhinus mrigala	Mrigala	Mrigal
	Labeo calbasu	Kalbasu	Kalbaus
Cobitidae	*Botia daris*	Loach	
Notopteridae	*Notopterus chitala*	Feather back	Chital
Bagridae	*Mystus aor*	Catfish	Aair
	M. tengra	Catfish	
Siluridae	*Ompok bimaculatus*	Butter catfish	Pabda
	Ompok pabda	Butter catfish	
	Wallago attu	Freshwater shark	Boal
Schilbeidae	*Alia coila*		*Kajoli
Pangastidae	*Panagasius pangasius*	Pungus catfish	Pangus
Claridae	*Clarius batrachus*	Asian catfish	Magur
Heteropneustidae	*Hetropneustes fossilis*		*Shingee
Nandiadae	*Nandus nandus*		*Bheda
Anabentidae	*Anabas testudineas*		*Koi
Channidae	*Channa marulius*	Gaint snakehead	Gagor
	C. punstatus	Green snakehead	Lata
	C. striatus	Striped snakehead	Shoal
Mastacembelidae	*Macrognathus aculeatus*	Spring eel	Tara baim
	Mastacembelus armatus		*Baim
	M. puncalus		*Guicha
Penacidae	*Penaeus monodon*	Gaint tiger shrimp	Bagda
	P. indicus	White shrimp	
	P. japonicus		

* Bengali popular name

the total fish catch of the country.

Hilsa, is also the most popular fish in the country.

Shrimps are a major foreign exchange earner for most Asian countries including Bangladesh. Export of shrimps stands next in earnings to garments, jute and jute goods, and leather ; it contributed to 6.50 % of the total export earnings in 1991 to 1992. The major exports market for Bangladesh frozen shrimps are the U.S.A, Japan and Germany. Twenty five shrimp species have been identified in Bangladesh, of which 8 commercial species (Fig. 3) are available in the trawl fishery. Although shrimps represent only 2.5% of the total marine catch, it is considered an important money making component of the catch.

During 1994–95, export earnings from fish and fishery products increased considerably to Tk. 13,000 millions (US $ 325 m ; Tk.40=US $ 1) in foreign exchange, of which the export of shrimp alone contributed to Tk.10,400 millions (US $ 260m) (DOF, 1994). Of the country's total shrimp catch of 101,025 tons, 53,520 tons were from the water bodies and about 23,530 tons were from coastal shrimp farms (HUSSAIN and UDDIN, 1995).

1.3. Types of Fisheries in Bangladesh

Bangladesh is bestowed with vast and highly diverse aquatic resources, which can be categorized as (a) inland capture fisheries, (b) freshwater and brackish water aquaculture, and (c) marine fisheries. The inland fisheries category is again subdivided into the open water capture fishery and the closed water culture fishery. The open water capture fishery is constituted by rivers, estuaries, canals, flood plains, reservoirs and inundated paddy fields and ponds, covering an area of 4.3 million

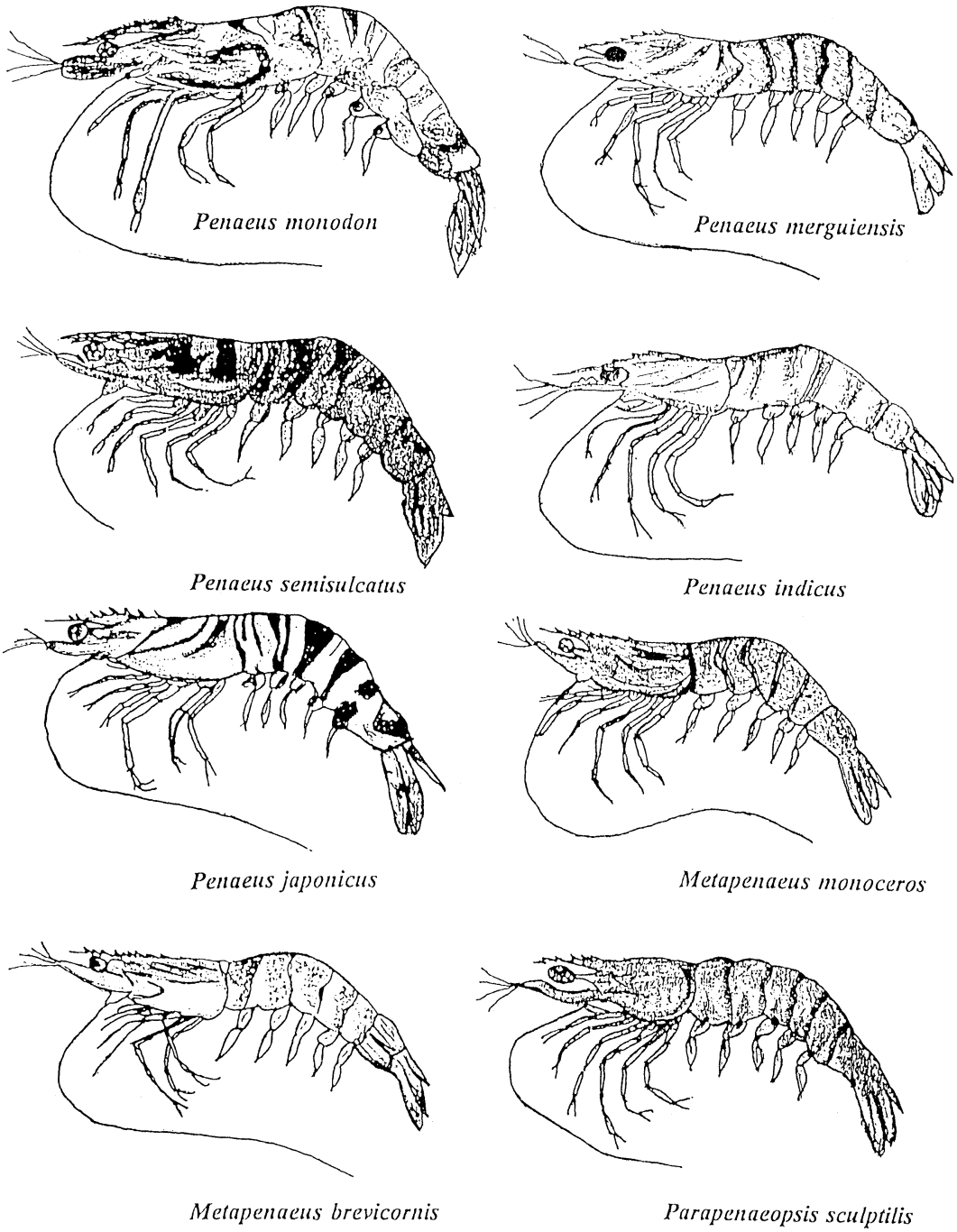

Fig. 3. Commercially important marine shrimps of Bangladesh.

Table 3. Estimated area of different fisheries resources and their production in 1993–94.

Source	Water area (ha)	Production (tons)	% contribution to total production
A. Inland fisheries			
a. Inland open water capture			
Rivers & esuaries	1,031,563	137,000	12.6
Flood plains	2,832,079	353,000	32.5
Beels & Haors	114,161	57,000	5.2
Reservoir	68,800	5,150	0.5
Sub-Total	4,046,603	552,150	50.8
b. Inland closed water culture	146,890	231,000	21.2
Ponds	5,488	2,000	0.2
Oxbow lakes (Baors)			
Brackish water farms	125,000	42,000	3.9
Sub-Total	277,378	275,000	25.3
Inland Total(a+b)	4,323,981	827,150	76.1
B. Marine fisheries			
Industrial		15,000	1.4
Artisanal		245,000	22.5
Marine Total		260,000	23.9
GRAND TOTAL(A+B)		1,087,150	100.00

hectares. The rivers and estuaries contribute the major component of open water capture fishery production, about 0.13 million metric tons and 12.6% of the total national production during 1993–94. The major group in riverine fisheries is Hilsa and the second most important group is the Indian major carps. The rest of the catch consists of other medium and minor carps, catfishes, snakeheads and shrimp. Rivers are also the most important source of major carp seed for closed water culture fisher ies. The culture fisheries include 150 thousand hectares of freshwater ponds, 5 thousand hectares of oxbow lakes and about 125 thousand hectares of coastal shrimp farms. The country has a 480 km coastline of along the Bay of Bengal with an area of 64,000 km^2. These vast and varied aquatic resources support artisanal and commercial fisheries as well as offer opportunities for aquaculture development. The inland, coastal and marine water resources along with their productions are shown in Table 3.

1.4. Aquaculture

Throughout the world, aquaculture is being looked upon as a panacea for meeting the increasing demand for fish, as catches from open waters are declining due to overexploitation and degradation of fish habit ats ; in these respects, Bangladesh is no different. Inland water bodies of Bangladesh are highly productive and give about 76% of the total fish production. The fish production from inland open water capture fisheries is declining continuously due to massive construction of flood control structures, overexploitation, extraction of water for irrigation, intensive agriculture and industrial development, erosion and siltation, reclamation of land for human settlement, pollution, destruction of mangrove forests, etc. At the same time demand for fish has increased because of the rapidly expanding population. Over the last fifteen years, the fish consumption per caput in Bangladesh has declined by about 30%. Pollution from industrial and municipal wastes have had devastating effects on fish stocks of the country. Unless appropriate action is taken to reverse the present declining trend of open water capture fisheries, the overall situation will not improve even if it is possible to make substantial headway in culture fisheries.

Table 4. Major pollutants of the environment in Bangladesh.

1. Industrial Pollution
A. Paper & Pulp Industries
B. Fertilizer industries
C. Leather industries
D. Textile industries
E. Sugar industries
2. Thermal pollution
3. Agro-chemical pollution
4. Municipal wastes
5. Oil pollution
6. Solids and sludges
7. Microbial contamination

Degradation of the environment through natural and anthropogenic interventions has been identified as the primary causes for the decline in open water capture fishery production. Due to rapid industrial development of the country, industrial pollution may, in time, become a threat to the aquatic environment. No systematic studies have been done so far on the impact of industrial pollution on aquatic life. In recent years, the impact of aquatic pollution on human and animal life has become a matter of special concern of ecologists in general, and aquaculturists in particular. Major pollutants of Bangladesh are shown in Table 4.

The present paper aims to draw attention to some of the environmental management problems with respect to fishery resources.

2. Major pollutants and their sources

2.1. Industrial pollution

Bangladesh now contains 30-thousand industrial units, of which about 24 thousand are small and cottage industries. The industrial establishments are mostly located on the shores of rivers and other waterways. Almost all the industries in Bangladesh lack waste treatment facilities. They do not use any treatment for effluents. Pollution in these areas can be highly concentrated. They discharge their treatment liquid and solid wastes directly or indirectly into the water bodies, which finally find their way into the Bay of Bengal. This problem also increases the concentrations of heavy metals in aquatic ecosystems. Heavy metals produce undesirable effects on animal life, even if they are present it extremely minute quantities.

A national survey by the Department of Environment identified 903 units as major polluters under 13 categories (Table 5). There are more 600 chemicals that are classified as hazardous and toxic. The chief contaminants are ammonia; chromium and other heavy metals from fertilizer and tanneries; mercury from paper and pulp chloralkali units; and phenols from pulp and paper, refinery, pharmaceutical and paint industries. These pollutants affect

Table 5. Major industries and their probable toxic pollutants in Bangladesh.

Industry	Number	Water borne effluents
Textile Industries	298	Alkali, Chlorine, Chromium
Tanneries	176	Chromium, Sulphates, SS, BOD
Pharmaceutical Industries	166	Mineral & organic acids, Phenol
Jute Industries	92	SS
Iron & Steel Mills	57	Acids, Cyanides, SS
Rubber & Plastic Industries	34	Solvents, Oils, SS, BOD
Pesticide Industries	25	Cyanides, Lead, Arsenic
Chemical Industries	23	Acids, Alkalis, Ammonia
Sugar Industries	16	SS, high BOD
Paper & Pulp Industries	05	Chlorine, Mercury, SS, BOD, Phenol
Fertilizer Industries	05	Ammonia, Arsenic, Chromium, Urea
Distilleries	03	SS, high BOD
Cement Industries	03	SS
Total	903	

SS=Suspended solids, BOD=Biological oxygen demand

the fishing industry both quantitatively and qualitatively; i.e., quantitatively by affecting the natural productivity of fisheries, and qualitatively by affecting the value of such organisms as food. Most of the industrial effluents contain constituents that are harmful to fishery organisms and, through consumption of them, to human life.

a. Paper and pulp industries

Paper and pulp industries are the major industries in Bangladesh. These industries depend on forests and agricultural residues (jute cuttings) for the supply of fibrous raw materials. The Karnaphuhi paper mills and the Karnaphuli rayon complex is the target chemical industry located on the shore of the Karnaphuli River in Chittagong region. There are three large paper industries and a number of smaller paper and paper products industries. In these mills there was no external treatment plant for effluents. The wastes from the process plants include discharge from washes etc. The dissolved dyes and other impurities impart a brown colour to the water. The waste water is called "black liquor". Facilities to recover "black liquor", generated by cooking bamboo and wood chips, and by bleaching systems, are most inadequate. These plants also dump solid wastes, fibre, wood particles, solids and inorganic compounds into the river. The Khulna newsprint mills, hard board mills from the Khalispur industrial belt, discharge untreated wastes directly into the Bharib river (ESCAP, 1988). These mills continuously discharge nearly 4,500$m^3 h^{-1}$ of waste water containing high levels of suspended solids (300 to 500 ml l^{-1}) and sulpher compounds. Occasional fish kills from the Kushiyara River in Sylhet have been reported due to effluents discharged by the paper mill near Fenchuganj (BHOUYAIN, 1983).

b. Urea fertilizer industries :

Bangladesh is blessed with natural soil fertility for crop production. Labour intensive farming, supplemental with organic fertilizer and green manure comprise traditional farming practices. Urea, triple super phosphate (TSP) and murate of potash are the major chemical fertilizers used in Bangladesh. The total amount of fertilizers used annually in Bangladesh, about 1.5 million tons increased over 20% during the preceding four years (REAZUDDIN, 1990).

Urea fertilizer industries constitute the largest industry and as individual units these are world size units. All these units discharge effluent waste water into large following rivers. Ammonia in effluent water comes from a variety of sources, but in the context of Bangladesh, the chief sources are urea factories. A concentration of 1.2 to 3.0 ppm of free ammonia or ammonia base is toxic but its hydrolysis into ammonia causes toxicity to aquatic species. Fish kills caused by the effluents from a urea fertilizer factory on the shore of the Sitalakhya River near Dhaka from March to April has become a regular phenomenon in recent years. The scientists of the Department of Environmental Pollution Control have recorded an ammonia level of 200 ppm in the Sitalakhya River at the sites of fish mortality (BHOUYAIN, 1983). Fish caught from the river downstream of the mill site reportedly emit a strong foul odour making them unfit for human consumption (REAZUDDIN, 1990).

c. Leather tanning industries

The leather tanning industry, an important foreign exchange earner, has some 170 tanneries of small, medium and large sizes with a total annual production of 7 million square meters of leather from 10 million cow, goat, sheep and buffalo (RAHMAN, 1993). It may be noted that 30% of total raw hide production takes place during the Eid-ul Azha festival. Waste water from the leather tanning industry contains some of the most offending pollutants. These untreated waste waters from this area are discharged into the Buriganga River. The combined waste water from tannery is highly coloured, due to the presence of vegetable tan liquor, and foul smelling. It is also alkaline and contains high concentrations of suspended and dissolved solids. Current estimates are that 40 metric tons of solids waste (sodium sulfide and chromic sulfide) are produced daily in the area and that 50% is hazardous due to its high chromium content. These chemicals are highly

toxic and chromosol is bioaccumulated in food chain. Quite a large quantity of the processing chemicals enter waste water and is discharged without treatment into the river directly.

The highly in soluble chromium is damaging throughout the area, in particular in the river and flood plain that receives the waste water discharges from the tanneries. The huge amount of toxic pollutants discharged into the Bay of Bengal threatens marine life. The chromium concentration in the surface water of the Bay of Bengal is 2.20 ppm, dangerous to the marine biota.

d. Textile industries

Dyeing and finishing processes are two important steps in the textile manufacturing process. However, in the dyeing and finishing processes, a considerable amount of waste water is generated. Textile waste water contains notoriously toxic substances, like chromium from dyes. Chlorine and fungicides in contribute to high alkalinity, colour and an oxygen consuming organic load. In the textile dyeing and printing industries in Bangladesh, 2.5 to 3.5 thousand metric tons of dyeing chemicals are used. A fraction of these chemicals contain heavy metallic compounds which are toxic and have persistent in the environment. Due to discharge of large volumes of putrescible organic wastes, long stretches of these have developed anaerobic conditions, making the water unfit for drinking, agriculture, fisheries and other uses.

e. Sugar Industries

The sugar industry is another important agriculture-based industry in Bangladesh. About 2% (0.4 to 0.5 million acres) of total arable land is used for sugarcane cultivation and it is unlikely that this area will be further increased. Sometimes fish mortalities were found in waterways near Mobarakganj sugar mills in Jhenadah and Setabganj sugar mills in Dinajpur district due to the effluent discharges from these mills (ALI, 1991).

Environmental standards and present pollution status at urea plants, tanneries, textile mills and sugar mills of Bangladesh are shown in Table 6.

2.2. Thermal pollution

Thermal pollution is potentially one of the most critical of all water pollution problems. Thermal pollution may result from the heat discharged into receiving waters. The extent of thermal pollution chiefly depends on the volume of receiving water. The power plants at Ghorasal and Siddhirganj are two sites that pose significant threats of thermal pollution to the Sitalakhya river. The site at Ghorasal is particularly vulnerable where the cumulative power generation would be about 1000 MW. When condenser water from power plants is discharged directly into rivers, 50% or more of the cross sectional area or volume of flow of river water should be free of significant temperature increase due to heat additon to provide a pathway for fish and to ensure survival of free floating and drifting fish eggs, larvae and other organisms that are temperature sensitive. Several reports have appeared from time to time in newspapers regarding heavy mortality of fish in the Sitalakhya River.

2.3. Agrochemical pollution

Bangladesh is one of the important rice growing agricultural countries. With the advancement of scientific knowledge, the use of fertilizers and insecticides for higher crop yields are increasing day by day. Growing demands for rice for an ever increasing population has led to the modernization of agriculture. Irrigation and use of fertilizers and pesticides are essential for the present agriculture. The pollution hazards for aquatic life are increasing significantly with the widespread use of pesticides in agriculture. The area of land covered by deep water rice is over 2×10^6 ha (HAQUE *et al.*, 1992). The ecosystem of this area is highly seasonal, i.e., it remains under water for 5 months and contribute to fish production (DOF., 1986).

The first pesticide was introduced to Bangladesh in 1957. More than 250 pesticides (insecticides, fungicides, herbicides, nematicides, acaricides, algicides, etc.) are presently available in the market, but their recommended doses and toxic effects on fish are not clearly known (ALAM, 1995). ALAM *et al.*, 1995 have

Table 6. Environmental standards and present pollution status for urea factories, tanneries, textile mills and sugar mills of Bangladesh.

Parameters mg/l	Standard	Industry			
		Urea	Tanneries	Textile	Sugar
pH	6.5−8.5	9.12	4−10	8−11	4.6−7.1
Temperature	20−30℃	40℃	−	−	−
Acidity	<20	−	−	−	−
Alkalinity	70−100	−	475	300−900	−
Ammonia	0.025	−	−	−	−
NH_3-Ammonical nitorogen (as N)	1.2	300	12−1,970	−	−
Urea	−	2500	−	−	−
BOD	6.0	−	−	200−600	2200
COD	−	150	9,600	−	4380
Carbondioxide (dissolved)	6.0	−	−	−	−
Chloride (Residual)	0.01	−	−	−	−
Chloride	600	−	175−18,000	−	−
DO	4−6	−	−	−	−
Flow (m^3/h)	−	400−800	−	−	−
Hardness (as CaCO3)	80−120	−	−	−	−
Chromiun (total)	0.05	25	2.6−2,800	up to 3	−
Coliform (total, mg/100ml)	5000	−	−	−	−
Total solids	<1500	8600	−	1000−1600	3500
SS	25	−	−	30−50	800
Copper	<0.4	−	−	−	−
Lead	0.05	−	−	−	−
Mercury	0.001	−	−	−	−
Nitrite	0.03	−	−	−	−
Oil & grease	0.01	−	−		

Source : Rahman (1993)

reported that the number of registered rice pesticides marketed in Bangladesh was 66; 25 are used in significant amounts by the paddy farmers. The most commonly used pesticides in Bangladesh are shown in Table 7. The indiscriminate use of those pesticides on our crop fields may pose a serious threat to our potential aquatic resources. In Bangladesh there are huge areas that undergo shallow to medium flooding conditions (flood depth of 0.3 to 1.8 meters respectively during the flood monsoon). These areas are potentially suitable for integrated farming. Rice-cum-fish culture is a unique way of diversifying food production and increasing the income of farmers. Organophosphorus, organochlorine, carbamates, pyrethorids are among hundreds of poisonous chemicals that farmers have been spraying on their crops to fight against insects and pests.

In the rainy season, most small fishes migrate towards the flood plain and use the crop fields as spawning and nursing grounds for a certain period of time. Hence, the application of pesticides in improper doses kills almost all the fishes. Due to pesticidal pollution, the natural breeding and nursery grounds have become endangered, and ultimately, the breeding behaviour and reproductive cycle of fishes will also be changed. Most of the farmers are reported to have caused mortality of fishes in the paddy fields due to the use of pesticides. The indiscriminate use of pesticides surely affects the non-target organisms, including fish. This is one of the major causes of declining fish populations in the natural habitats of Bangladesh.

Organophophate and carbamate group pesticides used in Bangladesh have shorter soil residence times than do organochlorines. In the

Table 7. Pesticides used mostly in Bangladesh.

Granular	Liquid
*Basudin-10G	Aerovin-80WP
Furadan-5G	Aeromal-57EC
Curatex-3G	Bidrin-24SCW
Ekalux-5G	*Decis-2.5EC
*Diazinon-14G	*Diazinon-60EC
Padan-10G	Dimecron-100EC
	*DDVP-100EC
	*Dieldrin-20EC
	Ekalux-25EC
	Elsan-50EC
	Fyfanon-57EC
	Lebaycid-50
	Malathion-57EC
	Marshall-20EC
	Mipcin-75WP
	Nogos-100EC
	*Ripcord-10EC
	Roxion-40EC
	Sumithion-50EC
	Zithiol-57EC
	*Cymbush-10EC
	*Sumicidin-20EC

*Extremly hazardous to fish at the dose recommended by each chemical company.

case of organophosphorus pesticide use, the phosphates released promote eutrophication. In Bangladesh, organophosphorus pesticides are commonly used by the farmers in crop fields to control insects and pests. These chemicals end up in the water bodies after being washed away with the rain water, or flood water and are likely to have harmful effects on fish food organisms, fish eggs, larvae, fry and other aquatic life. In heavily polluted water bodies, pesticides or the products of their decomposition are invariably present among many different residues. It has been assumed that 25% of the total amount of pesticides used may reach the coastal waters and cause seawater pollution (ESCAP, 1988). Therefore, the pollution load in the Bay of Bengal in the form of pesticide residues is about 1800 tons yr^{-1} (MAHMOOD *et al.*, 1992).

A DDT manufacturing factory operating in Chittagong produces 100 tons of DDT daily. DDT was banned in Bangladesh 10 years ago, but it is still used for public health purposes, reportedly used for mosquito control, although many developed countries have either restricted or totally banned its use. This DDT is also reported to be used clandestinely as an adulterating agent by local formulators and dealers. Effluents from the DDT plant is drained into the river system directly via a ditch. DDT affects the photosynthetic capacity of certain algae and thereby interferes with primary productivity in the aquatic environment. It is estimated that half life of DDT in an ecosystem is 10 to 15 years. At high concentration, DDT's effects range from mortality to retardation of growth, impairment of reproduction in fish and invertebrates, increase in fish thyroid activity and reduction of natural compensatory reaction to stress and diseases.

Chemical insecticides and pesticides affect fish life in various ways, causing direct death of fish in different stages of their lives. The use of halogenated hydrocarbons as herbicides and pesticides, including DDT, is of special concern for fisheries.

2.4. Municipal wastes

The cities and human settlements in the coastal areas of Bangladesh do not have any domestic waste treatment facilities. Therefore, the human effluents, either directly or indirectly, find their way untreated into the rivers and eventually to the Bay of Bengal (ESCAP, 1988). Every day a considerable amount of blood and viscera of about 400 slaughtered animals from the Firringhee Bazar and Dewan hat slaughterhouse find their way into the River Karnaphuliy. KHAN and KHANAM (1992) recorded BOD levels in the Chaktai canal of Chittagong and the Karnaphuliy river estuary as 255 to 540 mg l^{-1} and 0.70 to 3.4 mg l^{-1} respectively.

Through transport of organic matter in the sewage in moderate quantities, some fertilization of fishing grounds takes place. In many fishing areas, the productivity of the water is derived exclusively from the discharge received from the land. The very high productivity of the Bay of Bengal is considered to be enhanced by the discharge of various types of organic sewage carried in by most of the major rivers of the sub-continent and beyond. However, excessive concentrations of organic

putrescible substances can seriously damage fisheries, if oxygen, present in limited quantities, is used up in the process of putrefaction, thus creating zones which may be devoid of fisheries organisms. Further, excessive fertilization of water bodies encourages the production of poisonous plankton species resulting in toxic concentrations in fisheries products sold for human consumption. In addition, untreated sewage in huge quantities may cause unacceptable concentrations of pathogenic organisms locally in waters, which are otherwise very rich in nutrients. AHMED (1985) stated that the mortality of fish and other aquatic life in the Buriganga River was a result of deoxygenation and toxic gases.

2.5. Oil pollution

Oil pollution is a potential threat to the aquatic environment. It results from the crude oil transport systems, waste oil from ships and mechanised vessels, refining, handing losses, etc. Generally, more than 50% of the oil pollution in the aquatic environment comes from urban activities and through run-off. International oil tanker routes in the southern Bay of Bengal also contribute to the oil pollution in the marine coastal environment, which occurs due to wreckage of oil tankers and accidental oil spills. It has been estimated that 1700 million tones of oil is transported across the oceans annually ; estimates of oil influx to oceans vary between 2 and 5 million times a year, i.e., between 80 to 200 litre of oil is spilled somewhere in the ocean every second (JICA 1997). In Bangladesh, localised oil pollution is said to be heavy in the vicinities of Chittagong and Chalna ports. More than 1200 ships and 40 to 50 oil tankers in Chittagong port and about 600 ships in Mongla port are handled annually.

According to the department of shipping, about 2500 registered power driven river crafts and numerous unregistered small power boats, including oil tankers, ply the coastal waters of Bangladesh. In addition to these, the number of power driven trawlers and other boats engaged in fishing in the Bay of Bengal is about 3000. Different types of waste oil like ballast and bilge water from ships, tankers, mechanized boats, etc. and crude oil leakage, oil emulsion and oil residues from other sources are entering the water bodies of the marine environment. Ship breaking operations in Chittagong and Mongla are also responsible for oil pollution.

Oil pullution affects different species of organisms in different ways. The thin layer of oil on the water surface reduces light penetration and the exchange of oxygen and carbon dioxide across the air-sea interface, inhibiting photosynthesis and causing depletion of dissolved oxygen. It is reported that fish eggs and larvae may be killed at concentrations ranging from 10^{-5} to 10^{-3} ml l^{-1} of oil. Other studies have shown that fish eggs develop abnormally at oil concentrations between 1 and 10 ppm. At a concentration of 0.01 ppm, fish eggs hatch irregularly and late, and larvae from such eggs may be deformed. Some other sublethal effects are behavioural disturbance, changed migratory patterns and disturbed reproductive patterns. Larval stages of marine invertebrates are 10 to 100 times more sensitive to oil than adults.

2.6. Solids and sludges

Solid wastes generated from chemical industries may pose some difficult disposal problems. Small scale enterprises such as metal working, machine tools, and dyeing are frequently among the offenders for environmental degradation. Often such enterprises dump their wastes in their neighbourhoods. Such neighbourhoods often consist of shanty towns and, in the absence proper land use planing and regulations regarding location of industries, the informal sub-sectors cause considerable local degradation. Thus for example, TSP plant generates large amounts of gypsum as a reaction byproduct. The utilization of this gypsum has been limited and dumping of large amounts of gypsum is a problem due to unavailability of adequate space.

Sometimes rubbish of various kinds is carried with currents or just thrown into the river systems from the banks, vessels, dwellings, etc. These effluents are kitchen wastes, remains of cargoes and packaging, engine room wastes, wire bottles, plastics, and other objects. Use of non-biodegradable plastic products, such as plastic shopping bags, disposable syringes,

bowls, nets, nylon ropes, packing items, etc., are increasing day by day and cause pollution in the country. In Dhaka alone, there are nearly fifty plastic factories which produce about 7 to 7.5 million polythene bags daily (IBRAHIM, 1992). It is reported that plastic bags and other products are also dumped directly in the Chittagong and Mongla port areas. Plastic is an harmful as oil spilage for marine biota.

2.7. Microbial contamination

Fish in common with all other organisms, are afflicted with a wide variety of bacterial and viral diseases. In the polluted water of the Karnafuli river estuary near sewage disposal areas, as many as 18 thousand coliform bacteria 100 ml^{-1} were reported, which is far higher than safe levels recommended by WHO. The large-scale microbial contamination of our water bodies that resulted in 1987, in heavy morality of the fish stocks, due to what has been called "Epizootic ulcerative syndrome", calls for special attention. The disease affects fishes such as *Puntius, Channa, Labeo, Catla,* and their juveniles. An investigation was done to identify the causative agents and to study the epidemiology of the disease, but the results are not yet conclusive.

3. Conclusion

In present days, there is talk everywhere on pollution. "Prevention is better than cure"-is a proverb in medical science. This proverb also holds true in pollution control. It is obvious that water bodies of Bangladesh are directly or indirectly becoming polluted due to input of so many polluting agents. We do not know how much heavy metals we are accumulating each day.

Therefore, the proper management of natural resources is essential to protect the environment. A sound environmental policy supported by necessary regulation is necessary now. However, a thorough survey of the impact of environmental degradation on fisheries should be carried out before definite recommendations are made. We must remember that we do not have much time left.

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