M.Sc. (Final) Semester –IV (Zoology)
Paper III (a): Fishery Biology- Taxonomy and ecology of Pisces

Pollutants affecting fishery waters with special reference domestic pollutants, industrial water, Radio-active wastes

The term pollution is broadly refers to any undesirable change in the natural quality of environment brought about by physical, chemical, or biological factors. The high rate of increase human population, rapid expansion in the industrial and urban activities and modernization of agriculture has resulted in generation of high volume of waste material causing gradual deterioration of valuable resources of biological productivity

AQUATIC POLLUTION

Aquatic systems are considered as suitable sites for disposal of and recycling the sewage and toxic wastes and drain off the excess to the sea. However, the increasing pollutant load and the over exploitation of the water resources for potable supplies, irrigation, industries and thermal power plants to meet the requirements of the ever-increasing population, significantly reduces their assimilative capacity. Thus, the dual stress exerted on the watercourses is ultimately faced by the biological communities inhabiting them. Of this fish is the most important aquatic community concerning the man.

Definition: The water pollution has been defined as 'any man made alternation of physical, chemical or biological quality of the water which results in unacceptable depreciation of the utility of the environmental value of water'.

Sources of water pollution: To understand the causes, effect and control of pollution, the sources of pollution should be clearly classified. The sources of water pollution with reference to fisheries can be classified into following categories: 1. Domestic sewage 2.Industrial organic and inorganic wastes 3. Radioactive wastes

1. Domestic sewage: In India, raw or partially treated sewage and laundry detergents coming from the household are allowed to discharge into the nearby rivers. Based on the census of 1981, magnitude of sewage pollution in India: It is estimated that nearly 33 million tones of sewage is generated daily in our country which is directly proportional to the population of the country. The enormity of sewage pollution in our river water is also reflected in the river Ganga in which more than 70% of the total pollution load is contributed by the sewage.

2. Industrial organic and inorganic wastes: In India, pollution of river water takes place at various centers of industrialization, chiefly at Delhi, Bombay, Calcutta, Madras, Kanpur, Hyderabad, Bangalore, Ahmadabad, Baroda, Rourkella, Jamshadpur, Visakhapatnam, Cochin etc. Industries generate a significant quantity of wastewater and discharge it into rivers and lake. Industrial discharges generally contain organic substances, solids and mineral acids. Pulp and paper, dairy and textile industries generate putrifiable organic waste, while industries manufacturing organic-chemicals, pesticides, fertilizers, dyes and pigments, non-ferrous metals, steel and chloroalkali generate hazardous and toxic in organic waste (heavy metals).

3. Radioactive wastes: Sources of contamination of the aquatic environment by radioactive materials are; radioactive fallout-during the period of atmospheric testing of nuclear weapons, Nuclear reactors and plants, nuclear-powered ships and submarines, laboratory experiments with and medicinal use of radioisotopes.

Changes in the physico-chemical parameters of water due to pollution:

Physical parameters

(a) Temperature: Temperature of water may increase due to thermal pollution when water is used to cool power stations and due to waste heat from industries. (b) Turbidity & colour: Turbidity of water may increase due to soil erosion or heavy algal bloom due to high level of organic and inorganic nutrients from sewage water or agricultural waste. Turbidity, dye and pigment pollutants affect the general colour of water. (c) Depth & flow: Flow and depth of the water body may be reduced due to heavy siltation of sediments coming from land erosion. (d) Light: Due to high turbidity and colouration of the water bodies, penetration of light is reduced.

Chemical parameters

(a) pH: pH of water may be acidic due to acid rain that originates largely from burning of coal and oil. Acids also originate in large quantities from mines and various industrial processes (waste from DDT factory, battery, vinegar, tanneries). Fish usually live at pH levels between 6.0 and 9.0, although they may not tolerate a sudden change within this range. (b) Dissolved oxygen: Dissolve oxygen level of water is reduced to greater extent when (i) heavy sewage pollution or other effluents containing high organic matter are discharged into it. These are broken down by the microorganisms, which used up the dissolved O_2. (ii) Inorganic effluents containing readily oxidisable substances such as sulphites and ferrous salts can produce a similar effect. (iii) Eutrophication and turbidity often reduced the dissolve oxygen level of water bodies. (iv) Presence of synthetic detergents and oils lowering the re-oxygenation rate of water. (v) Discharge of cooling water from industries also reduced the dissolve oxygen level of water bodies. (c) CO2: Eutrophication and organic pollutants responsible for depletion of dissolve

oxygen increase the CO2 level in water bodies, due to decomposition of undecomposed or partially decomposed organic matter. (d) Alkalinity: Wastes associated with tanning, wool scouring, the mercerizing of cotton and the manufacture of certain chemicals (in chloro-alkali industries) may contain caustic soda (NaOH), sodium carbonate or lime. Such alkaline effluents may have a pH of 12-14 and lethal to all types of stream life, including bacteria. (e) Salinity: Excessive amount of salts brought by sewage; and effluents from chloro-alkali industries increase the chloride level thereby salinity of water, which is responsible for increase in the osmotic pressure. Salinity also reduces dissolve oxygen level. (f) Dissolved solids: (i) Nitrates and phosphates: Water polluted by agricultural wastes, soil erosion and organic pollutants (sewage & biodegradable synthetic detergents) are rich in nitrates and phosphates. (ii) Heavy metals: Hg, Zn, Ni, Cd, Pb, Mn, Cu, Fe, Cr, As, Se etc are present in natural water in very trace amount that's why they are called trace elements. However, in polluted waters their concentrations are increased in many folds. They come from mining, refining, paper and pulp industries (Cr), mercury electric appliance industries, vinyl chloride synthesis, caustic soda industries using mercury cell, organo-mercuric fungicides industries, lead processing industries, storage batteries, water pipes (Pb), industrial discharges, metal or plastic pipes (Cd), metal processing and dye industries, mines, drainage (Zn).

Effects of Aquatic Pollution on Fish and Fisheries

On Ecology

1. Eutrophication: Pollution due to domestic sewage increases the organic load and pollution due to agricultural waste (residual fertilizers) and soil erosion containing nutrients such as nitrates; phosphates, potassium etc. fertilize the water and increase the rate of productivity of the aquatic ecosystem. This results in higher growth of phytoplankton. Water becomes turbid due to excessive growth of phytoplankton and soil eroded particles. Excessive amount of nutrients change the algal community from one of great diversity of species to one of a few; the species which are eliminated are commonly those which form the food of the herbivorous animals which in turn feed the fisheries resources of the area. The changes in the plant population thus indirectly cause changes throughout the entire ecosystem, even in organisms, which are not directly affected by the pollution.

Aquatic life face severe oxygen shortage due to;

i) Bacterial Decomposition of untreated sewage into their inorganic components assimilates dissolve oxygen from the water in the process. ii) High turbidity restricts the penetration of sunlight in deeper layers and benthic plants could not photosynthesize. iii) When algal bloom die, they sink to the deeper waters and in the

process of decomposition, all the oxygen can be consumed. This leads to anaerobic decomposition and generation of toxic substances like hydrogen sulphide, ammonia, mercaptans and organic amines. At times when dissolved oxygen in water is at it's lowest and these substances at their peak values the water smells bad and become unsuitable. The whole process is referred to as 'eutrophication', as a result of which there is excessive growth of phytoplankton due to nutrient enrichment, increase in turbidity and death of benthic plants, depletion of dissolved oxygen and consequent suffocation of fish and mollusks that inhabit deeper waters.

BIOLOGICAL EFFECTS ON FISH:

Pollutants might effect a given population without being lethal to adult organisms in many ways.

i) Migration: Mechanism used for orientation and navigation by migrating organisms is not well known, but in some cases chemo toxicants clearly plays an important role. Sub-lethal concentration of pollutants may interfere with the normal migration pattern of organisms thereby change the composition of population or species diversity. Salmon, trout and many other anadromous fishes have been excluded from their home streams by pollution, though it is not known whether the reason is that a chemical cue has been masked or because the general chemical environment of pollution is offensive to the fish.

ii) Incidence of diseases: A long-term exposure of sub lethal concentration of pollutants may make an organism more susceptible to a disease. It is possible that some organic pollutants will provide an environment suitable for the development of disease producing bacterial and viruses. In such case, even though the pollutant is not directly toxic to the adult organism it could still have a profound effect on the population of the species over a longer period.

iii) Behaviour: Much of the day-to-day behaviour of a species may also be mediated by means of chemo toxic responses. The finding and capture of food and the search for a mate during the breeding season are included in this category of activity, and again any pollutant interfering with the chemo receptors of the organism would interfere with the behavioural patterns essential to an survival of the population.

iv) Physiological Processes: Pollutant may interfere with various physiological processes without necessarily causing death, which may interfere in the survival of a species. DDT depresses photosynthesis in planktonic algae, but only at concentrations greater than its solubility in water. Respiration might also be adversely affected, as could various other enzymatic

processes. The toxic substances and suspended sediments when injure the mucous membrane of the gills effects the respiration.

v) Life cycle: The larval forms of many species are much was sensitive to pollution than the adults. In many aquatic species millions of eggs are produced and fertilized but only two of the larval produced need to grow to maturity and breed in order to maintain the standing stock of the species. For these species, the pre-adult mortalities rate is enormous even under the best of natural conditions.

vi) Nutrition and food chain: Pollutants may interfere with the nutrition of organisms by affecting their ability to find pray, by interfering with digestion or assimilation of food, by contaminating the pray species so that it is not accepted by the predator. On the other hand, if predator species is eliminated by pollution the pray species may have an improved chance of survival. The oil kills the sea urchins, which used young, newly developing kelp as food and the kelp beds developed luxurious growth within a few months. Heavy metals and halogenated hydrocarbons e.g. DDT, BHC, Endosulfan etc. are particularly harmful because they tend to bioaccumulate. These chemicals are easily adsorbed into the body but excreted very slowly resulting in bioaccumulation, which may further enhance in the food chain.

vii) Genetic effects: Many pollutants produce genetic effects, which can have long-range significance for the survival of species. Radioactive contamination can cause mutations directly by the action of radiation on the genetic material. Oil and other organic pollutants may include both mutagenic and carcinogenic compounds. A large majority of these mutations is detrimental to the survival of the young and many are lethal.

Effects of pollution on eggs, spawn, fry on breeding grounds and feeding grounds

Effects on fish eggs; spawn and fry:

Fish eggs are much more resistant than the adult fish. Eggs would develop normally between pH 4 to 5 on the acid side and 8 to 9 on the alkaline side. In water more acid than pH 4.0, the eggs displayed exosmosis and collapsed, in water more alkaline than pH 9.0 there was endosmosis, the eggs swelled and yolk became white. The critical oxygen tensions are about 40 mm Hg for newly fertilized eggs and rises, as the embryo develops, to about 100 mg Hg (about 60% saturation) at the time of hatching. Trout and Salmon lay their eggs in gravel, through which water must percolate while the eggs batch and the fry live on the food from the egg yolk. Oxygen shortage due to pollution in the water flowing through the gravel, an insufficient rate of water flow due to deposition of silt in the spawning beds, or a combination of both these adverse factors will hold up the development of fish eggs, delay hatching and proves fatal to the embryos.

Survival of larval fish fry and fingerlings:

(a). Food acquisition: Larval fish is able to feed only on the tiniest of zooplankton and phytoplankton, thus early growth and survival of fish depends upon the densities of small cladocerans and rotifers and phytoplankton. Aquatic pollution is toxic to these plankton and pose threat to survival of fish fry.

(b). Predation: Survival of larval fish is probably influenced more by predation than by feeding. These very small fish are vulnerable to virtually every other predator. Not only visual feeding fish but also other predators such as predaceous copepods may have considerable influence on larval fish densities. Protective cover, such as aquatic macrophytes must be especially critical in minimizing fish predation on small fish. Any factor(s), such as turbidity, wave action, siltation that would reduce vegetative cover, could also minimize larval fish survivorship.
Fry and fingerlings are more susceptible to pollution than adult fish.
Resistance to pollution: Egg> Adult>Larvae

Destruction of breeding & spawning grounds:

For any nest, building fish or any fish in which the eggs attach to a particular substrate the nature of the substrate is important in successful spawning. Aquatic vegetation often provides the very substrate within which or on which eggs are laid and may protect eggs from wave action and erosion. Gravel bed is good for spawning. The role of nearby structure (gravel) of aquatic vegetation is less clear, but it doubtless makes nest defense from predator more effective.

A lowered level of dissolved oxygen due to the presence of organic pollution, which in itself is not toxic to may significantly reduce the chances of salmon reaching the spawning grounds because of fatigue and reduction of swimming velocity.

Soil particles due to land erosion carried out run-off water and suspended matter present in sewage and trade wastes gets deposited on the river bed or behind the weirs and cause silting of the bed. Siltation in river and reservoirs diminishes the (i) quantum of water flow (ii) flow rate of water and (iii) water level, thereby reducing the spawning success. Heavy siltation also destroy the nesting materials (e.g. Aquatic vegetation) for fishes and cover the gravel structure by silt deposits thereby natural spawning of fish is prevented due to lack of suitable spawning area and increases egg mortality. This can be serious in respect of major carps, trouts, salmonids and other fishes requires special environment for breeding.

Either fish failing to reach their spawning or feeding areas, because they avoid polluted waters or perhaps because pollutants interfere with their chemical sense and they are not able to recognize their home waters.

Effect on feeds and feeding grounds of fishes:

Turbidity: Silts and clay greatly reduce the euphotic zone in rivers and reservoirs. Turbidity severely restricts the zone within the water body where visually feeding fish can efficiently find and attack their pray. Turbidity also reduces fish vision within the euphotic zone.

Siltation: Heavy silt deposits smoothers benthic vegetation and invertebrate checking its growth. This reduces the production of benthic vegetation. Salmonoids in streams need places to feed and hide from predators. The feeding places are usually in or below the gravel riffles that produces aquatic food organisms. This feeding place is destroyed by siltation. Larval fish is able to feed only on the tiniest of zooplankton and phytoplankton, thus early growth and survival of fish depends upon the densities of small cladocerans and rotifers and phytoplankton. Aquatic pollution is toxic to these plankton and pose threat to survival of fish fry.

Eutrophication: Excessive amount of nutrients changes the algal community from one of great diversity of species to one of a few; the species, which are eliminated commonly those, which from the food of the herbivorous animals which in turn feed the fisheries resources of the area. The species, which grow in abundance, are generally the blue-green algae and other species, which are mostly unsuitable as feed for fishes.

Heat discharge: Because of this macro algae and sea grass disappear resulting decline of fish product due to lack of shelter for juvenile stages of commercial species of food organisms and reduced food for associated herbivores.

Effects on fishing and fishery products:

Fishing: Fishing gear and operations may be adversely affected by various kinds of pollutants. Over fertilization may cause fouling and clogging of nets, traps and other fishing gears by masses of macro algae or other plants and animals drifting in the water or using the materials as substratum.

Fishery products: A common reason for the discarding of catches and the discontinuance of fishing in certain areas is the tainting of the fish by unpleasant odors and tastes caused by petroleum derivatives, even at concentrations significantly below lethal levels. Waste from refineries and discharges of petroleum from ships are causing increasing damage to fishing in this respect.

Colouring: Colouring has a similar effect to tainting on the fish's marketability that is a fish product with a modified colour is practically worthless. The "green Oyster" of Japan and Portugal, coloured by incorporated copper and zinc and "red herring" of Canada due to internal bleeding by elemental phosphorous are examples. There is evidence that pollution can cause

morphological changes, teratogenic effects, skin ulcerations and other lesions, as well as various other diseases especially fungal in fish and shellfish.

CONTROL OF WATER POLLUTION

Some of the methods of water pollution control are;

1. Dilution: Dilution seems to be the most attractive method of waste disposal. Diluting the polluted water mass to such an extent that the harmful effect of the pollutant is made ineffective. However, the disposal programme must be in coordination with a programme of environmental management to guarantee adequate supplies of fresh water for the dilution process.
2. Efficient use (Reuse): One of the most important conservation activities is the use of freshwater in such a way that we get the very most for our efforts, without depleting it. Efforts should also be directed to increase the usability of low grade or polluted water. Treatment of domestic sewage for industrial cooling is a good example of efficient use.
3. Alternative use: Where the waste material recovery is not economical, its alternative use should be examined e.g. pulp, which cannot be easily recovered, is being trapped at the outfall area of sulphite waste and is being used for the manufacture of cardboards. The uses of heated water for fish culture in many European countries and in North America have encouraging results. In the temperate region, many species of fish and shellfish grow during only a brief part of the year because the water is too cold for growth during the winter.
4. Recovery of by products: Recovery of by-products such as sodium hydroxide from sulphite waste, calcium oxide from sulphite waste, oil from hydrogenated vegetable oil and soap, mercury from chloro-alkali industry effluents and so on should be practiced.
5. Waste treatment/Purification:

There are many processes available for treatment and purification of waste before disposal.

(A) Chemical treatment: Chemical treatment has long been used for industrial waste and for treatment of water for human consumption. Recently it has come into use also for treatment of domestic sewage in order to remove phosphates, heavy metals and other pollutants. For industrial wastewater treatment, this treatment is desired if the colour of effluent is too intense. Normally colour removal is carried away by adsorption on clays and activated carbon, coagulation with lime, aluminum sulphite etc. but treatment costs are high and not suitable for removing organic matter.

(B) Biological treatment: In biological treatment optimum conditions are provided for natural self-purification in lagoon with the help of trickling filters, activated sledge or waste

stabilizing ponds. Use of treated or partially treated sewage for fish culture is a traditional method of biological treatment of organic waste, in which organic matter is mineralized, nutrient content considerably reduced and producing over one ton of fish per hectare per year without additional feeding.

(C) Biochemical treatment: It is considered better than chemical treatment because it not only removes colour, but also help in BOD reduction and removal or organic matters. Biochemical oxidation is in fact a unit operation that conveys water-soluble organic compounds and each capable of converting 30-70% of soluble convertible carbonaceous materials having high BOD to insoluble carbonaceous material, CO_2, water and energy.

6. Water pollution control legislations:

i) Water (prevention and control of pollution) Act-1974, first legislation towards pollution controls.

ii) The water (prevention and control of pollution) Cess Act, 1977.

iii) The Environment (protection) Act, 1986

iv) Ganga Action plan (1985). The central Ganga Authority was constituted in Feb.1985 to evolves and oversee the implementation of long term Ganga Action plan for cleaning the river Ganga.