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MARINE POLLUTION — ITS EFFECTS ON LIVING RESOURCES WITH SPECIAL REFERENCE TO AQUACULTURE

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ABSTRACT

Due to large scale industrialisation and indiscriminate discharge of effluents with high BOD, toxic chemicals and particulate matter reach the aquatic environment, either directly or indirectly. Enrichment of the coastal waters through nutrients and minerals lead to immediate and long term effects on the biota and fishery resources causing severe eutrophication or mass mortality. Among a large variety of pollutants which reach the aquatic environment, the domestic sewage, agricultural pesticides, industrial wastes, oil and oil dispersants, radioactive wastes and the polluted water from the coconut retting zones causes deliterious effects in the inshore and fish farming areas.

The paper documents the effects of pollution on the aquatic environment and the biota as well as the fishery resources especially in the fish farming areas. The toxic industrial effluents and their effect on the planktonic algae and zooplankton together with the effects of organochlorine compounds on the growth, survival and reproduction of cultivable organisms and the stress they produce on the ecosystem are also discussed.

INTRODUCTION

THE EMPHASIS in recent years has been to augment fishery resources through large scale coastal aquaculture in estuarine and contiguous low lying areas. The open seas are also chosen for sea farming of shellfishes. When development projects are aimed at increasing food production, the discouraging factor that could offset this aim is the pollution of the inshore, estuarine and coastal waters connected by river systems. Rivers have been described as the greatest instruments of marine pollution and the main action of the river borne pollutants is in estuarine and coastal waters which are the most vulnerable aeas from the point of aquaculture and fisheries.

Most of the protein food harvested from the marine and estuarine environment are subjected to varying degrees of environmental pollution. When pollution is heavy, these organisms can be destroyed or rendered inedible or if consumed become a cause of human ailment. Some of the major pollutants that cause havoc to aquaculture systems are sewage, industrial effluents containing heavy metals and toxic chemicals, pesticides, hydrocarbons, dredged soil and thermal pollution.

The rapid growth of industries in India since independence, especially in major coastal urban areas, have steadily deteriorated water quality in the estuarine and coastal environment. The major areas are Bombay-Kalyan, Calcutta-Asanol Durgapur area, Madras, Vizakhapatnam, Udyogamandal near Cochin and Chaliyar near Calicut. It is estimated that there are at present 670 textile mills, 1600 tanneries, 600 sago and starch mills, 180 sugar mills, 77 distilleries, 25 nitrogenous fertilizer factories, 125 dairies and other units discharging untreated or partially treated waste waters into the aquatic environment (Shastri,1979). The river systems which receive these industrial pollutants have suffered considerable degradation over the years and whenever mass mortalities of fish occur the public attention has been drawn. But, what has gone unnoticed is the long-term effect of these pollutants such as destruction to spawning grounds, prevention of migratory fish and genetic isolation of certain species.

Apart from the effects on the ecosystem by pollutants in the natural aquatic environment, there are also practical considerations for aquaculture. Perhaps even more important than in the natural environment, water quality is vital in aquaculture. A major threat to the entrepreneurs in aquaculture is disease to the cultivable organisms. This threat can be aggravated by adverse water conditions which impose a threat on the cultured animal. Pollutants invariably contribute towards increase of stress to the organisms. Other than the adverse effects, the vital question of product acceptability is also closely linked to the problems of water quality in aquaculture.

In view of the emphasis given to aquaculture in recent years, the Central Marine Fisheries Research Institute has taken up investigations to identify the sources of pollution, monitoring the major pollutants and studying the lethal and sub-lethal effects on finfishes and shellfishes including their larval forms. This paper is aimed at reviewing and discussing the results of investigations carried out in different areas and the possible effects of common pollutants on the cultivable organisms.

Industrial Effluents

The major pollutants which can pose serious threat to aquaculture are from pulp and paper industry, fertilizer and chemical industries. It is estimated that 250,000 to 350,000 litres of waste water will be discharged for every tonne of paper that is produced. For example, the pulp division of the Gwalior Rayons Factory at Calicut discharges 75 million litres per day. The combined effluents from the Udyogamandal industrial area discharged into Periyar River is estimated at 172 millions litres per day. These effluents contain a variety of toxic substances such as mercury, zinc, copper, cadmium, lead, fluorides, ammonia, urea and chlorine apart from radioactive materials, oil and grease, etc. Some of these substances are directly toxic while others are indirectly harmful due to their decomposition or oxidation by chemical or biological action. Once any of these industrial effluents reaches the culture systems it can seriously affect the quality of the cultured products and cause reduction in the yield.

Whether released to air, water or soil, significant amounts of heavy metals are eventually carried into estuarine and coastal water systems. Heavy metals important trace components of the sea water, may function in both the regulation and stimulation of biological processes. Some metals have known biological functions such as copper, zinc, manganese, magnesium, etc. and are required in varying concentrations for growth and metabolism of all organisms. Many of these metals are found in organisms in concentrations that are high in comparison to the surrounding medium. Hence, the biota concentrate many heavy metals relative to their environment. The invertebrates appear to have a particularly high capacity for concentrating metals from the environment when they filter plankton during feeding. Because of the ability of many metals to form complexes with organic substances, there is a tendency for them to be fixed in the tissue and not to be excreted. Some of these elements have no apparent biological function and it appears that organisms have little capability for selective uptake or excretion. Such metals may not be toxic to the host organisms, such as zinc or copper in oysters, but they may be passed up the food chain to higher organisms including man.

The bioaccumulation of metals varies from metal to metal and differs among the various organisms. Some of these metals are bio-accumulated through the food chain, so that predators have the highest concentrations. Studies of uptake by the mussel *Mytilus edulis* of Zn, Mn^{54}, Co^{58} and Fe^{59} showed that the principal accumulation of these metal radio-nuclides occurs through the food and the transfer directly from the water is relatively minor (Pentreath, 1973). Bioaccumulation of copper by oysters and other invertebrates has been known for a long time. Copper tends to give the oysters not only green colour, but a rather unpleasant metalic taste. While the concentration of copper in sea food has never been considered a serious threat to human health, the marketing of such sea food is seriously affected. However, considering the impact of these biological accumulation on the organism itself the possible sublethal effect such as on neurophysiology, enzyme activity, endocrinology, parasitology and disease, and carcinogenic and mutagenic effects as well as other impacts at the cellular levels have to be taken into consideration.

Most common form of organic pollution is due to the presence of carbohydrates, fats, proteins and other organic substances found in sewage and dairies and food processing and tanning industries. For the assessment of these pollutants the BOD test is commonly used which gives the oxygen consumption of the effluent at 20°C. The ISI has set a limit of 100 mg/l for the industrial effluents and 5 mg/l for shellfish and commercial fish culture. The oxygen demand will increase by blooms of noxious algae which may further deteriorate the dissolved oxygen content of the waters. A study of the diurnal variation of the dissolved oxygen content of such polluted waters may reveal anoxic condition during the pre-dawn period in culture systems. Extreme vigilance is required under such conditions.

Apart from the deoxygenation, residual chlorine in excess of 1 ppm and presence of ammonia in excess of 1.2 mg/l or lowering of pH due to discharge of acids are some of the causes of frequent mass fish mortalities in the estuarine waters. Silas and Pillai (1976) reported an instance of mass fish mortality in the Udyogamandal-Cochin area. About 15 species of fishes and shellfishes were collected which consisted of both pelagic as well as demersal forms. The pH (4.8) clearly indicated that the pollutant was acid and acidemia caused instant death to the entire fauna in the vicinity. They also observed large scale fish mortality in another area of the Cochin Backwater caused by the effluents from a fertilizer factory. On a day of severe pollution the water sample showed the following features; temperature 30°C; dissolved oxygen 0.86 ml/l; pH 8.18; alkalinity 842.8; ammonia 333 mg/l. Incidentally, the ISI standard of tolerance limit for ammonia is 1.2 mg/l (maximum) for marine coastal waters.

Jayapalan *et al.* (1968) studied the effects of effluent discharge from a fertilizer factory in this area and stated that 'the effluent discharges from the factory directly flows into the river water'. These effluents affect the normal physico-chemical nature of the river water at various places in different ways. They observed the annual variation in pH was from 4.7 to 9.5 at various points from the immediate vicinity of the discharge towards downstream.

Sewage

Extensive studies on the distribution and seasonal cycles on the indicator bacteria carried out in Cochin Backwater and the inshore environment have revealed the occurrence of numerous genera such as *Pseudomonas*, *Aeromonas*, *Acromobactor*, *Flavocacterium*, *Vibrio*, *Streptococcus*, *Hemophilus*, *Micrococcus* and enterobacteriaceae. Table 1 gives the seasonal variations of total coliforms, faecal coliform and faecal streptococci in the sediments of the Cochin Backwater along with faecal index.

TABLE 1. *Occurrence of bacterial pollution indicator organisms (form 10³/gm) in the Cochin Backwater sediments for the period February 1974 to January 1975 together with faecal index*

Months		Total coli	Faecal coli	Faecal Strepto-cocci	Faecal index FC : FS
January	..	51.74	20.93	27.35	0.76
February	..	58.35	34.22	7.42	4.61
March	..	—	—	—	—
April	..	86.72	10.42	2.05	5.08
May	..	79.77	17.65	6.13	2.87
June	..	88.63	10.54	0.17	6.20
July	..	53.16	35.50	7.50	4.73
August	..	63.69	30.08	7.05	4.26
September	..	46.40	39.21	14.37	2.72
October	..	—	—	—	—
November	..	45.92	27.85	26.35	1.06
December	..	52.60	27.03	20.36	1.32

The high values of total bacterial counts are recorded during the post-monsoon period. Faecal coliforms are also found to be abundant in the post-monsoon period. The faecal index values (above 4) indicate that during certain months the sources of pollution is from human waste. It has also been observed that sandy sediments harboured more pollutional organisms which may be released upon resuspension following dredging and other activities. The ISI has prescribed the following limits for bacteria in the aquatic environment.

Tolerance limits for

Bathing, recreation, shellfish and commercial fish culture and salt manufacture	Harbour water
Coliforms MPN index per 100 ml, max. 1000	2500

Oil Pollution

Oil Pollution of the marine and estuarine environment can occur from a variety of sources such as accidental spills from tankers and off-shore wells, nearshore ship operations, urban and industrial sewage effluents and transported through the atmosphere. However, chronic low level contamination of localised areas originates primarily from the discharge of oil from nearshore ship operations and from industrial and sewage effluents. The direct lethal effects of oil pollution on fauna and flora have been extensively studied from nearshore waters. However, sublethal effects such as food-chain alteration and reduced resistance to environmental stress have received very little attention. It is already known that certain hydrocarbon fractions are remarkably stable in the marine environment and these hydrocarbons may detrimentaly affect the feeding responses of lobsters (Blummer *et al.*, 1973). Marine fishes and crustaceans respond to the chemical stimuli induced by oil pollution which triggers numerous kinds of behavioural response including feeding. Sub-lethal level of crude oil on lobsters have been observed to bring in changes in the sensing movements, feeding behaviours and gill operation (Blummer and Sass, 1972).

During the most susceptible part of the life-cycle of fish, *i.e.* the development of eggs and larvae, oil pollution can be critical. Abnormalities at various stages of embryonic developments have been observed in experiments using oil treated seawater. To study the interaction of oil on aquaculture further experimentation is required on the concentration, distribution and persistance of the aromatic and sulphur containing fractions. Large scale accidental spillages in the vicinity of aquaculture areas can have a devastating effect on organisms as demonstrated by the recent disaster of 'AMICO CADIZ' in March 1978. However, persistant sub-lethal oil pollution can have prolonged effect on the survival and growth of the cultivable organisms.

Thermal Pollution

Temperature of the ambient water, when altered from natural levels can be a lethal, or controlling or directive factor for fish (Fry, 1947). Below a specific temperature, with variations for species, activity becomes reduced to low levels. When temperature rises above the optimum activity dimnishes considerably and at high levels, death results (Sylvester, 1972).

In the marine environment thermal effluents may cause a local increase in salinity as well as temperature, thus affecting the distribution of organisms. Reproductive cycles may be disrupted by elevated temperatures and migration routes may be altered (Coutant, 1968). With increasing temperature, toxicities of some substances are increased and the resistance to disease lowered (Jones, 1964). In the presence of domestic and industrial wastes, a slight increase in temperature could cause fish mortalities through synergism. Synergism results when total effect of two or more substances is greater than the effect of each separately. Deviations from optimum temperature could also cause a cessation of spawning behaviour or an increase of abnormal fry.

Pesticides

The green revolution in its wake has necessitated the introduction of high yielding varieties of food crops which are comparatively more susceptible to the attack of pests. Hence in recent years large doses of pesticides have been used to augment agricultural production. Though banned in several countries, farmers in India have been using chlorinated hydrocarbons in place of biodegradable pesticides due to the cost-factor involved in procurement and application. This has resulted in considerable build up of DDT and such other pesticides in the waterways and sediments. DDT in commercial pesticide formulations for agriculture and other uses is somewhat impure and in addition to the major component, PP' DDT, it contains ortho para DDT and DDD. Although these compounds are very similar in structure, PP'DDT is virtually inactive and DDD is only moderately toxic to a range of restricted species. Although all these are extremely insoluble in seawater they can act by skin contact with particles which can be dissolved in skin lipids. It can also be ingested with food. So, in culture systems adjacent to paddy fields or connected to run-off from paddy field there is the likelihood of contamination from organochlorine compounds.

Most of the marine fishes are extremely susceptible to PP'DDT while crustaceans tend to accumulate the same in high concentration beneath the exo-skeleton. Besides, the biodegradation of PP'DDT even to 50% level takes a few years and complete elimination takes several decades. Two other common pesticides Dieldrin and Endrin have respectively 40 times and 100 times more toxicity than DDT. In recent years organophosphorus pesticides such as Malathion and Parathion and carbonate compounds are also increasingly used. Though these are also very toxic to fresh water fishes, the danger to the marine environment has been considered at present insignificant. Large scale development of aquaculture in the low lying areas adjacent to extensive paddy fields requires careful evaluation of the presence of pesticides in the ecosystem.

Conclusion

The national policy for marine fisheries development envisages a production of 2.8 million tonnes by 1983 and coastal aquaculture has been given top priority in the development programme in view of its great potential for augmenting production and providing employment opportunities as well as its role in integrated rural development.

It is not enough if production is increased through various inputs in aquaculture but stability of production must be enhanced and ensured. For this purpose it is imperative that factors such as aquatic pollution which diminish production and upset planning should be effectively controlled through various measures such as ;

1. Value judgement to set the level of acceptable and deleterious effects considering economic, political and social factors.
2. Strong national policy to ensure that potentially hazardous materials do not occur in one place and at one time in sufficient quantities to produce deleterious effects.
3. Water quality criteria and standards for inland, estuarine and coastal areas.
4. Proper effective programmes by Research and development organisations to control pollution and establish tolerance levels.
5. Recycling of wastes for cultivable organisms.

The approach to the protection of the marine environment with reference to aquaculture industry should be considered in totality taking environmental development as an integral programme. For this purpose a national pollution control and abatement programme is suggested on the following lines (Lesaca, 1977).

(*a*) Identification, surveys and monitoring of polluted areas.

(*b*) classification of rivers, waterways and other water bodies or watersheds in accordance with best usage or objective.

(*c*) measurement of parameters needed to establish aquatic pollution.

(*d*) periodic inspection and assessment of effects and impacts of pollution from all sources.

(*e*) industrial installation of pollution control equipment.

(*f*) research to identify local ecological conditions and establish tolerance levels of aquatic resources to pollution.

(*g*) review and revision of existing rules and regulations.

The Indian Standard Institution has set tolerance limits for industrial effluents discharged into marine coastal areas and for water quality after receiving discharges (ISI—7967 and 7968, 1976). In the latter the standards are same for bathing, recreation, shellfish and commercial fish culture and salt manufacture. Specifications have been indicated for colour and odour, floating material, suspended solids, oil and greasy substances and also for lethal chemicals such as arsenic, mercury as well as free ammonia, phenolic compounds etc. But at present there is no agency to enforce the criteria or standards. In this context, the recent findings on the chlorination of drinking water, points to the sad reality that certain chemicals which serve us well today hold many hidden dangers. Because of its great oxidising power, chlorine is highly reactive and combine in a variety of ways with both inorganic and organic compounds. Some such compounds are suspected as carcinogens and mutagens. Hence constant up-dating of criteria and standards and perpetual vigil are essential so that the oceans which have a finate capacity to assimilate man created wastes remain a safe environment for all the living resources they support.

References

BLUMER, M. AND J. SASS 1972. Oil Pollution : Persistance and degradation of spilled fuel oil. *Science*, **76** : 1120-1122.

COUTANT, C. C. 1968. Behaviour of adult salmon and steel head trout migrating past Hanford thermal discharges. pp. 8-11. *Biological effects of thermal discharges : Annual progress report for* 1967. 1. Biological Sciences. Battelle-Northwest, Richland, Wish. BNWL-714. In :

FRY, F. E. J. 1947. Effects of the environment on animal activity. *Publ. Ont. Fish. Res. Lab.*, **68** : 1-62.

JAYAPALAN, A. P., K. M. SASIDHARAN AND V. ACHUTHAN NAIR 1976. Some aspects of the physico-chemical and biological variations of Periyar water due to the effluent discharge from FACT. *Bull. Dpt. Fish. Kerala*, **1** (1) : 47-60.

JONES, E. 1964. *Fish and river pollution*. London, Butterworths, pp. 203.

JOHNSTON, R. 1976. *Marine Pollution*. Acad. Press, London.

LESACA, R. M. 1978. National and International responsibilities towards aquatic pollution control. Fifth FAO/SIDA Workshop on Aquatic Pollution in relation to protection of living resources. *FAO, TF—RAS* 34 (*SWE*) *Suppl.*, **1** : 459 pp.

SHASTRI, C. A. 1979. Technological problems of effluent treatment. *Sem. Org. Kerala State Prod. Coun.*, Oct. 1979 (MS).

SILAS, E. G. AND V. K. PILLAI 1976. Water pollution and fish mortality in the Cochin Backwater. *Proc. Nat. Sem. Env. Poll.*, Cochin, pp. 323-327.

SYLVESTER, J. R. 1972. Possible effects of thermal effluents on fish. *Environ. Poll.*, **3** : 205-215.