AQUACULTURE AND POLLUTION

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The relation between aquaculture and pollution is a complex one. Animals living in a water body are affected by changes in the chemical and physical quality of that water. An increase in water temperature can be beneficial up to certain point, above which it becomes detrimental and ultimately lethal; but a change involving an increase in level of a chemical which is not normally present can very often cause deleterious effects.

The animals are sensitive to the physical and chemical changes to which many of them have a low tolerance range. Even changes within their tolerance range can affect the physiology of the animals so as to influence their growth rate, fecundity and mortality. The tolerance of the animals also varies with their stage of development. Thus a very young animal may be more sensitive to a pollutant than an adult. This account is intended to bring together the information available on the common pollutants and their tolerance levels in the cultivable fishes, crustaceans and molluscs that are important in aquaculture.

Nature of the culture systems and their relation to problem of pollution

Fishes living in a culture system are subjected to changes in water to a greater extent than those in the natural surroundings as they cannot select the environments in which they live. The fishes and prawns living in an estuary or lagoon can often escape from a local pollutant by moving to other areas. Obviously this is not possible for fish confined in a pond or cage.

Based on the mode of feeding of the culture animals, two types of aquaculture systems can be distinguished. In the first one, fishes depend for food on the plants and animals produced in the farm area in which they live as againt the second one in which the fishes are confined in dense populations in small areas such as cages and small ponds and wholly depend on artificial feeds. In both these systems the sensitivity to changes in water quality differs. In the first system pollution affects not only the culture animals but also the animals and plants on which they feed. This system, therefore, is likely to be more easily damaged by pollutants than the second one where the damage inflicted is directly on the culture animals. In India, we have both types of systems; but standards and criteria for varying acceptable limits of pollutants have not been evolved. It is imperative that our fisheries and allied institutions engaged in pollution investigations jointly formulate acceptable limits for both types of aquaculture systems so that suitable control measures could be evolved in order to maintain the quality of the products.

Biological effects of pollutants

Of the many different toxic substances that find their way into the estuaries and coastal waters and affect the physiology of the animals inhabiting them, pesticides occupy the top most place. The agricultural sector has using different types of organochlorine and organophosphate compounds for the eradication of pests. Recent studies on the effects of insecticides on marine organisms demonstrate that concentrations which are not sufficient to control many species of insects, nevertheless, can inhibit, the productivity of phytoplankton (Butler and Springer, 1963); kill or immobilise crustaceans, fishes and molluscs (Eisler, 1970); kill eggs and larvae of bivalve molluscs (Davis, 1961); induce deleterious changes in tissue composition of molluscs and teleosts (Eisler,1967; Eisler and Edmud, 1966; Eisler and Weinstein, 1967); affect distribution of schooling and feeding behaviour of fishes (Hiatt *et al.*; 1953); and interfere with ovary developments in molluscs and teleosts Boyd, 1964 Eisler, 1970. It has been observed that clams and oysters can concentrate pesticides from the medium by factors of 70,000 and more (Butler, 1966). Fishes also can concentrate appreciable quantities of insecticides directly from the medium and retain them for at least 4 months (Croaker and Wilson, 1965). Marine species are unable to acquire resistance to pesticides and suffer heavy mortality when exposed to relatively low pesticide levels. In general organochlorine insecticides are more toxic to marine fishes and crustaceans than organic phosphate insecticides and detergents. Table 1 gives the toxicity levels of some organochlorine and phosphorus insecticides under controlled environmental conditions to marine teleosts, crustaceans and molluscs.

Criteria for water quality in fish culture

Domestic garbage and industrial effluents containing materials that precipitate in seawater, settle on the bottom or float, can cause trouble to aquaculture. Shellfish may be killed if the beds of the farms are covered with settling substances. Materials from mining operations also can cause the same deleterious effects to shellfish by causing disturbance to their feeding mechanisms. Industrial effluents, depending upon their intensity and nature, can cause havoc to both culture animals as well as the plankton forms on which they feed. Measurements conducted with C^{14} have indicated that the effluents discharged into Chaliar river (near Calicut, Kerala) affect photosynthesis right up to the Beypore estuary, 16 km downstream from the point of impact.

The Indian Standards Institution has prescribed certain limits for water quality after receiving discharges (ISI, 1976a) and for industrial effluents (ISI,1976b) especially in sellfish and commercial fish culture (Tables 2 and 3).

The use of garbage, dairy waste and sewage as organic fertiliser to increase productivity of fish ponds has been practised for a long time. Organic wastes such as cow-dung and manure from poultry and piggery can be directly used for fertilising fish ponds; but in the case of sewage, it is to be subjected to primary and secondary treatments with high rate trickling filter or by activated sledge process. In India, there are 132 sewage fed farms covering an area of 12,000 hectares (Dehadrai and Ghosh 1978). These authors have cited many instances of successful culture of fishes in sewage-fed farms in different parts of the country.

Before recycling domestic waste water through fish pond, it is desirable to treat it so that the organic load is reduced considerably. The organic load of waste waters is generally expressed in terms of its Biochemical Oxygen Demand (BOD) which in the case of raw sewage generally lies between 150-600 mg/1. Primary treated sewage effluent contains less organic matter than raw sewage and more nutrients than secondarily treated one and is preferred for fish culture in ponds where no supplementary fertilisers of foods are used (Dehadrai and Ghosh, 1978).

Beneficial effects in water quality from domestic and animal wastes, industrial organic wastes and heated effluents require careful study by aquaculturists so that a pollutant which in effect is a "displaced resource" can be profitably exploited for producing much required protein for filling up the nutrition gap. Coupled with this, bio-assay studies are also required to monitor the uptake of unwanted or toxic substances in the lipid pool by bio-accumulation in order to maintain the quality and safety of products of aquaculture.

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Table 1. *Toxicity levels of some organochlorine and phosphorus insecticides: 96 hour LC-50: |1 active ingredients*

	Teleosts	Crustaceans	Molluscs
Organochlorines			
Endrin	0.05 - 3.1	1.7 - 12	> 10,000
P,p-DDT	0.4 - 89	0.6 - 6	> 10,000
Heptachlor	0.8 - 188	8.0 - 440	> 10,000
Direldrin	0.9 - 34	7.0 - 50	> 10,000
Aldrin	5.0 100	8.0 - 33	> 10,000
Lindane	9 0 - 66	5.0 - 10	> 10,000
Methoxychlor	12.0–150	4.0 - 12	> 10,000
Organophosphates			
Dioxathion	6 - 75	38 - 285	> 25,000
Malathion	27 - 3,250	33 - 83	> 25,000
Phosdrin (R)	65 - 800	11 - 69	> 25,000
DDVP	200 - 2,330	4 - 45	> 25,000
Methyl parathion	5,200 - 75,00	2 - 7	> 25,000

From Eisler, 1972.

Table 2. *Tolerance limits for water quality after receiving discharges.*

Sl. No.	Characteristic	Tolerance limits for shellfish and commercial fish culture
1.	Colour and odour	No noticeable colour or offensive odour
2.	Floating material	No visible floating matter of sewage or industrial waste origin
3.	Suspended solids	No visible suspended sdoils of sewage or industrial waste origin
4.	pH value	8.5 to 8.5
5.	Free Ammonia (as N), mg/ l max	1.2
6.	Phenolic compounds (as C_6H_6OH), mg/1, Max	0.1
7.	Dissolved oxygen, Min.	40% saturation value or 3mg/1 whichever is higher
8.	Pesticides (chlorinated hydrocarbons) (as Cl), mg/1 ,Max	0.002
9.	Arsenic (as As), mg/1, Max	0.2
10.	Mercury (as Hg). ,, ,,	0.0003
11.	Oil and greasy substances (sampled in 30 cm surface layer) mg/1, Max	0.1
12.	Biochemical Oxygen Demand (5 days at 20° C), mg/1, Max	5
13.	Coliform bacteria, MPN index per 100ml, Max	1000
14.	Bio-assay test	Not less than 90% of test animals shall survive in 96 hour test

Table 3 *Tolerance limits for industrial effluents*

Sl. No. (1)	Characteristics (2)	Tolerance limit (3)
1.	Copper (as Cu), mg/1, Max	3.0
2.	Lead (as Pb), ,, ,,	1.0
3.	Chromium (as Cr), , ,,	1.0
4.	Cadmium (as Cd) ,, ,,	2.0
5.	Mercury (as Hg) ,, ,,	0.01
6.	Nickel (as Ni) ,, ,,	5.0
7.	Zinc (as Zn) ,, ,,	5.0
8.	Total suspended solids, mg/1, Max	
	a) for process waste waters	100
	b) for cooling water effluent	Total suspended matter content of influent cooling water plus 10%
9.	Particle size of :	
	a) floatable solids, Max	3mm
	b) settleable solids, Max	850 microns
10.	pH value	5.5 to 9.0
11.	Temperature, Max	45°C at the point of discharge
12.	Biochemical Oxygen Demand (5 days at 20°C), mg/1, Max	100
13.	Oils and grease, mg/1, Max	20
14.	Phenolic compounds (as C_6H_5OH) mg/1, Max	5.0
15.	Cyanides (as CN), mg/1, Max	0.2
16.	Sulphides (as S) mg/1, Max	5.
17.	Alpha emitters, uc/m1, Max	10-8
18.	Beta emitters ,, ,,	10-7
19.	Residual chlorine mg/1, Max	1
20.	Arsenic (as As) ,, ,,	.02
21.	Celenium (as Se) ,, ,,	0.05
22.	Ammoniacal nitrogen (as N), ,, ,,	50
23.	Chemical oxygen demand ,, ,,	250
24.	Pesticides :	
	a) Organo-phosphorous compounds (as P) ,, ,,	1
2	b) Chlorinated hydrocarbons (as Cl), ,, ,,	0.02
25.	Fluorides (as F), ,, ,,	15