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EFFECT OF PESTICIDES ON PHYTOPLANKTON PRODUCTION

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ABSTRACT

The effect of pesticides on natural phytoplankton was determined by incubating the plankton samples *in situ* at 1 m depth for different periods with various concentrations of the following pesticides: P'P,–DDT, lindane, endosulfan (Organochlorine), methyl parathion, malathion (Organophosphorus) and sevin (carbamate). Primary production was inhibited considerably by these pesticides. In most cases production decreased with increase in the concentration of the pesticides. The production values ranged from 24.1 to 89.07% of that of the control for the six pesticides tested. The organochlorine pesticides were found to be more toxic than the other two groups and carbamate (sevin) was the least toxic to phytoplankton. The toxic effect was in the order of PP. -DDT > endosulfan > lindane > methylparathion > malathion > sevin.

Key-words : Pesticides, phytoplankton, pollution.

INTRODUCTION

In recent years, much attention has been directed towards the problem of pesticide pollution of aquatic environments. At present, the production of pesticides in India is over 50,000 tonnes a year as against 25,000 tonnes in 1970-71 and 6,600 tonnes in 1960-61 (Joint Director of Agriculture, Tamil Nadu). Eventhough widespread occurrence of pesticides in aquatic environments including marine waters are known, their effects on plankton have not been extensively studied. Since a substantial part of the world's photosynthesis is performed by marine phytoplankton, interference by the pesticides would be disastrous, in the long run, to the biosphere.

Algae are useful indicators of potential pollution because they respond by stimulation, inhibition or both to all toxicants. In general, low concentrations of pesticides inhibit the growth of algae (Fisher, 1975). Reduction in the rate of photosynthesis in a number of marine algal species has been reported for organochlorine pesticides by Menzel, Anderson and Ranttke, (1970); Mac Farlane, Glooschessto and Harris (1972); Krishnakumari (1977); Subramanian, Lingaraja and Venugopalan (1979), for organophosphorus by Butler (1964) and for carbamate insecticides by Ukeles (1962). In the present study, the toxicity of various concentrations of DDT, endosulfan, lindane (Organochlorine), methylparathion, malathion (Organophosphorus) and sevin (carbamate) to natural phytoplankton were studied adopting *in situ* method.

MATERIALS AND METHODS

Experiments were carried out in Vellar estuary at a station opposite to marine Biological Station. Water samples were taken from a depth of 1 m with a PVC van Dorn water sampler and filtered through a funnel lined with silk bolting cloth (200μ) to remove the larger zooplankton. The filtered water was collected in 2.5 l dark bottles. The bottles were gently shaken to redistribute any settled organisms and the water sample was then slowly poured into 175 ml light oxygen bottles. Equal number of dark bottles were also filled. One sample was taken for initial oxygen analysis and a second one was preserved with Lugol's iodine solution for the identification of algae. Two controls were used with and without acetone. One of the controls was treated with 1 ml acetone. Oxygen bottles were set up after adding the pesticide to each bottle to give a final concentration of 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 ppb. The experiments were conducted in duplicate. Acetone was used as the carrier solvent. Pesticides used were of technical grade. They are (i) 100% p'p,-DDT supplied by M/s Hindustan Insecticides Limited, (ii) endosulfan (M/s All India Medical Corporation), (iii) 99.5% lindane (M/s Pesticides India Limited, (iv) 95% malathion (M/s Cynamaid India Limited), (v) 80% methyl parathion (M/s All India Medical Corporation) and (vi) 100% sevin (M/s Union Carbide India Limited). Equal amount of water was removed before adding pesticide stock solution. The bottles were stoppered and suspended 1 m below the surface and incubated for 3 hours. At the end of the incubation period, the light and dark bottles were removed and the primary production was estimated as described by Strickland and Parsons (1968). Algal samples preserved in Lugol's iodine solution were concentrated by allowing them to settle. The concentrated algal samples were identified using Utermohl's inverted microscope.

RESULTS AND DISCUSSION

Analysis of the phytoplankton samples revealed that *Biddulphia sinensis*, *B. mobilensis*, *Chaetoceros coartum*, *C. peruvianum*, *Coscinodiscus gigar*, *Rhizosolenia robusta*, *R. alata*, *Skeletonema costatum*, *Thalassiothrix franenfeldii* and *T. nitzschllides* were the dominant species. Due to the presence of different algal species, it is difficult to ascertain the role played by any one particular algal species in terms of its individual contribution to the total photosynthesis observed. The production values ranged from 24.1% to 89.07% of that of the control for the six pesticides (Table I). The lowest production was noticed at 20 ppb of DDT whereas the highest production occurred at 2 ppb of sevin. The minimum production observed at 20 ppb concentration of different pesticides was 24.1% for DDT, 25.13% for endosulfan, 27.69 for lindane, 35.69% for methyl parathion, 41.54% for malathion and 45.34% for sevin.

In most cases a significant decrease in production occurred at all concentration of pesticides tested. There was no effect of the solvent on primary production. 74.9% and 54.36% reduction in primary production were observed at 20 ppb of DDT and sevin respectively whereas at 2 ppb the reduction

Table I. Effect of different concentrations of pesticides on photosynthesis compared to that of control. Control 100%, Acetone 100%.

Concentration (ppb)	DDT	Endosulfan	Lindane	Methyl parathion	Melathion	Sevin
2	72.57	73.84	82.06	85.64	85.87	89.07
4	65.64	70.00	75.38	81.53	84.69	87.44
6	58.98	62.31	68.21	75.90	82.06	83.07
8	52.82	54.87	61.63	70.26	74.36	77.95
10	46.67	49.49	52.31	64.10	66.67	67.94
12	41.54	45.64	46.15	58.47	57.44	60.00
14	37.44	37.95	41.03	50.77	53.33	54.10
16	33.34	35.38	35.90	45.13	48.20	50.00
18	28.21	28.72	31.79	40.00	44.62	45.89
20	24.10	25.13	27.69	35.39	41.54	45.64

were 27.43% and 10.9%. Approximately a 50% reduction in primary production was noticed at the concentration of 8 ppb of DDT, 10 ppb of endosulfan, 10 ppb of lindane, 14 ppb of methyl parathion, 16 ppb of malathion and 16 ppb of sevin.

Of the six pesticides tested, DDT (organochlorine) was highly toxic whereas sevin (carbamate) was the least toxix to phytoplankton, the order of toxicity being organochlorine > organophosphorus > carbamate. In general, considerable decrease in photosynthesis compared to that of the controls and solvent treated samples was observed even at very low concentrations of the pesticides. The production rate decreased from 72.57% at 2 ppb to 24.3% at 20 ppb of DDT when compared to other pesticides tested. Wurster (1968) reported 40% reduction in the rate of photosynthesis of neritic phytoplankton community at a concentration of 10 ppb of DDT. But in this study, the reduction in photosynthesis for the same concentration (10 ppb) of DDT was 53.33%. Primary production by *Skeletonema costatum* in culture was not affected at a concentration of 2 ppb of DDT, however, it started to decline at above 2 ppb and was completely inhibited at 15 ppb (Subramanian, Lingaraja and Venugopalan, 1979). A 13% growth inhibition in *Monochrysis lutheri* at 20 ppb of DDT was observed by Ukeles (1962). The highly toxic nature of organochlorine pesticides might be due to an uptake mechanism involving surface adsorption, followed immediately by very rapid adsorption across the cell wall. The possible reason reported by Sodergren (1971), was their persistent nature and resistance to biodegradation.

Endosulfan was less toxic than DDT but more toxic than the other pesticides. The production rate decreased from 73.84% at 2 ppb to 25.13% at 20 ppb. The percentage reduction in photosynthesis at 2 ppb and 20 ppb were 26.16% and 74.87% respectively. Lindane was still less toxic to the natural phytoplankton community. The productivity of phytoplankton treated with lindane was 82.06% at 2 ppb and 27.69% at 20 ppb. Reduction in primary production was noticed and the same was reported earlier also by Krishnakumari (1977) for the freshwater alga *Scenedesmus acutus*. The accumulation of pesticides in plankton, can have unforeseen effects in the aquatic biotopes. In general, pollutants such as pesticides are not degraded to a large extent by algae (Butler, Deason and O'Kelly, 1975; Sodergren, 1971; Hollister, Walsh and Forester, 1975).

Primary production at 2 ppb of malathion and methylparathion were almost equal. But malathion was found to be less toxic than methyl parathion when the concentration increased. One of the earlier reports was a 10% decrease in productivity at low concentrations of parathion (Butler, 1964). In the present study, 14% decrease in production at the lowest concentration (2 ppb) of parathion and malathion was observed.

The carbamate pesticide, sevin was the least toxic to phytoplankton as compared to other pesticides tested. The decrease in production was 11.93% at 2 ppb and 54.36% at 20 ppb concentration. From 10% to total inhibition of growth at 100 ppb concentrations of sevin in different phytoplankton communities were reported by Ukeles (1962).

Investigations on unialgal cultures revealed that inhibition of photosynthesis increased with time of exposure to pesticides (Wurster, 1968; Menzel, Anderson and Ranttke, 1970; Subramanian, Lingaraja and Venugopalan, 1979). But in all cases decrease in cell number was first observed. The primary effect of the pesticide might be on cell division and growth and that the decrease in photosynthetic rate was merely a reflection of the effect (Fisher, 1975).

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REFERENCES

Butler, P.A., 1964. In : Pesticide Wildlife Studies, 1963. *USDE Fish Wildlife Service Circular*, 199 : 5.

Butler, G.L., T.R. Deason, J.C. O'Kelley, 1975. Loss of five pesticides from cultures of twentyone planktonic algae. *Bulletin of Environmental Contamination and Toxicology*, 13 : 149–152.

Fisher, N.S., 1975. Chlorinated hydrocarbon pollutants and photosynthesis of marine phytoplankton : a reassessment. *Science*, 189 : 463–464.

Hollister, T.A., G.E. Walsh, J. Forester, 1975. Mirex and marine unicellular algae : accumulation, population growth and oxygen evolution. *Bulletin of Environmental Contamination and Toxicology*, 14 : 753–759.

Krishnakumari, M.K., 1977. Sensitivity of the algae *Scenedsmus acutus* to some pesticides, *Life Sciences*, 20 : 1525-1532.

Mac Farlane, R.B., N.A. Glooschessto and R.C. Harris, 1972. The interaction of light intensity and DDT concentration upon the marine diatom *Nitzschia delhicatissima* Cleve. *Hydrobiologia,* 39 : 373–382.

Manzel, D.W., J. Anderson and A. Ranttke, 1970. Marine phytoplankton vary in their response to chlorinated hydrocarbons. *Science,* 167 : 1724–1726.

Sodergren, A., 1971. Accumulation and distribution of chlorinated hydrocarbons in cultures of *Chlorella pyrenoidosa* (Chlorophyceae). *Oikos,* 22 : 215–220.

Strickland, J.D.H. and T.R. Parsons, 1968. A manual of seawater analysis. *Bulletin of Fisheries Research Board of Canada.*

Subramanian, B.R., T. Lingaraja and V.K. Venugopalan, 1979. Effects of low concentrations of DDT on the growth and production of marine diatom *Skeletonema costatum* (Grev), *Current Science,* 48(5) : 226–228.

Ukeles, R., 1962. Growth of pure cultures of marine phytoplankton in the presence of toxicants. *Applied Microbiology,* 10 : 532–537.

Wurster, C.F., 1968. DDT reduces photosynthesis by marine phytoplankton. *Science,* 159 : 1474–1475.