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TOXICITY OF PESTICIDES ON PHOTOSYNTHESIS OF DIATOMS

NAFISA SHOAIB, PIRZADA JAMAL AHMED SIDDIQUI*, AMJAD ALI, ZAIB-UN-NISA BURHAN AND SEEMA SHAFIQUE

Centre of Excellence in Marine Biology, University of Karachi, Karachi-75270, Pakistan
**Corresponding author e-mail: Jamal.siddiqui@yahoo.com*

Abstract

Pakistan being an agricultural country, a large amount of pesticides are used, including organophosphates and synthetic pyrethroids. These pesticides are released through rivers and other tributeries into the coastal environment, thus posing a contiuous threat to marine organisms. In the present study two species of diatoms *Amphora* and *Navicula* were selected for the assessment of impact of organphosphate and pyrethroid toxicity on these primary producers. The study shows that rate of photosynthesis was inhibited in both *Amphora* and *Navicula* species exposed to pesticide. The acute toxicity of pesticide was determined by measuring IC50 of the test organisms. IC50 calculated for diatom species depicts that different pesticides had variable effects on the photosynthesis of microalgae. High sensitivity of marine organisms is alarming as it may have implications on the marine ecosystem and fisheries. The results are also useful in setting control limits for the release of these chemicals in nature.

Introduction

Pollution in aquatic environment has been a major concern worldwide. Agrochemicals, such as pesticides pose a continuous threat to the marine ecosystem. Pakistan is an agricultural country and one of the major cotton producers in the world. Therefore, organophosphates and synthetic pyrethroids are largely used against cotton pests in Pakistan. Marine and freshwater microplankton species show a variable sensitivity to pesticides. Generally photosynthesis and growth of microplankton is negatively affected on exposure to pesticides. It is estimated that these microalgae may account for 40 to 45% of oceanic production and are considered as more productive than all the worlds' rainforests (Mann, 1999). Although diatoms are generally not employed in ecotoxicological studies due to their slow growth and difficulty in culture, but a number of reports show effects of pesticides on these organisms. Some previous studies showed reduction in photosynthesis and growth of diatoms exposed to 2, 4-D, atrazine, metobromuron, triazines (Andus 1970; Chai & Chung 1975; Brown & Lean 1995) and some organophosphates (Mohapatra & Schiewer, 1996; Mohapatra *et al*., 1997). Considering ecological importance of diatoms and that these organisms may serve as affective indicators of pollution. They are sensitive to change in salinity, temperature, pH and pollution (John, 1983). Changes in diatom population structure would indicate changes in marine environment (John, 1983). Ecotoxicological effects of pesticides have not been observed on microplankton species inhabiting Pakistani waters, therefore, the present study was undertaken to assess the ectoxicological effect of organophosphate and pyrethroid pesticides on photosynthesis of two diatom species.

Materials and Methods

Collection of samples, isolation & identification: Diatoms were isolated and purified from water samples collected from Manora Channel using a phytoplankton net (55 µm mesh) towed for ten minutes in the surface water. Water samples were brought to the laboratory in a cool box for isolation of diatoms using spread plate and serial dilution techniques (Rippka, 1988) employing f/2 medium (Guillard & Ryther 1962, Guillard 1975). The species of diatoms were identified on the basis of their morphological characters described previously (Kutzing, 1844; Heimdal, 1970; Tomas, 1997). Two organophosphates (methyl parathion and chlorpyriphos) and two synthetic pyrithroids (fenvalerate and fenpropathrin) were used in this study.

Experimental design: Effect of pesticides on photosynthesis of two laboratory grown cultures of diatoms was assessed using 'Light and Dark bottle method' (Strickland & Parsons 1968). A set of triplicate Light and Dark bottles were used for control and for each pesticide concentration (0.02 ppm, 0.06 ppm and 1 ppm). A known volume (5 ml) of well homogenized culture was inoculated in all bottles. One set was incubated in light and the other set was secured in the dark at constant temperature (36±1ºC) conditions for three hours. At the end of experiment, content of each of the light and dark bottles were fixed for the analysis of dissolved oxygen using Multimeter ion specific meter (Hanna C100). Gross photosynthesis was calculated as described by Strickland & Parsons (1968). The IC_{50} values were determined by using Log log graph.

Result

Effect of organophosphates and pyrethroids was observed on the photosynthesis of two species of diatoms, viz., *Amphora* sp. and *Navicula* sp. Results showed that the toxic effect of pesticides on both diatom species increases with increase in concentration of all pesticides tested (Tables 3 and 4). Both diatom species appeared to have variable sensitivity against different pesticides (Tables 1 & 2). For example, *Amphora* sp. is more resistant to fenpropathrin (IC_{50} = 52 ppm), whereas *Navicula* sp., showed high sensitivity to this pesticide (IC_{50} = 0.03 ppm; Table 1). Table 2 depicts rank of each pesticide pertaining to the degree of its toxicity (IC_{50} value) to each diatom species. The most toxic pesticide for *Amphora* sp., was fenvalerate, followed in decreasing order of toxicity by chlorpyrifos, methyl parathion and fenpropathrin. On the other hand, fenpropathrin had highest toxic effect on photosynthesis in *Navicula* sp., which was followed by chlorpyrifos, fenvalerate and methyl parathion in the decreasing order of toxicity. The minimum range of photosynthesis at 95% confidence limit was found to be 19.86-22.13% of fenpropathrin for *Navicula* sp., (Table 4) whereas the minimum range of photosynthesis at 95% confidence limit was found to be 26.00-28.53% of chlorpyrifos for *Amphora* sp., (Table 3).

Table 1. Effect of organophosphate and pyrethroid pesticides on photosynthesis of diatoms. Values are concentration of pesticides at which photosynthesis is reduced by 50% of control values.

Diatoms	IC_{50} ppm			
	Chlorpyrifos	Methyl Parathion	Fenvalerate	Fenpropathrin
Amphora	0.18	0.34	0.15	52
Navicula	0.06	0.4	0.1	0.03

Table 2. Ranking of toxicity of organophosphate and synthetic pyrethroid pesticides on some diatoms. Numbers 1-4 are assigned in decreasing order of toxicity.

Diatoms	Chlorpyrifos	Methyl Parathion	Fenvalerate	Fenpropathrin
Amphora	2	3	1	4
Navicula	2	4	3	1

Table 3. Reduction in photosynthesis of *Amphora* sp. exposed to pesticides for three hours.

Compound	ppm	Mean	S.D.	Range at 95% confidence limit
Chlorpyrifos	0.02	99.24 ±	0.295	98.90-99.57
	0.06	66.66 ±	0.33	66.29-67.04
	1	27.27 ±	1.11	26.00-28.53
Methyl parathion	0.02	89.77 ±	0.22	89.52-90.03
	0.06	74.99 ±	1	73.85-76.13
	1	34.09 ±	1.04	32.90-35.27
Fenvalerate	0.02	87.03 ±	1	85.89-88.16
	0.06	59.25 ±	1.25	57.83-60.66
	1	31.48 ±	2.5	28.65-34.30
Fenpropathrin	0.02	97.07 ±	1.02	95.91-98.23
	0.06	73.03 ±	1	71.89-74.16
	1	71.91 ±	0.08	71.82-72.00

Values are percent as mean photosynthesis of control value

Table 4. Reduction in photosynthesis of *Navicula* sp. exposed to pesticides for three hours.

Compound	ppm	Mean	S.D.	Range at 95% confidence limit
Chlorpyrifos	0.02	75.62 ±	2	73.35-77.88
	0.06	50.41 ±	2.5	47.57-53.24
	1	45.37 ±	1.59	43.56-47.71
Methyl parathion	0.02	62.18 ±	1.46	45.39-48.70
	0.06	57.14 ±	1.05	55.95-58.32
	1	47.05 ±	1	61.04-63.31
Fenvalerate	0.02	62.74 ±	1.25	61.32-64.15
	0.06	53.92 ±	1.02	52.76-55.07
	1	38.23 ±	1.23	36.83-39.62
Fenpropathrin	0.02	62.18 ±	0.84	61.22-63.13
	0.06	33.61 ±	0.38	33.18-34.04
	1	21 ±	1	19.86-22.13

Values are percent as mean photosynthesis of control value.

Discussion

The general inhibition of photosynthesis in both *Amphora* and *Navicula* species, tested in the present study, is in good agreement with some previous studies showing inhibitory effect of pesticides on algal species (Andus, 1970; Chai & Chung, 1975; Subramanian, Lingaraja & Venugopalan, 1979; Rajendran *et al*., 1983; Lorenzo *et al*., 2000; Mohapatra *et al*., 2003).

The data on the effect of different pesticides on two indigenous diatom species inhabiting coastal waters of Pakistan is being reported for the first time and these two species have not been examined before elsewhere. Our results showed that a diatom species has variable sensitivity against a given pesticides and that different pesticides have variation in the toxicity to particular species. This inter-species variation has been shown earlier (Kallqvist & Romstad 1994) which would lead to selective success of more resistant species to grow in natural waters. The consequential ecological imbalance may cause population explosions of one or more resistant species (Korringa, 1968) thereby altering the species composition of a natural phytoplankton community (Wurster, 1968a, b). Implication of absorbtion and uptake of pesticide by diatoms and other primary producers in fishery industry may be evident from the fact that the absorbed pesticides are efficiently transferred to organisms of higher trophic levels (Barron 1990) including fish and shrimp on which the fishery industry thrives in Pakistan. Our results (IC50) demonstrate the effective concentration of pesticides and are useful to set control limit for the release of such chemicals in the natural waters.

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