Impact of Monocrotophos on the Physico-Chemical and Biological Parameters of Oxidation Ponds

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Abstract

Oxidation pond is a simple scientifically designed pond, where BOD reduction takes place by supporting algal-bacterial growth. It is one of the low cost waste treatment methods to treat the raw sewage, settled sewage and industrial effluents. Studies were carried out on the toxicity of monocrotophos on the physico-chemical and biological parameters of oxidation ponds. The level of pH, DO and density of algae and protozoa were decreased and BOD and phosphate concentrations were increased as the concentration of monocrotophos increased in the oxidation pond. The activity of enzymes, namely catalase, amylase, protease and phosphatase were reduced in ponds treated with higher concentration of monocrotophos. The assessment of monocrotophos toxicity on the biodiversity of algae and protozoa showed that the algal species namely, *Oscillatoria brevis* and *Chlorella vulgaris* were dominant and the most tolerant species and *Cosmarium melanosporum* and *Euglena viridis* were recorded as a most sensitive species to monocrotophos treatment. Among protozoans, *Colpoda cucullus* was recorded as the dominant as well as tolerant species and *Stylonychia pastuluta* was recorded as most sensitive species to monocrotophos treatment.

KEYWORDS: Oxidation pond, algae, protozoa, monocrotophos, BOD, DO, enzymes

1. Introduction

Monocrotophos (O,O-dimelhyl-2-methyl carboxy-1-methyl vinyl phosphate) is a yellowish brown liquid miscible in water in any ratio and is having both insecticidal and acaricidal properties. Monocrotophos is extensively used in India for cotton and rice-fields to control stem-borers, non-sucking pests and chewing insects (Swamy and Mohan, 1990; Tripathy and Patnaik, 1992). The toxicity of monocrotophos is not limited to the sucking and chewing insects, but also is found to be toxic to mammals and birds (Stickel, 1975). The report of FAO/WHO shows some residual amounts of monocrotophos in various food stuffs and drinking water (Liapis *et al.*, 1994).

High performance liquid chromatographic method was used for the analysis of monocrotophos in the biological sample (Sharma *et al.*, 1990; Hormann and Tribolet, 1994). It has been found that monocrotophos which was widely used in the cultivation of ground nut enhances the activities of enzymes namely dehydrogenase and protease in soil (Rangaswamy *et al.*, 1994). Ammonification and nitrification mediated by microorganisms was stimulated by the presence of monocrotophos in the soils (Rangaswamy and Venkateshwarlu, 1990; Bongale, 1990).

Interaction of monocrotophos with cyanobacteria was studied and it was observed that monocrotophos induce acid phoshatase activity in Cyanobacteria and two members of Cyanobacteria, *Aulosira fertilissima* and *Nostoc muscorum* grew maximally in the presence of monocrotophos even in the absence of in-organic

phosphate in the medium (Subramanian *et al.*, 1994). The information on the impact of monocrotophos on aquatic microorganisms is scanty. Hence the present research work is carried out to investigate the impact of monocrotophos on the physico-chemical and biological parameters of oxidation pond under laboratory conditions.

2. Materials and Methods

The experiment was designed according to the procedure of Patil, 1986. The pesticide, monocrotophos 53% w/w manufactured by Cheminova India Ltd., Gujarat, was used for the present study. The percentage concentration selected were 0.3%, 0.6%, 0.9% and 1.2% respectively in four sets of oxidation pond. The concentration selected was based on the range finding tests. The experiments were carried out for 20 days. Observations were made by collecting 150 ml of sample from each pond. On every fifth day the samples were analysed for pH, water temperature, DO, BOD, TDS and phosphate by following the standard methods prescribed in APHA (1995). Catalase activity was determined according to the method of Luck (1974). Amylase and phosphatase activities were determined according to the procedure of Sadasivam and Manickam (1992). Protease activity was determined according to the procedure of Jayaraman (1985). Algal count was made using Lacky's drop method and Protozoa were enumerated by using a counting device called Sedgewick-Rafter cell (S-R cell) (Trivedy *et al.*, 1998).

3. Results

The data on the physico-chemical and biological parameters of the sewage samples both in the control and different percentages of monocrotophos treated ponds on day 20 are shown in Table 1. The correlation coefficient values for physico-chemical and biological parameters on day 20 are shown in Table 2. The percentage mortality of bacteria, algae and protozoa are presented in Fig. 1.

4. Discussion

4.1 Physico-chemical parameters

The raw sewage recorded a pH of 7.0±0.0. It increased to 9±0.0 in control pond on day 15. The water temperature in the raw sewage recorded was 25.5±0.0°C. It increased to a maximum of 34±0.0°C in the pond water treated with 0.3% monocrotophos. The pH and water temperature recorded a significant positive correlation with DO and all biological parameters and recorded a significant negative correlation with TDS, BOD and phosphate concentration.

The TDS concentration recorded in the raw sewage was 700±0.49mg/l. It increased to more than 800mg/l in all oxidation ponds throughout the experiment. It negatively correlated with all physico-chemical and biological parameters except with BOD and phosphate levels with which a significant positive correlation was recorded. The DO value recorded in the raw sewage was 8±0.12mg/l. It increased in all experimental ponds throughout the experiment. It reached a maximum value of 19.2±0.24mg/l in the control pond on day 15. The DO values recorded a significant positive correlation with pH, water temperature and all biological parameters and recorded a negative correlation with TDS, BOD and phosphate concentration.

The BOD value in the raw sewage recorded was 300±0.2mg/l. It decreased in all oxidation ponds throughout the experiment. The minimum BOD of 90±1.14mg/l was recorded in control stabilization pond on day 20. Pearson *et al.* (1987) reported that the bacteria present in the stabilization pond decompose the biodegradable organic matter and release CO_2, ammonia and nitrates. These are utilized by the algae together with sunlight and photosynthetic process releases oxygen enabling the bacteria to breakdown more organic waste and at the same time accomplish reduction in BOD levels. The percentage of BOD reduction on day 20 was

recorded as 70%, 50%, 40%, 30% and 12% respectively in control, 0.3%, 0.6%, 0.9% and 1.2% of monocrotophos treated oxidation ponds. Based on these values, 20 days EC_{50} value calculated as 0.3 % of monocrotophos. The BOD values were negatively correlated with all physico-chemical and biological parameters except with TDS and phosphate levels with which a significant positive correlation was observed.

The phosphate concentration in the raw sewage recorded was 5.8±0.04mg/l. It slightly reduced in all oxidation ponds throughout the experiment. The phosphate load in sewage is principally removed by precipitation as hydroxyapatite $[Ca_5(PO_4)_3OH]$ at alkaline pH values which are developed due to photosynthetic activity (Anonymous, 1973). Curtis and Mara (1994) further explained that part of the phosphate is removed during anabolic uptake by the green algae. The reduction of PO_4 was calculated on day 20 as 31%, 22.4%, 13.8%, 12.1% and 6.9% respectively in control, 0.3%, 0.6%, 0.9% and 1.2% of monocrotophos treatment. The phosphate values were negatively correlated with all physico-chemical and biological parameters except with TDS and BOD values with which a significant positive correlation was reported.

4.2 Biological parameters

The level of enzyme activities namely catalase, amylase, protease and phosphatase in the raw sewage was 0.833±0.04 units, 5.0±0.12 units, 2.0±0.12 units and 0.8±0.12 units respectively. All enzyme activities increased in all stabilization ponds but a slight reduction in activities in the pond treated with monocrotophos were recorded throughout the experiment. The enzyme activities recorded a significant positive correlation with pH, water temperature, DO and densities of bacteria, algae, and protozoa and recorded a significant negative correlation with TDS, BOD, and phosphate concentrations.

The density of bacteria recorded in the raw sewage was $10x10^6$ (±0.0) cfu/ml. It decreased to 10^3 cfu/ml in all stabilization ponds throughout the experiment. The percentage mortality of bacteria calculated on day 20 was16.7%, 26.7%, 33.3%, and 40.0% respectively in 0.3%, 0.6%, 0.9% and 1.2% monocrotophos treated oxidation ponds (Fig. l). The correlation matrix on density of bacteria revealed that it positively correlated with pH, water temperature, DO, and all biological parameters and negatively correlated with TDS, BOD, and phosphate levels.

The density of algae recorded in the raw sewage was 2± 0.0 individuals/ml which increased in all experimental ponds throughout the experiment. The percentage mortality of algae on day 20 was calculated. It was recorded as 21.5%, 37.5%, 50% and 62.5% respectively in 0.3%, 0.6%, 0.9% and 1.2% of monocrotophos treated ponds (Fig. 1). Based on these values, 20 days LC_{50} values calculated was 0.88% of monocrotophos. The impact of monocrotophos on 14 algal species was observed. Out of these, 6 belonged to Chlorophyceae, 5 belonged to Cyanophyceae, 2 belonged to Bacillariophyceae and one belonged to Euglenophyceae. *Oscillatoria brevis* and *Chlorella vulgaris* were dominant and the most tolerant species and *Cosmarium melanosporum* and *Euglena viridis* were recorded as a most sensitive species to monocrotophos treatment. Bhasker *et al.*, (1992) observed that a member of Cyanophyceae, *Nostoc muscorum* grew minimally with monocrotophos in rice soil even in the absence of inorganic phosphate in the medium. In the present study *Nostoc piscinale* showed little tolerance and recorded as dominant species in control and in the pond treated with 0.3% monocrotophos and subdominant species in ponds treated with 0.6%, 0.9% and 1.2% of monocrotophos. The algal density recorded a significant positive correlation with pH, water temperature, DO,

and all biological parameters and a negative correlation with TDS, BOD and phosphate levels.

The density of protozoa recorded was 1± 0.0 individuals/ml in the raw sewage. It increased in all stabilization ponds throughout the experiment. The percentage mortality of protozoa was calculated on day 20 compared to the control values. It was recorded as 20%, 25%, 45%, and 60% respectively in 0.3%, 0.6%, 0.9% and 1.2% of monocrotophos treated ponds. Based on these values, 20 days LC_{50} value was recorded as 0.99% of monocrotophos. The impact of monocrotophos on 7 species was studied. Out of these, 5 belonged to Ciliata, one belonged to Mastigophora and one belonged to Sarcodina. *Colpoda cucullus* was recorded as the dominant as well as tolerant species and *Stylonychia pastuluta* was recorded as most sensitive species to monocrotophos treatment. The protozoa density was positively correlated with pH, water temperature, DO and all biological parameters and negatively correlated with TDS, BOD, and phosphate levels.

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Table 1: The physico-chemial and biological characteristics of sewage samples in control and different concentration of monocrotophos treated oxidation pond samples on day 20 (Mean±SD).

Day	20				
Parameters	Control	0.3%	0.6%	0.9%	1.2%
pH	8.5±0.08	7.5 ±0.0	7.5 ±0.0	69 ±0.0	6.0 ±0.0
Water Temp.(°C)	25±0.41	25 ±0.0	24.5 ±0.0	24.5 ±0.0	24 ±0.0
TDS (mg/l)	850±1.63	860±1.63	863±1.63	867±1.63	890±1.63
DO (mg/l)	16±0.24	14 ±0.2	12 ±0.2	10 ±0.33	6 ±0.33
BOD (mg/l)	90±1.14	150±1.22	180±1.22	210±1.31	264±1.31
Phosphate(mg/l)	4.0 ±0.9	4.5 ±0.9	5.0 ±0.94	5.1 ±0.98	5.4 ±0.98
Catalase	20.83±1.88	20.0±1.71	18.33±1.55	16.67±1.63	15.83±1.88
Amylase	29±1.31	25 ±1.39	22 ±1.39	19.5±1.31	15 ±1.39

Protease	14.9±1.22	13.9±1.39	11.9±1.39	10.0±1.31	8.0 ±1.39
Phosphatase	7.9±0.12	7.9 ±0.16	6.9 ±0.16	6.5 ±0.16	6.0 ±0.16
Bacteria x 10^3 cfu/ml	30±0.82	25 ±1.63	22 ±1.63	20 ±1.63	18 ±1.63
Algae/ml	400±2.45	390 ±3.27	250±2.45	200±2.45	150±2.45
Protozoa/ml	200±1.63	160±1.63	150±1.63	110±0.82	80 ±0.82

Table 2: The correlation matrix for physico-chemical and biological parameters in control and different concentration of monocrotophos treated stabilization pond samples on day 20.

Parameters	pH	T	TDS	DO	BOD	PO_4	Catalase	Amyl.	Prot.	Phosph.	Bact.	Algae
T	+0.885	1.000										
TDS	-0.967	-0.927	1.000									
DO	+0.975	+0.963	-0.974	1.000								
BOD	-0.985	-0.986	+0.950	-0.985	1.000							
PO_4	-0.927	-0.919	+0.877	-0.941	+0.976	1.000						
Catalase	+0.930	+0.938	-0.887	+0.963	-0.967	-0.958	1.000					
Amylase	+0,979	+0.949	-0.953	+0.992	-0.998	-0.974	+0.977	1.000				
Protease	+0.950	+0.961	-0.932	+0.990	-0.976	-0.950	+0.993	+0.987	1.000			
Phosphatase	+0.882	+0.973	-0.876	+0.957	-0.937	-0.940	+0.984	+0.955	+0.983	1.000		
Bacteria	+0.947	+0.891	-0.878	+0.942	-0.983	-0.994	+0.962	+0.977	+0.950	+0.924	1.000	
Algae	+0.873	+0.961	-0.853	+0.945	-0.936	-0.953	+0.985	+0.952	+0,976	+0.997	+0.938	1.000
Protozoa	+0.987	+0.902	-0.939	+0.981	-0.989	-0.947	+0.973	+0.988	+0.979	+0.929	+0.966	+0.924

+ indicates positive correlation between two parameters; All values are significant at 5% level
- indicates negative correlation between two parameters

Fig. 1: Percentage mortality of bacteria, algae and protozoa in different concentration of monocrotophos.