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REMOVAL OF PESTICIDE MONOCROTOPHOS USING WETLAND PLANTS

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ABSTRACT
Pesticide contamination of the environment has several adverse effects on the ecosystem. Monocrotophos is one of the pesticides which is banned or severely restricted in Canada and the European Union, but it is still used in India. In the present study, the wetland plants, *Scirpus schoenoplectus and Cyperus rotundus* plant species were used to check their efficacy to remove monocrotophos from water. *Scirpus schoenoplectus*, *Cyperus rotundus* plants were treated with 0.8 ppm of monocrotophos for 15 days. It was found that *Cyperus rotundus and Scirpus schoenoplectus* were equally efficient plant for the treatment of water contaminated with the pesticide monocrotophos up to the concentration of 0.8 ppm. There was no adverse impact on the physical appearance of plants used.

KEYWORDS: Monocrotophos**,** Phytoremediation, *Scirpus schoenoplectus***,** *Cyperus rotundus.*

INTRODUCTION

Pesticide is defined as a substance used for destroying, preventing, repelling or mitigating any pest[1]. Pesticides consist of insecticides, herbicides, fungicides, virucides, and others. The use of pesticides in agriculture is increasing to improve crop production. Per hectare use of pesticide in India is the lowest, *i.e.* 0.6 Kg/ha among all the developed and most of the developing countries. As a consequence, the use of pesticide has caused contamination of soil and water components of the environment[2]. Moreover the exposure of humans to excess amount of pesticides can be harmful for the health. Insecticides impede the normal functioning of the nervous system. Organochlorine and organophosphates stimulate the nervous system[3]. There is destruction of nerve fibers due to chronic exposure to organophosphates. It also leads to muscle tissue damage (myopathy)[4]. Organochlorines accumulate in the adipose tissue. Physico-chemical methods used to treat pesticides are not efficient and effective. Pesticide residue remains in the soil-water environment and enter the food chain[5]. Hence, bioremediation techniques are required to degrade pesticides. Phytoremediation is approaches where plants are used remediate polluted soil and water. The Plants remove pollutants through selective uptake capabilities of their root systems and their ability to bioaccumulate and degrade the pollutants. The pesticide ethion was removed by using *Eichhornia crassipes*. It was found that the rate of disappearance of ethion was more in the planted non-sterile and sterile treatment as compared to the unplanted non-sterile and sterile treatment. Plant uptake and phytodegradation contributed towards 69% removal of ethion while microbial degradation contributed towards 12% removal of ethion[6]. Monocrotophos is an insecticide which belongs to the vinyl phosphate group. It has a systemic nature and used for the control of pests on crops such as rice, cotton, sugarcane etc. It is used to control insects which feed on plants through chewing, sucking and boring (aphids, jassids, mites, budworm, and stem borer)[7]. Monocrotophos has become an easily affordable pesticide as it is out of patent. It's low cost has resulted in its increased demand in India despite growing evidence of its adverse impact on health [8]. Monocrotophos is included in the PIC procedure because of its high toxicity which could cause problems under conditions of use in developing countries. Worldwide national authorities have banned or severely restricted the use of Monocrotophos (MCP) based on the risks to human health, and on the detrimental effects on birds, bees and aquatic organisms [9]. It is toxic to bees, birds, mammals and aquatic invertebrates. The acute lethal dose (oral) of monocrotophos (LD_{50}) is 21 mg/kg for rats[10,11]. It is highly toxic orally, as well by inhalation or absorption through the skin. Early symptoms of poisoning may include excessive sweating, headache, weakness, giddiness, nausea, vomiting, hypersalivation, abdominal cramps, diarrhoea, blurred vision and slurred speech. Inhalation or skin contact may increase the susceptibility to the pesticide without showing immediate symptoms [12]. According to World Health Organization, the fatal dose of monocrotophos is 120 mg to humans [13]. When inhaled, it affects the respiratory system in the form of discomfort in the chest and shortness of breath [14]. Thus the removal of Monocrotophos from environment becomes essential. Monocrotophos (MCP) is widely used in India to protect economically important crops. Its hydrolysis rates in soil and aqueous environment are pH dependent and half-lives are 131 and 26 days in pH 3 and 9 at 25 °C. MCP persists in soil in the dark for 30 days at neutral pH. When it is sprayed on crops, it may remain as soil residue and also enter water sources such as rainwater and ground water because of seepage through soils. The

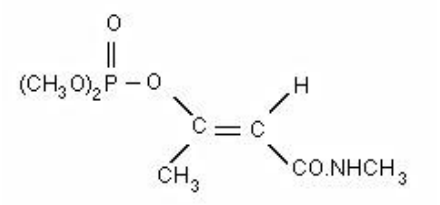
contamination of MCP in groundwater ranges from 0.2ppm to 1ppm [15]. Two cultures, namely *Arthrobacter atrocyaneus* MCM B-425 and *Bacillus megaterium* MCM B-423, were isolated by enrichment and adaptation culture technique from soil exposed to MCP. The isolates were able to degrade MCP to the extent of 93% and 83%, respectively, from synthetic medium containing MCP at the concentration of 1000 mg l−1, within 8 d, under shake culture condition at 30 °C. The cultures degraded MCP to carbon dioxide, ammonia and phosphates.[16] The poplar tree which is fast growing and deep-rooted, has been found to be useful in the remediation of groundwater. It requires large volumes of water, and hence, it absorbs contaminated groundwater. This technique has been used for the remediation of soil and groundwater contaminated with atrazine [17]. Hybrid poplars have been found to remove high levels of nitrate and atrazine from groundwater[18].

In this study an attempt has been made to remove Monocrotophos by using wetland plants found in natural wetland areas. These plants can be later used in an engineered wetland system for removal of pesticides in rural area. The detailed chemistry of the pesticide Monocrotophos has been shown in the Table 1.

TABLE 1: Chemistry of the pesticide Monocrotophos

Type of pesticide	Name	Persistence in (Half life)	Toxicity	Use on crop
Organophosphate Insecticide	Monocrotophos	Soil: 131 days Water:26 days in pH 3 and 9	Highly toxic Potential carcinogen Affects CNS	Cotton,rice and sugarcane, pulses

MATERIALS & METHODS



Monocrotophos, is an organophosphorus pesticide, IUPAC name dimethyl-1-methyl-2-methylcarba moyl) vinyl phosphate. Pure monocrotophos is colourless crystals, soluble in water, aliphatic alcohols and acetone. It has a mild ester odour [19][20][21].

Physico-chemical properties of Monocrotophos

IUPAC name Dimethyl (E)-1-methyl-2 -(methyl carbamoyl) vinyl phosphate

Physical state	crystals in pure form
Melting point	54-55°C
Vapour pressure	Pa at 20°C: 0.0003
Water solubility	g/100ml at 20°C: 100 (goo
Colour	colourless (pure form)
Odour	mild ester odour

Spectrophotometric determination of Monocrotophos

Preparation of calibration curve

A. Standard Monocrotophos (Sigma- aldrich): A stock solution (µg ml^{-1}) was prepared in ethanol. A working standard solution was prepared from it.
B. Sodium nitrite**:** 1% (m/v) sodium nitrate solution was prepared in 10% (v/v) hydrochloric acid.
C. Sodium hydroxide aqueous solution (1.0 mol^{-1}).
D. 2,4-Dinitrophenylhydrazene: (Sigma-Aldrich) 0.2% m/v solution of 2,4-dinitrophenylhydrazene is prepared by dissolving appropriate weight in 250 ml 1M HCl solution.

Procedure: - An aliquot of test solution containing 1.5 - 6.5 mg of monocrotophos was taken in a 25 ml volumetric flask, and then 1.0 ml of 1M Sodium hydroxide was added. The solution was kept in cool water (5-10ºC) for 30 min, then 1.0 ml of diazotized 2, 4-dinitrophenylhydrazene were added to each. The solution was kept 15min for full colour development. It turns to yellow coloured species. The solution was then diluted with distilled water and the absorbance was measured at 490 nm against a reagent blank

Determination of monocrotophos in water [22]

The water samples were extracted with 10 ml portion of chloroform extract and the chloroform extract was evaporated to dryness. Then the residue was dissolved in 10 ml of (1:10) acetic acid. Aliquots in 25ml volumetric flasks was coupled with 2ml 2, 4-DNP followed by addition of NaOH and analyzed at 490nm.

Acclimatization and Exposure of plants to monocrotophos

Three wetland plants *viz. Scirpus schoenoplectus and Cyperus rotundus* were selected for the study. Selected plant species were acclimatized for 30 days in modified Hoagland's solution [21]. Plants then treated with 0.8 ppm of monocrotophos for 15 days.Commercial grade pesticides was used for the treatment by taking equivalent amount of monocrotophos 3% GR insecticide. Amount of pesticide removed was estimated by spectroscopic method on alternate days. Plants were weighed before and after the treatment. Plants were weighed before and after the treatment. Most efficient plants for phytoremediation of the pesticides were estimated based on obtained results [22].

FIGURE 1: Acclimatization of Scripus and Cyperus

RESULTS & DISCUSSION

Acclimatization of plants:

Plants were kept in Hoagland's solution for 25days as shown in Fig 1

Effect of monocrotophos on the physical appearance of plants

Plants were weighed before and after the treatment. No adverse effects of monocrotophos was observed on the weight of any plant species, while there was an increase in the weight of *Scirpus schoenoplectus and Cyperus rotundus* when they were treated with 0.8mg/l monocrotophos. No adverse impact on the physical appearance was seen after the treatment with monocrotophos. Table 2 and table 3 summarize weights of plants before and after the treatment. Fig.2 shows *Cyperus rotundus* before and after pesticide treatment.

TABLE 2: Changes in weight after treatment with monocrotophos *Cyperus rotundus*

Treatment of *Cyperus rotundus*	Initial weight in grams	Final weight in grams	Increase in weight (g)	P-value
Control-no MCP	19.6	22.96	3.36	0.19
0.8mg/l of MCP	31.6	38.44	6.78	

TABLE 3: Changes in weight after treatment with monocrotophos *Scirpus schoenoplectus*

Treatment of *Scirpus schoenoplectus*	Initial weight in grams	Final weight in grams	Increase in weight (g)	p-value
Control- no MCP	27	35.86	8.86	0.21
0.8 mg/l of MCP	25	39.25	14.25	

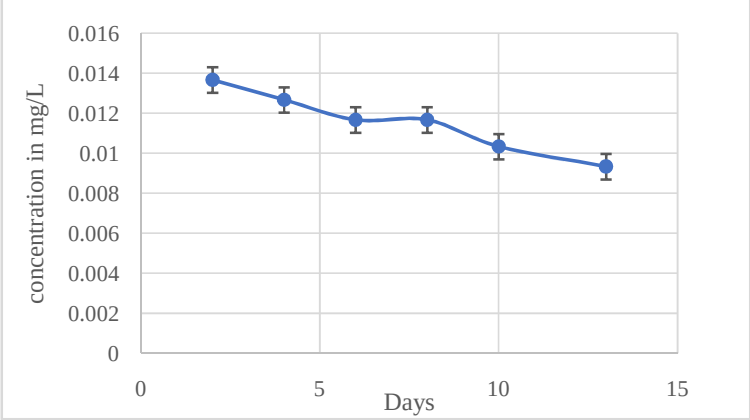


FIGURE 2: Removal of monocrotophos by per gram of *Cyperus rotundus*

Removal of monocrotophos *Cyperus rotundus* (per gram of plant weight basis)

Cyperus rotundus plants were treated with 0.8mg/l of monocrotophos commercial grade pesticide for 15 days. Removal of monocrotophos by per gram of the plant was calculated. Removal of monocrotophos by per gram of Cyperus rotundus is shown in the Fig 2.

On an average, removal of monocrotophos by *Cyperus rotundus* per gram of plant weight in 15 days was found to be 0.073 ± 0.01mg/l when treated 0.8mg/l of

monocrotophos. Constant rate of removal was observed further. Highest removal of monocrotophos was observed on second day ie. 0.014mg/l per gram of plant weight when treated with 0.8mg/l of monocrotophos.

Total removal of monocrotophos by *Cyperus rotundus* in 15 days (0.8mg/l)

Cyperus rotundus plants were treated with 0.8mg/l of monocrotophos commercial grade pesticide for 15 days. Total removal of monocrotophos by *Cyperus rotundus* was calculated for 15 days and is shown in Fig 3.

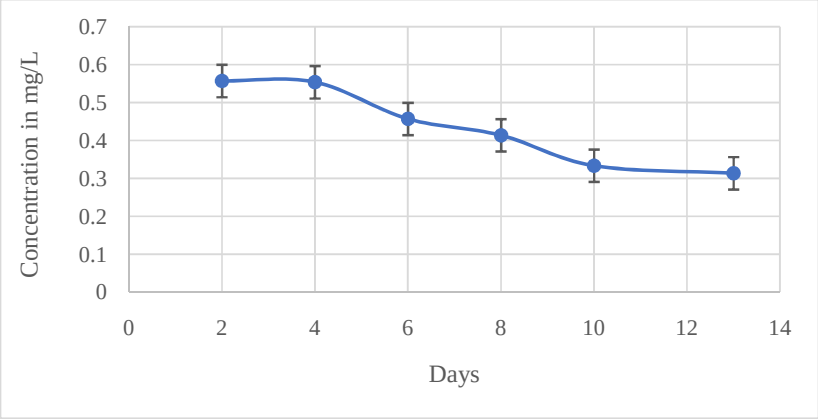


FIGURE 3: Total removal of monocrotophos in 14 days by *Cyperus rotundus* (0.8mg/L)

The total removal of monocrotophos in 15 days by *Cyperus rotundus* when treated with 0.8mg/l was found to be 2.5 mg/l. Maximum removal of monocrotophos was observed on the second day with a removal of 0.44 mg/l when treated with 0.8mg/l of monocrotophos.

Removal of monocrotophos by *Scirpus schoenoplectus* (per gram of plant weight basis)

Scirpus schoenoplectus plants were treated with 0.8 mg/l of monocrotophos commercial grade pesticide for 15 days. Removal of monocrotophos by per gram of the plant was calculated and is shown in Fig 4.

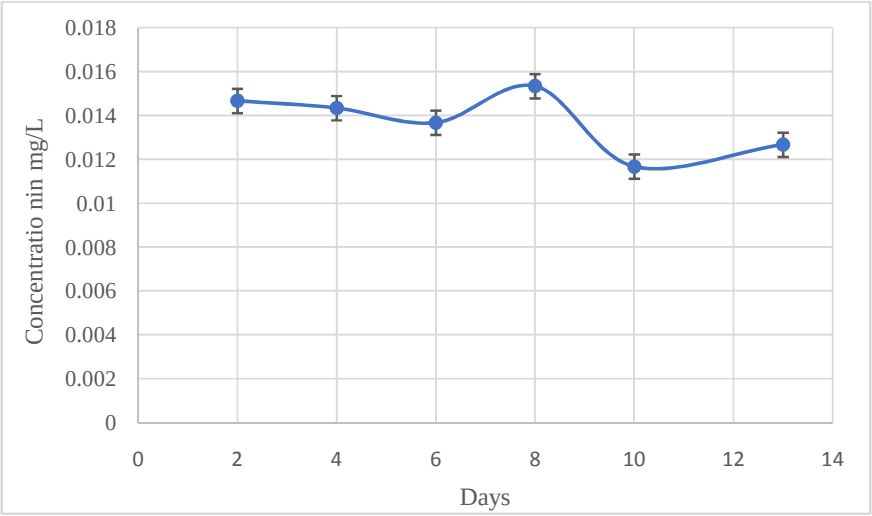


FIGURE 4: Removal of monocrotophos by per gram of *Scirpus schoenoplectus*

On an average, removal of monocrotophos by *Scirpus schoenoplectus* per gram of plant weight was found to 0.083 ± 0.01mg/l when treated with 0.8 mg/l of monocrotophos. Highest removal of monocrotophos was observed on second day *i.e.* 0.015 mg/l per gram of plant weight when treated with 0.8 mg/l of monocrotophos.

Total removal of monocrotophos by *Scirpus schoenoplectus* in 15 days (0.8mg/l)

Scirpus schoenoplectus plants were treated with 0.8 mg/l of monocrotophos commercial grade pesticide for 15 days. Total removal of monocrotophos by *Scirpus schoenoplectus* was calculated for 15 days an3d is shown in Fig 5.

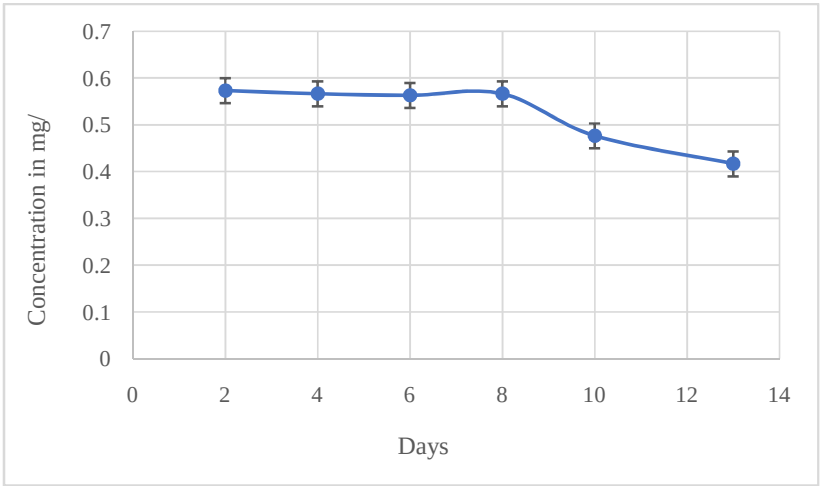


FIGURE 5: Total removal of monocrotophos in 14 days by *Scripus schenoplectus* (0.8mg/l)

The total removal of monocrotophos in 15 days by *Scirpus schoenoplectus* when treated with 0.8mg/l was found to be 2.6 mg/l. Maximum removal of monocrotophos was observed on the second day with a removal of 0.38 mg/l when treated with 0.8mg/l of monocrotophos.

Removal of monocrotophos from Hydroponic solution containing 0.8 mg/l of monocrotophos (per gram of plant weight basis)

The comparison between removal of monocrotophos by Scirpus schoenoplectus and Cyperus rotundus was compared and is shown in Fig 6. From the results it can be seen that both the plants are equally efficient in removal of Monocrotophos.

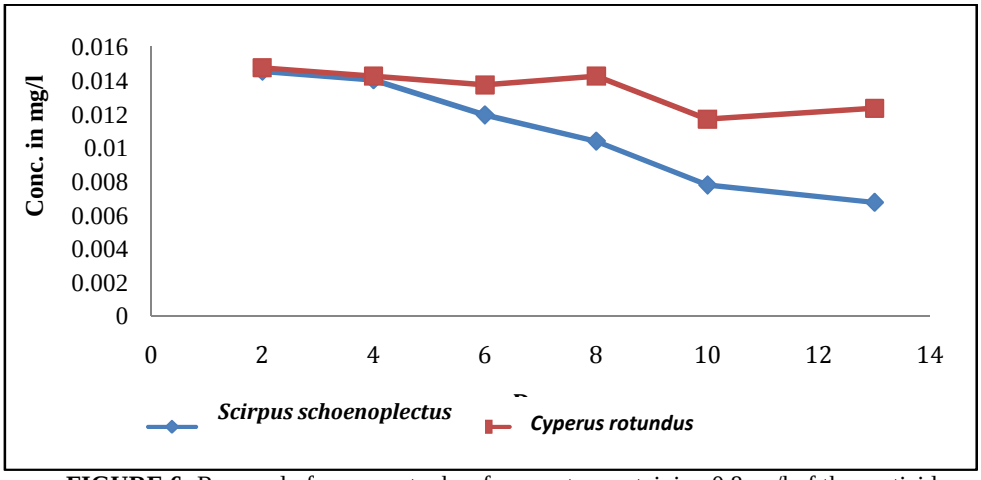


FIGURE 6: Removal of monocrotophos from water containing 0.8mg/l of the pesticide

CONCLUSION

Monocrotophos up to 0.8 ppm has no adverse impact on the physical appearance of plants, *Cyperus rotundus and Scirpus schoenoplectus* were equally effective in the removal of monocrotophos.

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