Effect of pesticides on soil characteristics in selected paddy cultivated areas of Kanniyakumari District

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Abstract- The study was designed to investigate the effect of pesticides on the soil physico-chemical characteristics in the selected paddy cultivated areas of Kanniyakumari district. Soil samples were collected seven days before and after the application of pesticides like carbofuran, chlorantraniliprole and profenofos from the flooded paddy field after cropping. The physico-chemical properties were determined by following standard methods and the results were tabulated. The results obtained in the present study are discussed in terms of changes in the soil physical and chemical characteristics. The experimental results showed that the characteristics like soil pH and Electrical conductivity differed significantly after pesticide application against the respective control. Likewise the organic carbon,available phosphorus, potash, boron, Magnesium, iron, manganese, zinc and copper show marked increased or decreased in its level in the pesticide applied soil samples to that of the respective control.

Keywords- Pesticides, paddy field, soil, physico-chemical characteristics

I. INTRODUCTION

Soil is a fundamental resource base for agricultural production systems. Besides being the main medium for plant growth, soil functions to sustain plant productivity, maintain environmental quality, and provide nutrition for plants, animals and human health. Soil is the natural habitat of microorganisms particularly Actinomycetes, bacteria and fungi. These microorganisms play an essential role in maintaining the ecological balance of the soil (Kalyanee Sharma and Hemen Sharma, 2011). Soil contamination or soil pollution is caused by the presence of man-made chemicals or other alterations in the natural soil environment. Agricultural chemicals, industrial activity or improper disposal of wastes typically causes it.

Pesticides in recent years are widely used in modern agriculture to control various insect pest populations and with the growing use of these pesticides in agricultural soils, there may be an interaction with soil organisms and their metabolic activities (Baxter and Cummings, 2008).

The presence and bio-availability of pesticides in soil can adversely impact human and animal health, and beneficial plants and soil organisms. These are detrimental to living organisms in the soil, vital to soil health and productivity.

Pesticides in soil undergo a variety of degradative, transport, and adsorption / desorption processes depending on the chemical nature of the pesticide and soil properties. Pesticides are applied to protect crops from pests and diseases only around 15% 0f the preparation hits the target. The rest is distributed in the soil and air. Pesticides interact with soil organisms and their metabolic activities and may alter the physiological and biochemical behaviour of soil microbes (Maleeka Begum and Rajesh, 2005). Carbofuran (CAS 1563-66-2) is a most toxic carbamate pesticide. It is marketed under the trade name furadan. It is used to control insects in a wide variety of field crops. Chlorantraniliprole (CAS 500008-45-7) is a synthetic, ryanoid insecticide. Chlorantraniliprole have been widely applied in rice field against rice borers. Profenofos (CAS 41198-08-7) is an organophosphate insecticide. It can be used on a variety of crops including cotton and vegetables such as rice, potato and soya bean.

The presence of organic matter may alter the behaviour of pesticides in soils. The addition of organic materials to flooded soils enhanced the bacterial degradation of some organochlorine insecticides such as BHC, DDT, methoxychlor and heptachlor (Yoshida, 1978). The changes in the level of macro and micro nutrients pesticide applied soil might be due to the chelation ability of these pesticides (allowing them to accumulate in this form in soils) where they form complexes with these metal co – factors essential for enzyme activities thus immobilizing them in soil reducing their availability to plants. While some compounds chelate with a single or few metal species, glyophosate is abroad spectrum chelator with macro and micro nutrients. It is this strong, broad spectrum chelating ability that also makes the pesticides, a potent antimicrobial agent since the function of numerous essential enzymes is affected (Ganson and Jensen, 1988). So the present study was designed to investigate the effect of pesticides on soil characteristics in selected paddy collected areas of Kanniyakumari District.

II. MATERIALS AND METHODS

Sample collection

The soil samples were collected from the experimental field of two paddy cultivated spots of Kanniyakumari District, viz., Aandarkulam in Agasteeswaram Block (Sample – 1), Parakkai in Rajakkamangalam Block (Sample – 2). The soil samples were collected seven days before (control) and seven days after (experimental) application of pesticide from the flooded paddy field. Two representative soil samples were collected from the above mentioned areas from the upper 10 cm of the soil profile with an amount of 1Kg per sample. A set of soil sample before pesticide application as control was also collected from the study area. The collected soil samples were packed in sterile polythene bag and labelled for the study of physicochemical characteristics.

Physicochemical properties of soil

The physico chemical properties viz., soil pH, electrical conductivity, organic carbon, available phosphorus, available potash, available boron, available sulphur, available calcium, available magnesium, available iron, available manganese, available zinc and available copper were determined by the following methods.

pH

Calibrate the pH meter using buffer solutions. The pH of soil is determined in 1:2.5 soil water suspensions. Take 10 gm sample of soil sifted through 2 mm sieve in a 50 or 100 ml beaker. Add 25 ml of distilled water, stir well for about 5 minutes and keep for half an hour. Stir well again and take the reading using the pH meter.

Electrical conductivity

The clear supernatant of 1:2.5 soil water suspension prepared for pH measurement can be used for estimation of EC. Calibrate the conductivity meter using KCl solution prepared and determine the cell constant. Determine the conductivity of the supernatant liquid.

Organic carbon

Grind the soil to pass through a 0.5 mm sieve avoiding iron or steel mortars. Transfer a weighed sample, containing 10-25 mg of organic carbon (approximately 0.5 to 1 gm of soil), but not in excess of 10 gm soil, into a 500 ml wide mouth conical flask. Add 10 ml of 1N K2Cr2O7 and

swirl the flask gently to disperse the soil in the solution. Then rapidly add 20 ml of concentrated H2SO4. Immediately swirl the flask gently until the soil and the reagents are mixed, then more vigorously for a total of one minute. Allow the flask to stand on an asbestos sheet for about 30 minutes. Then add 200 ml of water to the flask. Add 3-4 drops of o-phenanthroline indicator and titrate the solution with 0.5N ferrous ammonium sulphate.

As the end point approaches, the solution takes on a greenish cast and then changes to a dark green colour. At this point add the ferrous ammonium sulphate drop by drop until the colour changes sharply for blue to red. Make a blank determination in the same manner, but without soil, to standardize the Cr2O72-.

Calculation

$$\text{Organic carbon (\%)} = \frac{(\text{meq } K_2Cr_2O_7 - \text{meq } F(NH) SO) \times 0.003 \times 100 \times 1.3}{\text{gm water free soil}}$$

$$\text{O C (\%)} = \frac{\{10 \times 1 - \text{Titre value(ml)} \times \text{Normality of Fe(NH}_4)_2SO_4\} \times 0.003 \times 100 \times 1.3}{\text{gm water free soil}}$$

$$\text{O C (\%)} = \frac{\{10 \times 1 - \text{Titre value(ml)} \times \text{Normality of Fe(NH}_4)_2SO_4\} \times 0.39}{\text{gm water free soil}}$$

Phosphorus

Weigh out 5 gm of soil to a 100 ml conical flask and add 50ml of Bray No.1 reagent and shake for exactly 5 minutes. Filter through Whatman No.42 filter paper. To avoid interference of fluoride. 7.5 ml of 0.8 M boric acid (50 gm of H3BO3 per litre) can be added 5 ml of the extract if necessary. Calculation

$$\text{Available k (mg kg}^{-1}\text{ soil)} = \mu g\ K\ ml^{-1}\text{ of the aliquot} \times \frac{25}{5}$$

$$\text{Available k (mg kg}^{-1}\text{ soil)} = \mu g\ K\ ml^{-1}\text{ of the aliquot} \times 5$$

$$\text{Available k (kg ha}^{-1}\text{ soil)} = \text{Available K (mg kg}^{-1}\text{ soil)} \times 2.24$$

Boron

Weigh 20 gm of air dried processed soil in a 250 ml quartz or other boron free conical flask and add 40 ml of distilled water. Add 0.5 gm of activated charcoal and boil for 5 minutes on a hot plate, filter immediately through Whatman No.42 filter paper. Cool the contents to room temperature and transfer 1 ml aliquot of blank, diluted boron standard, or sample solution into a 1o ml polypropylene tubes. Add 2 ml of buffer and mix. Add 2 ml of azomethine – H reagent, mix, and after 30 minutes, read the absorbance at 420 nm on a spectrophotometer. Prepare a standard curve plotting B concentrations (0 to 10 µg B ml-1) on X axis and absorbance on y axis.

Calculation

$$\text{Amount of B in sol (mg kg}^{-1}\text{ soil)} = \frac{\text{Absorbance reading 40}}{\text{Slope from curve}} \times 20$$

$$\text{Amount of B in sol (mg kg}^{-1}\text{ soil)} = \frac{\text{Absorbance reading}}{\text{Slope from curve}} \times 2$$

Sulphur

Shake 10 gm of air dried processed soil with 50 ml of 0.15% CaCl2 solution in a 250 ml conical flask for 30 minutes. Filter the extract through Whatman No.42 filter paper and estimate the sulphate content by turbidimetric procedure.

Pipette out 10 ml of the soil extract into a 25 ml volumetric flask.Add 1 gm of BaCl2 crystals and swirl to dissolve.Add 1 ml of 0.25 % gum acacia solution, make up the volume with distilled water and shake well.Within 5 to 30 minutes of development of turbidity, read the absorbance at 440 nm on a spectrophotometer.

Calculation

$$\text{Amount of sulphur (mg kg}^{-1}\text{ soil)} = \text{concentration from the instrument} \times \frac{25}{10} \times \frac{50}{10}$$

$$\text{Amount of sulphur (mg kg}^{-1}\text{ soil)} = \frac{\text{Absorbance for the sample}}{\text{slope of Std. curve}} \times 12.5$$

Calcium and Magnesium

Shake 5 gm of soil with 25 ml of neutral normal ammonium acetate for 5 minutes and filter immediately through a dry Whatman No.42 filter paper. First few ml of the

filtrate may be discarded. From the soil extract Ca and Mg can be estimated by atomic Absorption Spectrophotometry (AAS). The chemical interference, resulting from the formation of stable compounds between Ca and Mg ions and the accompanying anions may reduce the absorption. This interference may be overcome by using a realising agent such as Lanthanum or Strontium.

Calculation

$$\text{Available Ca/Mg (mg kg}^{-1}\text{ soil)} = \mu\text{g Ca/Mg ml}^{-1}\text{ of the aliquot} \times \frac{25}{5}$$

$$\text{Available Ca/Mg (mg kg}^{-1}\text{ soil)} = \mu\text{g Ca/Mg ml}^{-1}\text{ of the aliquot} \times \frac{5}{5}$$

Fe, Mn, Zn and Cu in acid soils (ph<6.5)

Shake 2 gm of soil with 20 ml of 0.1M HCl for 5 minutes. Filter through Whatman No.42 filter paper. Collect the filtrate and estimate the contents of Fe, Mn, Zn and Cu using an Atomic Absorption Spectrophotometer.

Calculation

$$\text{Amount of micronutrient (mg}^{-1}\text{ Kg soil)} = \frac{\text{Concentration from the instrument} \times 20}{2}$$

$$\text{Amount of micronutrient (mg}^{-1}\text{ Kg soil)} = \text{Concentration from the instrument} \times 1$$

III. RESULT AND DISCUSSION

Soil pH is a measure of hydrogen ion activity of the soil water system and indicates whether the soil is acidic, neutral or alkaline in reaction. The changes in the pH of the study site are represented in Table 1 & 2. The soil pH differed significantly after pesticide application. The soil pH recorded was 4.6 in S1 and S2 after carbofuran application and found strongly acidic and the value was lesser to that of the respective control (5.3 and 5.7). Soil pH may affect pesticide adsorption, abiotic and biotic degradation processes (Burns, 1975). It influences the sorptive behaviour of pesticide molecules on clay and organic surfaces and thus, the chemical speciation, mobility and bioavailability (Hicks et al., 1990). For instance, the sorption of prometryn to claymontmorillonite is more at pH 3 than pH 7 (Topp et al., 1997).

Table : 1 Physico chemical characteristics of soil sample S1 and S2

Sl No	Parameter	Before pesticide application (Control) S1		Before pesticide application (Control) S2		After pesticide application (Experimental) S1		After pesticide application (Experimental) S2	
		Reading	Rating	Reading	Rating	Reading	Rating	Reading	Rating
1	pH	5.3	Strong acid	5.7	Strong acid	4.6	Very strong acid	4.6	Very strong acid
2	EC dSm-1	0.27	Normal	0.29	Normal	0.12	Normal	0.25	Normal
3	Organic Carbon (%)	2.7	High	2.91	High	2.2	High	2.87	High
4	Available Phosphorus (Kg/ha)	23.52	Medium	20.03	Medium	25.93	High	9.9	Low
5	Available Potash (Kg/ha)	297	Medium	231	Medium	176	Medium	209	Medium
6	Available Boron (ppm)	0.11	Deficiency	0.15	Deficiency	0.04	Deficiency	0.09	Deficiency
7	Available Sulphur (ppm)	9	Sufficiency	17	Sufficiency	8	Sufficiency	11	Sufficiency
8	Available Calcium (ppm)	670	Sufficiency	430	Sufficiency	590	Sufficiency	310	Sufficiency
9	Available Magnesium (ppm)	417	Sufficiency	241	Sufficiency	306	Sufficiency	234	Sufficiency
10	Available Iron (ppm)	21.8	Sufficiency	18.12	Sufficiency	17.9	Sufficiency	16.03	Sufficiency
11	Available Manganese (ppm)	3.9	Sufficiency	5	Sufficiency	2.7	Sufficiency	3	Sufficiency
12	Available Zinc (ppm)	0.9	Deficiency	3	Deficiency	1.2	Sufficiency	2	Sufficiency
13	Available Copper (ppm)	1.2	Sufficiency	1.3	deficiency	1	Sufficiency	0.9	Sufficiency

Table: 2. Comparitive analysis of the physico chemical characteristics of pesticides applied soil of S1 and S2

Sl. No	Parameter	S_1	S_2
1	pH	4.6	4.6
2	Ec (dsm-1)	0.12	0.25
3	Organic carbon (%)	2.2	2.87
4	Available phosphorus (Kg/ha)	25.9	9.9
5	Available potash (Kg/ha)	176	209
6	Available boron (ppm)	0.04	0.09
7	Available sulphur (ppm)	8	11
8	Available calcium (ppm)	590	310
9	Available magnesium (ppm)	306	234
10	Available iron (ppm)	17.9	16
11	Available manganese (ppm)	2.7	3
12	Available zinc (ppm)	1.2	2
13	Available copper (ppm)	1	0.9

Soil electrical conductivity is a measure that correlates with soil properties that affect crop productivity including soil texture, cation exchange capacity. The electrical conductivity of the soil sample ranges from 0.12 dsm-1 (S1) to 0.25   dsm-1(S2). The electrical conductivity of the soil was minimum after pesticide application (Table 1& 2).

Soil organic carbon has been defined as organic fraction of soil including plants, animals and microbial residues, fresh and all of all stages of decomposition, and the relatively resistant soil humus. Organic carbon was found higher before pesticide application in Sample 1 and 2. The soil organic carbon after pesticide application ranged from 2.2% to 2.87% in S1 and S2. The total organic carbon in the soil depends on the amount of natural and commercial fertilizers present in the soil. Moreover, it can cause severe water stress and nutritional imbalances in plants. Generally, seedlings are more sensitive than established plants to elevated total organic carbon (Raman and Sathiyanarayanan, 2009).

Phosphorus is an essential element classified as a macronutrient, because of relatively large amount of phosphorus is required by plants. The soil available phosphorus in the control content ranged from 20.03 kg/ha to 24.08 Kg/ha where as in the case of experimental samples, the value recorded ranged from 9.9 Kg/ha (S2) to 25.93 Kg/ha (S1). In potash differed significantly after pesticide application and ranged from 209 Kg/hato 308 Kg/ha. The result shows a decreasing trend in the available potash after pesticide application in the two stations (S1& S2,).

The available boron was found deficient in all the four samples before and after pesticide application. Whereas, the amount of sulphur, calcium, magnesium, iron and manganese are available in sufficient quantities in both the control and experimental soil samples.

The available boron was found deficient in both samples before and after pesticide application. Whereas, the amount of sulphur, calcium, magnesium, iron and manganese are available in sufficient quantities in both the control and experimental soil samples

REFERENCES

[1] Baxter, J. and Cummings, S.P. (2008).The degradation of the herbicide bromoxynil and its impact on bacterial diversity in a top soil. Journal of Applied Microbiology 104, 1605-1616.

[2] Burns, R.G. and Edwards, J.A. (1980). Pesticide breakdown by soil enzymes. Pest. Sci., 11: 506-512

[3] Ganson, R and Jensen, M. (1988). The effect of some insecticides on the number of amylolytic microorganism

and Azotobactersin apple nursery soil. Jug. Voc., 31(2): 177-184.

[4] Hicks, R.J., Stotzky, G. and Voris, P.V. (1990). Review and evaluation of the effects of xenobiotic chemicals on microorganisms in soil, applied microbial., 35: 195-253.

[5] Kalyanee Sharma Bhagabati and Hemen Sarma (2011)Differential effects of pesticides on soil microflora in cultivated soil of Indian rice field agro ecosystems. Journal of applied and natural science 3: 277-279.

[6] Maleeka Begum, S.F. and Rajesh, G. (2015). Impact of microbial diversity and soil enzymatic activity in Dimetoate Amended Soil series of Tamilnadu. Intrnational journal of science, environment and Technology, Vo,4, 1089-1097.

[7] Raman N. And Sathiyanarayanan. (2009). Physico chemical characteristics of soil and influence of cation exchange capacity of soil in an around Chennai. Pollut. J. Environ. 11(3): 193-198.

[8] Topp, E., Vallaeys, T. and Soulas, G. (1997). Pesticides Microbial Degradation and effects on microorganisms. In: Modern soil Microbiology. Pp: 547-575.

[9] Yoshida, T. (1978). Microbial metabolism in rice soil. International Rice Research Institute, Philippines, pp: 445-463.