

Ecotoxicological Effects of Pesticides on Soil and Soil Macrofauna

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ABSTRACT

*Soil is one of the largest ecosystems supporting both biotic and abiotic components living on it. Use of agrochemicals such as pesticides and fertilizers in agriculture rather than traditional practices leads to deterioration of soil and biodiversity. In the present work, comparative analysis of various soil properties as well as of macro-invertebrate community was done at three different study sites (Pasture, Pesticide non-treated and pesticide-treated site). The findings indicate some significant decrease in density and biomass of macro invertebrate community, and changes in physico-chemical parameters in the pesticide-treated field as compare to the other two sites. **Summary-**Application of pesticides has detrimental effect on physico-chemical as well as the faunal communities found in the soil. Dominance index increases where as diversity index decreases in pesticide applied plots as compared to pasture.*

Keywords: Pesticide, physicochemical parameters, Ecological indices.

INTRODUCTION

About 30% of the food grown in the world is lost annually because of the effects of weeds, pests, and diseases (IAEA, 1987) and for its remedy pesticide has been occupied a special place in our agriculture. But the indiscriminate and extensive use of agrochemicals posing detrimental influences on the exposed flora and fauna with inhibition of the growth of microorganisms (Kalia *et. al.*, 2010). More than 60-70% of population of India is dependent on agriculture, which covers the maximum portion of its economy (Sachdeva, 2007). For full filling the high demand of food stuff there is abundant use of the chemicals which ultimately get deposit in the soil causing detrimental effect on soil fauna. Simultaneous inoculation of different pesticides causes 99% decrease of biodiversity than individual pesticides (Relyea, 2005; Faria *et. al.* 2007). The main objective of the present study was to observe the alteration in the soil physicochemical parameters with the community analysis of macroinvertebrates present in three different fields like Pasture (PAS), Pesticide non-treated crop field (PNTC) and Pesticide treated crop field (PTC) in Bargarh district (Latitude 21.333°N and Longitude 83.616°E) of Odisha, India was taken for study.

MATERIAL AND METHOD

First of all three different study sites such as Pasture, Pesticide non-treated rice crop field and Pesticide treated rice crop field were chosen and 10×10 m² area was selected from each plot for soil sampling. In a randomised manner ten replicates each of 25×25 cm² areas was taken from each individual study site. From each area sub samples of soil were taken from 10cm up to depth 30cm in the month of September. It was to

be aware that during the time of farming one of the rice crop fields was treated with organic manure, fertilizers with as usual pesticides where as the other was without pesticide. Macro-invertebrates captured from each sub sample were put into labelled polythene containing 5% formalin (Anderson and Ingram, 1989) and also categorized into different groups. After that physicochemical analysis of each subsample amounted 500gm air-dried soil sieved with 2mm sieve was undertaken with standard methods.

Physicochemical analysis of Soil samples

Standard methods were followed for physicochemical test of various soil parameters. pH and Water holding capacity were determined by Anderson and Ingram method (1989), Organic carbon was assessed with Walkley and Black method (1934), Calcium and Magnesium content were determined by Digital flame photometry method. Electrical conductivity by Rhoades (1982), available phosphorus content by Anderson and Ingram, (1989) method, and Potassium availability were determined by Digital flame photometry method.

Comparative analysis of Macro invertebrate community

Ecological indices like Diversity index (Shannon and Weaver, 1963), Dominance index (Simpson, 1949) and Evenness index (Margalef, 1975) of macroinvertebrate were found out and observed for further analysis..

RESULTS

Physic-chemical Soil parameters

Noticeable fluctuation in the values of soil parameters was observed by the experiment as given in the Table-1. The study showed 1.26%, 23.87%, 8.57%, 0.55%, 5.03% and 0.70%, 9.31%,

7.25%, 1.22%, 0.92% decrease in soil physicochemical parameters such as pH, water holding capacity, organic carbon, calcium, and magnesium whereas increase in soil electrical conductivity, available phosphorus and potassium

content showed 7.25%, 2.64%, 56.16% and 4.23%, 93.41%, 49.57% pesticide-treated the field with respect to pasture and pesticide non-treated crop field respectfully.

Table-1. Physicochemical parameters of soil (0-30cm) in different soil types

Sl. No.	Soil Parameter	Pasture Site (PST)	Pesticide Non-Treated Site (PNTC)	Pesticide Treated Site (PTC)
1	pH	7.16± 0.22	7.12± 0.19	7.07± 0.22
2	Water holding capacity(WHC) in %	4.86± 0.3	4.08± 0.32	3.7± 0.34
3	Organic Carbon (OC) in g%	0.7± 0.03	0.69± 0.06	0.64± 0.1
4	Magnesium (Available as MgO) in ppm	330.2± 28.42	316.5± 19.35	313.6± 23.73
5	Electrical Conductivity (EC) in mmho cm ⁻¹	0.69± 0.09	0.71± 0.14	0.74± 0.13
6	Phosphorus (Available as P ₂ O ₅) in ppm	9.6± 4.12	18.05± 4.27	34.91± 6.4
7	Potassium (Available as K ₂ O) in ppm	126.43± 3.57	132± 9.68	197.43± 20.99
8	Calcium (Available as CaO) in ppm	602.1± 12.69	606.17± 8.69	598.8± 11.18

*Values indicate Mean ± SD

Also, Two Way ANOVA for different soil parameters like water holding capacity, organic carbon, magnesium, phosphorous, potassium, and calcium gave information about significant variation between the study sites especially with respect to pesticide-treated site.

Biological community analysis

The Table 2 depicts the percentage of density and biomass of annelids and arthropods. The population density of annelids and arthropods was figured as 7.17%, 6.46%, 5.49%, and 92.83%, 93.54%, 94.51% respectively in the pasture field, in pesticide non-treated field and pesticide-treated crop field. Similarly there was increase in arthropod biomass but decrease in annelid biomass when pasture is compared with pesticide non treated and treated crop fields.

Table-2. Percentage of Density and Biomass of macro-invertebrate community in pasture (PAS), pesticide non-treated and pesticide treated field.

Sl. No.	Macro invertebrate community	Pasture field (PAS)		Pesticide non-treated field (PNTC)		Pesticide treated field (PTC)	
		Density %	Biomass%	Density %	Biomass%	Density%	Biomass%
1	Annelida	7.17	33.13	6.46	31.87	5.49	25.36
2	Arthropoda	92.83	66.87	93.54	68.13	94.51	74.64

Use of pesticides showed significant decrease in density and biomass of the macroinvertebrates in different fields and also among the organisms of the observed sites (Two Way ANOVA at <0.05 level of Significance)). The ecological indices were influenced by the agrochemicals. The Simpsons index was found to be 0.173, 0.181 and 0.194 in the pasture, nontreated cropfield and pesticide field, respectively. But Shannon Diversity index and Magalef's evenness index were found to be lowest in pesticide treated crop field and highest in pasture (Table-3)

Table-3. Ecological Indices of Macro invertebrate community in different Fields (0-30cm soil depth) Considering Density (No./m²).

Sl. No.	INDEX	Pasture field (PAS)	Pesticide non-treated field (PNT)	Pesticide treated field (PST)
1	Simpson's Dominance (D)	0.173	0.181	0.194
2	Shannon Diversity (H)	0.459	0.375	0.283
3	Margelef Evenness (J)	0.121	0.099	0.075

DISCUSSION

Soil Physicochemical parameters

Water holding capacity is dependent on the SOM of soil (Lal,1986) informed that. The present investigation has been found decrease in soil water holding capacity and other soil parameters like pH,

Organic Carbon, magnesium etc. This may be due to the resilience in the soil enzymes helping in C (β-glucosidase and β-galactosidase), N (urease), P (phosphatase), and S (sulphates) cycle (Karaca *et al.* 2011). The contribution of macro invertebrates

and soil microbial biomass carbon towards the physicochemical parameters is significant (Sethi *et al.* 2013). Increase in Phosphorous and Potassium content and deficiency of nitrogen is possible by the annexation of fertilizers in the fields over a long period. And for calcium content, it is higher in pesticide non-treated crop field.

Macro invertebrate Community analysis

According to the World Health Organization data, only 23% of pesticides affect target organisms whereas rest causes surface runoff, leaching, and percolation into soil water environment creating depletion in biodiversity. Soil macro fauna such as the earthworm, termites, and litter-dwelling arthropods play a crucial role in regulating infiltration, immobilization of nutrients, water and maintaining soil properties (Lavelle *et al.*, 1992) but these are negatively sensitive towards the chemicals used to it (Hammad *et al.* 2012). In this study, annelid groups got diminished in their number in the pesticide non-treated as well as in pesticide-treated field over pasture field which may be due to effect of pesticides on their metabolism. The ecological study revealed that Simpson's Dominance index increased in the biocommunity of pasture to pesticide non-treated and pesticide-treated crop field accordingly unlike Shannon's diversity index and Margalef evenness index. All these variations are due to detrimental effect of pesticides (Ribera *et al.* 2001).

In the pesticide-treated site, the high incorporation of pesticides have deleterious effects on soil organisms and depletion of these relates to the lowering of neutralization capacity of soil organic matter (SOM).

CONCLUSION

This ecotoxicological assessment on pesticide's impacts on soil informed that soil fauna act as bio indicators reflecting the soil health, and it may help to determine the proper amount of pesticides to be applied in crop fields. Alternate approaches like Integrated Pest Management System, Non-Pesticide Management System, Community Managed Sustainable Agriculture, Organic farming practices should be followed (Ponraman *et al.* 2016).

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