RESEARCH PAPER | Environmental Science | Volume : 5 | Issue : 1 | Jan 2015 | ISSN - 2249-555X

IMPACT OF PESTICIDES ON SOIL MICROBIAL BIOMASS

KEYWORDS: Pesticides, herbicides, microbial biomass, soil respiration

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ABSTRACT *To find out the effect of regular pesticides used in tea gardens, the pesticides were applied in forest ecosystem. A reduction of 39.5% microbial biomass occurred in pesticide applied plots along with 25% increase in soil respiration.*

Introduction:

Soil organisms belong to varied taxonomic groups constituting of flora and fauna. Soil flora include roots of higher plants, algae, fungi, actinomycetes and bacteria and soil fauna constitute groups belonging to various taxonomic groups. They belong to various phyla like Protozoa, Rotifera, Tardigrada, Nematoda, Gastrotricha, Platyhelminthes, Nemertina, Annelida, Mollusce and Arthropoda (Swift et.al., 1979).

Tea, a perennial agro-foresting system provides employment to 3-4 million people in India and earns about 10 percent of our foreign exchange.

Crop losses in tea due to pest has been assessed by various workers (Barber, 1901; Das, 1974; Rao and Murhty, 1976). In addition to causing direct crop and plant losses, the quality of made tea is adversely affected by pests (Murthy and Chandrasekharan, 1979).

To ameliorate the crops from the ravages of pests various kinds of pesticides came into practice which are chemically classified as chlorinated hydrocarbons, carbamates, Organophosphates and heavy metals. The list of dominant pesticides used in tea agroecosystem has been given in Table 1. Due to prevalence of fungal infection the use of fungicides based on copper and nickel are in wide use. Nickel is used as liqnik which is used in all stages of life.

The concern about ecological effect of agrochemicals started during 1950s and 1960s when pesticides used in agro systems found to affect wild life (Rudd, 1964; Moore, 1966; Sheail, 1985). Some of the serious drawbacks of widespread use of pesticide are (1) Development of genetic resistance. Since 1950 there has been dramatic increase in the number of insect species with genetic resistance to one or more insecticides, (2) creation of new pests – the repeated use of broad spectrum pesticides also creates new pests and converts minor pests to major pests, (3) mobility and biological amplification of persistent pesticides, (4) threat to non-target organisms-the pesticide though meant to kill the pests, but its potency to kill also effects the other beneficial non target organisms, (5) Short term threat to human health-human beings on exposure to high levels of pesticides during manufacturing or applying without proper safety precautions may suffer from illness and in extreme cases may die, (6) Long term threats to human health-though direct evidence is not there but autopsies have shown that bodies of people who died from cancer, cirrhosis of liver, hypertension, cerebral hemorrhage contained fairly high levels of DDT or its products like DDD and DDE (Tyler and Miller, 1988).

Most of the research works dealing with chemical stress describe LC50, LD50 and some biochemical or physiological alternations. Chemical conc. which immediately kills the organisms is termed as lethal level. But sub-lethal level of chemicals seriously influences the positive contribution of an organism towards the ecosystem. To infer the impact of chemical stress by examining at sub-cellular and metabolic level is not enough to predict the impact beyond the individual level. Therefore ecotoxicological approach is essential for ecologists (Senapati et.al., 1992).

So in the present study the impact of pesticide application on the soil microbial biomass and respiration in the tea gardens of Tamil Nadu and the adjacent reserve forest ecosystems were evaluated.

Material and methods:

10 plots of 10m x 10m were selected in flat forest areas which were close to the tea fields of the estate. The plots were demarcated by stone pillars. A transitional zone of 3m was left between two consecutive plots. In 5 plots the pesticides and herbicides as applied in adjacent tea garden was applied and in rest five plots no application of pesticides was done.

During the course of 8 months nickelchloride and copperoxychloride were applied 6 times. Copperoxychloride and nickelchloride were being applied simultaneously. Calaxin and vinofan was applied simultaneously once. Ekalux, MIT 505 and sulfex were applied once but on separate days. Copperoxychlorides and Liqnik were applied at the rate of 3g, 1^{-1} water, hec^{-1} and 3.79g, 1^{-1} water, hec^{-1}, respectively.

Vinofan, Calaxin, ekalux, endosulfan, MIT 505 and sulfex were applied at the rate of 5ml, 1^{-1} water, hec^{-1}, 1.8ml, 1^{-1} water, hec^{-1}, 2.5ml, 1^{-1} water, hec^{-1}, 3.5ml, 1^{-1} water, hec^{-1}, 3.33ml., 1^{-1} water, hec^{-1} and 3.33 g., 1^{-1} water, hec^{-1} respectively.

After 8 months of application of pesticides regularly as practiced in adjacent tea gardens soil the soil samplings were done as per T.S.B.F. method (T.S.B.F.1989). Three samples from each plot were taken.

Soil Microbial Biomass: Part of the soil samples taken from different plots was air dried and sieved by 2mm. sieve. Microbial Biomass C was measured by fumigation incubation

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method (Jenkinson and Powlson, 1976) as described by Vance et.al. (1987 a,b).

Soil metabolism: Quantification of soil metabolism has been done by Alkali absorption method (Witkamp, 1966). The measurements were done at 25±20°C.

From the microbial biomass and soil metabolic rate data microbial metabolic quotient was estimated.

All the data obtained from the different experiments were analysed statistically and significance was analysed using t-test and ANOVA (Gupta, 1980).

Results & discussion

Table 2 indicates some soil microbial parameters of ecosystem due to impact of pesticide application.

Soil microbial biomass (MBC) in pesticide applied plot was found to be 1040, 1080 and 1190 mg C, kg-1 soil at 0-10cm, 11-20cm and 21-30cm depth, respectively. And in the control plots at 0-10, 11-20 and 21-30cm depth the soil microbial biomass was found to be about 1720, 1540 and 1420 mgC, kg-1 soil respectively. At 0-10cm, a reduction in microbial biomass by about 39.5% was observed when pesticide was applied. Significant reduction in the microbial biomass (at 0.001 level) was observed on application of pesticide at 0-10 and 11-20cm depth.

Basal soil respiration increased with the application of pesticides. At 0-10cm. basal soil respiration was found to be 8.20 and 6.55 mg C, kg-1 soil, hr-1 in the pesticides applied plot and control plot, respectively. That means basal soil respiration in pesticide applied plot increased by about 25% (0-10cm depth) as compared to the control plots. At 0-10 and 11-20cm depth a significant increase in basal soil respiration was observed at 0.001 and 0.01 level of significance respectively in pesticide applied plots.

At 0-10cm the microbial metabolic quotient of soil was found to be higher in the pesticide applied plot by about 50% as compared to control plot. In the pesticide applied plots the MMQ was found to be 0.008, 0.007 and 0.005 at 0-10, 11-20 and 21-30cm depth, respectively. But in control plot at 0-10, 11-20 and 21-30cm depth, the MMQ was found to be 0.004 in all the depths.

In the present study significant reduction in microbial biomass was observed with simultaneous increase in basal soil respiration.

Functionally the microbes bring about most of the transformation of resources during decomposition (swift et. al., 1979). The decomposer microbes are classified into necrotrophs, which exploit the living organisms resulting in the rapid death of food resources. This group includes herbivores, plant parasitic microbes, predators (nematodes, trapping fungi etc) and microtrophs. The biotrophs exploit their living food source for longer time like root feeding nematodes, obligate plant parasites and mutualistic symbionts such as mycorrhiza, legume nodules. Saprophytes utilize food which is dead. Nutrient uptake is also influenced by activity of micro-organisms which contribute to decomposition. Micro-organisms from rhizosphere liberate soluble phosphate (Nicholas, 1965). The fungi act as bridge between the plant and soil solution. Nutrients enter into plants through translocation process through fungal hyphae (Mosse et. al., 1976).

Determination of soil respiration is one of the best approaches for the evaluation of biological activity (Lundergarh, 1972). The lowering in microbial biomass and increment in respiration and thereby increase in microbial metabolic quotient indicate the disruption in the soil system due to application of pesticide in the forest experimental plots (Basu and Pati, 1991). The applications of pesticide are ultimately resulting in deterioration of mineralization process and thus decrease in soil fertility.

TABLE – 1: List of dominant pesticides used in tea agro-ecosystem

Sl. No.		Types of Pesticides	Dose	Rounds, Yr^{-1}
A.		**Heavy metal**		
	(i)	Fytolon (Copper Oxychloride)	210g – 350g, ha^{-1}	36
	(ii)	Liqnik (Nickel Chloride)	265g, 70 1^{-1} water, ha^{-1}	36
B.		**Chlorinated Hydrocarbons**		
	(i)	Endosulfan	700ml, 200 1^{-1} water, ha^{-1}	4
	(ii)	Grammaxone	30ml, 10 1^{-1} water, ha^{-1}	4
C.		**organophosphorus**		
	(i)	Zolone	11, 200 1^{-1} water, ha^{-1}	4
	(ii)	Quinolphos	750 ml, 300 1^{-1} water, ha^{-1}	4

TABLE – 2 Soil microbial parameters of forest ecosystem due to impact of pesticide application

Parameter	Depth (cm)	Reserve Forest Pesticide Applied Plot	Reserve Forest Control Plot
Microbial Biomass	0-10	1040 ± 7 *	1720 ± 4
(MBC) (mgc, kg^{-1} soil)	11-20	1080 ± 3*	1540 ± 4
	21-30	1190 ± 1*	1420 ± 4
Basal Soil Respiration	0-10	8.20 ± 0.10*	6.55 ± 0.08
(mgc, kg^{-1} soil, hr^{-1})	11-20	7.15 ± 0.08°	6.19 ± 0.32
	21-30	5.93 ± 0.07*	5.79 ± 0.05
Microbial Metabolic	0-10	0.008	0.004
Quotient (MMQ)	11-20	0.007	0.004
(mgc, kg^{-1} MBC, hr^{-1})	21-30	0.005	0.004

*** Significant at 0.001 level, ° Significant at 0.01 level,**

 # Significant at 0.05 level

Volume : 5 | Issue : 1 | Jan 2015 | ISSN - 2249-555X

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