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Effect of Pesticides Application in Soils of Cardamom Hills in, Idukki, Kerala.

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***Abstract*- An understanding of the effect of pesticides is essential for rational decision-taking regarding their authorization. The retention of a pesticide by soil can prevent its short-term access to ground or surface waters and its effects on non target organisms, but the persistence of the under graded pesticide or of harmful metabolites constitutes an ever present – and cumulative – risk to the environment and, eventually, to human health. The soil mineralogy, chemical decomposition and atmospheric conditions highly influence the pesticide retention and release of it and consequently the degradation of the compound. The analysis conducted on water samples across the entire district shows that the water sources are protected from contamination by any pesticides. However, the indiscriminate use of pesticides in Cardamom plantations will be a threat to the Indian Cardamom Hills, the Idukki District since the persistent pesticide residue of endosulfan, DDT and organophosphorous toxic chemicals are present in high concentration. The soil mineralogy of Idukki is favorable to its persistence and hence strict control and awareness to farmers for judicious use of pesticides is necessary to avoid pollution of water sources and contamination of the soil.**

Keywords: Persistent pesticide residue, Cardamom plantation, Soil sensitivity, GIS applications. Environmental protection.

1. INTRODUCTION

The use of pesticides especially in ensuring the sustainability of large quantities of high quality agricultural produce has been steadily increasing over the past. Health effects of pesticides depend upon their chemical characteristics, solubility in water and vapor pressure[1]. How long the pesticide remains in the soil depends on how strongly it is bounded by soil components and how readily it is degraded. Common pesticides used in Cardamom plantations are 'organophosphorous' and ' organochlorine' compounds. Although some organophosphorous compounds are highly toxic to humans, they generally break down rapidly and rarely have been found in the environment. Organochlorine compounds such as Endosulfan, are more toxic and its half life varies from weeks to months depending upon the physical and chemical properties of soil system such as moisture content, organic matter and clay contents[2]. Another group are carbamate pesticides including aldicarb, carbofuran, and oxamyl. These compounds tend to be soluble in water and weakly adsorbed to soil. Consequently, if not degraded in the upper soil layers, they have a tendency to migrate to groundwater. This necessitates great care in selection of sampling points for pesticide analysis in water[1].

1. MATERIALS AND METHODS

Idukki town is located at 9^0 51′N 76°58′E / 9.85°N 76.97°E Coordinates (Fig.1). The project area consists of Idukki District and the sampling points are Devikulam, Udumbanchola, Peermade and Thodupuzha Talukus. Soil samples were collected from 38 large and medium plantations across the District based on a random sampling technique from the data base collected from authorized agencies. The sampling points were marked with GIS Coordinates for identification and for further monitoring (Fig. 2).

Fig.1 Idukki District Taluks

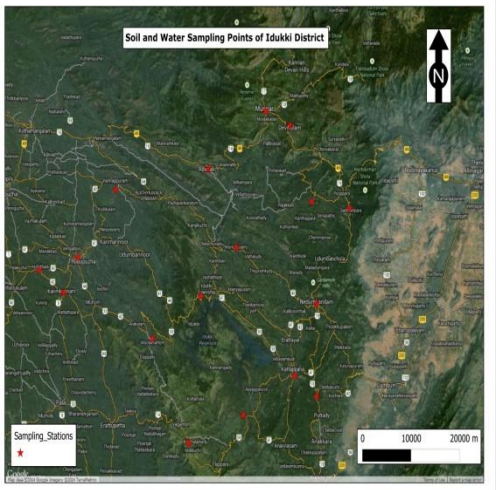

Fig.2 Soil and water sampling points of Idukki district

A chain of custody procedure was followed to ensure the legitimacy of each sample. Soil response to environment depends on soil structure, geochemical parameters (mineralogical and chemical characteristics), soil-water interaction etc [3] . Soil samples were collected from the study areas in March to July 2013 and January 2014, during and after rainy season. Each soil sample was a composite of 10 subsamples collected from each site using random sampling method within a grid. A grid was established by identifying the approximate center of a field and dividing the field into 5 rows. Soil was collected from each row and from a depth of 0-15 cm using a soil auger [4]. After the collection of sample the soil auger, bucket, sieve and mixing tool were rinsed with tap water and dried before next use. The subsamples were dried under shades for 24 hours and thoroughly mixed and sieved through 4.75 mm brass sieve and stored in air tight plastic bags. The samples were labeled with place and date of collection, code number etc and shipped to the Laboratory within 48 hours of collection.

2.1 Soil Sensitivity to Environment

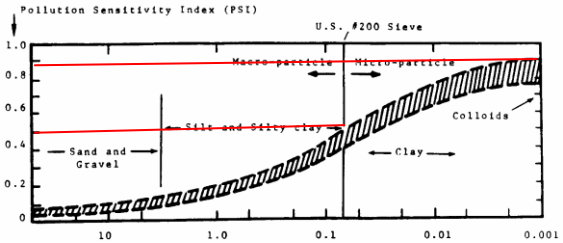

Fig.3 Sensitivity Index and Particle Size in mm
(Fang1976)

The sensitivity of soil to environment (Fig.3) depends not only on the local environment but also influenced by mineral structure, such as particle size, bonding characteristics between particles, ion exchange capacity, etc. The smaller the soil particle, greater is its ability to interact with the environment. The weaker the bonding energy between particles or higher the cation exchange capacity, the higher the sensitivity of the particles to the environment [5].

The grain size distribution of the soil samples collected from the project area were carried out as per IS:2720 (part IV) to study the soil sensitivity index (fig.4). From fig.3 the sensitivity index of particle size less than 75 microns (0.075 mm) is approximately 0.7. From the soil analysis conducted, more than 75 % of the samples contain average 40% of its particles less than 75 microns or bearing a sensitivity index 0.7. The pH of soil water and % water content are measured to study the soil characteristics and to predict the fate of the pesticide residue and effectiveness in degradation (Fig. 5).

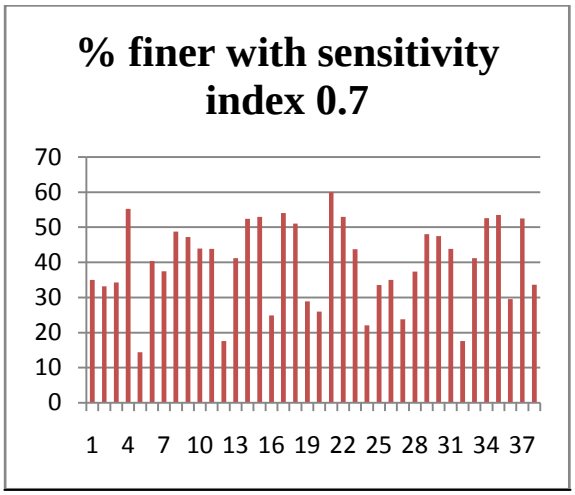

Fig.4 % finer with sensitivity index 0.7

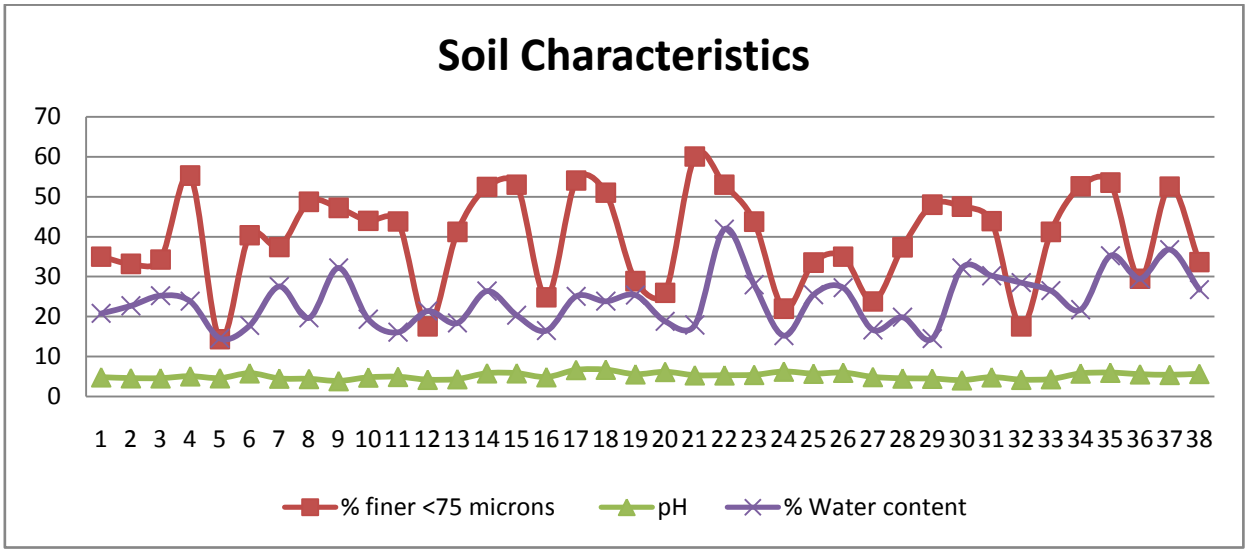

Fig.5. soil characteristics

2.3. Residue analysis

Qualitative and quantitative analysis of organochlorine insecticides in soil was carried out based on Asensio-Ramos M, Hernandez-Borges.J, Revelo-Perez.L,Rodriguez-Delgado.M.A, 2010 and evaluation procedure was of a modifide QuEChERS method for the extraction of pesticides from agricultural, ornamental and forestal soils [6]. For quantitative determination of organochlorine insecticide residues GCECD and GC-MS are used. Calibration standards, like internal standards, prepared from certified standard material

2.3.1. Instrumentation

Shimadzu GC-2010 with ECD and FPD detectors. Auto sampler AOC 20i , Capillary column DB – 5 (30Mx0.25mmx 0.25µm) (Agilent Technologies, USA), Carrier gas–Nitrogen (99.999%), Flow rate– 0.79mLmin^{-1} and Injection volume - 2µL. The GC-ECD was set up at injector temperature-250^{0}C, detector temperature-300^{0}C, and run time is 70.33min. The GC-FPD was set up at injector temperature – 250^{0}C, detector temperature – 300^{0}C, column flow rate -1.0mLmin^{-1}, injection volume - 2µL, hydrogen flow-95mLmin^{-1}, zero air flow-120mLmin^{-1}, runtime is 29.57 min

2.3.2. Procedure

1kg Sample is homogenised, air dried at room temperature and sieved (2mm sieve). Weigh 10 ± 0.1 g sample into centrifuge tube (50 mL). Then add 20 ml acetonitrite and shake vigorously for one
minute. To this, add 4g $MgSO_4$ and 1g NaCl and centrifuge at 3300rpm for 4 min. Take 10mL
supernatant in to 15mL polypropylene centrifuge tube containing 1.5g $MgSO_4$ and 0.25g PSA (Primary Secondary Amine). Shake well and sonicate for 1 min and centrifuge at 4400 rpm for 10min. 4mL supernatant solution is evaporated to dryness using rota vapour at 40^{0}C. Reconstitute with 1mL n-Hexane for GC-ECD & GC- FPD analysis. (If aqueous phase is present, add very small amount of anhydrous Na_2SO_4 and filter).
Confirmation of residues was carried out by GC-MS. GC conditions are same as in GC-ECD. The GC-MS instrument parameters for qualifier ion and quantifier ion settings are - Column : DB-5 MS Ultra inert, Column Flow : 0.79 mL min^{-1}, Carrier gas : Helium , Ionization : Electron Impact Ionization, Ionization Temperature : 200°C, Interface Temperature : 290°C

2.3.3. Detection level of Pesticide contamination

Mobility of organochlorine in soil is generally limited, although it is greater in sandy soil. They tend to be bound in clay soils with limited leaching. Residues of the parent compound or metabolites can be found in soil, sediment, vegetable samples and in vertebrates/invertebrates for extended periods. Their solubility in water is low, although residues can be detected in water where there is extreme contamination and, particularly, on suspended matter in water. The Limit of Quantification (LOQ) set up for the analysis are 0.01mgKg^{-1}, 0.05 mgKg^{-1}, and 0.01 mgKg^{-1} for Organochlorine, Organophosphorous and Synthetic pyrethroids respectively.

3. RESULTS AND DISCUSSIONS

Among 38 no of soil samples collected and tested, 18 no of soils were contaminated by various persistent pesticide residues. The residual concentration of persistent pesticides found in samples with their identification code is given below (Fig.6)

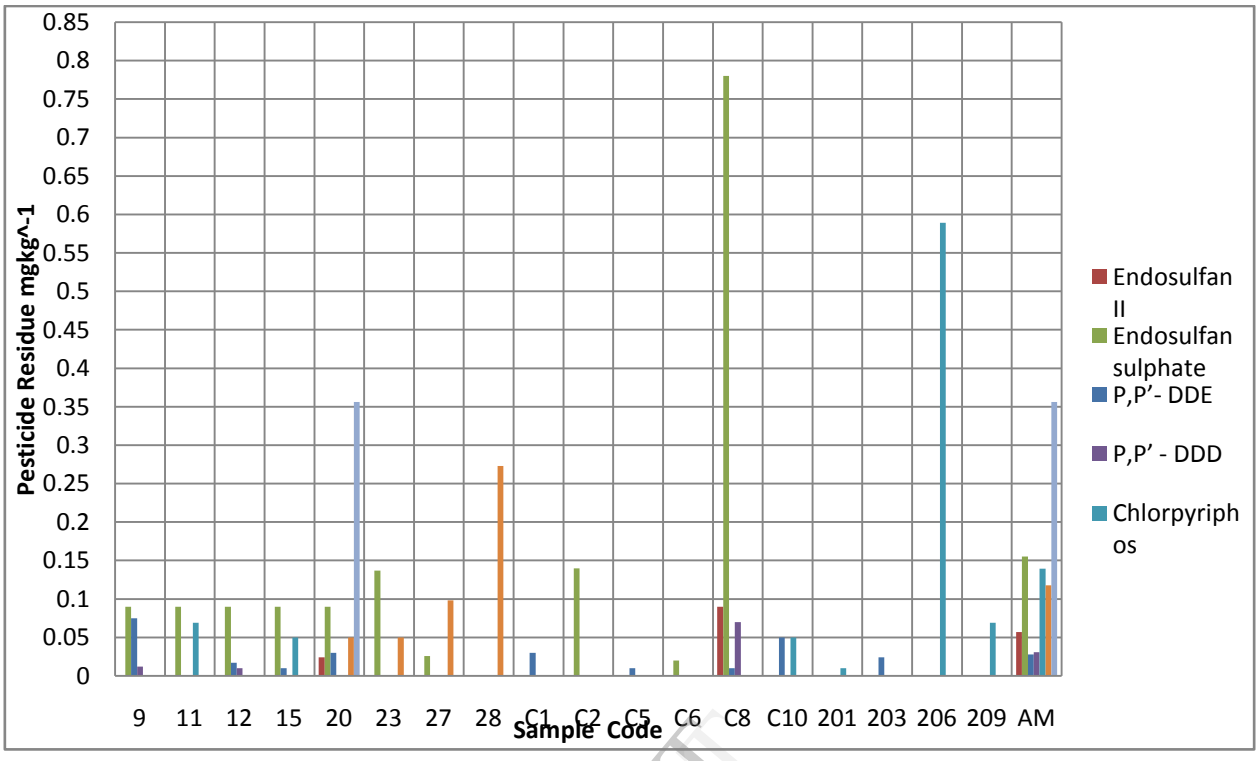

Fig. 6.Pesticide Residues and sample codes.

Analysis was carried out to interpret experimental data. A total of 4 OC residues were identified, confirmed and quantified (Fig.6). The analysis shows that there is a probability of getting endosulfan in soils of Idukki district cardamom plantations at 31.6 % within a range of 0-0.87 mgKg^{-1} and a mean value of 0.093 mgkg^{-1} as shown in Table1. DDT, another OC pesticide are present in 29 % of the soil samples in the range of 0.01 - 0.087 mgkg^{-1} with a mean value of 0.0193 mgkg^{-1}. Organophosphorous pesticides Chlorpyriphos, Quinalphos and Ethion were present in 21 % of the samples within a range of 0.01- 0.589 mgkg^{-1} and a mean value of 0.1122 mgkg^{-1} . The probability of contamination of the soil in the cardamom plantations by any of these pesticides is as high as 82 %.

Table 1. Results of pesticide residue analysis

Name of Pesticides	**Arethmetic Mean (mgkg^-1)**	**µgKg-1)**
Endosulfan-I	0	0.0
Endosulfan II	0.00633333	6.3
Endosulfan sulfate	0.086278	86.3
Total Endosulfan	0.092611	92.6
P,P'- DDE	0.014222	14.2
P,P' - DDD	0.0051	5.1
P,P' - DDT	0.0000	0.0
Total DDT	0.0193	19.3
Chlorpyriphos	0.0465	46.5
Quinalphos	0.02616667	26.2
Ethion	0.03955556	39.6
Total organophosphorous	0.1122	112.2
Total pesticide residue in soil samples	0.22690196	226.9

The test of hypothesis is carried out to establish the experimental results and its predictions. The test of hypothesis at 5 % significance level and degree of freedom 17 shows that the residues of endosulfan, DDT and organophosphorous pesticides are available in the soil at 0.10 mgKg^{-1} ,0.03 mgKg^{-1}, 0.12 mgKg^{-1} respectively.

4. CONCLUSIONS

1. The sensitivity index of the soils form cardamom plantations shows that it is highly sensitive to adsorption of pesticide residues as the % of finer particle less than 75 micron size is 40 % in 75 % of the soil samples. The soil environment is at high risk due to indiscriminate use of pesticides and the soil texture is favourable to its retention. However the meteorological factors, high rain fall and low temperature are the favourable factors which reduce the intensity of risk and control the degradation of pesticides especially the organochlorine pesticides into highly toxic compounds before it leaves the hills.

2. Endosulfan, even though it is banned, it is being used widely in cardamom plantations of Idukki district and the soil is polluted with endosulfan sulfate, the major degradation product of technical endosulfan which is a mixture of two isomers(α and β). The presence of endosulfan at 31.6 % with a significance level of 5 % shows that it is easily available to farmers even though stringent monitoring by the authorities is there. The results of the research conducted across the cardamom plantations of entire the district were taken together, it is hypothetically confirmed that the concentration of persistent pesticide residue is 0.10 $mgKg^{-1}$. The highest value of endosulfan residue 0.87 $mgKg^{-1}$ represent a recent application since its principal degradation product, endosulfan sulfate is 0.78 $mgKg^{-1}$ for the same sample and the half life of endosulfan in soil is 30-70 days.

3. DDT a common OC pesticide and its bye products is present in 29 % of Idukki cardamom plantations soil with a significance level of 5 %. The residual concentration of DDT at 0.03 $mgKg^{-1}$ was identified and confirmed in the soil samples from cardamom plantations and this shows that it is frequently been used by the farmers even though the same is a banned toxic chemical. The largest value of Technical DDT is 0.087 $mgKg^{-1}$. It contains P,P'- DDE 0.075 $mgkg^{-1}$ P,P'- DDD 0.012 $mgKg^{-1}$. It is known that P,P'- DDT is the principal isomer of technical DDT. Generally DDE and DDD resist further chemical and biological degradation. This phenomenon is usually used as an indicator for the time lapse of DDT usage. If the ratio of P,P' – DDT/DDT metabolite is > 0.5, it indicate recent usage[7] . In the present study P,P' – DDT was not detected in any of the samples. It would seem to imply an earlier usage before several years of the ban, as it is highly persistent in soil media and its half life is 2-15 years.

4. The presence of organophosphorous pesticide residue in the soil samples from cardamom plantations gives a clear message that the pesticides Chlorpyriphos, Quinalphos and Ethion are using frequently in cardamom plantations and the residual concentration is as high as 0.589 with a mean value of 0.112 $mgkg^{-1}$. It is statically proved that the residual concentration of organophosphorous pesticides is 0.12 $mgKg^{-1}$ at 5 % significance level. As it is short lives in soil and its half life is 5-15 days, the higher concentration in the soil will leads to contamination of drinking water sources during runoff.

5. The total pesticide residue irrespective of the classification to Organochlorine and Organophosphorous pesticides is confirmed as 0.2269$mgKg^{-1}$ (226.9μgKg^{-1}) in the soil of cardamom plantations. Idukki District with the largest Cardamom Plantations and highest cardamom production centers occupies almost 30 percent of the cultivable land and consumes the highest quantity of pesticides, fungicides and insecticides than all other crops which is occupied by rest of the land. On an average, farmers use 27 kg of pesticides in a hectare (ha) of cardamom plantation and 9 kg in tea garden against India's average pesticide use of 0.5 kg per ha [8]. The huge consumption of pesticide in the project area warrants early interventions of various government agencies and policy makers to plan and implement a strategy which is conducive to environment and for farmers. As pesticides could not be banned and a complete shift to organic farming in cardamom plantations is impossible all on a sudden, it is highly recommended to control excess usage and indiscriminate application of highly toxic pesticides and fix a reasonable value for cardamom so that their attempt for high yield to make up the huge investment could be avoided.

6. As more and more researches and reports are coming out [9,10,11,12,13], the farmers are strongly supporting the authorities and the policy makers in taking stringent control over the use of these toxic chemicals which will destroy the life of present and future generations. The researchers all over the world is continuing their studies to monitor what is happening to the environment and giving early warning to the authorities for timely action. However the various decisions of the environmental protection agencies to protect the environment and the life of all living organisms could be effectively move forward until and unless the interest of the farmers are taken care of.

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