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Analysis of Persistent Pesticide Residue in the Water Samples of Idukki District, the Indian Cardamom Hills

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***Abstract*--Pesticide residues are the deposits of pesticide active ingredient, its metabolites or breakdown products present in the environment after its application, spillage or dumping. Residue analysis provides a measure of the nature and level of any chemical contamination within the environment and its persistence. The aim of this study was to investigate the pollution status of drinking water sources in Idukki District of Kerala, the largest cardamom production center in India. This paper presents the results of pesticide residue analysis of water samples collected from the project area following purposive sampling technique. The study shows that the water sources are not contaminated with persistent pesticide residues of the toxic chemicals used in Cardamom or Tea Plantations. But the soil nature is highly sensitive to adsorption and hence there is a high risk of contamination of the sources. However, judicious use of pesticides and its stringent monitoring prevents farmers from using banned toxic pesticides and can protect the environment and the human creations a win- win condition.**

Key Words- Below limit of quantification(BLQ), Cardamom plantation, Idukki District, Persistent Pesticide Residue, Water sample.

1. INTRODUCTION

Pesticides may reach the soil through direct application to the soil surface, incorporation in the top few inches of soil or through the unauthorized dumping of unwanted pesticide products. Pesticides can enter ground water resources and surface run-off during rainfall, thereby contributing to the risk of environmental contamination. All pesticides are subject to degradation or metabolism once released into the environment. The objectives of present study are,

- Identify contaminated areas and/or sources of contamination
- Study the drinking water quality
- Investigate residual levels of pesticide in the environment, soil and water.

The fate of pesticides in soil and water environments is influenced by the physio-chemical properties of the pesticide, the properties of the soil and water systems (presence of clay size particles, organic matter and pH), climate, biology, and other factors. The rates of degradation and dissipation vary greatly from pesticide to pesticide and situation to situation. The solubility of common pesticides in soil and water is very less and its half life period very short.

Any delay in preserving the sample or extracting the pesticide residues means there is an increased risk of degradation of any residues present, with a corresponding increase in the uncertainty regarding the analytical results and their interpretations. To have a minimum risk and to avoid uncertainty in results, protocols in line with National and International guidelines are followed during the research. This paper presents the results and analysis of 100 water samples collected from Idukki District and the protocol framed for conducting the field study covering large hilly area where the environment is exposed to frequent application of toxic pesticides. The sampling protocols were developed to meet regulatory mandates of the Pesticide Contamination Prevention Act (PCPA) of 1986 and to provide further understanding of the agronomic, chemical, and geographic factors that contribute the movement of residues to soil and water [1].

2. PROTOCOLS IN SELECTION OF SAMPLES

Statistics shows that Kerala is the largest cardamom production center in India and the annual production status is 8545 tones out of the National average production of 15500 tones (Fig.1, Table1). In Idukki District, an area of 55174 Ha of land, around 28 % of the total cultivable land is covered by cardamom plantation (Courtesy- Website Government of Kerala) which consumes the maximum toxic substances, an average of 27 kg per hectare per annum[2]. Considering the number of rounds of pesticide sprays and quantity of pesticides used in Indian Cardamom Hills (ICH) one can rate cardamom as the highest pesticide consuming rain fed crop in the world. Considering the toxicological parameters like per capita consumption, pesticide intensity and risk weighed active ingredients; the risk of contamination of water sources in Idukki District is likely from Cardamom plantations.

Table 1. Cardamom Production Status
(Courtesy- NABARD reports)

State/Spice	Area(Hec)	Production (Tons)
Karnataka– Cardamom (small)	26611	1725
Kerala – Cardamom (small)	41362	8545
Sikkim – Cardamom (large)	26734	3833
Tamil Nadu - Cardamom(small)	5255	965
West Bengal– Cardamom (large)	3305	470

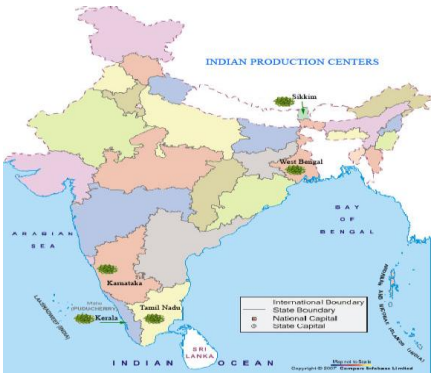

Fig. 1 Cardamom Production Centers

The high risk of pesticide residue in the water and soil environment of ICH where majority of the rural population depends on the surface water sources for their domestic purposes warrants a detailed investigation. This study aims to investigate the intensity of pollution and residual levels of pesticide in the environment by conducting detailed analysis on water samples collected from the project area.

2.1 Protocol in Selection of Water sampling points

In the agriculture industry, pesticides are one of the most common substances dealt with potential for adverse effects on human health. Health effects of pesticides depend upon their chemical characteristics. Common pesticides used in Cardamom plantations are 'organophosphorus and 'organochlorine' compounds. Although some organophosphorus compounds are highly toxic to humans, they generally break down rapidly in the environment and rarely have been found in groundwater. 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 water. 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. The most significant occurrences of groundwater well contamination have been with carbamate pesticides. Aldicarb - one of the most common carbamate pesticides has been detected in many wells near to its application. So, great care should be taken while selecting the points for sampling for pesticide analysis in water[3].

Selection of sampling sites for the present study was done based on Purposive Sampling Technique [4,5]. The population studied included all the water sources in Idukki District but points with more chances of contamination through runoff and nearer to Cardamom Plantation were selected. To achieve the maximum probability that all water sources are considered for selection process, the steps followed in selection of the sample units are,

- Evaluated the present water supply position and assessed the expected consumers from each source.
- The data base of Cardamom Planters were collected from authorized offices.
- Analyzed the threat of contamination of each sources
- Selected the points which have got the highest probability of contamination and affected consumers.
- Distributed the points geographically and Located the points with GIS Co-ordinates (Fig.2)[6].

2.2. Protocol in Water Sampling and Storage

The process of water collection requires thorough consideration keeping in mind the importance and intention of sampling. Factors such as depth of sampling point, temperature, water film formed on surface due to decaying vegetation, sediment load present at bottom etc. will influence the decision making. Volumes collected are commonly in the range of 0.5–2 litres. Containers used to carry/store water samples for residue analysis should be washed with clean water, followed by an acetone rinse and then allowed to dry before re-use.

Each sample container should be clearly marked using permanent ink or laser-printed labels with the following information:

- date and time of collection;
- place of collection; and
- sample type and identification

Measure the pH of the water and if it is above 8, seal the container with Teflon to avoid chemical volatilization of Endosulfan isomers if present. Otherwise adjust the pH below 7 by addition of phosphate buffer (pH 6) or acetate buffer (pH 5.4) [7].

The storage of samples is required when there is delay in shipping of the samples to the laboratory or the extraction of the sample is significantly delayed. In such conditions there are chances of degradation of the residue or absorption of the particles on to the walls of the sample container. Thus there is a need to keep the sample chilled and to transport it to the laboratory as soon as possible. Alternate methods are either the sample can be extracted in the field using solid phase extraction (SPE) technology or organic solvent (eg.dichromate) extraction shall be made within 48 hours.

A chain of custody procedure would ensure the legitimacy of each sample. Logbooks and sample

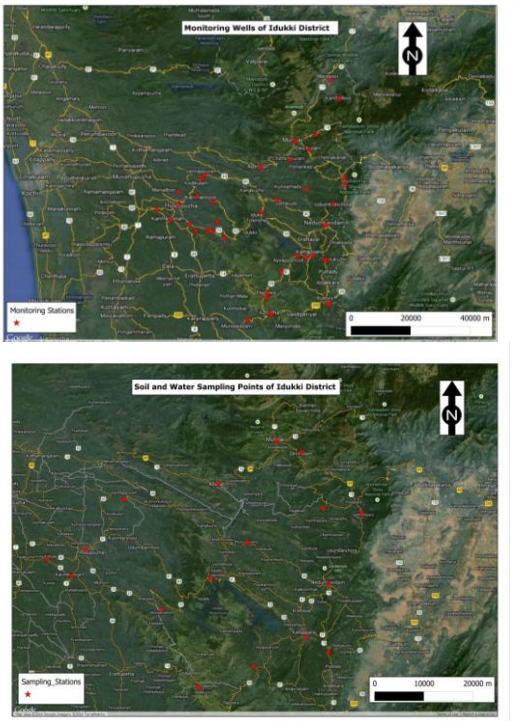

Fig. 2 Water sampling points - GIS images.

collection forms should contain information such as:

- site of sampling;
- date and time sampled;
- sample identification code;
- sample matrix (soil, water, composite);
- treatment such as preservation, if any;
- identity of sampler;
- method of transport;
- destination;
- specific analyses required (if applicable);
- date and time of arrival in laboratory; and
- Name and signature of person taking custody.

Based on the field data, it is observed that around 75 % of the total rural population depends on open dug wells, ground water or surface sources and the threat of consumption of contaminated water is very large if pesticide residue is present in the water samples. For the present study, 100 sampling points (Fig.2) were selected across the project area near to Cardamom plantations having maximum density of consumers and within the plantations in the ratio 74:26 respectively. Following the above standards, water samples were collected in one liter clean plastic container after rinsing with the water to be collected from the sampling wells from surface levels after removing the floating matters if any. pH of water was taken at the point of collection and as it was less than 8, no preliminary treatment done before keeping the sample in air tight position in a cool temp till Transported to Laboratory for testing [8].

2.3 Protocol in testing of water samples

Quantitative determination of insecticide residues by GCECD and GC-MS techniques are recommended for pesticide analysis [9]. Calibration standards, like internal standards, should be prepared from certified standard material and kept no longer than six months with new preparations being evaluated against the old standard. The samples were tested at two levels simultaneously. All the 100 water samples were tested for physical, chemical (including heavy metals) characteristics and analyzed for common pesticide residues. 13 selected samples from the plantations were tested at Pesticide Residue Research and Analytical Laboratory, Vellayani, Kerala, the NABL Accredited Laboratory for analyzing the presence of any pesticide residue which is being commonly used for Cardamom and to confirm the results so as to avoid any manual errors. The water samples tested in the Pesticide Residue Research and Analytical Laboratory, Vellayani, Kerala follows the guidelines issued by : Association of Official Analytical Chemists (AOAC) 18th Edition 2007: 991.07 and 990.06. The chemical characteristics of the water samples were tested in the approved Laboratory following standard methods of analysis.

2.4 Protocol in fixing Detection level of Pesticide contamination.

As per standards, drinking water should be free from all pesticide residues or it should not be contaminated by any foreign matter. For quantifying the contamination levels, WHO has given the details with respect to Endosulfan the highly toxic pesticide and explained that a health-based value of 20 µg/litre can be calculated on the basis of the Acceptable Daily Intake (ADI) of 0.006 mg/kg of body weight, with an allocation of 10% of the ADI to drinking-water, and with the assumption that a 60-kg adult consumes 2 liters of drinking-water per day. However, Endosulfan usually occurs at concentrations in drinking-water well below those at which toxic effects can be expected to occur, and it is therefore not considered necessary to derive a guideline value for endosulfan in drinking-water [10]. As it is a matter of great concern, the detection level of pesticide contamination is taken as 0.1 μgL^{-1} for this particular study.

3. RESULTS AND ANALYSIS

The water samples were tested for chemical characteristics, presence of heavy metals, toxic substances and persistent pesticide residue that may present in the water samples based on the nature of common pesticides, fungicides and herbicides widely used in cardamom and tea plantations. The observations are presented in Tables 2 and 3 below.

Based on the findings it is proved that pesticide residue is not present in the water samples above the Limit of Quantification - 0.1 μgL^{-1}. Or to say that the water sources of Idukki district is presently not polluted from pesticide residues. The reasons may be due to

[1] Impact of banning of highly poisoned pesticides and strict monitoring from government agencies.
[2] Awareness among the planters and quality control in plantations.
[3] Favorable climatic conditions.
[4] Biodegradation and chemical degradation of pesticides.

Following the recent spurt in concerns over heavy use of pesticides, ICRI has created awareness among farmers on

judicious use of pesticides. It holds mobile spice clinics, visits plantations and holds seminars with workers. More over pesticides are degraded by chemical and microbiological processes. Chemical degradation occurs through reactions such as photolysis, hydrolysis, oxidation and reduction. Biological degradation takes place when soil microorganisms consume or break down pesticides[11,12].

During the field study it is observed that the commonly used pesticides in Idukki district are Organophosphates, Carbamates and Herbicides having half life for few days only. The soil bacteria may degrade the residue and convert it into less toxic substances and hence not creating an alarming situation at present. Hence, the water can be used for drinking purpose and other domestic purposes after disinfection. However, the continued application of pesticides may change the soil texture and risk of contamination of water sources are prevailing in Idukki, the Indian Cardamom Hills and more stringent quality control and monitoring can protect the water sources against pollution from highly toxic persistent pesticide residues.

4. LIMITATIONS IN THE STUDY

Several studies were conducted to detect Environmental Pollution and Impact on Pesticide Residue all over the world. Specific studies on field level covering a large area of agricultural land which contributes the major mass of pollutants are not exhibited or not available for references. The practical difficulties in collection of water and soil samples covering large hectares of hilly terrain makes it costly and cumbersome for a researcher to do the research project. Only limited literature is available for getting guidance to conduct the study [13,14,15,16,17,18]. Cardamom plantations are mostly at hill tops and transportation was very difficult and possible only through special purpose vehicles. Moreover, the preservation and shipment of samples in large numbers immediately on collection from the hill stations to the nearest laboratory was not possible. In the present study the water samples could be tested within two days expecting limited error in the results.

TABLE 2. CHEMICAL ANALYSIS & PESTICIDE RESIDUE ANALYSIS OF DRINKING WATER SOURCES & PLANTATION SOURCES

Sl. No	Sample Identification	Month of collection	Location	EC	pH	Turbidity	TDS	Acidity	Alkalinity	Cl	TH	Ca	Mg	NO3	Fe	F	SO4	Alpha BHC,Beta BHC, Gamma BHC, Delta BHC, Alpha Endosulphan, Beta Endosulphan, Endosulphan Sulphate, Aldrin, Endrin, Heptachlor, Methoxychlor , 4,4' DDD, 4,4'DDT, Cu, Ph, Ni, Zn, Cd,Cr.
1	S 19	2013 Feb	Elappara	41.3	7.3	1.5	28.91	5	26	26	28	6.4	2.9	BDL	BDL	BDL	BDL	ND
2	S 23	2013 Feb	Kumali	68.1	7.3	1.7	47.67	5	32	20	52	11	5.8	BDL	BDL	BDL	BDL	ND
3	S 9	2013 Feb	Anakkara	69	7.4	1.1	48.3	4	30	24	50	13	4.4	BDL	0.05	BDL	BDL	ND
4	S 31	2013 Feb	Chakkupallam	83.4	7.4	2.3	58.38	5	44	26	64	13	7.8	BDL	BDL	BDL	BDL	ND
5	S 26	2013 Feb	Pampadumpara	39.1	7.3	1.8	27.37	5	30	20	22	4	2.9	BDL	0.05	BDL	BDL	ND
6	S 25	2013 Feb	Nedumkandam	57.9	7.3	1.4	40.53	5	30	28	40	9.6	3.9	BDL	BDL	BDL	BDL	ND
7	S 14	2013 Feb	Poopara	34.4	7.3	2.2	24.08	4	28	26	18	4	1.9	BDL	0.05	BDL	BDL	ND
8	S 35	2013 Feb	Udimbinchola	33.2	7.3	1.6	23.24	3	26	20	20	4	2.4	BDL	0.05	BDL	BDL	ND
9	S 68	2013 Mar	Peerumade	50.00	7.2	6.5	32.5	5	28	22	26	12	6.5	5	0.1	BDL	BDL	ND
10	S 69	2013 Mar	Kumily	70.23	6.9	2.1	45.65	5	32	26	30	8.5	4.3	6	0.05	BDL	BDL	ND
11	S 70	2013 Mar	Chakkupallam	43.31	7.1	5.1	28.15	4	26	30	30	17	8.6	1	0.3	BDL	BDL	ND
12	S 71	2013 Mar	Ayyappancoil	40.28	7	3.6	26.18	5	32	29	43	13	7.5	BDL	0.25	BDL	BDL	ND
13	S 72	2013 Mar	Nedumkandam	51.08	7	0.6	33.2	5	30	30	40	9.6	4.9	BDL	0.1	BDL	BDL	ND
14	S 73	2013 Mar	Udumbanchola	62.35	7.1	0.7	40.53	5	44	30	35	6.9	3.9	BDL	0.1	BDL	BDL	ND
15	S 74	2013 May	Munnar	44.77	6.8	1.9	29.1	4	30	18	34	9.4	4.8	6	0.1	BDL	BDL	ND
16	S 75	2013 May	Marayoor	33.20	6.6	0.1	23.24	3	30	28	42	9.4	4.8	4	BDL	BDL	BDL	ND
17	S 76	2013 May	Adimali	67.14	6.6	0.7	47	3	28	22	35	12	6.1	6	BDL	BDL	BDL	ND
18	S 77	2013 May	Devikulam	72.99	6.3	0.2	51.09	4	26	20	45	9.6	4.9	6	BDL	BDL	BDL	ND

19	SO 420	2013 May	Purapuzha	60.26	7.4	12.6	42.18	7	26	22	33	11	5.5	4	0.1	BDL	BDL	ND
20	SO402	2013 May	Munnar	55.81	7.3	0.7	39.07	6	32	26	43	6.4	3.1	2	0.2	BDL	BDL	ND
21	SO4026	2013 May	Vathikudy	38.21	7.2	5.2	26.75	3	30	30	30	7.5	4	2	0.3	BDL	BDL	ND
22	SO403	2013 May	Vellathuval	51.69	7.4	0.3	36.18	4	44	24	42	8	4.5	2	BDL	BDL	BDL	ND
23	SO404	2013 May	Kudayathoor	37.14	7.3	1.7	26.00	6	28	22	32	9.4	5.3	4	BDL	BDL	BDL	ND
24	SO405	2013 May	Kudayathur	40.00	7.2	1	28.00	7	38	28	45	6.7	3.9	2	BDL	BDL	BDL	ND
25	SO406	2013 May	Kudayathur	40.00	7.2	5.2	28.00	4	30	25	46	8	4.9	2	0.3	BDL	BDL	ND
26	SO407	2013 May	Idukki	62.86	7.1	0.6	44.00	5	44	23	65	9.2	5.3	4	0.1	BDL	BDL	ND
27	SO408	2013 May	Poopara	74.29	6.8	0.7	52.00	5	30	22	35	6.5	3.3	4	BDL	BDL	BDL	ND
28	SO409	2013 May	Kanthalloor	65.71	6.9	1.4	46.00	7	30	26	45	7.2	3.8	2	0.2	BDL	BDL	ND
29	SO410	2013 May	Udumbanchola	40.00	7	1.1	28.00	5	28	30	28	6.3	4.1	4	BDL	BDL	BDL	ND
30	SO411	2013 May	Ayyappancoil	36.76	7	17.5	25.73	4	26	24	28	8.9	4.7	8	BDL	BDL	BDL	ND
31	SO412	2013 May	Kalkoonthal	52.00	7.2	0.6	36.40	5	26	26	52	5.5	4.5	2	BDL	BDL	BDL	ND
32	SO413	2013 May	Elappara	58.57	7.1	1.9	41.00	6	32	24	50	9.8	3.5	BDL	0.1	BDL	BDL	ND
33	SO415	2013 May	Udumbannoor	38.67	7.3	1.2	29.00	4	30	20	64	6.4	4.1	0.5	0.1	BDL	BDL	ND
34	SO416	2013 May	Munnar	37.33	7.3	1	28.00	5	44	28	22	6.4	2.9	2	0.1	BDL	BDL	ND
35	SO417	2013 May	Kumily	39.00	7.4	3.6	29.25	5	30	20	40	11	5.8	1	0.2	BDL	BDL	ND
36	SO418	2013 May	Chakkupallam	50.67	7.4	2.2	38.00	6	22	20	18	13	4.4	26.6	0.1	BDL	BDL	ND
37	SO419	2013 May	Kudayathoor	38.55	7	1.7	28.91	7	23	22	20	13	7.8	BDL	0.1	BDL	BDL	ND
38	SO421	2013 May	Kumaramangalam	63.56	6.9	4.3	47.67	6	24	22	32	4	2.9	8.86	0.1	BDL	BDL	ND
39	SO422	2013 May	Vannapuram	64.40	6.7	2.2	48.3	4	22	24	24	9.6	3.9	2.2	0.1	BDL	BDL	ND
40	SO423	2013 May	Velliyamattom	35.67	6.8	1.6	26.75	5	30	29	32	4	1.9	8.86	BDL	BDL	BDL	ND
41	SO424	2013 Sept	Adimali	47.53	7.4	3.5	35.65	4	35	26	38	4	2.4	8.86	0.2	BDL	BDL	ND
42	SO425	2013 Sept	Rajakkad	30.67	7.5	1.7	23.00	6	24	20	22	4.3	2.4	11.1	0.2	BDL	BDL	ND
43	SO427	2013 Sept	Upputhara	36.00	7.2	2.0	27.00	5	30	24	29	3.4	2.1	8.86	0.05	BDL	BDL	ND
44	SO428	2013 Sept	Peerumade	60.00	7.3	2.3	45.00	6	24	26	38	6.4	3.1	7.15	0.1	BDL	BDL	ND
45	IDKB-031	2013 Sept	Kattappana	65.33	7.2	1.8	49.00	5	36	20	25	7.5	4	5	0.05	BDL	BDL	ND
46	IDKB-051	2013 Sept	Peermedu	50.37	7.5	1.4	37.78	6	45	28	38	8	4.5	4	0.2	BDL	BDL	ND

47	IDKO-011	2013 Sept	Karimkunnam	60.00	7.2	2.2	45.00	6	29	26	29	9.4	5.3	4	BDL	BDL	BDL	ND
48	IDKO-032	2013 Sept	Karimannur	55.04	6.9	6.7	41.28	5	38	20	34	6.7	3.9	5	BDL	BDL	BDL	ND
49	IDKO-052	2013 Sept	Devikulam	69.33	6.6	1.5	52.00	5	25	22	30	8	4.9	8.86	0.1	BDL	BDL	ND
50	IDKO-008	2013 Sept	Marayoor	74.67	7.1	1.7	56.00	5	23	26	38	7.4	5.3	17.7	0.05	BDL	BDL	ND
51	IDKO-109	2013 Sept	Vannappuram	39.00	7.1	4.7	29.25	5	34	30	43	6.5	3.3	4.48	0.1	BDL	BDL	ND
52	IDKO-213	2013 Sept	Rajakumari	95.33	6.9	2.3	71.50	6	30	29	35	7.2	3.8	17.7	0.05	BDL	BDL	ND
53	IDKO-314	2013 Sept	Santhanpara	86.67	7.4	1.8	65.00	3	25	30	39	6.3	4.1	17.7	BDL	BDL	BDL	ND
54	IDKO-416	2013 Octo	Nedumkandom	65.73	7.3	1.4	49.30	4	23	30	43	7.4	4	2	BDL	BDL	BDL	ND
55	IDKO-518	2013 Octo	Vathikudy	36.25	6.8	2.2	29.00	5	25	18	23	5.5	4.5	1	0.1	BDL	BDL	ND
56	IDKO-620	2013 Octo	Peruvanthanam	80.00	7.1	1.6	64.00	3	25	28	35	9.8	3.5	BDL	0.1	BDL	BDL	ND
57	IDKO-722	2013 Octo	Vandipperiyar	0.00	7.2	1.5		3	26	22	26	6.4	4.1	BDL	0.1	BDL	BDL	ND
58	IDKO-824	2013 Octo	Vandanmedu	73.75	7	1.7	59.00	4	32	20	28	7.3	4	BDL	BDL	BDL	BDL	ND
59	IDKO-925	2013 Octo	Upputhara	82.10	6.9	2.8	65.68	4	30	22	32	8.1	3.6	BDL	0.2	BDL	BDL	ND
60	IDKO-028	2013 Octo	Arakulam	36.94	6.8	2.3	29.55	5	44	26	35	8.6	3.4	BDL	0.2	BDL	BDL	ND
61	IDKO-130	2013 Octo	Thodupuzha Municipality	46.85	6.9	1.8	37.48	6	30	30	36	9	3.2	4.43	0.05	BDL	BDL	ND
62	IDKO-239	2013 Octo	Adimali	36.25	6.9	5.0	29.00	7	30	24	31	7.4	3.9	17.7	0.1	BDL	BDL	ND
63	IDKO-340	2013 Octo	Munnar	70.00	6.7	2.2	56.00	5	28	22	34	9.5	3	4.43	0.05	BDL	BDL	ND
64	IDKO-443	2013 Octo	Vazhathoppu	50.66	7.1	1.6	40.53	4	26	28	45	9.9	2.8	44.3	0.2	BDL	BDL	ND
65	IDK012	2013 Octo	Thodupuzha	46.20	7.2	1.6	36.96	5	28	25	25	10	2.6	35.4	BDL	BDL	BDL	ND
66	IDK03	2013 Octo	Muttom	37.98	7	1.5	30.38	4	32	23	23	7.4	3.7	8.86	BDL	BDL	BDL	ND
67	IDK04	2013 Octo	Arakkulam	90.31	7.7	2.8	72.25	4	28	26	38	7.2	3.6	BDL	0.1	BDL	BDL	ND
68	IDK05	2013 Octo	Vannapuram	57.50	7.1	1.1	46.00	5	30	20	30	8.1	3.6	BDL	0.05	BDL	BDL	ND
69	IDK06	2013 Octo	Karimannoor	46.25	7	2.3	37.00	4	26	24	30	8.6	3.4	4	0.1	BDL	BDL	ND
70	IDK07	2013 Octo	Vazhathope	56.25	7	1.8	45.00	5	32	26	24	9	3.2	2	0.05	BDL	BDL	ND
71	IDK08	2013 Octo	Kattappana	86.46	7.2	6.5	69.17	6	30	20	43	7.6	3.7	4	BDL	BDL	BDL	ND
72	IDK09	2013 Octo	Elappara	82.88	6.4	2.2	66.30	6	44	28	55	9.5	3	8	BDL	BDL	BDL	ND
73	IDK10	2013 Octo	Peruvanthanam	46.25	6.2	1.6	37.00	5	30	26	45	9.9	2.8	2	0.1	BDL	BDL	ND
74	IDKO2	2013 Octo	Karimkunnam	87.71	7.2	1.5	70.17	6	30	20	43	10	2.6	2	0.1	BDL	BDL	ND

75	101031303	2013 Mar	Elappara	66.50	6.3	1.7	46.55	3	28	22	46	8.1	3.7	4	0.1	BDL	BDL	ND
76	201031303	2013 Mar	do	56.14	6.8	6.0	39.30	4	26	26	54	11	2.4	8	0.1	BDL	BDL	ND
77	301031303	2013 Mar	do	37.14	6.9	8.0	26.00	7	26	30	39	11	2.2	BDL	0.03	BDL	BDL	ND
78	401031303	2013 Mar	do	64.29	7.1	11	45.00	5	32	29	47	12	2	1	0.2	BDL	BDL	ND
79	501031303	2013 Mar	do	55.71	7.1	1.4	39.00	6	30	30	48	8.5	3.4	BDL	0.1	BDL	BDL	ND
80	601031303	2013 Mar	Chenkara	92.86	7.1	0.2	65.00	5	44	30	59	8.5	3.4	1	0.1	BDL	BDL	ND
81	701031303	2013 Mar	Anavilasam	45.97	6.9	1.6	32.18	4	36	18	43	9.5	3	2	0.2	BDL	BDL	ND
82	802031303	2013 Mar	Chakkupallam	60.23	7	0.8	42.16	5	34	28	43	9.9	2.8	4	0.1	BDL	BDL	ND
83	902031303	2013 Mar	Nedumkandam	41.43	6.9	1.5	29.00	3	32	22	35	10	2.6	BDL	0.1	BDL	BDL	ND
84	1002031313	2013 Mar	do	83.14	7	1.7	58.2	4	30	20	34	8.9	3.3	2	0.2	BDL	BDL	ND
85	1102031313	2013 Mar	do	39.10	6.7	1.1	27.37	5	30	22	47	11	2.4	1	0.1	BDL	BDL	ND
86	1203031313	2013 Mar	poopara	57.90	6.7	2.3	40.53	3	28	26	39	11	2.2	1	0.2	BDL	BDL	ND
87	1303031313	2013 Mar	Moolathara, Poopara	34.40	6.6	1.7	24.08	5	26	30	36	9.2	3.1	2	0.2	BDL	BDL	ND
88	1403031313	2013 Mar	Thalakkulam, Poopara	33.20	7.2	1.4	23.24	3	36	24	36	8.1	3.6	6	0.2	BDL	BDL	ND
89	1503031313	2013 Mar	Pampadumpara	46.43	7.2	0.8	32.5	5	26	22	25	8.6	3.4	1	0.1	BDL	BDL	ND
90	1603031313	2013 Mar	do	65.21	7.2	1.6	45.65	4	32	28	31	9	3.2	2	0.2	BDL	BDL	ND
91	1703051313	2013 May	Kailasanad, Udumbumchola	40.21	7.2	1.5	28.15	5	30	25	35	9.3	3.1	3	0.25	BDL	BDL	ND
92	1803051313	2013 May	Kallupalam, do	37.40	7.1	1.5	26.18	3	44	23	49	9.5	3	2	0.2	BDL	BDL	ND
93	1903051313	2013 May	Namari, do	47.43	7.1	3.5	33.2	7	30	26	55	9.9	2.8	8	0.2	BDL	BDL	ND
94	2003051313	2013 May	Thalakkulam	57.90	6.7	2.3	40.53	4	30	20	43	10	2.6	4	0.2	BDL	BDL	ND
95	2104051313	2013 May	Kattappana	41.57	7	1.8	29.1	6	28	24	48	9.3	3	4	0.2	BDL	BDL	ND
96	2204051313	2013 May	Vallakkadav, Kattappana	33.20	6.7	1.4	23.24	4	26	26	49	11	2.4	3	0.15	BDL	BDL	ND
97	2304051313	2013 May	Moonnilavu, Thodupuzha	67.14	6.8	2.2	47.00	5	26	20	26	11	2.2	3	0.15	BDL	BDL	ND
98	2406051313	2013 May	Adimali, Munnar	72.99	6.8	1.6	51.09	3	32	28	35	12	2	2	0.1	BDL	BDL	ND
99	2506051313	2013 May	Kallar, Munnar	60.26	7.1	3.5	42.18	4	30	26	37	9.7	2.9	4.43	0.13	BDL	BDL	ND
100	2606051313	2013 May	Vallathooval, Anachal	55.81	7.1	4.8	39.07	5	44	20	49	9.8	2.9	13.3	0.18	BDL	BDL	ND

TABLE 3. PESTICIDE RESIDUE ANALYSIS OF WATER SAMPLES FROM CARDAMOM PLANTATIONS -CONFIRMATION TESTS

Period of testing	Sl.No	1	2	3	4	5	6	7	8	9	10	11	12	13
	Sample Identification Code	1010313	2010313	3010313	6010313	7010313	8020313	9020313	10020313	11020313	12030313	13030313	21040513	26060513
	Pestiicde tests Conducted	Results (LOQ -0.1(µgL)*												
Before and During Rainy Season	AlphaHCH	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Beta HCH	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	GammaHCH/Lindane	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Delta HCH	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Endosulfan-I	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Endosulfan-II	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Endosulfan sulphate	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	P,P' - DDE	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	P,P' - DDD	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	P,P' - DDT	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Chlorpyriphos	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Malathion	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Parathion-methyl	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Quinalphos	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Profenophos	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Ethion	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Fenvalerate	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	λ -Cyhalothrin	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Cypermethrin	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	β -Cyfluthrin	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
	Fenpropathrin	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ	BLQ
LOQ - Limit of Quantification – 0.1 μgL^{-1}. BLQ- BLQ - Below Limit of Quantification														

5. CONCLUSIONS

- The study conducted in Idukki District of Kerala where the pesticide application is the highest shows that the water sources are protected from toxic contaminants but the risk of contamination through soil is very high.
- It needs continuous monitoring and needs very stringent control measures in the pesticide application in cardamom and tea plantations.
- The planters should follow a standard protocol in the use of pesticides, their quality, quantity and period of application which gives the optimum yield and least harm to the environment.
- In the present study protocols were framed for investigating the presence of pesticide residue in water samples from very large hilly area to meet regulatory mandates of the Pesticide Contamination Prevention Act (PCPA) of 1986.
- The study results enable the researchers for further understanding of the agronomic, chemical, and geographic factors that contribute the movement of residues in water.

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