PESTICIDE CONTAMINATION IN THE DISTRICT NILGIRIS WITH SPECIAL REFERENCE TO SELECT AVIFAUNA

1994 - 1999

PROJECT REPORT

Submitted to Ministry of Environment & Forests
Government of India

Principal Investigator : Dr. V.S. Vijayan

Co-investigator : Dr. S. Muralidharan

Sálim Ali Centre for Ornithology & Natural History
Coimbatore - 641 108

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Junior Research Fellows : S. Balaji (August 1994 - October 1995)
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About the authors

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Preface

In the early 1960's, Rachel Carson's 'Silent Spring' brought out the moving tale of the silence in spring. A spring without the chirps and tweets of birds, and the buzzing of bees. All because of the application of large quantum of pesticides. It is paradoxical that it is during the same decade that India made a quantum jump in its use of pesticides in the wake of green revolution; just 1500mt of 1950s to 5,000 mt in 1960s. Since then there has been a rapid increase in the use of pesticide reaching one lakh mt currently, quite unmindful of the impact of these poisons on all life- forms.

Today, unfortunately, pesticides have become integral part of agriculture. As a result, our air, water and soil are contaminated with obnoxious chemicals which are detrimental to the biota including man. One of the most conspicuous victims of this is the various species of insectivorous birds. They have declined or disappeared locally from many parts of the country. Yet, there has been no structured system to monitor the contaminants in the birds or any other organisms, except some isolated studies on fishes.

The present project documented the levels of persistent organochlorine contaminants at different biological and non-biological components in the reservoirs in the Nilgiris. The presence, at times high levels of DDT, endosulphan and dieldrin in the vital tissues of fish-eating birds is a matter of serious concern. It is rather alarming to note that in such a small district as the Nilgiris, around 600 mt of pesticides and 28,000 litres of emulsified liquids are being used annually.

Apart from accumulation in the bird tissues through food chains, the high rainfall and laterite soil in the district facilitate speedy leaching of the toxic chemicals leading to contamination of water resources not only in the hills but also in the plains.

It may be noted that accumulation of toxic chemicals in the high trophic levels (birds), as recorded in the current study, is indicative of toxicity in the entire aquatic ecosystems in the hilly area. As the water is used for drinking and irrigation, it is prudent to commission a regular scheme to monitor the toxic levels.

Dr. V.S.Vijayan
Director

ACKNOWLEDGEMENTS

We express our gratitude to the Ministry of Environment and Forests, Government of India for financial support to this project. Dr R R Khan, Director, Hazardous Substance Management Division extended all possible help for the smooth running of the project and we are grateful to him. Tamil Nadu Fisheries Department extended support in terms of logistics in many of our study sites. We are thankful to the Assistant Director, Nilgiris and his field staff for the same. But for the support of the Tamil Nadu Forest Department it would not have been possible to include birds as one of the components in this project. We express our sincere thanks to the Chief Wildlife Warden and Messrs A Udhayan, Duraisamy, Ulaganathan, DFO Nilgiris for their support. Mr Dharmalingam, o/o the Joint Director, Horticulture, Ooty extended support and we are indebted to him. We are beholden to Drs A Reghupathy, S Chandrasekaran and S Kuttalam, Tamil Nadu Agriculture University Coimbatore who extended support whenever we approached them.

Mr V Ramesh extended untiring assistance in the laboratory and field. We appreciate Messrs R Jayakumar, R Shankardoss and V Dhananjayan, Research Scholars at SACON who helped us in sample processing and analyses during the later part of the project. We are thankful to our colleagues at SACON for their support. Mr K K Ramakrishnan helped us with preparation of the final report.

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1. INTRODUCTION

It is perhaps needless to say that agriculture occupies a place of prime importance in the Indian economy. It generates approximately 28% of Gross Domestic Product (GDP) and also employs about 60 % of labour force. The self-sufficiency in food grain production was possible only by use of high yielding varieties of seeds, chemical fertilizers, plant protection measures with modern implements. However, the large scale and unscrupulous use of chemical pesticides in intense agriculture has lead to many problems like health hazards, pollution of environment, adverse effects on non-target organisms, insecticide resistance in insects and unsustainable farming systems.

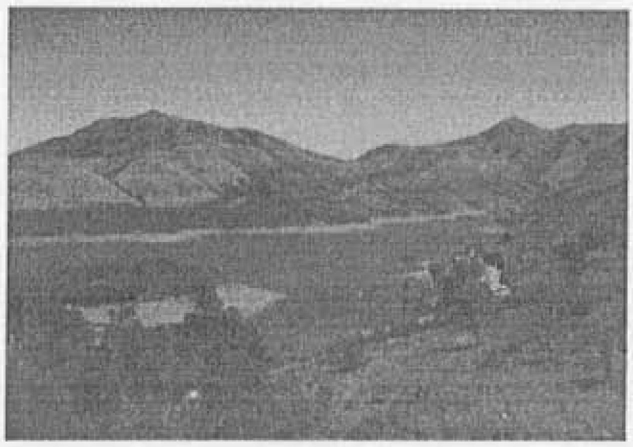
Import of 250 tonnes of DDT in the year 1947 to control malaria marks the beginning of pesticide use in India. Since then every year the consumption has been increasing in leaps and bounds. At present the total consumption has crossed 100 thousand mt.

Pesticides, particularly chlorinated organics have got very slow decomposition rate and long half-life. They endure in the system and put out their deleterious effects slowly on non-target organisms. In the international context chlorinated synthetics are mostly of historic interest, since only a few survive in today's arsenal. But, in India many are still being used as proper alternatives are yet to be tried. Further no long-term studies have been done to scale the amplitude of pesticide contamination in the environment or to measure the pesticide accumulation in wildlife. The present study was aimed at assessing the use of pesticides and to evaluate the current level of contamination with particular reference to organochlorines in various trophic levels in the Nilgiris district. The study also covers select species of birds, as they could serve as indicators of the quality of the environment.

HCH application on turmeric

2. STUDY AREA

The total geographic area of Tamil Nadu is 130 lakh ha. of which the Nilgiris district is 2.54 lakh ha. The district, popularly known as "Blue Mountain" and "Queen of Hills", includes the plateau, jungle clad slopes of uplands and some adjoining low land tracts. It is surrounded by Periyar district on the east, Kerala and Karnataka states on the west and north sides, and Coimbatore district on the south. Based on the rainfall, the Nilgiris is divided into the following four geographical tracts (Anonymous, 1989).



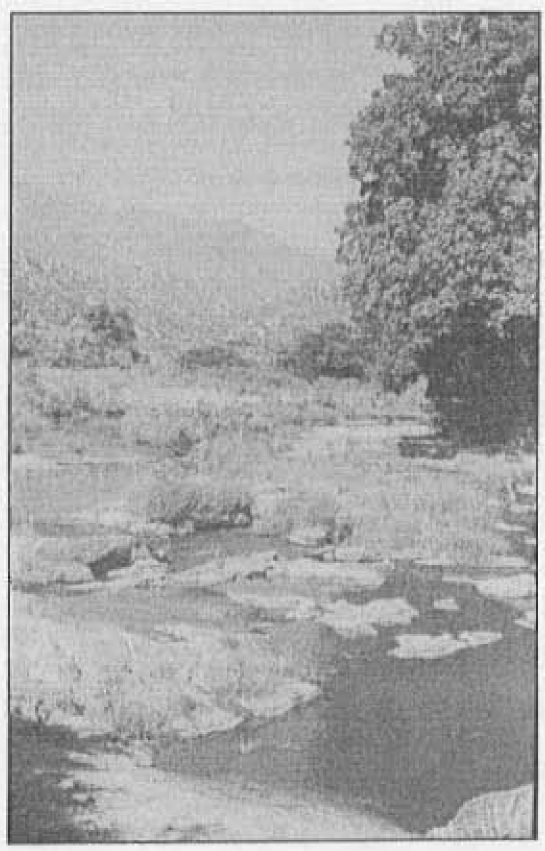
Emerald Reservoir

I. Udhaghamandalam

This tract receiving 900-2600 mm lies in the altitude of 1500 to 2500 meters MSL with undulating terrain. Of the total area of 1,19,813 ha which is equivalent to 47.03% of the district area, 16,625 ha. is under cultivation. There are four major rivers (Kundah, Moyar, Pykara and Upper Bhavani-Avalanche) which supplement the irrigation. Tea, orange, potato, cabbage, cauliflower, carrot and garlic are the major crops in this region.

II. Gudalur

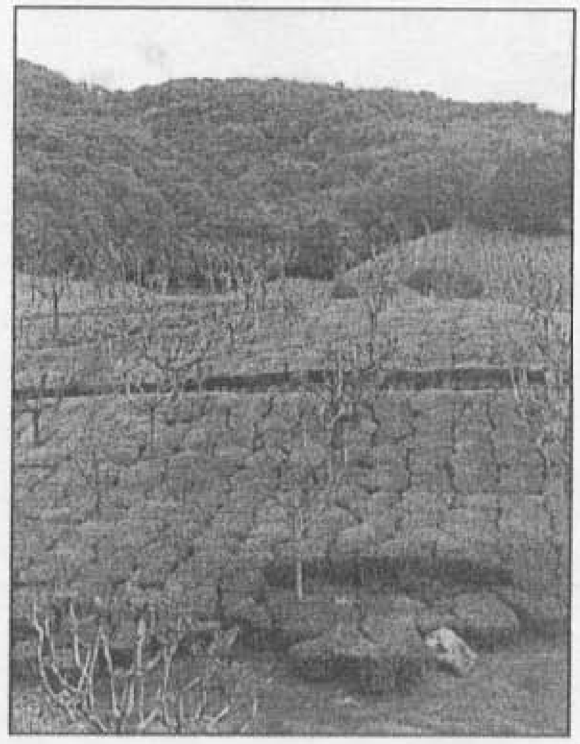
This tract lies on the west of Nilgiris district and gets 2270-3415 mm of rainfall. The total area of this zone is 72,171 ha. of which forest occupies 39,307 ha. Streams, tanks and wells are the major source of irrigation. Coffee, tea, ginger, orange, cardamom, pepper, rice, banana and vegetables are the principal crops. Cardamom is cultivated under multi layer system of cropping with arecanut and pepper.



Moyar River

III. Coonoor

The Southern and eastern parts of Nilgiris form this tract. This agroclimatic zone lies in the low and medium altitude and receives 1400 to 1700 mm of rain. The total geographical area of this block is 22,822 ha. of which 4,971 ha. is under forest cover. Streams and wells are the major source of irrigation. Tea, coffee, orange, peach, plum, potato, cabbage, carrot, pepper are the major crops.



Tea Plantation - A major source of contamination

IV. Kotagiri

Kotagiri agroclimatic zone forms the north eastern portion of Nilgiris district. It extends over an area of 39,681 lakh ha. of which only 10,506 ha. is under cultivation. The river Moyar is the major source of irrigation for the paddy and other annual crops, while wells and ponds also contribute substantially. The altitude of this region ranges between 1200 m and 1800 m. and it gets medium rain. The major agricultural crops are tea, potato and cabbage.

Climate

The Nilgiris on the whole is humid to temperate. The annual average rainfall is 1778 mm. The maximum temperature ranges from 19°C to 32°C and minimum from 3°C to 12°C.

3. BACKGROUND INFORMATION ON PESTICIDE CONTAMINATION IN NILGIRIS DISTRICT

Pesticide application on Garlic

Although there are no systematic work done to monitor the pesticide contamination in the district Nilgiris, the following pieces of information are available; testing of water samples from areas adjacent to potato fields indicated the presence of carbofuran at different levels (Rajukkannu Pers. comm), application of HCH to paddy against earhead bug has resulted in the contamination

Used pesticide cartons : A common sight

of water and crabs (Anonymous, 1988). Rajukkannu *et al.*, (1989) reported residues of a few nematicides in potato. Rao (1994) reported residues of DDT, HCH and carbofuran associated with high organic contents in the waters of Ooty lake.

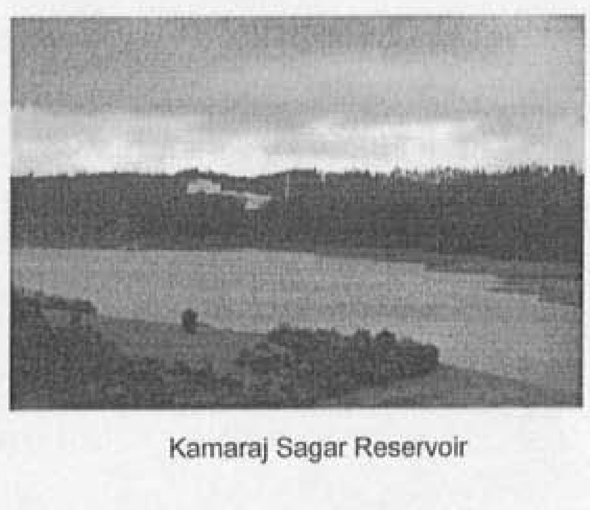
4. PROJECT PLAN IN BRIEF

The project was planned to be executed in four phases over a period of three years, and later extended by one and half a year on no cost basis. During the first phase, survey of the entire district was made to collect information on the type of pesticides used for various crops, identify study sites and select fish and bird species for the investigation. In phase II, standardization of methodologies and calibration of equipment were made. Phase III which was for a period of two years (1995-1997), involved seasonal collection of samples, and processing and analyzing them using Gas Chromatography following standard methods. Due to delay in obtaining permission from Tamil Nadu Forest Department, birds could be collected only during 1998-1999. During the IV phase, data collected were compiled, analyzed and the final report on the magnitude of pesticide contamination in the Nilgiris district is prepared.

5. METHODOLOGY

I. Field Survey

Information on the cropping pattern, common pests, pesticide consumption and major water bodies facing pesticide problem were collected and compiled. A survey was carried out in the entire district. Farmers, managers of tea and or, coffee estates, were interviewed and the information received were recorded in preformatted data sheet (Appendix I). Officials of the department of state horticulture and



Kamaraj Sagar Reservoir

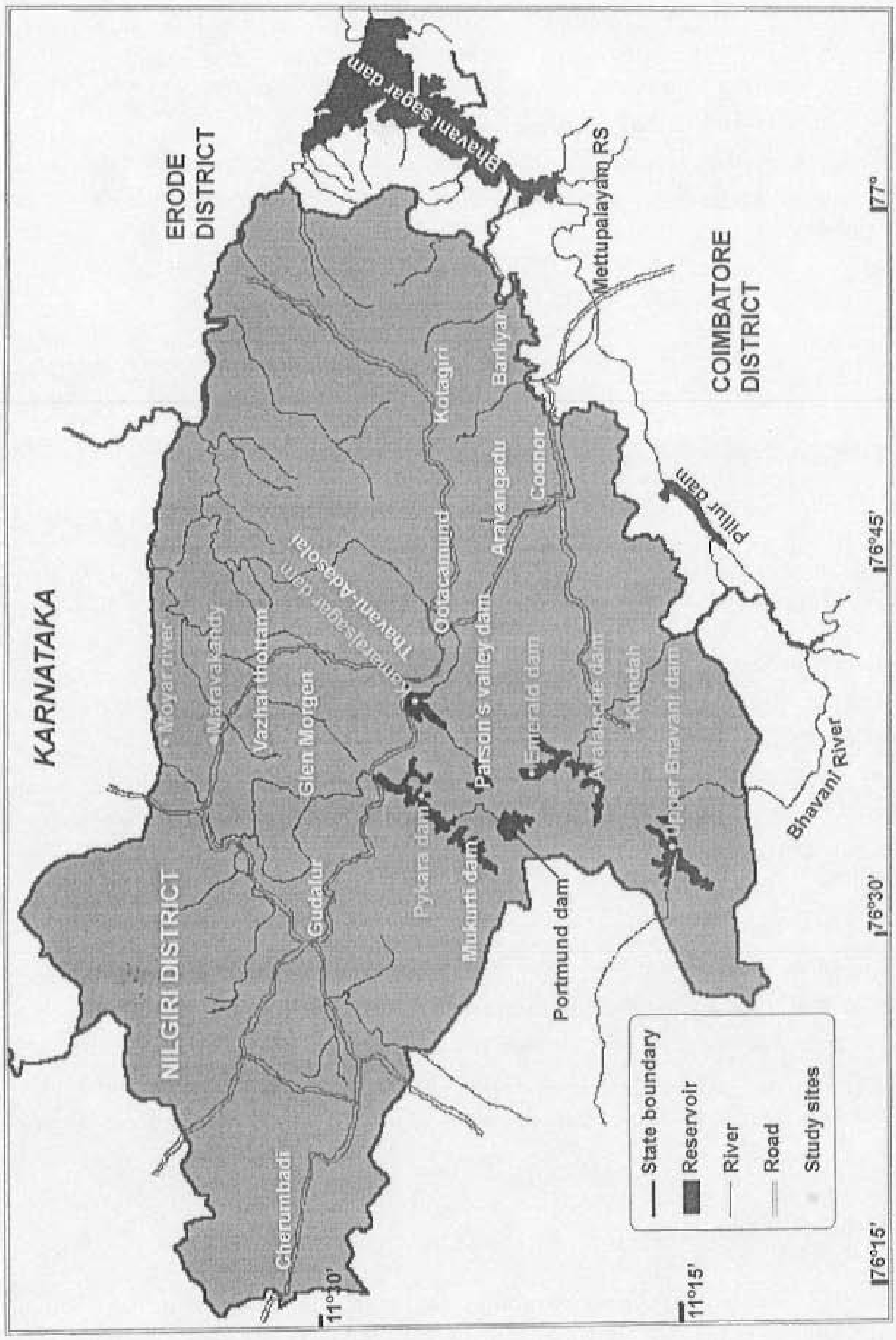


Figure 1. Map of Nilgiris showing the study sites

agricultural extension, and dealers of pesticides in the area were also contacted. Totally 487 farmers were interviewed for this purpose. Based on the survey reservoirs, namely Avalanche, Upper Bhavani, Emarald, Kamaraj Sagar, Pykara and Maravakandy, Ooty lake and rivers such as Coonoor and Moyar have been chosen for seasonal sampling (figure 1). It may be noted that the study sites varied among the components of the study.

II. Sample collection

a) Water

Samples of water (2 lit) in an integrated (space and depth) fashion were collected in glass bottles which were cleaned thoroughly and rinsed with hexane.

b) Sediment

Sediments samples were collected with the help of Ekman Dredge. Top 10-15 cm layer was considered for this purpose.

c) Fish

Standard fishing methods, such as gill net, cast net and line fishing were adopted for sampling. The method largely depended on the study site, vegetation cover and species of fish to be caught. Desired number of fishes in all species in all seasons could not be collected for many reasons. Reservoirs, namely Upper Bhavani, Emarald, Kamaraj Sagar, Pykara, Kundah and Maravakandy, Ooty lake and Moyar river have been chosen for seasonal sampling.

d) Birds

Six species of birds, four aquatic, namely Large Cormorant *Phalacrocorax carbo*, Pond Heron *Ardeola grayii*, Little Egret *Egretta garzetta*, Cattle Egret *Bubulcus ibis* and two terrestrial, namely Common Myna *Acridotheres tristis* and Jungle Babbler *Turdoides stiatus* were collected for the study from various parts of the district. Standard gear, namely noose and mist nets were used for trapping birds. The gadget differed among the species and the habitats.

III. Sample processing and analysis

Samples collected were processed adopting standard methods. Liquid-liquid extraction technique, using mainly hexane, was found to be more effective for water samples. For sediment samples solid-liquid technique with the help of mechanical shaker was adopted. As for tissue samples (fish and bird) are concerned, soxhlet extraction procedure was followed; tissue samples were homogenized thoroughly, blended with sodium sulphate (anhydrous) and loaded on to a thimble and extracted using hexane in soxhlet apparatus for 6 hours. All extracts were cleaned up using column chromatography (Silica gel/Florisil with anhydrous sodium sulphate) and after condensing with the help of rotary flash evaporator, the final product was taken to Gas Chromatograph for estimating the residues. Hewlett Packard Model 5890 Series II fitted with Electron Capture Detector was used for residue analysis. Instrument parameters and operating conditions for residue measurements in water, sediment and fish samples were as follow;

Gas liquid chromatograph	: Hewlett Packard Model 5890 Series II
Detector	: Electron Capture
Column	: Glass packed with 1.95% OV 210, +1.5% OV17
Carrier gas	: Nitrogen; Flow:- 35 ml/min
Temperature	: Column 200°C, injector 220°C and detector 240°C.

Under the standardized conditions, known concentrations of pesticide mixtures were injected and the chromatogram was obtained. Later the samples were injected under the same instrument conditions as mentioned above and the chromatograms were obtained and integrated on a PC with chemstation software. The instrument conditions differed for the bird tissues as we were interested in looking at residues of more number of pesticides. The following were the conditions;

Column	: HP 1 Capillary column (0.32 mm id, 0.21um film thickness)
Carrier gas	: Nitrogen; Flow:- 1.5 ml/min
Temperature	: Column 160°C for 3 min and with a temperature ramp of 2°c/ min up to 220°c with a hold time of 5 min; injector 250°C and detector 300°C.

Three isomers of HCH, namely alpha HCH, gamma HCH and beta HCH and four metabolites of DDT, namely *p,p'*-DDE, *p,p'*-DDD, *p,p'*-DDT and *o,p'*-DDT, and two metabolites of endosulfan (alpha and beta) have been tested in the samples of waters, sediments and fishes. While the fish samples were treated as a whole, tissues, namely brain, heart, liver, kidney and muscle were treated separately in birds. Further birds were additionally tested for residues of heptachlor epxoide, dieldrin, endrin, methoxychlor and chlordane.

6. RESULTS AND DISCUSSION

I. Field survey

There are primarily three seasons (sowing) of cultivation, namely irrigated (January-February), main (March-April) and autumn (August-September) in this district. Vegetables such as carrot, cabbage, cauliflower, potato; cash crops such as tea, coffee, cardamom, pepper, and fruits such as orange, peach, plum are the major cultivated crops. Pesticides falling under three major groups, namely organochlorine, organophosphate and carbamate are in wide use to treat the crops against pest attack. White grub, golden nematode, diamond back moth, white fly, berry borers are the major pests. Synthetic pyrithroids are also being used in considerable quantity. Many fungicides, especially M45, are being extensively used in vegetables particularly potato; roughly 18 to 20 rounds are sprayed before harvest. Approximately 600 metric tonnes of pesticides in the form of granules and powder and 28,000 litres in the form of liquids are used every year. A comparison on the total quantum of pesticide used during the last few years with that of 1980-81 in this district reveals that there has been a slight decrease in the use of granular pesticide with a steep increase in the use of emulsified liquid pesticide (figure 2). In all, roughly 45 to 50 types of pesticides are being used at present. The increase in consumption is directly related to the change in cropping pattern. For example the area under tea cultivation which was 27,115 h in 1980 has increased to 49,974 h during 1990; an increase of 84%. At present the total area under tea cultivation is roughly 50% of the total cultivable area in this district. It is necessary to mention that the quantum of pesticide used may not reflect the threat because, the toxicity differs among pesticides. It would be reasonable to presume that the pesticides used in this hill district will ultimately find their way into the plains. However, factors such as adsorption, decomposition have to be accounted for.

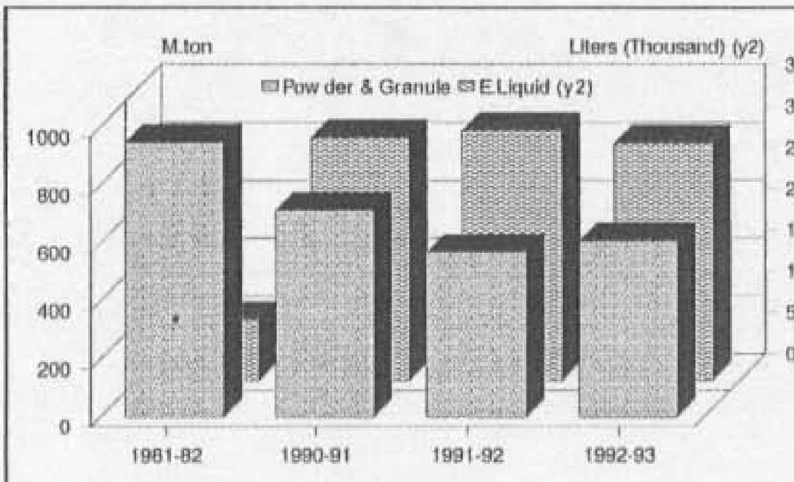


Figure 2. Pesticide consumption in Nilgiris District (1981-1993)

The district Nilgiris is prone to pesticide contamination, as the cropping pattern and the type of pesticides used are quite diverse. Because of the allotment of land for cultivation in catchment areas, along side streams, sholas and sanctuaries, even the sensitive areas are prone to contamination. In this district, high rainfall and laterite soil facilitate speedy leaching of the applied pesticides leading to contamination of water source.

II. Pesticide residues in water

Three isomers of HCH and four metabolites of DDT were detected in the waters (figure 3 a & b). The frequency of occurrence varied between 48 and 97 %.

Gamma HCH was the maximum (0.006 ppb) in the waters of Pykara followed by Kamaraj Sagar (0.005 ppb) with the frequency of occurrence up to 97%. The lowest concentration was in Upper Bhavani (0.0001 ppb). Alpha HCH was the maximum in River Coonoor (0.09 ppb) followed by Kamaraj Sagar (0.08 ppb) and the minimum in River Moyar (0.01 ppb). In the case of delta HCH, the waters of Pykara measured the highest level (0.82 ppb) and Ooty lake the lowest (0.005 ppb) (figure 3 a).

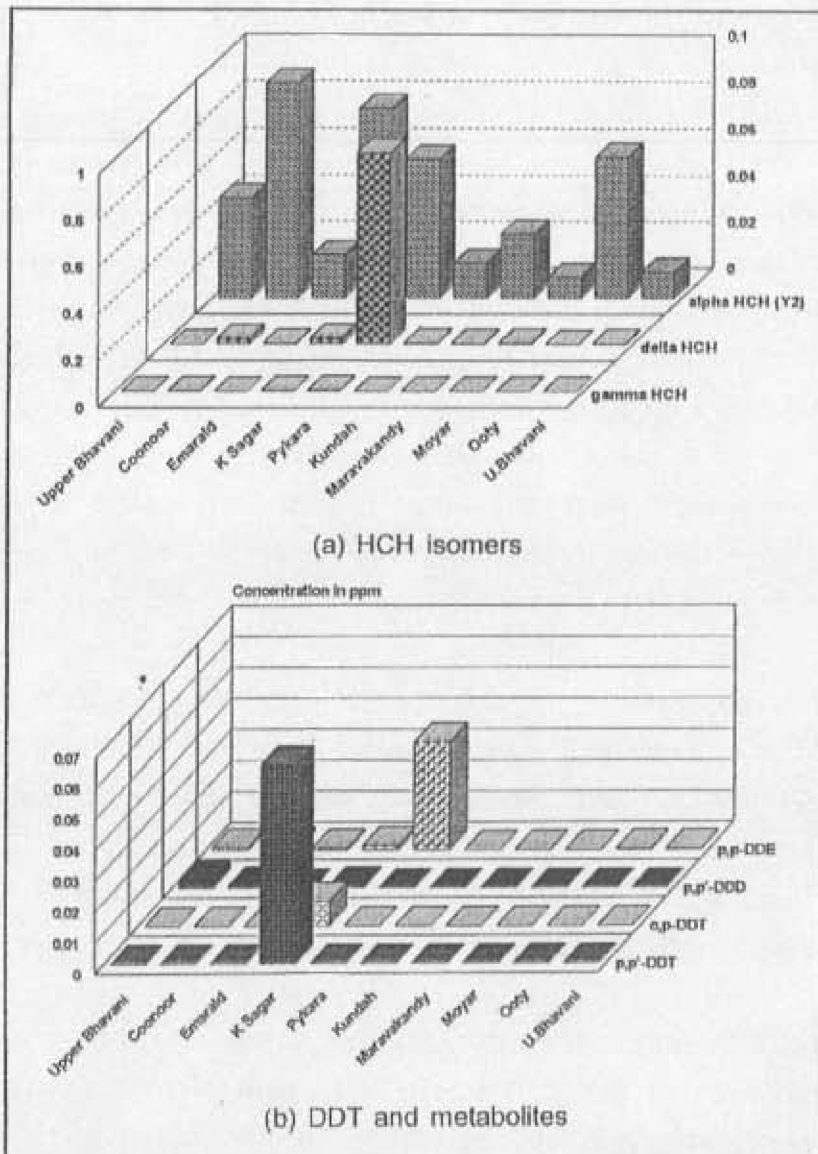


Figure 3. Pesticide residues in waters of Nilgiri district 1995-97

Residues of *p,p'*-DDT and *o,p'*-DDT were detected only in the waters of Kamaraj Sagar; 0.07 ppb and 0.01 ppb respectively. However, trace level of *o,p'*-DDT was detected in the waters of Pykara. *p,p'*-DDE could be detected in all the study sites, while *p,p'*-DDD in only three sites, namely Upper Bhavani, Coonoor River and Kamaraj Sagar; 0.003 ppb, 0.002 ppb and 0.001 ppb respectively (figure 3 b). While the frequency of occurrence for *p,p'*-DDE was 85%, it was 45% for *p,p'*-DDD. Traces of alfa endosulfan were found in the waters of River Coonoor and Maravakandy reservoir. Since endosulfan is not very persistent in water, analysis of water samples is rarely expected to provide sufficient cause and effect evidence. Further, beta endosulfan is most likely to be present in water only from direct application or spray drift. The World Health Organization (WHO) reported that although endosulfan has been detected in agricultural runoff and in surface water draining industrialized areas, contamination of surface waters with this compound does not appear to be widespread (WHO 1984). EPA (1982) stated that endosulfan concentrations in surface waters are generally <1 ppb. However, residues in dead fish would seem to be better indicators of exposure (Nowak *et al.*, 1995). Further EPA recommends that the amount of endosulfan in lakes, rivers, and streams should not be more than 74 ppb. This should prevent any harmful health effects occurring in people who drink the water or eat fish or seafood that live in the water. Further it may be noted that 28-hr LC 50 value for endosulfan ranges between 0.09 and 11.2 µg/l depending on the species and temperature. However, in the present study the levels of endosulfan detected in water are very trace. Levels of DDT and HCH of the present study are lower than those reported by Rao *et al.*, (1994) in Ooty Lake. If this is a sign of declining environmental residue level of the persistent chemicals in the Nilgiris, it is a welcome sign. However, it requires continuous monitoring.

Seasonal variation in organochlorine residues among the study sites was significant ($P<0.05$). Nevertheless, there were variations among the chemicals. The levels of total HCH and DDT were significantly low ($P<0.05$) during monsoon than that of summer and winter. The differences among the three years (1995 - 1997) are not significant ($P>0.05$) indicating that the residue level in the environment is not changing substantially fast. Hence, the data are not discussed year wise.

The differences in contamination among stations could be related to the usage of pesticides in the catchment area and also the pattern of rainfall. However, the concentration need not be always linearly proportionate to the rainfall. When the levels of contamination recorded in the present investigation were compared with those available elsewhere in India, they are lower than the levels reported by Agarwal *et al.*, (1986) in river Jamuna, Delhi, Mishra (1989) and Bakre *et al.*, (1990) in Mahala water reservoir, Jaipur, Kulshrestha *et al.*, (1990) in three rivers, namely Khan near Indore, Kashipra near Ujjain and Chambal near Kota, and Nayak *et al.*, (1995) in river Ganga and in the waters of Keoladeo National Park, Bharatpur (Muralidharan 2000). Hence, the levels in water reported in the present study need not be considered as unsafe or alarming. However, considering the fact that HCH is still being used in the entire Nilgiri district and very high levels of endosulfan has been detected in tissues of Cormorants and fishes, we have to be all the more careful.

The levels of other pesticides (HCH and DDT) recorded in water although not very high and not expected to pose any greater risk through direct toxicity, may, if absorbed, get accumulated in the food chain and affect aquatic organisms and also their predators in long-run. Many of the water bodies although located in different altitudinal gradient enabling mixing of water and dilution of contaminants, it does not happen usually unless there is excessive rainfall. Hence, water loss is mainly through evaporation and percolation. Although the contaminant in the water could settle down in the sediment, as the water spread area reduces in size or as the volume and/or toxicity of contaminants increase(s), the ability of the waterbody to accommodate and eliminate the contaminants gets impaired. When this point is reached, the wetland can become a source of toxicity rather than a sink (Fitzapatrick and Bhomk 1990).

III. Pesticide residues in sediments

Many organic pesticides and trace elements are hydrophobic; that is, in aquatic environments they tend to be associated with sediment particles and biological tissues rather than dissolved in water. For this reason, sampling bottom sediment and fish is an effective way to assess the occurrence of these contaminants in the aquatic environment.

Three isomers of HCH, namely alpha, gamma and delta, two metabolites each of DDT and endosulfan were detected in the sediments collected from the study sites in Nilgiri district. Delta HCH was detected only in Kamaraj Sagar. Gamma HCH was the maximum in the sediments of Maravakandy (0.07 ppb) reservoir and the minimum in the sediments of Emarald reservoir (0.006 ppb). Alpha HCH measured the maximum in the sediments of Maravakandy and Kamaraj Sagar with the values of 1.34 ppb and 1.27 ppb respectively, while it was the lowest in Moyar river (0.65 ppb). The below detection limit was detected in the sediments of Ooty lake, Upper Bhavani and Kundah (figure 4 a).

p,p'-DDD was detected only in the sediments of Pykara. *p,p'*-DDE was detected in the sediments of all the study sites excluding Moyar River; the highest in Ooty lake (0.54

ppb) and lowest in Kamaraj Sagar (0.003 ppb) (figure 4b). Residues of beta endosulfan was not in detectable level except in Emarald (0.42 ppb). Although endosulfan is used extensively on vegetables and tea to control different kinds of pests, the residue level is not indicative of the same. Variation in contamination level among study sites was noticed. However, it differed among pesticides. Both DDT and HCH showed less significant variation (P>0.05), indicating that the presence of these chemicals do not vary among places.

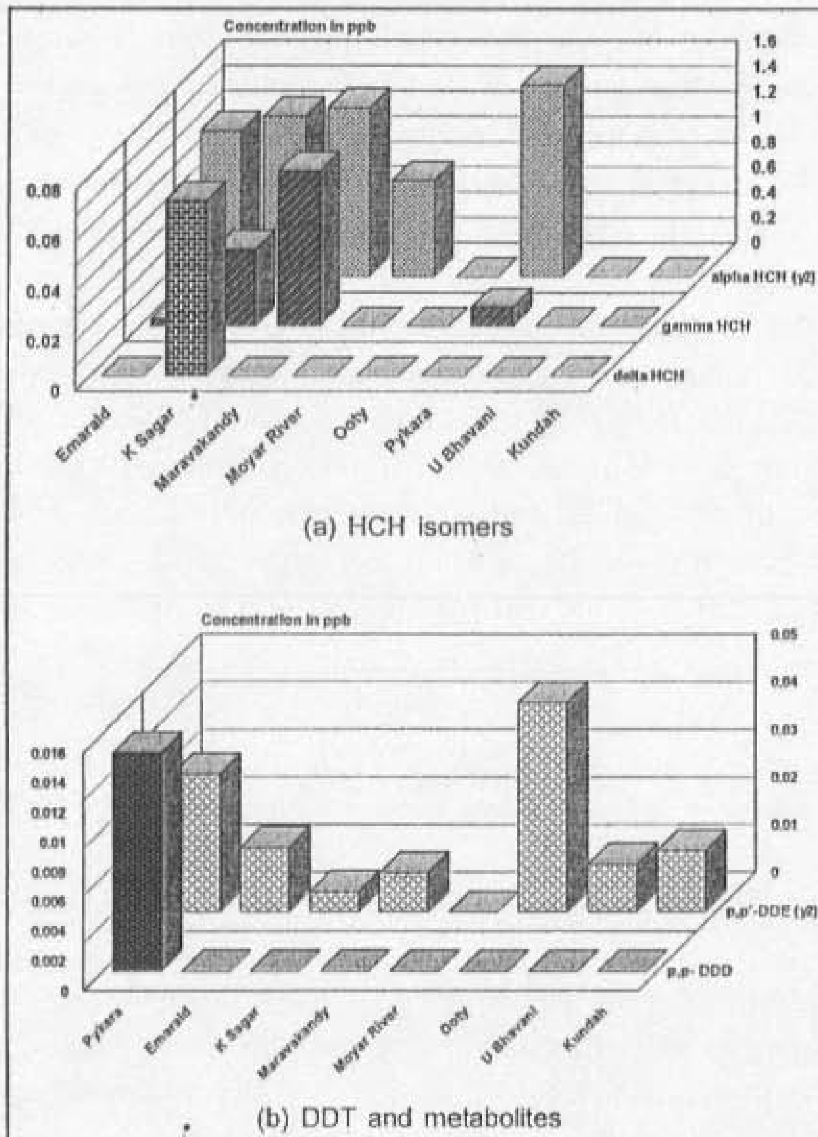


Figure 4. Pesticide residues in sediments of Nilgiri district 1995-97

Seasonal variation among the study sites was not significant (P>0.05). Similarly differences among years were also not significant (P>0.05) except gamma HCH. This situation may be because of the presence and quantity of residues may be influenced by a number of factors including the runoff potential and intrinsic properties of the pesticides (Kreuger *et al.*, 1999).

Further, the levels of all the pesticides and metabolites are lower than the levels recorded in the sediments of Mahala water reservoir, Jaipur (Misra 1989). It may be noted that very little information is available on the levels of organochlorine residues in the sediments in India. Guidelines for all the pesticides are not available in the literature to assess the contamination status of the sediments of the study sites. However, as per the Canadian sediment quality guidelines Probable Effects Level (PEL), in none of the study sites, the concentrations of total DDT exceeded the 6.75 µg/kg level (Environment Canada, 1999).

Canadian Sediment Quality Guidelines define three levels of protection:

- Concentrations of chemicals in sediments below the guidelines that are not associated with biological effects,
- Concentrations between the guidelines and the Probable Effects Level (PEL) that may occasionally be associated with adverse effects and
- Concentrations above the PEL that are expected to be frequently associated with biological effects.

Such guidelines are lacking in India. To protect the aquatic life, more particularly the benthic organisms, guidelines have to be setup taking into consideration of the Indian context.

Sediment quality guidelines have a broad range of potential applications. They can serve as final goals or interim targets for national and regional toxic chemical management programs, as benchmarks, targets or prioritization tools for the assessment and remediation of contaminated sites, or as the basis for the development of site-specific objectives. In addition, they may be used as environmental benchmarks for international discussions on emission reductions; as environmental guidelines on trade agreements; in reports on the state of regional or national sediment quality; in the assessment of the efficacy of environmental regulations; in evaluations of potential impacts of developmental activities; and in the design, implementation and evaluation of sediment quality monitoring programs. Sediment quality guidelines are generally used as screening tools and in the formulation of initial management decisions. They are often used in combination with other sediment assessment approaches such as toxicity tests, community assessments or bioaccumulation.

Sediments provide habitat for many aquatic organisms but is also a major repository for many persistent chemicals that are introduced into surface waters. Concentrations of contaminants are often several orders of magnitude higher in sediment than in overlying water. Thus the long-term release of low concentrations of chemicals into water can result in elevated concentrations in sediments. Contaminated sediments may be directly toxic to aquatic life or can be a source of contaminants for bioaccumulation in the food chain. While many contaminants tend to sorb to sediments, concentrations of the contaminants are not highly correlated to bioavailability (Ingersoll 1991). However, the present investigation did not look at this aspect.

Pesticide occurrence in sediments could result in adverse effects on sediment living organisms. Denitrifying microorganisms are of particular concern since they contribute to reduce the nitrogen load from agricultural land to eutrophicated lakes. Svensoson and Leonardson (1992) demonstrated the inhibitory effect of the fungicide fenpropimorph on denitrification in lake sediments of southern Sweden, whereas the denitrifying microorganisms were unaffected by addition of the insecticide fenvalerate. It may be noted that although the present study did not include the referred pesticides, both the pesticides are being used in the Nilgiris as fungicides quite extensively. Hence, although the ill effects are not documented, it is quite possible that the system is suffering. Regarding the persistent organochlorine pesticides, since considerable quantity of a few pesticides, namely gamma HCH and endosulfan are being used, regular monitoring is recommended.

IV. Pesticide residues in Fishes

In all, around 1050 fishes comprising six species of fishes, namely *Cyprinus carpio communis* (scale carp), *C c nudus* (leather carp), *C c specularis* (mirror carp), *Salmo gairdneri gairdneri* (rainbow trout), *Oreochromis mossambicus* (cichlids), *Barbus carnuca* were collected seasonally from the study sites, namely Ooty lake, Kamaraj Sagar, Pykara, Emerald, Kundah, Upper Bhavani and Maravakandy reservoirs and analysed for pesticide residues. The results have been compiled in two angles so as to look at site and species wise pattern.

Fishes of Kamaraj Sagar had the highest residue levels of all the pesticides detected (figure 5 a & b). The fishes of Kamaraj Sagar recorded the highest level of delta HCH (77.68 ppb) followed by Ooty lake (65.52 ppb), while Upper Bhavani was the lowest (1.29 ppb). Gamma HCH was the maximum in the fishes of Kamaraj Sagar and Pykara; the minimum was in the fishes of Kundah. Alpha HCH also showed almost the same pattern as that of Gamma HCH, however its lowest was in the fishes of Upper Bhavani (0.40 ppb) (figure 5 a).

The maximum of concentration of *p,p*-DDD, *p,p'*-DDT and *o,p'*-DDT was detected in the fishes of Ooty lake followed by Kamaraj Sagar reservoir with the valuues being 4.12, 5.25, 23.72 and 3.13, 3.58, 21.79 ppb respectively. *p,p'*-DDD was the minimum in Maravakandy (0.074 ppb) and below detection level in Upper Bhavani, Kundah and Pykara.

p,p'-DDT and *o,p'*-DDT was the lowest in Upper Bhavani and Pykara respectively, while it was not detected in the fishes of Kundah. *p,p'*-DDE was detected in the fishes of all the study sites with the highest in Ooty lake (15.25 ppb) and Kamaraj Sagar

(12.97 ppb) and lowest in Upper Bhavani. (0.58 ppb) (figure 5 b).

Of all the study sites alpha endosulfan was detected only in two locations, namely Kamaraj Sagar (16.24 ppb) and Pykara (5.4 ppb), whereas beta endosulfan did so in the fishes of Kamaraj Sagar (2.23 ppb) and Moyar (3.25 ppb).

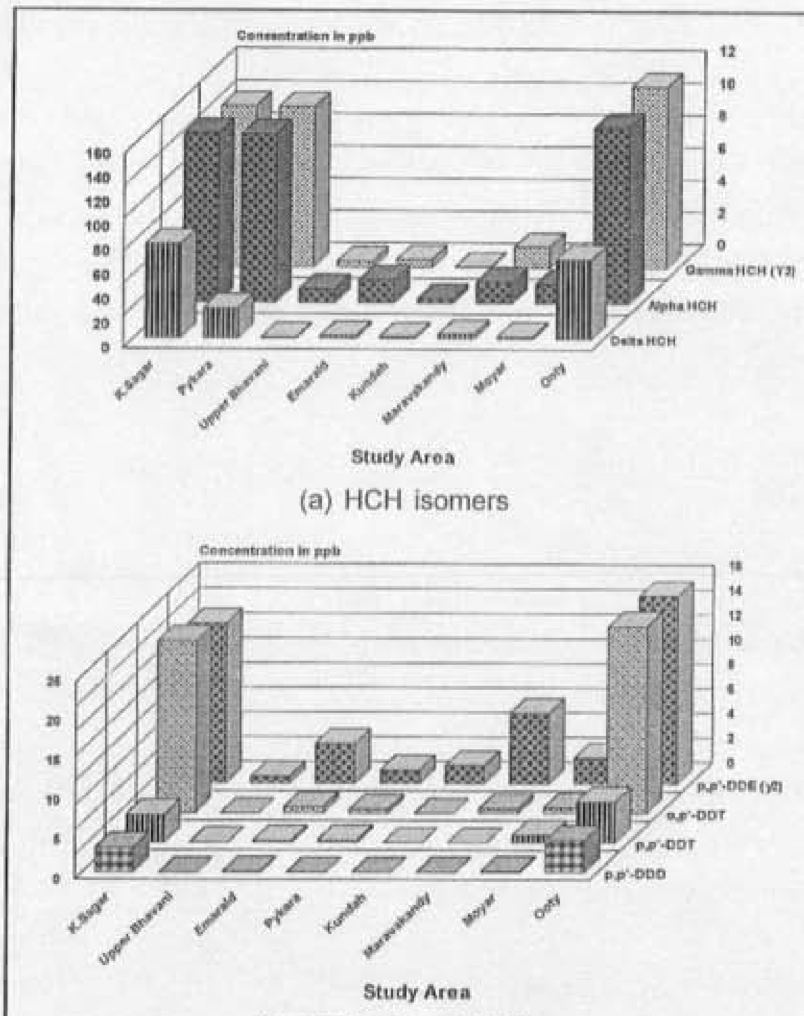


Figure 5. Organochlorine pesticide residues in fishes of Nilgiri district (1995 – 97)

It may be noted that in all the reservoirs included in the present study, power generation is in place. Invariably in all the study sites, according to the fishermen who have been fishing for many years, the fish catch, mainly carps has been decreasing. While unscientific water level management and other ecological reasons could be attributing to the decreased fish yield, impact of agriculture inputs could not be ruled out.

Even if these chemicals are present in very trace quantities in water, they are hazardous because fishes are known to concentrate them to 100s of folds. Unfortunately, these chemicals are not always selective and many have adverse effects on non-target organisms. These compounds may also be detrimental to fish by interfering with their metabolism and / or reduced egg hatchability. Moreover, while the present investigation is restricted to organochlorine pesticides, impact due to other chemicals such as organophosphates and carbamates can not be ruled out.

V. Variation in pesticide residues among various species of fishes included in the study

All the species of fishes varied in the pesticide load (figure 6 a & b) significantly ($p<0.001$). Of the six species studied, *Oreochromis mossambicus* had the highest level of alpha HCH followed by *Cyprinus carpio communis* and *C c specularis* had the lowest level (5.98 ppb). In the case of gamma HCH, *Barbus curmuca* measured the maximum and *C c nudus* the minimum. Delta HCH ranged from 0.04 ppb in S g gairdneri to 7.51 ppb in *C c nudus* (figure 6 a).

Oreochromis mossambicus had the highest residue of *p,p'*-DDE (5.86 ppb) and *o,p'*-DDT (0.72 ppb). *p,p'*-DDD was not in detectable level in any of the six species of fishes except in *Oreochromis mossambicus* (0.12 ppb). Similarly *p,p'*-DDT was in detectable level only in *Oreochromis mossambicus* (0.72 ppb) and *S g gairdneri* (0.05 ppb) (figure 6 b).

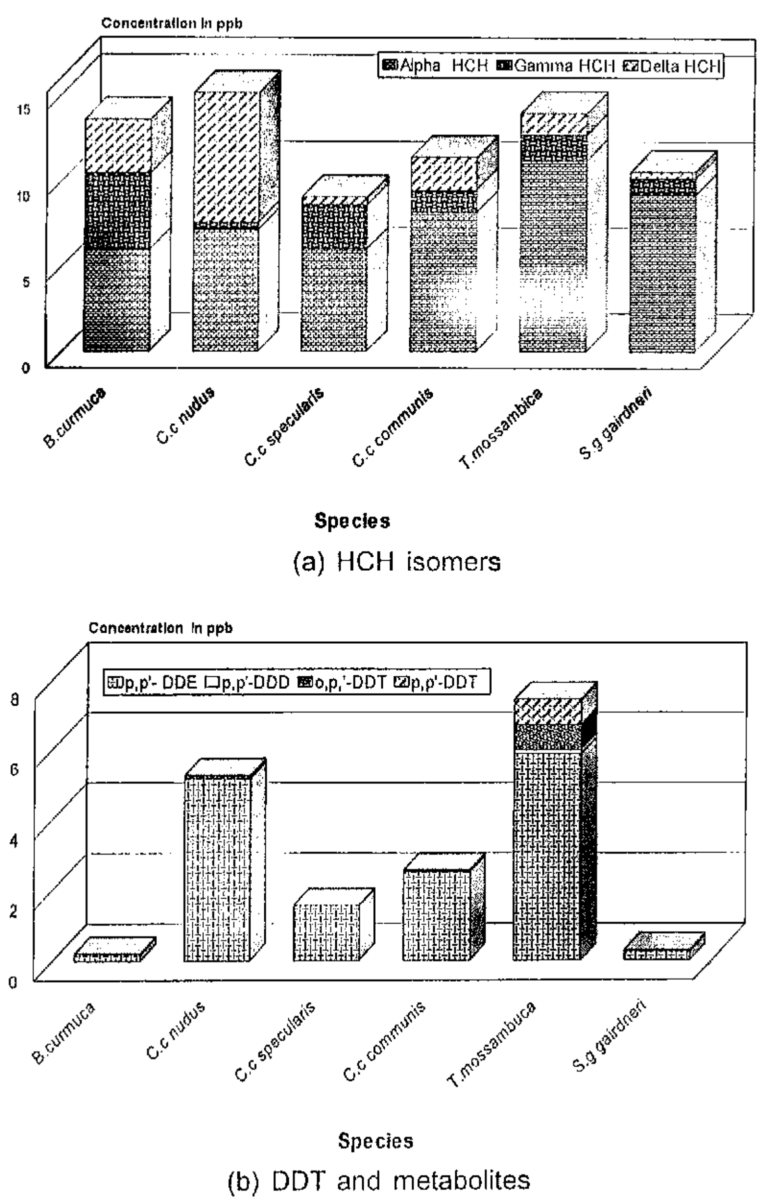


Figure 6. Variation in pesticide residues among a few species of fishes of Nilgiri district (1995 - 97)

Endosulfan was detected in three species, namely *C c specularis* (1.95 ppb), *C c communis (2.05 ppb) and Oreochromis mossambicus* (2.02 ppb). Further, it may be noted that these residues of endosulfan were detected in fishes collected during March–April (1996), the main cultivation season in the Nilgiris. The absence of beta endosulfan residues in fishes may be a consequence of low persistence of beta isomer in the aquatic environment. Since beta endosulfan is less soluble in water and more strongly bound to the soil particles than alpha isomer (Beyers *et al.*, 1965), alpha isomer is carried by run-off to the aquatic environment.

Residues of organochlorine in fishes have often been used as indicators of contamination of aquatic environments (Phillip 1980). Residue level is dependent on the concentration to which the fishes were exposed, exposure time and time between exposure and sample collection. In addition, the results can be confounded by other factors such as species of fish and the sex, size and also lipid content of individual animals (Nowak *et al.*, 1995).

Endosulfan is reported to be highly toxic to fish (the 28-h LC 50 = 0.09 - 11.2 µg/l depending on the species and temperature). Fishes have been shown under laboratory conditions to accumulate endosulfan directly from water, giving whole body concentration factor up to 2755 times than in the water. Studies show that endosulfan although is readily detoxified and excreted by fish, it can accumulate while they are exposed. Levels found in the present study are much below known toxicity values and also below levels known to be associated with ill effects. However, further studies are expected to reveal more information.

The district Nilgiris is characterized by high agricultural and fishing activity and almost all the water bodies included in the present study do receive agricultural runoff. Under this circumstances, it is expected that even if there is no immediate impact, in long run, there going to be change in the fish community.

Newell *et al.*, (1987) had reported a guideline value of 200 µg/kg of total DDT in fishes for the protection of fish-eating birds. Although in none of the fishes included in the present study, the levels of DDT exceeded the referred guideline value, we need to be conscious. Many organochlorine pesticides and PCBs also have been linked to hormone disruption and reproductive problems in aquatic animals (Colborn *et al.*, 1993). Fishes are the most effective indicators of environmental contaminants present in the water as they have greater potential to bioaccumulate and biomagnify the contaminants more particularly the persistent organochlorines. Although many of the organochlorine group of pesticides have been banned, still we find unsafe levels of residues in the environment. Further, many shot-lived pesticides belonging to organophosphate and carbamates are being used quite extensively in the name of replacements. But the impact created by these ephemeral substances on the aquatic ecosystems and particularly fishes are not assessed. These fishes are also considered to be conveyers of chemical carcinogens to the human population. Although not much of information is available on the levels of residues in the fishes, the available information show presence of 6300 µg/g (total HCH) and 7077 µg/g of total DDT in the fishes of village ponds in India (Dua *et al.*, 1996). Unfortunately these levels have not been related to any effects on fishes, fish-eating birds and human beings.

Misra (1989) recorded a maximum concentration of *p,p'*-DDT (47.7 ug/g) and *p,p'*-DDE (17.09 µg/g) in *Labeo bata* collected from Mahala water, Rajasthan, India, but did not reported any effects. It may be noted taht the concentrations recorded in the fishes included in the present study are less than the concentrations referred above.

As the organochlorine pesticides have adverse effects not only on the fishes and other aquatic ecosystems, but also on the public health, their regular monitoring is strongly advised. Although we have phased out in considerable quantity many organochlorines due to their established ill effects, still there are many being used for agricultural crop pests and public health purposes. Further, whatever we used till recently are expected to be in the environment for many more years.

VI. Dietary exposure

In this study attempts have been made to estimate the average daily intake of organochlorine residues to man through consumption of fishes and the results are presented (location and species wise) in table 1. Based on the guideline available in the literature, the dietary intake concentrations are calculated. Precisely the residue levels in fishes are multiplied by the presumed consumption quantity of 250 g per week. The results are expressed in terms of µg/person/day and compared with the Acceptable Daily Intake (ADI) recommended by UHEP/FAO/WHO (1989) and ADI of Provisional Health Canada (1996).

The World Health Organization (WHO) has recommended a minimum per capita consumption of 11 kg of fish per annum for Indians (Kumari *et al.*, 2001) in terms of meeting the protein requirement. In India, information available on the dietary intake of organochlorine pesticides by people through consumption of fish is scarce except a couple of reports. Kannan *et al.*, (1992) reported higher proportion of HCH and DDT dietary intake on the basis of total food stuff consumption. Kumari *et al.*, (2001) calculated the daily intakes of DDT, HCH and endosulfan to be 3.48, 8.48 and 0.61µg respectively through consumption of Gangetic fishes. The estimated dietary intakes reported in the present study are higher than the intake levels reported in the above referred studies.

Table 1. Comparison of Average Dietary Intake (ADI) of organochlorine residues with FAO/WHO guidelines (µg/person/day)

S.No		ΣHCH*	ΣEndosulfan**	ΣDDT***
	Places			
1.	Ooty	6706.9	0.0	1456.5
2.	Kamaraj Sagar	1264.8	7.6	109.9
3.	Moyar	527.1	86.7	101.5
4.	Emarald	536.1	0.0	122.2
5.	Maravakandi dam	281.8	0.0	407.2
6.	Upper Bhavani/Avalanche	333.3	0.0	17.7
7.	Kundha	208.5	0.0	56.9
8.	Pykara	50.0	0.0	72.5
	Species			
1.	*Cyprinus carpio nudus*	1375.6	0.0	139.8
2.	*Oreochromis mossambicus*	431.4	61.9	245.5
3.	*Cyprinus carpio communis*	391.5	0.0	89.3
4.	*Barbus curmuca*	460.8	0.0	10.9
5.	*Cyprinus carpio specularis*	297.3	17.8	37.7
6.	*Salmo gairdneri gairdneri*	333.3	0.0	17.7
	FAO/WHO (1989) Limits	-	450	300
	Health Canada (1996)	18	-	1200

* - (total of alfa, gamma and delta HCH)
** - (total of alfa and beta endosulfan)
*** - (total of *p,p'*-DDT, *p,p'*-DDD, *p,p'*-DDE and *o,p'*-DDT)

Matsumoto *et al.*, (1980) reported total average intake of PCBs by a Japanese person to be 2.6 µg (60 kg body weight), of which about 80% came from fishes and the rest from sea food. In the present study, the calculated dietary intake of total HCH through consumption of fishes collected from Ooty lake and Kamaraj Sagar reservoir exceeded the ADI level of 18 µg (Health Canada 1996) by 372 and 60 times respectively.

On the whole, consumption of any of the 95 % of fishes available in the entire distrcit would mean to exceed the recommended ADI. Similarly DDT intake exceeded the 300µg of ADI (FAO/WHO) in 11 % of the fishes.

Among all the species included in the present study, *Cyprinus carpio nudus* is the most contaminated one, while *Cyprinus carpio specularis* and *Salmo gairdneri gairdneri* are the less contaminated species. Of the eight locations included in this study, dietary intake of total DDT through consumption of fishes from Ooty lake and Maravakandi dam are two to five folds higher than the FAO/WHO limits of 300 (µg/person/day). Intake through fishes of Pykara appears to be the least. However, fishes of Pykara cannot be considered safe as very high levels of endosulfan was detected in the fishes found in the stomach of Large Cormorant. But another argument could be that as the levels of endosulfan in the fishes collected during the regular sampling did not show very high level of endosulfan, we may presume that the cormorants might have fed elsewhere before they were caught at Pykara. However, endosulfan intake is comparatively less than the ADI limits. It may be noted that the recommended ADI limits for total DDT include all the six metabolites of DDT but, the present study included only four metabolites, namely *p,p'* DDT, DDE, DDE and *o,p*-DDT. Hence, the dietary intake of total DDT could be more than the values reported presently.

It can be concluded from the present study that the dietary intake of HCH and DDT through consumption of fishes from all the study sites is very high. It shows the widespread occurrence of these residues in the aquatic system and their continued usage. More specifically consumption of fishes from Ooty lake will create health hazards to human if the situation continues to be the same.

VII Pesticide residues in birds

Six species of birds were examined for organochlorine residues. Name of the species and number of samples included in the present study are tabulated in Table 2.

Table 2. Birds included in the study

S.No.	Name of the species	Number of individuals
1.	Large Cormorant *Phalacrocorax carbo*	10
2.	Little Egret *Egretta garzetta*	10
3.	Cattle Egret *Bubulcus ibis*	5
4.	Pond Heron *Ardeola grayii*	10
5.	Common Myna *Acridotheres tristis*	10
6.	Jungle Babbler *Turdoides striatus*	10

I. Results

a) Large Cormorant

Out of the ten Cormorants included in this study, five individuals recorded unusually very high levels of endosulfan, as high as 217.2 ppm. Hence, endosulfan in those five individuals is treated seperately (Table 3). It may be noted that among the six species of birds analysed for organochlorine residues, the Large Cormorant recorded the maximum concentrations of endosulfan and dieldrin. The average concentration of

Table 3. Levels of total endosulfan in Large Cormorant (N = 5).

Organ	Brain	Liver	Kidney	Muscle	Food content
Average	10.90±14.9	126.80±100.2	112.88±57.2	217.2±124.9	2.33±206.5

endosulfan in the other five individuals ranged from 2.74 in brain tissue to 41.87 ppm in muscle. The concentration of heptachlor epoxide does not show much variation among the organs; it vareid between 0.16 and 0.56 ppm. Residues of the most persistent chemical, the *p,p'*-DDE was detected in all the tissues. Fairly high concentation of *p,p'*-DDE was detected in muscle (10.29 ppm) and liver (5.58 ppm), while the lowest concentration was in food content (0.15 ppm). The concentation of *p,p'*-DDT and *p,p'*-DDD ranged from 0.7 to 4.10 ppm and 0.02 to 0.93 ppm respectively. The average concentration of total HCH and dieldrin ranged from 0.24 to 2.33 ppm and 0.038 to 21.83 ppm respectively (figure 7).

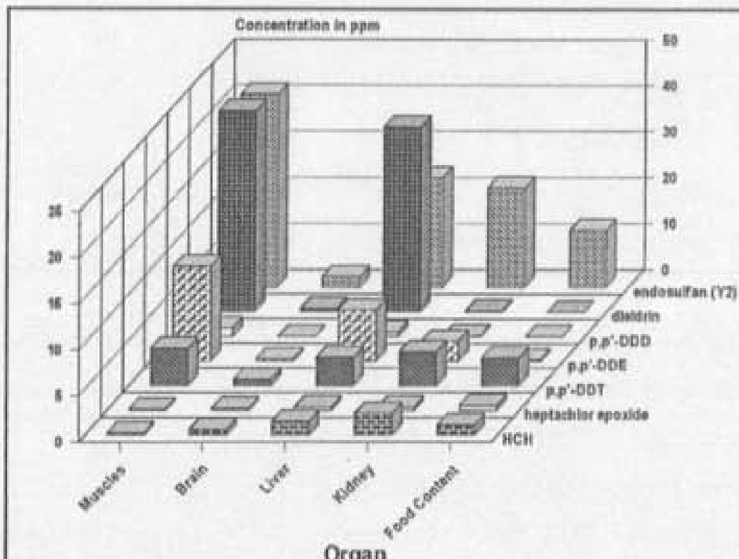


Figure 7. Organochlorine residues among various tissues of Large Cormorant

b) Little Egret

The primary organochlorine residues detected among the tissues were *p,p'*-DDE and endosulfan. Of the various tissues analysed, muscle recorded the maximum mean concentration of *p,p'*-DDE 10.01 ppm while brain the minimum (0.008 ppm) (figure 8).

Interestingly, one of the ten birds analysed showed a maximum of 99.5 ppm of *p,p'*-DDE in muscle tissue. Concentration of *p,p'*-DDE was several fold higher than the concentration of *p,p'*-DDT and *p,p'*-DDD. The average concentration

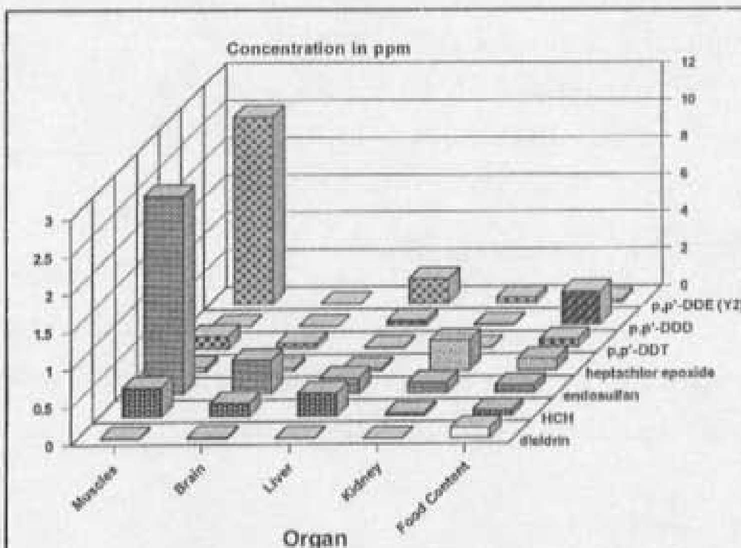


Figure 8. Organochlorine residues among various tissues of Little Egret

of *p,p'*-DDT and *p,p'*-DDD varied from 0.01 to 0.173 ppm and 0.001 to 0.447 ppm respectively. Total endosulfan was the highest in the muscle tissue (2.64 ppm) and the lowest in the food content (0.105 ppm).

The levels of dieldrin and heptachlor epoxide were comparatively lower than the other chemicals detected with values ranging from 0.003 to 0.136 ppm and 0.034 to 0.40 ppm respectively. The highest levels of HCH was detected in muscle (0.39 ppm) followed by liver tissues (0.31 ppm), while kidney (0.04 ppm) recorded the lowest.

C) Cattle Egret

Residues of organochlorine chemicals were found more often in liver and muscle tissues than brain and other organs.

The maximum concentration of dieldrin was detected in muscle (0.21ppm) while it was below detection limits in food content. Total endosulfan was the highest in muscle tissues (4.364 ppm) and the lowest in brain (0.006 ppm).

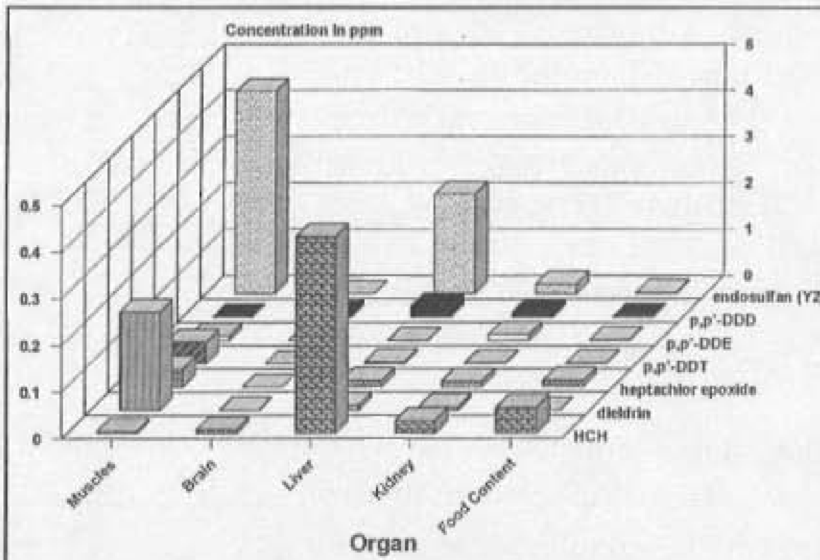


Figure 9. Organochlorine residues among various tissues of Cattle Egret

The residues of HCH were the second highest contaminant in this species (figure 9). The mean concentrations of HCH residues among the organs ranged from 0.005 to 0.42 ppm. The most persistent chemical *p,p'*-DDT and its metabolite *p,p'*-DDE was not detected in the brain tissue of any of the ten individuals analysed, whereas 0.007 ppm of *p,p'*-DDD was recorded in brain. However, 0.013 and 0.01 ppm of *p,p'*-DDE was detected in kidney and muscle tissues respectively. The maximum residue of (0.04 ppm) of heptachlor epoxide was detected in muscle tissues and minimum in brain (0.001 ppm).

d) Pond Heron

The concentration of organochlorine residues detected in liver and muscle tissues were higher than the other tissues in Pond Heron. The residues of HCH were detected in all the tissues, with the maximum (0.27 ppm) and minimum (0.013 ppm) liver and kidney tissues respectively. The residues of *p,p*-DDT and its metabolites varied widely from non-quantifiable to moderate levels. The highest concentration of *p,p'*-DDE, the most persistent residue, was detected in brain (0.48 ppm) tissues and lowest in food content (0.006 ppm) and kidney (0.004 ppm) (figure 10).

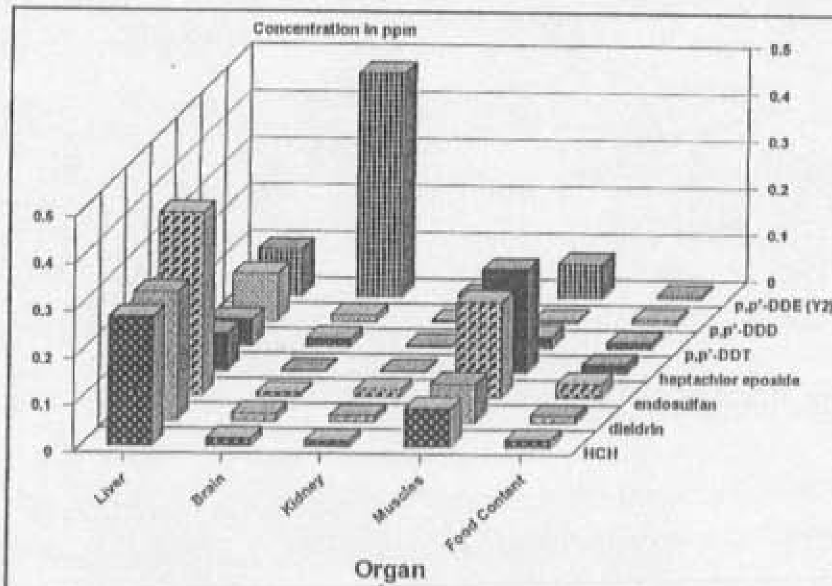


Figure 10. Organochlorine residues among various tissues of Pond Heron

The total endosulfan concentrations varied from 0.007 ppm in brain tissue to 0.20 ppm in muscle. Liver tissue recorded the maximum of 0.27 ppm of dieldrin followed by muscle (0.08 ppm) while it was the least in kidney (0.013 ppm). The heptachlor epoxide did not exhibit much difference in the contamination pattern among the organs in Pond Heron with values ranging between 0.004 ppm in brain and 0.22 ppm in muscle.

e) Common Myna

Among the various tissues analysed for organochlorine residues, the muscle and liver tissues recorded the highest concentrations (figure 11). The mean maximum concentration of *p,p'*-DDE was recorded in muscle (5.34 ppm) and minimum in kidney (0.001 ppm) tissues. The concentration of *p,p'*-DDT

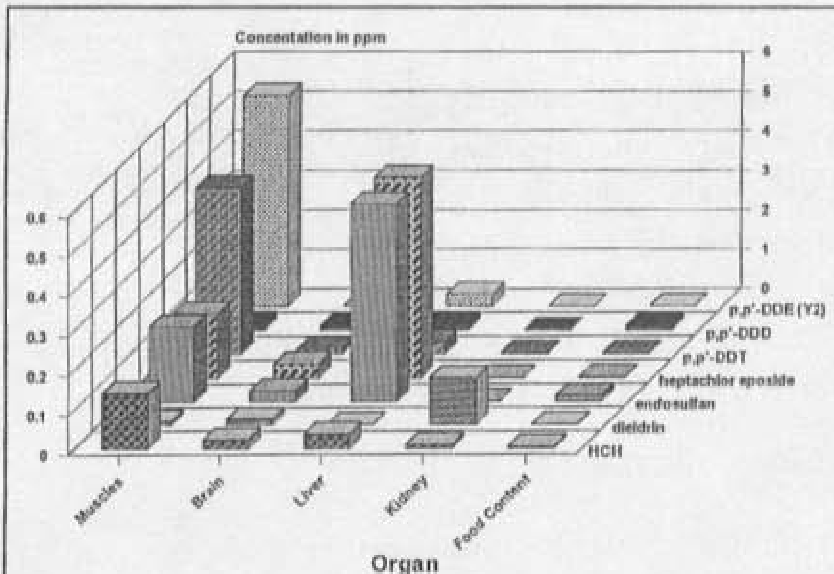


Figure 11. Organochlorine residues among various tissues of Common Myna

and *p,p'*-DDD among the tissues ranged from 0.003 to 0.42 ppm and 0.001 to 0.02 ppm respectively.

The level of dieldrin was in trace with the values falling within a narrow range of 0.002 to 0.12 ppm. The liver tissues recorded the maximum levels of total endosulfan and heptachlor epoxide, 0.49 and 0.51 ppm respectively. Brain tissues recorded the lowest load of total organochlorine residues than other tissues. The residues of HCH among the organ ranged from 0.005 to 0.14 ppm.

f) Jungle Babbler

The mean concentrations of organochlorine residues in Jungle Babbler were lower than the other species included in the present study.

Among the organs, muscle tissues recorded comparatively higher levels. The mean residual concentrations of HCH among the tissue did not show much variation and it ranged between 0.01 ppm and 0.1 ppm. The highest concentration of total endosulfan (0.83 ppm) and dieldrin (0.03 ppm) was recorded in muscle tissue while heptachlor epoxide was detected only in muscle (0.13 ppm) and kidney (0.01ppm) tissues. Contamination of this species by DDT and its metabolites occurred at lower levels. Among the metabolites, the residues of the most persistent *p,p'*-DDE was higher than the other metabolites, with a level of 0.001 ppm in food content and 0.04 ppm in muscle tissues (figure 12).

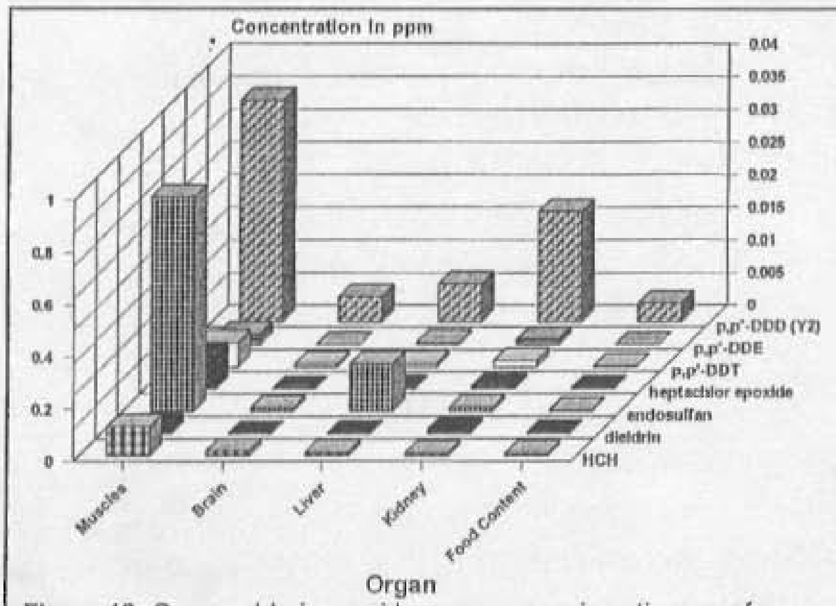


Figure 12. Organochlorine residues among various tissues of Jungle Babbler

Statistical analysis

One sample 't' test was performed to know the variation of organochlorine residues among the species and tissues. A statistical software student version 10 was used for the analysis. Variations in organochlorine residues among the species and organ were significant ($P < 0.05$) except dieldrin.

ii. Discussion

a) HCH and its isomers

The isomers of HCH namely alpha, beta, gamma and delta were detected in the tissue of the all the six species of birds. Total HCH residues among the four species of fish-eating birds were higher than the concentration recorded in two terrestrial species. There is no much information available on the mortality of birds due to HCH poisoning in the wild in India and elsewhere. However, some information generated in the laboratory give some basic information about HCH and its toxicity. Rock doves when treated with 72 ppm of gamma HCH, one bird that died on the 7^{th} day had 31.6 ppm in the liver. Birds those were sacrificed during dosing had 18.7 to 67 ppm in liver. Birds those were sacrificed after 15 days of dosing had 1.2 to 37.1 ppm in the liver. While not diagnostic, these residues can be related to dangerous exposure to the toxicant. The results of the present study do not fall within toxic levels, but indicative of exposure.

The total HCH concentration in brain tissue of Cattle Egret in the current study were comparable with the earlier total HCH concentration reported by Kaphalia *et al.*, (1981). However, the Large Cormorant, a piscivorous bird recorded very high concentration of total HCH in liver (nd to 18.73 ppm) and kidney (nd to 54.34 ppm). The piscivorous species that feed mainly on small fishes and insects contained the highest concentrations of pesticide residues than the terrestrial birds. Among the species, HCH residues were higher in aquatic birds than those in terrestrial birds which is somewhat similar to those observed in birds from South India (Ramesh *et al.*, 1992; Tanabe *et al.*, 1998). This could be largely based on the contamination level of the food item.

Technical HCH is still being used in India in large quantities (approximately 36 million kg/year) for agriculture purposes and elevated levels of HCHs have been common in most environmental samples collected from India (Ramesh *et al.*, 1992). HCH is the most predominantly detected contaminant among the birds and these residues can be expected to creat toxic effect to birds (Minth *et al.*, 2002). But details of the effects are not available.

b) *p,p'*-DDT and it metabolites

Technical grade DDT, applied in the field, breaks down to several metabolites due a number of physical and biological factors in the environment. Of these compounds, only *p,p'*- derivatives have been related to adverse environmental effects. And hence, only those three metabolites are discussed here.

The proportion of *p,p'*-DDE was the highest among the DDT compounds, in different body organs of all the six species of birds examined and it indicates the greater ability of birds to transform *p,p'*-DDT to *p,p'*-DDE (Minth *et al.*, 2002). The residues of parent compound, *p,p'*-DDT and the metabolite, *p,p,'*-DDD are less frequent in occurrence. Interestingly, Large Cormorant contained a relatively higher proportion of *p,p'*-DDT than those in other species examined. Results of the present study show the continuous presence of persistent *p,p'*-DDE in the environment.

Although DDT was initially considered as a boon in handling pest outbreaks, subsequently environmental problems loomed larger than the positive aspects. As a result, DDT was banned in many parts of the world. However, the use continues in a few countries, particularly for control of insects and disease vectors (Blus, 1996). In India it is being used for control of malaria and kala azar. The annual consumption is estimated at 14 million kg (Singh *et al.*, 1978). An earlier study on organochlorine residues in some Indian birds by Kaphalia *et al.*, (1981) showed that the arithmetic mean concentration of *p,p'*-DDE, *p,p'*-DDT in brain tissue of Cattle Egret were 0.028 and 4.976 ppm respectively which is somewhat lesser than the concentration recorded the current study. It is also reported that the accumulation in this species was higher than that of chicken and pigeon while less than the concentration of recorded in flesh-eating birds like kite and vulture Kaphalia *et al.*, (1981). Birds can store sub-lethal doses in their body fat, and this accumulation can cause poisoning or deleterious effects later when fat reserves are utilized. Delayed effects can be produced also by consumption of very minute amounts of DDT (as little as 0.0003 ounces daily during a two-month period). There may be no outward effects on the adult birds, but production and fertility of eggs and survival of young will be reduced significantly (George, 1958).

The concentration of *p,p'*-DDE and *p,p'*-DDD recorded in the present study are less than the concentration reported by Prouty *et al.*, (1982) in brain tissue of Cooper's hawk (p,p,-DDE 200 mm; *p,p'*-DDD 16 ppm; and *p,p'*-DDT 46 ppm), which is confirmed to be DDT poisoning. Experimental studies by Stickel and Stickel, (1970) on Cowbirds had shown that lethal residues of DDT plus DDD in the brain generally exceed 30 ppm. Stickel, (1984) mentioned that resides of DDE in the brain were clearly diagnostic if the residues levels exceeded 300 ppm. Stickel *et al.*, (1970) concluded that brain concentration of $\geq$ 65 ppm of DDD indicates an increasing likelihood that death was due to poisoning. Reports on the levels of DDT in the liver tissues indicative of lethality are also available. However, it appears to differ from residues in the brain tissues. In the United States the only liver analysis from wild birds that apparently died from DDE was that of a Great Blue Heron that had 246 ppm in the brain and 570 ppm in the liver (Call *et al.*, 1976).

The environmental persistence of historically applied organochlorine pesticides has been well documented in the northern hemisphere (Loganathan and Kannan, 1994). Because of the persistency, detection of reissues has been regular affair and the birds and other wildlife are put in to continuous risk. DDT and derivatives are quite stable and are resistant to enzyme action; thus, residues accumulate in biological tissues. The levels of DDT residues present in the body are occasionally taken as an index of contamination by DDT and its metabolites of the local environment (Kaphalia *et al.*, 1981). Recent studies dealing with other biological samples, such as fish, soil and water collected from various locations in the Indian regions have revealed relatively high proportions of DDT and its derivatives, suggesting ongoing application of DDT in the environment. It is also reported that the concentration of DDT incorporated by birds comes exclusively from terrestrial environments. However, birds inhabit diverse ecosystems and feed on a variety of prey, their exposure may vary widely in degree and type of contaminants.

c) Cyclodiene insecticides

Three cyclodiene pesticides (dieldrin, endosulfan and heptachlor epoxide) have been included in the present study. Aldrin readily gets converted to dieldrin. This conversion has been proved by many earlier studies. However, Flickinger and Mulhern (1980) found aldrin fairly persistent in the yellow mud turtle. While a lot of information is available on dieldrin, it is very less in aldrin. Perhaps this is due to the fact that aldrin readily gets converted to dieldrin; thus the effects seen in animals exposed to aldrin may be caused by dieldrin (Peakall 1996). The study by Muralidharan (1993) is in concurrence with this.

Dieldrin

It is a highly toxic organochlorine pesticide. Many species of wildlife have died as result of eating food contaminated with dieldrin. Stickle *et al.*, (1969) reviewed several cases of dieldrin poisoning. Study by Flickinger, (1979) reported death of snow geese in Texas rice fields where seeds were treated with aldrin, which readily converted to dieldrin.

Muralidharan (1993) reported mortality of Sarus Crane and a few other granivorous birds in Keoladeo National Park, Bharatpur. Between 1987 and 1990 18 Sarus Cranes, more than 50 Collard Dovess and a few Blue Rock Pigeon were found dead during winter in Bharatpur, which coincided with the application of aldrin in the crop fields around the Park. Brain tissues of Sarus Carne, Collard Dove and Blue Rock Pigeon contained an average of 19.33, 15.18 and 20.42 ppm wet weight of dieldrin respectively.

Dieldrin in other tissues ranged from 0.78 ppm to 92.26 ppm in Sarus Crane, 3.44 ppm to 66.17 ppm in Collared Doves and 16.92 ppm to 20.99 in Blue Rock Pigeon. Residues of aldrin were as highs as 89.75 in the gastrointestinal tract of a Sarus Crane and 104 ppm in a Collared Dove. Very high reissues of aldrin in the gastrointestinal tract and dieldrin at mush higher quantities in the brain than the lethal levels (4-5) clearly indicated that dieldrin after being metabolized from aldrin, was responsible for deaths.

The registration committee under the Indian Insecticide Act of 1968 banned the chemical with effect from January 1994. However, the problem to the birds of the Park, particularly Sarus Crane is not over as the termite problem in the agricultural field around the part is a continuous phenomenon. Hence, the farmers resort to using the next available chemical, namely endosulfan or chlorpyriphos or monocrotophos and birds do get exposed and every year there are reports about mortality of birds.

In the present study, very high concentrations of dieldrin in muscle (216.4 ppm), liver (199 ppm) and brain (2.8 ppm) tissue of Large Cormorant and 16.48 ppm in liver of Cattle Egret (table 2) indicate the possible toxic effect of dieldrin to these species. A study on feral pigeons (Turtle *et al.*, 1963) had showed that the levels of 9-39 ppm of dieldrin in the flesh are indicative of poisoning. On the basis of a combination of laboratory and field examinations, it was estimated that the lethal level of dieldrin in the brains of birds to reach or exceed 4 ppm (Stickel *et al.*, 1969). It is also reported that about 1 ppm or more of dieldrin in the brain on a wet-weight basis may pose a grave hazard to some birds (Heinz and Johnson, 1982). In the light of the above, it may be suggested that the levels recorded in the present investigation are hazardous to the species specified.

Heptachlor epoxide

A metabolite of heptachlor was detected in one or more tissues of all the birds studied. However, the concentration was less than the other residues analysed. There are not many studies available on the effects of heptachlor epoxide on birds. However, the concentrations detected in these species are comparable with the concentrations reported in the Red-Tailed Hawk near a site of terrestrial contamination in New York State (Stone and Okoniewski 2000).

It is also reported that heptachlor epoxide contributed, along with chlordane residues in the brain (2.8 ppm heptachlor epoxide and 2.1 ppm oxychlordane), could weaken a bird sufficiently so that it could be hand captured. Depression of brain ChE activity indicative of antichlolinesterase pesticide exposure was observed in two birds collected at the Scotch Plains roost in 1997. However, ChE depression was well below the threshold of 50 % that is associated with acute antichloinesterase poisoning (Hill and Fleing, 1982). Stansley and Roscoe (1999) reported that dieldrin levels in poisoned birds were inversely correlated with levels of both heptachlor epoxide and other chlordane residues, suggesting an additive or synergistic interaction. However, it is also reported that the organochlorine residues in herons were related to diet and age of the species (Niethammer *et al.*,1984). This could not be tested in the present study.

Endosulfan

Bird poisoning due to endosulfan have not been widely reported in the literature. Endosulfan is rapidly eliminated and does not appear to accumulate in warm blooded animals. Bioconcentration factor in birds and mammals are less than one (National Research Council Canada 1975). Further endosulfan sulfate in tissues, rapidly reaches a plateau and are readily eliminated when exposure ceases (Maier-Bode 1968). The lowest reported dietary toxicity of endosulfan in birds is reported to be 805 ppm (Hills et al., 1975). Geese which were fed for 17 days on weeds within strawberry fields sprayed with endosulfan (21 ibs/100 gal) exhibited no signs of poisoning and no residues were detected in livers, body fat or stomach content (Dustan 1965).

The proposed criteria of 0.0004 ug/l total endosulfan allowable within waters should be adequate to protect birds and mammals. Schimal *et al.*, (1977) reported bioconcentration factors of endosulfan in two species of fishes after 28 days exposure to 0.035 ug/l endosulfan in flowing water to be 245 and 2755. If these bioconcentration factors were applied, potential concentrations available for consumption by birds would be 0.1 ppb and 0.3 ppm respectively. These concentrations are well below the lowest known effect levels for birds and mammals.

Studies carried out by Matthiessen *et al.*, (1982) recorded less than 0.2 ppm of endosulfan in tissues of a few fish-eating birds, namely Fish Eagle, Red Cormorant and Pied Kingfisher. Insectivorous birds, namely Little Bee-eaters contained 0.043 and 0.019 ppm in brain and liver tissues respectively. Further four other insectivorous birds, namely Grey-backed Bush Warbler, Heuglin's Robin, Black-eyed Bulbul and Scops Owl collected from area after one year of spray had no detectable residues in their tissues.

Endosulfan was first introduced in the 1950s in India and it recently gained more popularity, in practical terms, notoriety mainly in Kerala because of its extensive and prolonged use by Kerala Plantation Corporation on cashew plantation.

In the present study total endosulfan was the highest in the muscle tissues of Large Cormorant, Little Egret, Cattle Egret and Jungle Babbler and in the liver tissues of Common Myna and Pond Heron. Of all the six species of birds included in the present study, 5 individuals of Large Cormorant collected from Kamaraj Sagar measured unusually very high levels of endosulfan II in all the tissues with the maximum being 540 ppm in the muscles tissues. It is interesting to note that the stomach content of these four Cormorants (fishes) also had very high level of endosulfan II; it ranged between 18 and 236.3 ppm. It very clearly indicates that there might have been some localized application of endosulfan which might have contaminated the fish in the vicinity of Kamaraj Sagar. It is difficult to predict or ascertain the exact source of contamination and also the exact waterbody where from these birds might have picked up the contaminated fishes. It may be further noted that no such high levels of endosulfan were recorded in any of the fishes collected from any other water bodies covered in the present study. The implications of such high levels of endosulfan in all the body tissues as well as in the fishes found in the stomach are not predictable due to lack of published information.

High levels of endosulfan detected in the tissues of the Cormorants evidenced by similar levels in the fishes dissected out from the stomach of the birds indicate that the chemical had got into the bird only recently. However, it is not possible to find out the exact place where from these birds might have picked up these fishes. It may be noted that the water and fish samples collected from Kamaraj Sagar during the entire study period did not have high levels of endosulfan residues. There are also no reports available in the literature on the possibility of food chain accumulation of endosulfan comparable to the levels reported in the current study.

It may be noted that endosulfan is used widely in the Nilgiris to control a verity of pests on the vegetables and tea. And it may be possible to find residues in the water and also in the fishes through runoff although the present study did not measure any high levels in the water as well as fishes. But, the presence of high levels of endosulfan in the Cormorants and also in the fishes found in the stomach of the birds suggests that it could be accidental.

III. Conclusion

Harris *et al.*, (2000) reported DDT in the eggs of American Robin and earth worms twenty years ofter its applications at levels comparable to those observed in fields studies where mortality or reproductive effects occurred. Hence, the presence of DDT in the biological and non-biological components included in the present study need not be perplexing. Birds do not always react in the same way to the same chemicals. The Heron provides an excellent example; no decline comparable to that of the Peregrine Falcon and Sparrow hawk has been observed, yet Herons on average appear to carry larger residues than any other birds. Moreover, the information on temporal and spatial trend are necessary to monitor the effectiveness of control measures aimed at limiting release of persistent organic pollutants into the environment (Alcock *et al.*, 2002). Hence, in India although a few persistent chemicals, namely DDT and dieldrin have been banned, unless we monitor the environmental residue levels periodically, the effectiveness of the ban and impending danger to birds and other wildlife cannot be assessed. It may be worth mentioning that DDT and dieldrin are used for malaria and locust control respectively in various part of the country.

Among residues, HCH and endosulfan residues were higher in piscivores than in omnivores and granivores, which is somewhat similar to those observed in birds from Vietnam (Minth *et al.*, 2002). As the status of the fish-eating birds included in the present study is relatively at the top of the aquatic ecosystem, assessment of these birds offer an opportunity for better understanding of the effects of contaminants, at least within the district Nilgiris. Moreover, these fish-eating birds could serve as surrogate species to predict contaminant levels in a few raptorial species of birds where there is overlap of food web as Weseloh *et al.*, (2002) had demonstrated.

Variation in organochlorine residues among the organs and species clearly indicates the difference in residue accumulation capacity among the species. The presence of persistent organochlorine pesticides in liver and brain indicate that they are still being accumulated in birds where they are likely being introduced into higher levels of the food chain (Krol *et al.*, 2002). Additional research is needed on the uptake of organochlorine by birds as well as the toxic interactions among pesticides and related compounds to better define the risks to wildlife, birds and other in the district.

7. SCOPE FOR THE FUTURE STUDY

The present investigation looked at the contamination levels of only the persistent organochlorine. However, as referred elsewhere in the report, there are number of organophosphorous pesticides being used at considerable quantum. Although these chemicals do not stay in the system for a long time, they are also capable of creating ecological imbalance at various levels. Hence, an in-depth study is being planned to be executed in phased manner. It is imperative to implement stricter environmental controls in the district Nilgiris, specifically considering the fragile nature of the ecosystem in order to minimize potential risk to wildlife and also the human beings.

8. STRATEGIES TO OVERCOME PESTICIDE HAZARDS

Future consumption and invention of pesticides in the country present a complex problem. Nevertheless, it looks impossible to dispense with the use of pesticides and other chemicals to meet the growing food requirement by the ever growing human population in this country. There is a need to promote safe and efficient use of pesticides for sustainable agricultural production in the country although the best will be to dispense with the use of chemicals and adopt organic forming. Integrated Pest Management (IPM) programmes for all the crops are needed. There has to be government support for organic farming. To minimize the overdependence on pesticides in crop protection and to avoid hazards to the users of the pesticides, efforts should be made to develop and promote effective and sound Integrated Pest Management programmes. Ecologically and economically sound IPM includes a variety of options such as improved agricultural practices including use of resistant crop varieties, use of non-chemical methods of pest control and pesticide use to manage pest below a level where they cause economic losses. There are enough evidences in states, namely Tamil Nadu, Andhra Pradesh and even Orissa where IPM has gained acceptance among the rice farmers.

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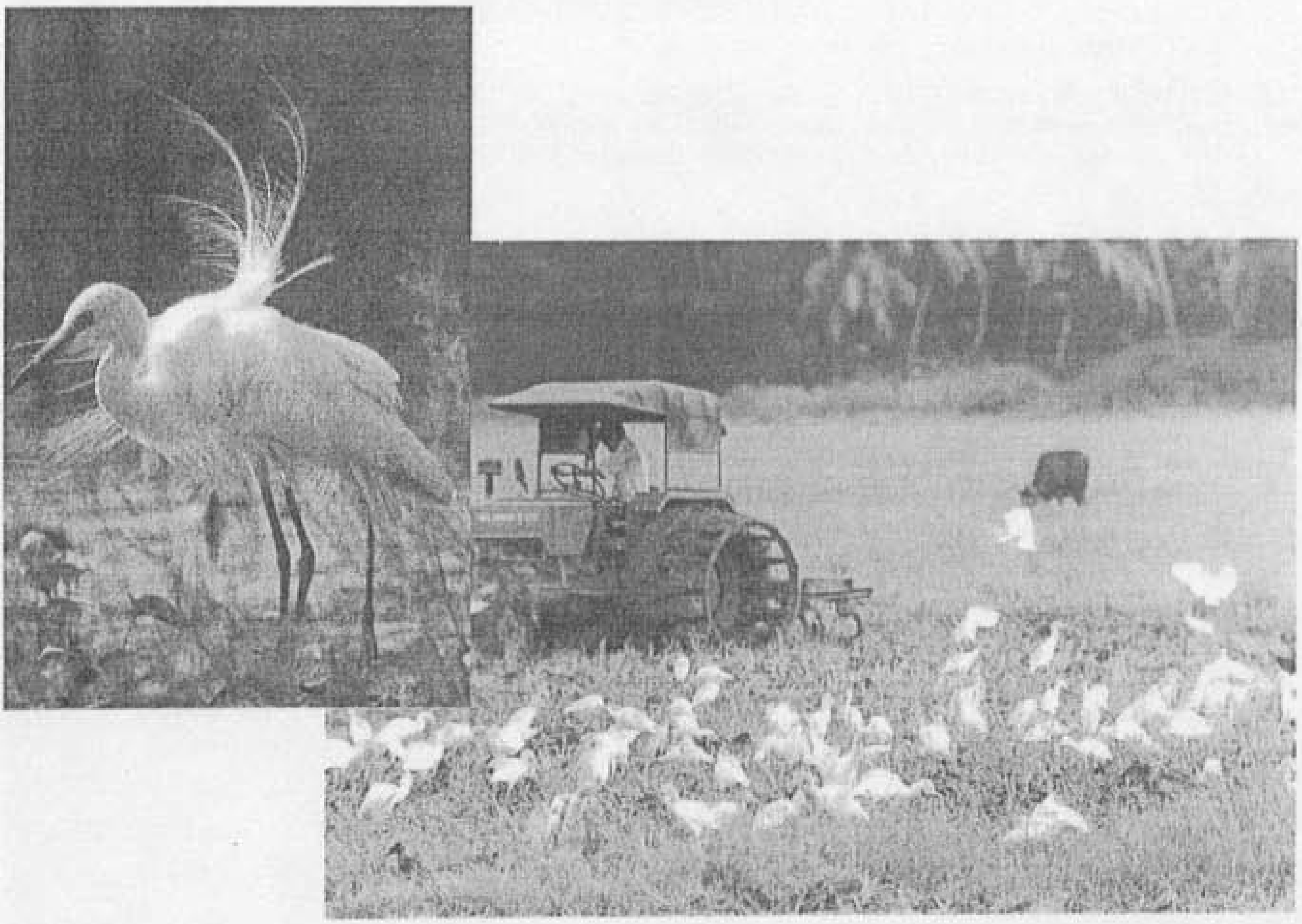

Annexure 1.

Name of the person interviewed: Mr..................................		Village:			Taluk:	Date:	Data sheet No. Recorded by Mr.........................
Crop under cultivation	Growth stage of	Name of the pest & nature of	Area under cultivation	Terrain	Whether the crop attracts birds? If so	Migrant/local others (specify)	Feeding habit of of the bird
1.							
2.							
3.							
Name of the pesticide	Source	Group	Pesticide form	Tot. No. of application during the life span of crop	Quantity of pesticide applied per spray (kg/lit per acre)	Total quantity applied during the life span of the crop (kg/lit.per acre)	Mode of application
1.	Govt. ☐ Pvt. ☐ Others ☐	OC ☐ OP ☐ Carbamate ☐ Others ☐	E.liquid ☐ Dust ☐ Granules ☐				Hand spray ☐ Power spray ☐ Others ☐
2.	Govt. ☐ Pvt. ☐ Others ☐	OC ☐ OP ☐ Carbamate ☐ Others ☐	E.liquid ☐ Dust ☐ Granules ☐				Hand spray ☐ Power spray ☐ Others ☐
3.	Govt. ☐ Pvt. ☐ Others ☐	OC ☐ OP ☐ Carbamate ☐ Others ☐	E.liquid ☐ Dust ☐ Granules ☐				Hand spray ☐ Power spray ☐ Others ☐

Name of the water body which gets the runoff:- ....

Remarks, if any: