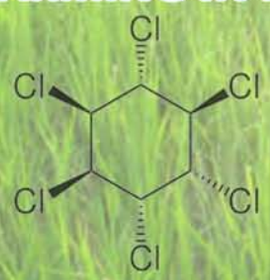
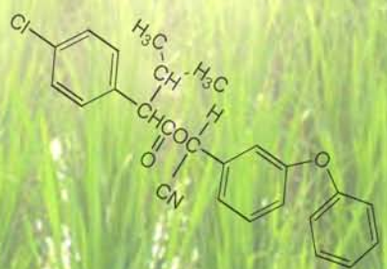
MONITORING OF PESTICIDE RESIDUES IN SELECT COMPONENTS OF AN AGROECOSYSTEM ADOPTING ORGANIC AND CONVENTIONAL FARMING IN PADAYETTI VILLAGE, PALAKKAD DISTRICT, KERALA





Final Report

Submitted to Department of Environment and Climate Change
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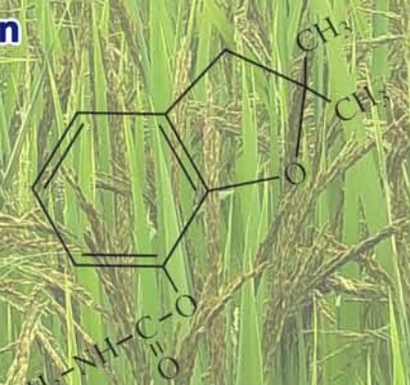
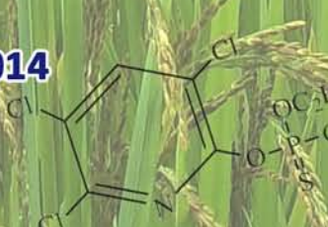


Sálim Ali Centre for Ornithology and Natural History (SACON)
(Aided by the Ministry of Environment, Forests and Climate Change, Govt. of India)
Coimbatore - 641 108, INDIA

DECEMBER 2014



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In collaboration with

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EXECUTIVE SUMMARY

Intensive agriculture to meet the ever increasing food demand by growing human population, has led to increasing concern on the impacts, including loss of soil fertility, diminishing soil biodiversity and of course, lack of sustainability in the entire process. Challenged by these concerns there have been attempts, world over, to develop alternate methods of farming which are environment-friendly and economically viable. At this juncture, Kerala State Biodiversity Board through Department of Environment and Climate Change launched a demonstration project to conserve agroecosystem biodiversity by totally avoiding chemical inputs in Palakkad district, known as the "*Granary of Kerala*" in 2009. As part of this project, the present study was carried out to monitor the pesticide residues in organic and conventional paddy agroecosystem in Padayetti village, Palakkad. Samples of components, namely sediment, crab, snail, fish, frog, paddy, fodder (straw) and cow-milk were collected from organic and conventional farms on seasonal basis and processed for multiresidue estimation. Quantitative and qualitative analyses of a set of historical (20 OCs) and currently-used-pesticides (12 OPs, 6 SPs and 2 Cbs) were performed by GC-MS. Data have been compiled to check the overall load of pesticides and variation in residues between the farming practices, among seasons (*Kharif*, *Rabi* and summer), years and trophic levels. Further, within the group, levels of individual pesticides and their isomers or metabolites have also been compiled wherever applicable. This could help understand the implications with reference to potential health risks associated with the exposure to these pesticides, usage pattern or policy of the government in existence at national (FSSAI, India) and International (USEPA; European Commission; Health Canada; FAO/WHO Codex Alimentarius) level.

Questionnaire survey was conducted among farmers to know the cropping pattern, common crop pests, chemical pesticides and fertilizers used in the village. Information on pesticide application, source, frequency of application, chemical group, quantity, mode of application were collected and compiled. In addition to documenting current use of pesticides, information on historic use was also gathered. Forty nine out of 69 households in Padayetti village are engaged in paddy cultivation. Around 30 farmers practice organic farming while the rest use chemical fertilizers and pesticides. A few farmers adopted convenient farming. Most of them have kitchen gardens and cultivate vegetables without any chemical input.

Their experience in farming ranges between 20 and 40 years. Organic farmers use farm yard manure, vermicompost, biogas slurry, neem, castor and groundnut oil cakes, biopesticides, plant extracts such as garlic, ginger, chilli and N, P, K bionutrients. As part of the farmers' field school programme, all the farmers were trained by the Kerala State Biodiversity Board on system of rice intensification (SRI) technique, various biological pest control measures, organic manure and vegetable bed preparations in the fields with help of experts.

Pesticide residues in different components in the agroecosystem in Padayetti village, Palakkad district

a) Residues of organochlorine (OC) pesticides

Residues of persistent OCs were detected in 16.67% of samples analysed with the highest (HCH: 30.90 ± 9.83 ng/g) in sediments of conventional farms collected during *Kharif* season (2009-10) and lowest (2.34 ng/g) during summer (2010-11). Levels of Σ-OCs were below detection limit (BDL) in sediments from organic farms. Among the OC residues detected in different biotic components, Σ-HCH was higher in the tissues of freshwater snail *Pila globosa* (83.91 ± 4.17 ng/g; 2009-10 *Kharif*) followed by freshwater paddy field crab *Geothelphusa dehaani* (72.30 ng/g; 2011-12 summer) and Indian rice frog *Fejervarya limnocharis* (33.22 ± 16.48 ng/g); 2009-10 *Rabi*) collected from conventional farm than organic farm. Presence of trace amounts of Σ-DDT, Dieldrin and Heptachlor in few samples of crab, snail and frog collected from both the farms could be due to past usage in this region. Residues of γ-HCH in snails varied significantly among the seasons ($p < 0.05$; $F = 8.03$). However, the variation of the values between the farms was not quite significant ($p > 0.05$; $F = 4.11$). Further, due to less detectable levels of OCs in other components collected from both the farms, no statistical test was performed. Levels of Aldrin, Endrin, Chlordane and Mirex were at BDL in all the components studied from both the farms.

b) Residues of Organophosphate (OP) Pesticides

Among a set of recently used OPs analysed, residues of Chlorpyrifos (22.07 ± 4.80 ng/g; 2009-10 *Rabi* season) and Triazophos (10.47 ± 7.24 ng/g; 2009-10 summer season) were slightly higher in conventional farm sediments than organic farm. Among the individual OPs

tested in crabs, Chlorpyrifos was detected in 10.81% of samples from conventional farms, while Methyl Parathion, Parathion Ethyl, Phosphamidon and Phenthoate were detected in fewer than 4% of the samples. Both Phorate and Triazophos were detected at 5.18 and 9.96 ng/g respectively in snails collected from conventional farms during *Rabi* and *Kharif* seasons (2009-10). In fishes, Methyl Parathion and Phenthoate were found at 3.23 and 2.78 ng/g in *Channa punctatus* and *Puntius sophore* from conventional farms during summer 2009-10 respectively. Phosphamidon (2.98 ng/g) was detected in *Cirrhinus mrigala* collected during *Rabi* season of the same year. Concentrations of Quinalphos and Phorate were 2.62 ± 1.02 ng/g and 1.02 ± 0.29 ng/g respectively, in *Fejervarya limnocharis* during *Kharif* (2010-11). Parathion Ethyl (1.02 ng/g) was detected in *Hoplobatrachus crassus* in the same season and year. Trace amounts of Chlorpyrifos (1.83 ng/g) was detected in *Thavalakannan* variety of paddy from conventional farm during *Rabi* (2009-10). But in fodder, Σ-OP residues were detected in 40% of the freshly harvested paddy straw from conventional farms ranging between 2.02 ng/g (*Aishwarya*; *Rabi*, 2011-12) and 14.62 ± 1.63 ng/g in the same variety and season during 2009-10. Among all the OP compounds, Methyl Parathion (30.09 ng/g; 2011-12 summer) was detected in milk samples collected from cows which were fed with feeds available in the market and fodder grown in conventional farms than in milk collected from cows fed with only feeds grown in organic (22.64 ng/g; 2010-11 summer) farms. It may be noted that pesticide residues in cattle feed such as fodder grass, readily available feeds, grain mixtures, cotton seeds and groundnut cakes are the major source of contamination in the milk. The levels of Pirimiphos Ethyl and Ethion were BDL in all the components. The statistical analyses of the OP residues in various components showed that Σ-OP residues varied significantly between organic and conventional farm sediments ($p < 0.05$; $F = 0.79$) as well as crab *(*$p < 0.05$; $F = 9.5$) and fodder ($p < 0.05$; $F = 4.15$).

c) Residues of Synthetic Pyrethroid (SP) Pesticides

Levels of SP, Σ-Fenvalerate were fairly high in only one of the sediments from conventional farms (62.80 ng/g) during *Rabi* season (2011-12). Among the other components, crab *Geothelphusa dehaani* (59.58 ng/g; *Kharif* 2011-12), frogs *F. limnocharis* (26.91 ± 9.19 ng/g) and *H. crassus* (42.15 ng/g) during 2009-10 *Kharif and Rabi* seasons, snail *Pila globosa* (20.33 ng/g; 2009-10 *Kharif*) and freshly harvested paddy straw (*Jothi matta*: 6732.55 ng/g; 2009-10 *Rabi*), from conventional farms had high levels of Σ-Fenvalerate. Fenvalerate-II residues in

crabs varied significantly between the seasons ($p < 0.05$; $F = 6.80$). It was observed that out of 109 frogs collected, seven had deformities (6.42%). Interestingly, all the deformed frogs were from conventional farm. Species with deformity were *F. limnocharis* (n=6) and *H. crassus* (n=1). High concentrations of Fenvalerate in deformed *F. limnocharis* (26.91 ± 9.19 ng/g) and *H. crassus* (42.15 ng/g) might have contributed to the deformity. However, not all the frogs collected from conventional farms showed external deformities. High concentration of these contaminants is of great concern, especially when the increasing accumulation potential of these compounds in the food chain is considered. Thus, to avoid the negative effects of agricultural pesticides on faunal diversity, especially in the paddy agroecosystem, we urge the farmers to at least minimize, if not avoid completely in the use of these fast degrading pesticides.

d) Residues of Carbamate (Cb) Pesticides

Commonly used Carbamate pesticides, namely Carbaryl and Carbofuran were analysed. Among all the components collected during the years, one of the dead crabs collected from the conventional farm recorded 3501.91 ng/g of Carbaryl (*Rabi* 2011-12) suggestive of poisoning. Trace levels of these residues (5.23 ± 1.5 ng/mL) were also detected in two of the conventional farm milk samples analysed during summer (2009-10). Residues of Carbofuran (2.09 ng/g) were detected in one of the *F. limnocharis* from conventional farm during *Rabi* (2011-12). This reflects the use of Carbaryl and Carbofuran in the conventional farming practice. Although we have no data on the total application of both Carbaryl and Carbofuran in the study sites, we learn from the farmers that spray up to 250 and 750 g/ha respectively in the area. It may be worth mentioning that around 225 and 500 MTs of Carbaryl and Carbofuran respectively is being used in India on various crops. The elimination of Carbaryl is rapid and takes place mainly through the urine, feces and milk of dairy animals. However, even minute quantities of its residues in food chains may produce toxicological effects following their consumption in man and animals. Even though Food Safety and Standards Authority of India (FSSAI) has not established any limit for Carbaryl in milk, the residue level was lower than the MRLs (50 ng/mL) fixed by FAO/WHO.

e) Conclusion and Recommendations

Data generated in the present study could not be compared to assess any trend on a time scale, due to lack of historical information on the residue levels of OCs in the study area. However, presence of HCH, DDT and Cyclodiene isomers and metabolites in both the farms clearly indicates that these insecticides are still in the environment. Due to their persistence, it is difficult to eliminate the OCPs by simply avoiding their use, as many years are required for them to disappear from the environment.

Residues of OC, OP, SP and Cbs in different components recorded in the paddy agro-ecosystem in the present investigation are found to be mostly below stipulated MRL, but their presence in conventional farms is of great concern. Most agricultural produces meet legal limits every year, but it does not always mean safe. While the risks of a pesticide depends on how much of it is consumed and how toxic that particular pesticide is. Hence it is hard to say exactly is safe. Moreover levels that are safe for adults may be harmful to children.

We have noticed that the overall usage of pesticides has come down in the Padayetti agroecosystem and even a few farmers adopting conventional farming applied only fast degrading chemicals based on need. Adoption of integrated pest management (IPM) strategies involving a variety of biological and physical methods to control pests is also dangerous because farmers will not use correct dosage. For the long-term perspectives, paddy farms with Non-pesticide Management (NPM) practices provide a sustainable alternative in terms of both economic as well as an ecological point of view.

To keep the paddy farming more sustainable, ancient practices such as mixed cropping, crop rotation and growing of legume plants should be tried. Use of organic manure and effective biological pest control measures should be promoted. Data generated through this study provides reference points for future assessment of OC, OP, SP and Cb residue levels in organic and conventional farm produces. Extensive awareness programme to dissuade farmers from using pesticides through contact programmes and media should be organized. Perceivable changes can happen only when the farmer is convinced about efficacy of organic farming. Therefore, agricultural scientists must reorient themselves, in the light of the fast degrading environment and loss of biodiversity and in line with the organic farming policy of the State, interact with the farmers and also create a talent pool in all districts, if not

Panchayats and Wards in the state to ensure a toxic free food for all. In general, our findings call for urgent action to reduce the level of OP, SP and Cb exposure and their effects on wildlife and human health. Additionally, the following recommendations are made.

Some of the currently-used pesticides such as OPs, SPs, and Cbs are highly toxic across the food chain including man. These classes of pesticides have relatively short half-lives in tissues, but nonetheless can still evoke toxicity. Hence, while regulatory agencies in India should impose restrictions on the use of these pesticides, farmers themselves should abandon them. In India although submission of toxicity data on birds and mammals are necessary for registration of a new molecule, for amphibians till date, no reference is made in the registration process. Our results indicate that existing risk assessment procedures for pesticide formulation need to be strengthened to protect also the amphibians. We hope that our work will encourage further investigations on the role of agrochemicals on frog declines, given that to-date there has been relatively very little research on contaminants in India.

Some of the currently using OPs such as Chlorpyrifos, Phorate, Triazophos, Quinalphos and Malathion, and SPs such as Fenvalerate and λ-Cyhalothrin were detected very frequently in most of the paddy agroecosystem components collected from the conventional farms and, they are proven to be injurious to human health and biodiversity and hence their use in the state should be banned.