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Quantitative Analysis of Pesticide Residues in Some Pond Water Samples of Bangladesh

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Abstract: This study was undertaken to investigate the extent of contamination from pesticide residues in pond water samples of Bangladesh. Twenty water samples collected from different locations of Bangladesh were analyzed for the presence of organochlorine (OCs) and carbamate pesticide residues. Packed column Gas Chromatographic (Electron Capture Detector Mode) and High Performance Liquid Chromatography (HPLC) technique were used to determine the concentration levels of those pesticide residues. The results indicate some water samples contaminated by organochlorine and carbamate pesticide (carbaryl and carofuran). The concentration of organochlorine pesticide, DDE and heptachlor in water sample no. 1 were 0, 0.014 and 0.048 ppm, respectively. The concentration of organochlorine pesticide, DDE, DDD and DDT in water sample no. 3 were 0, 0.014, 0.052 and 0.316 ppm, respectively. The DDT, DDE, DDD and heptachlor were found within the WHO guideline value of water quality (2 μgL^{-1} and 0.03 μgL^{-1}). The concentration of carbaryl in water samples nos. 4, 8 and 10 were 0.609, 0.168 and 0.146 ppm, respectively. The residue level of carofuran pesticide was found to be in range of 0.398-2.208 ppm. The highest concentration for carbofuran was 2.208 ppm in water sample no. 9, while the lowest concentration was 0.398 ppm in water sample no. 19. The concentration of carbofuran was also found within the acceptable ranges according to the WHO guideline value of water quality.

Key words: Water samples, pesticide, organochlorine pesticide, carbamate pesticide.

Introduction

Pesticide is a term used for a broad range of chemicals, synthetic or natural, that serve to control insects, fungi, bacteria, weeds, nematodes, rodents and other pests. They are applied to soil or sprayed over crop fields, and therefore released to the environment, especially in water. Some of them could cause serious ambient contamination, and threaten human health. In this connection, monitoring pesticide residues is one of the most important aspects in minimizing potential hazards to human health.

Bangladesh is an agro-based country. Agriculture is her economic backbone with the production accounting for about one third of the gross domestic product. In Bangladesh, 40% of the crop loss can be attributed to attack by pests and insects which is a significant loss. The widely cultivated high yielding variety is highly vulnerable to pests and diseases. So the use of pesticide is now an inherent part of agriculture for pest control.

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Due to use of pesticides for agriculture the pond water around the paddy fields may get contaminated. Although pesticide is beneficial for pest control but it also poses a harmful effect to our environment such as the pollution of pond water by the pesticide. After application of pesticide in the crop fields, the pesticide is degraded in the soil by the soil microorganism to some extent but many of the toxic pesticide is transported into pond water by agricultural run of rain water from the crop field. So the pond water is highly contaminated due to this agricultural run off pesticide.

Ever since the detection of organochlorine insecticides in the environment in the 1960s, the concern about pesticides in water supplies has been high. This has led to the introduction of regulations regarding the concentrations of pesticides permitted in drinking water. In the European Community (EC), the EC Drinking Water Directive (EC Directive 80/778/EEC) sets the quality to be achieved for various parameters, including pesticides, in drinking water. Parameter 55 of the Directive sets a maximum admissible concentration (MAC) of 0.1 μgL^{-1} for single pesticides and 0.5 μgL^{-1} for total pesticides.

Pacioni and Veglia (2007) determined poorly fluorescent carbamate pesticides in water, bendiocarb and promecarb, using cyclodextrin nanocavities and related media. The limits of detection (L_D, μgL^{-1}) for the best conditions were 0.57±0.02 for BC with HPCD and 0.091±0.002 for PC with βCD in water. WHO (1993) has established drinking water guidelines for 33 pesticides. Fatta et al. (2007) studied organochlorine and organophosphoric insecticides, herbicides and heavy metals residue in industrial wastewaters in Cyprus. Most industries in Cyprus possess permits either for disposal at central wastewater treatment plants (the treated effluent of which is reused or disposed into the sea), or discharge on soil, or reuse either for irrigation or groundwater recharge or discharge into the sea. Barlasv and Akbulut (2006) studied the contamination levels of organochlorine pesticides in water and sediment samples in Uluabat Lake, Turkey. Considerable amounts of organochlorine pesticides were detected in water and sediment samples during one-year study in this lake. Amine and Palleschi (2006) detected carbamic and organophosphorous pesticides in water samples using a cholinesterase biosensor based on Prussian Blue-modified screen-printed electrode. AChE-based biosensors have demonstrated a higher sensitivity towards aldicarb (50% inhibition with 50 ppb) and carbaryl (50% inhibition with 85 ppb) while BChE biosensors have shown a higher affinity towards paraoxon (50% inhibition with 4 ppb) and chlorpyrifos-methyl oxon (50% inhibition with 1 ppb).

Jayashree and Vasudevan (2006) studied organochlorine pesticide residues in ground water of Thiruvallur district, India. Concentrations of pp-DDT and op-DDT were 14.3 μgL^{-1} and 0.8 μgL^{-1}. The maximum residue (15.9 μgL^{-1}) of endosulfan sulfate was recorded in Kandigai village bore well. Shukla and Kumar (2006) determined organochlorine pesticide contamination of ground water in the city of Hyderabad. All the samples analyzed were found to be contaminated with four pesticides i.e., DDT, beta-Endosulfan, alpha-Endosulfan and Lindane. DDT was found to range between 0.15 and 0.19 μgL^{-1}, beta-Endosulfan ranges between 0.21 and 0.87 μgL^{-1}, alpha-Endosulfan ranges between 1.34 and 2.14 μgL^{-1} and Lindane ranges between 0.68 and 1.38 μgL^{-1}, respectively.

This pollution of pond water causes great ecological impact on the pond water ecosystem such as the accumulation of toxic pesticide (DDT) in the fatty tissue of fishes due to its lipophillic properties and as a result it reaches in high concentration in the top level of consumer such as human through the cycle of food chain. So the ecological balance is highly damaged. The purpose of this study was to determine the type and concentration levels of pond water and to propose a sound recommendation for minimizing the pesticide pollution of pond water in Bangladesh.

Materials and Methods

Sampling

The pond water samples were collected in glass bottles from the designated area of Bangladesh. Then they were kept in cooled condition in the Agrochemical and Environmental Research Division (AERD) of Bangladesh Atomic Energy Research Establishment until extraction.

Sample Extraction

The sample containers were shaken and each 500 mL portion was transferred to a separating funnel (1000 mL) fitted with glass stopper. 100 mL double distilled hexane was used for extraction with shaking for 5 min. It was kept for 10 min to settle down. Then hexane extract was separated and collected in conical flask. Two further extractions were done by adding 50 mL double distilled hexane. The combined hexane extract was treated with 5 g anhydrous sodium sulphate to remove trace of water. The water-free extract was evaporated to a small volume (1-2 mL) by rotary vacuum evaporator and transferred to a small glass vial.

Clean Up

The hexane extraction was subjected to clean up by florisil column chromatography (DFG Manual of Pesticide Residue Analysis, 1987). The column was fitted with double distilled n-hexane about two third and 5 g of deactivated florisil was slowly applied into the column by gently tapping with a non-contaminated glass rod to avoid bubble formation in the column packing. The absorbent was allowed to settle down. Then the top 1.5 cm of the florisil column was packed with anhydrous sodium sulphate. Elution was done with 2% diethyl ether in hexane (5 mL/min). The elute was concentrated to 1-2 mL using rotary vacuum evaporator and again transferred to glass vials. Solvents were completely dried by a mild nitrogen blow. The evaporated sample was dissolved in hexane at first time and then made to volume 1-2 mL in a volumetric flask for Gas Chromatography. After GC treatment, the sample solvent was again evaporated by a mild nitrogen flow. The evaporated sample was dissolved in acetonitrile and then made to volume 1-2 mL in a volumetric flask for high performance liquid chromatography (HPLC).

Sample Analysis

For pesticide residue analysis, aliquot (usually 1 µL) for GC and 20 µL for HPLC was injected by microlitre syringe into the GC fitted with electron capture detector (ECD) and into the high performance liquid chromatography with photo diode array detector (PDA).

Results and Discussion

Twenty water samples collected from different regions of Bangladesh were analyzed for the presence of organochlorine pesticide residues. According to the results of this study, two samples were found to be contaminated with organochlorine pesticide residues (Table 1). The DDE and heptachlor were detected in water sample no. 1, while DDT, DDE and DDD were found in water sample no. 3. The concentration level of DDE and heptachlor was found within the WHO guideline value of water quality (2 μgL^{-1} and 0.03 μgL^{-1}).

Table 2 shows the results that of the 20 samples only thirteen samples were found to be contaminated with carbamate pesticide residues. Of the thirteen samples, only three samples were found to be contaminated with carbaryl and ten samples were found to be contaminated with carbofuran residues. The carbofuran residue levels in these samples were in the acceptable range according to the WHO guideline value of water quality (7 μgL^{-1}).

Other study on water samples indicated that the organochlorine residues in water samples from irrigation canals at Meghna Dhangonda irrigation project ranged

Table 1: Amount of organochlorine (OC) pesticide residues in pond water samples

Sample No	*Organochlorine pesticide residues in water samples (ppm)*							
	Aldirin	*Dieldrin*	*Endrin*	*DDT*	*DDD*	*DDE*	*Lindane*	*Heptachlor*
WS1	ND	ND	ND	ND	ND	0.014	ND	0.048
WS2	ND	ND	ND	ND	ND	ND	ND	ND
WS3	ND	ND	ND	0.316	0.052	0.014	ND	ND
WS4	ND	ND	ND	ND	ND	ND	ND	ND
WS5	ND	ND	ND	ND	ND	ND	ND	ND
WS6	ND	ND	ND	ND	ND	ND	ND	ND
WS7	ND	ND	ND	ND	ND	ND	ND	ND
WS8	ND	ND	ND	ND	ND	ND	ND	ND
WS9	ND	ND	ND	ND	ND	ND	ND	ND
WS10	ND	ND	ND	ND	ND	ND	ND	ND
WS11	ND	ND	ND	ND	ND	ND	ND	ND
WS12	ND	ND	ND	ND	ND	ND	ND	ND
WS13	ND	ND	ND	ND	ND	ND	ND	ND
WS14	ND	ND	ND	ND	ND	ND	ND	ND
WS15	ND	ND	ND	ND	ND	ND	ND	ND
WS16	ND	ND	ND	ND	ND	ND	ND	ND
WS17	ND	ND	ND	ND	ND	ND	ND	ND
WS18	ND	ND	ND	ND	ND	ND	ND	ND
WS19	ND	ND	ND	ND	ND	ND	ND	ND
WS20	ND	ND	ND	ND	ND	ND	ND	ND

WS= Water Sample; ND = Not Detected.

Table 2: Amount of carbamate pesticide residues in pond water samples

Sample No	*Carbamate pesticide residues in water sample (ppm)*	
	Carbaryl	*Carbofuran*
WS1	ND	0.542
WS2	ND	ND
WS3	ND	ND
WS4	0.609	ND
WS5	ND	1.760
WS6	ND	0.915
WS7	ND	0.494
WS8	0.168	ND
WS9	ND	2.208
WS10	0.146	ND
WS11	ND	0.431
WS12	ND	ND
WS13	ND	0.864
WS14	ND	ND
WS15	ND	ND
WS16	ND	0.964
WS17	ND	ND
WS18	ND	0.643
WS19	ND	0.398
WS20	ND	ND

WS = Water Sample; ND = Not Detected.

from 0.2 to 6.75 ngL^{-1} and total DDT residues found in the soil samples of the same area ranged between 5.92 and 11.2 respectively (Alam et al., 1999). On the other hand, water samples from a Begumgmanj crop field were found to contain DDT residues at 19 gL^{-1}, well above the value of 2 μgL^{-1}. Besides that DDT, DDE and dieldrin were present in some water samples obtained from the irrigated crop fields at Gaibandha (Matin et al., 1998). In most cases, the residue levels were found to be with in WHO guidelines (World Health Organization, 1993). However, groundwater samples from Nayahat were apparently free from residues. In comparison to all regions and other studies, we detected the higher concentrations of DDT, DDE, DDD and heptachlor with their respective concentrations of 0.316, 0.014, 0.052 and 0.048 ppm. Besides, the highest concentration for carbofuran and carbaryl were 2.208 and 0.609 ppm and the lowest concentrations were 0.398 and 0.146 ppm, respectively, in water samples.

The presence of organochlorine pesticide in this study indicates that these banned pesticides (except heptachlor) are still used by farmers. The cause may be the available illegal importation of this pesticide from the neighbour country due to lack of strong monitoring in the border area. Due to availability of this pesticide the farmers also misuse this pesticide. So strong monitoring and regulatory control must be adopted to control the misuse of the pesticide by farmers otherwise the environment of our country may be highly polluted by this pesticide.

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