Soil & Environ. 26(2): 102-105, 2007

Dichlorodiphenyl trichloroethane (DDT) in soil and sediment samples at different locations of Dhaka city in Bangladesh

M.A. Zaman[1*], S.M. Ullah[2], K.T. Osman[1] and M.A.Z. Chowdhury[3]
[1]Department of Soil Science, University of Chittagong 4331, Bangladesh
[2]Department of Soil, Water and Environment, University of Dhaka, 1000, Bangladesh
[3]Institute of Food and Radiation Biology, Atomic Energy Research Establishment, Ganakbari, Savar, Dhaka, Bangladesh

Abstract

Twelve surface soils from paddy field and fourteen sediment samples from lake and river at different locations of Dhaka city were collected during premonsoon transition and rainy seasons. Dichlorodiphenyl Trichloroethane (DDT) was measured using ELISA (Enzymed-Linked Immuno Sorbent Assay) method. All soil (0.001-0.038 ppm) and sediment samples (0.0013-0.040 ppm) except two lake sediments contained DDT. The soil and sediment matrices of different locations were contaminated by DDT where it was used for public health purposes. Clay and organic colloids seemed to be the carrier in transporting DDT from primary to secondary sources. Correlations were made between DDT and physicochemical properties of soil and sediment samples where positive relationship of DDT existed only with organic matter and clay content of both soil and sediments.

Key words: DDT, surface soil, sediment, Dhaka city, ELISA

Introduction

Dichlorodiphenyl Trichloroethane (DDT) has proven to be recalcitrant which is used against soil insects, pest, ants, armyworms, cutworms, grasshoppers etc. It remains in the environment for a very long time. Its ability to accumulate in the food chain for decades after application to soil and potential to elicit toxic effects lead to create great concern to the people (Harner *et al*., 1999). Public concern also has recently increased due to its presence in milk and meat for human through consumption and its accumulation in body fat as sources of poisoning (Oudejans, 1994).

In Dhaka, like other parts of Bangladesh, presides are used for agricultural and other purposes. In metropolitan areas of the city, pesticides are used mainly for mosquito control. A considerable amount of pesticides is still applied to the cropland. The indiscriminate usage of DDT results in ubiquitous and persistence of this contaminant in various environmental media like soils and water of Dhaka. Thus, DDT is a matter of great concern to the habitants of the Dhaka City. The above situation encouraged the monitoring of DDT content in soil of Dhaka city which was not done previously.

Immunological methods for detecting insecticide residues in food and environmental samples offer several advantages over gas chromatographic methods. While maintaining comparable sensitivity, they are simple and cost effective and can be adapted for field use (Gee *et al*., 1995; Lee *et al*., 1995).The purpose of the present study was to know concentration of DDT in soils and sediments of some selected areas of Dhaka city.

Materials and Methods

Soil and sediment sampling

Soil and sediment samples were collected from different locations of Dhaka district (Table 1) during May-June period which covers both the pre-monsoon transition and rainy seasons. Twelve composite soil samples of 0-15 cm depth and fourteen sediment samples of 0-5 cm depth were collected.

Preparation of soil and sediment samples

Soils and sediment samples were air dried, ground and passed through a 2 mm sieve and preserved in plastic containers for physical analysis. Another portion of the soils was screened through 0.5 mm (32 mesh) sieve and preserved in plastic containers at a temperature of –20 °C for chemical analysis and extraction.

Analytical methods

Particle size distribution of the soils and sediments was determined by hydrometer method (Day, 1965). Cation exchange capacity (CEC) was determined after extraction of the cations with ammonium acetate (Black, 1965). Soils and sediments pH was measured in soil/sediment-water suspension (1:2.5) using a corning glass electrode pH-meter. Organic carbon was determined by wet-oxidation method of Walkley and Black (1934). The extraction, analysis, calculation and recovery of DDT were made by the methodology of EnviroLogix Inc. (EnviroLogix Inc., 1999). The Envirologix DDT plate kit is a competitive enzyme-linked immunosorbent assay (ELISA) and used for detecting DDT residues in soil samples.

*E-mail: akhtarcu@yahoo.com

Table 1. Information of soil and sediments samplings of Dhaka district, physico-chemical properties and DDT concentrations

Serial No.	Source	Location	Depth (cm)	Sand %	Silt %	Clay %	Texture	pH	OC %	CEC meq100g^{-1} Soil	DDT concentration (ppm)
1.	Paddy field	East Nandipara	0-15	15.3	51.2	33.5	SiCL	7.7	1.27	9.39	0.034
2.	Paddy field	DIT Road, Rampura	0-15	25.6	42.8	31.6	SiCL	6.0	0.89	15.1	0.038
3.	Paddy field	Anandanagar, Merul, Badda	0-15	17.4	54.3	28.3	CL	7.1	1.43	14.20	0.035
4.	Paddy field	Ainkha, Keraniganj	0-15	26.3	53.7	20.0	SiL	4.5	0.66	18.75	0.0052
5.	Paddy field	Kamrangirchar (Near Bariband)	0-15	35.2	30.4	11.4	L	6.7	0.53	6.60	0.0010
6.	Paddy field	Aminbazar,	0-15	42.3	44.6	13.1	L	5.6	0.96	8.91	0.0012
7.	Paddy field	Ashulia, (North-west of road)	0-15	8.8	60.1	31.1	SiCL	7.4	1.12	14.70	0.013
8.	Paddy field	Ashulia (South-east of road)	0-15	9.2	56.3	34.5	SiCL	6.4	1.13	20.89	0.0083
9.	Paddy field	Taltala, Uttara	0-15	19.6	39.7	40.7	CL	6.9	0.82	26.05	0.0052
10.	Paddy field	Vaturia, Dakkhinkhan,	0-15	17.2	53.8	29.0	SiCL	6.8	0.77	12.43	0.0090
11.	Paddy field	Kachkura, Dakkhinkhan,	0-15	25.4	58.1	16.5	SiL	6.4	0.82	10.30	0.0030
12.	Fallow land	Hazaribag	0-15	14.9	64.4	20.7	SiL	6.2	1.23	10.13	0.014
13.	Lake sediment	Gulshan- aridhara (right dike)	0-15	15.5	64.2	20.3	SiL	6.0	1.08	10.12	0.0043
14.	Lake sediment	Gulshan- aridhara (Left dike)	0-5	20.1	56.7	23.2	SiL	6.7	1.20	10.17	0.0025
15.	Lake sediment	Banani (Right dike)	0-5	34.3	40.1	25.6	L	5.7	0.40	10.9	0.0017
16.	Lake sediment	Bananai (Left dike)	0-5	32.9	38.0	29.1	CL	6.0	0.30	10.28	ND
17.	Lake sediment	Cricent Lake(Right dike)	0-5	25.0	58.7	16.3	SiL	7.5	0.42	8.50	0.002
18.	Lake sediment	Cricent Lake(Left dike)	0-5	29.6	48.4	22.0	L	7.0	0.57	8.30	0.007
19.	Lake sediment	Shangshad Bhaban, (Right dike)	0-5	29.0	39.7	31.3	CL	7.3	1.12	10.60	0.0079
20.	Lake sediment	Shangshad Bhaban, (Left dike)	0-5	35.5	40.5	24.0	L	6.1	0.55	9.30	ND
21.	Lake sediment	Dhanmondi Lake, (Right dike)	0-5	33.2	46.5	20.3	L	7.9	0.53	9.55	0.0015
22.	Lake sediment	Dhanmondi Lake (Left dike)	0-5	22.1	51.8	26.1	SiL	5.1	0.37	10.18	0.0013
23.	Lake sediment	Rampura lake	0-5	8.3	63.5	28.2	SiCL	6.5	1.39	11.60	0.033
24.	Lake sediment	Romna park lake	0-5	17.6	52.3	30.1	SiCL	7.2	2.79	11.10	0.035
25.	River sediment	Buriganga, Pagla	0-5	27.4	36.2	36.4	CL	7.0	1.45	12.80	0.040
26.	River sediment	Turag river near Tongi Bridge	0-5	64.1	21.3	14.6	SL	5.0	1.34	4.50	0.0038

OC: Organic carbon; CEC: Cation exchange capacity; CL: Clay Loam; L: Loam; SiCL: Silty Clay Loam; SiL: Silt Loam; SL: Sandy Loam

Results and Discussion

Soil and sediment characteristics

Soil and sediment characteristics are presented in Table 1. Soil pH ranged from 4.5 to 7.7 with a relatively higher pH in East Nandipara and sediment pH ranged from 5.0 to 7.9. Total organic matter content for soil varied from 0.92% in Kamrangirchar to 2.46% in Anandanagar and from o.69% in Banani (Right dike) to 4.80% in Ramna Park Lake for

Table 2. Correlation between DDT and physico-chemical characteristics of soil

Soil/sediments characteristics	Correlation Co-efficient (r) with DDT conc. in soils	Correlation Co-efficient (r) with DDT conc. in sediments
Sand	-0.342 ns	-0.401 ns
Silt	+0.116ns	+0.121 ns
Clay	+0.460 ns	+0.634*
pH	+0.361 ns	+0.291 ns
Organic carbon	+0.618 *	+0.754 **
Cation exchange capacity(CEC)	-0.046 ns	+0.541*

**: Significant at $p \leq 0.01$ level; *: Significant at $p \leq 0.05$ level; ns: non significant

sediment. The organic matter (OM) content (0.92-2.46%) in the surface soil was moderately higher than that normally found in soils of Bangladesh [normal range: <1-1.7% (BARC, 1999)]. Cation exchange capacity (CEC) varied from 6.60 to 26.05 meq $100g^{-1}$ and from 8.30 to 12.80 meq $100g^{-1}$ for soil and sediment, respectively. Texture for soil ranged from clay loam to silt loam and for sediment from clay loam to sandy loam (Table 1).

DDT residues in soil

DDT residues have contaminated all of the surface soils of paddy field, lake and river in Dhaka (Table 1). DDT concentrations varied from 0.001 ppm to 0.038 ppm in soil and 0.0013 ppm to 0.040 ppm in sediment samples.

The soils of paddy fields were contaminated with DDT due to its application for Malaria eradication. The contamination of soils at Hazaribag is likely to be related to DDT uses for mosquitoes control and its release from wastes of tannery factories, where DDT might have been used for initial preservation particularly in rural areas. The lakes and pond sediments at different locations inside the Metropolitan area of Dhaka are likely being contaminated with DDT through its surface run-off, particle transport, aerial transport, precipitation and deposition from highly polluted areas, especially where DDT is used for public health purposes.

The river sediment of Buriganga contained more DDT, because it received the more washings of the city containing DDT used against mosquitoes and other insects. In many cases, DDT contents in paddy field soil were somewhat higher than those of lake, ponds and rivers.

Clay and organic matter act as the carriers for pesticide transport through soil just as they do for surface transport (White and Kookana, 1998). Clay and organic colloids carry DDT, transported with flood, irrigation or rainwater and finally deposited at the bottom of lake and river sediments. It may be noted that indoor spraying of DDT for Malaria control seemed to be main cause of accumulation of DDT residues in different locations of Dhaka. The DDT applied in the past years is still present in soil because of its great molecular stability, and insoluble with residence time in soils of at least 10 years (Loganathan and Kannan, 1994).

The pesticide-untreated areas of Dhaka were contaminated through washings, volatilization and spray drift from the adjacent DDT contaminated areas, through volatilization, surface runoff, spray drift, etc.

In Hazaribag, three sources of DDT might be discussed. The first source is from DDT application in this area for controlling mosquitoes. The second source of DDT is from the nearby Kamrangirchar agricultural land (where DDT was found in the surface soil) by volatilization, air transportation, surface runoff, precipitation etc. Finally, the important source of DDT is the animal fat, which is susceptible to contain DDT and released as effluents of raw skins during processing. The animal feeds like grass, rice bran, straw, other agricultural by-products, contain a considerable amount of pesticides, which are eaten by domestic animals and finally they (especially DDT) are dissolved and accumulate in the body fat of animals. Thus, DDT enters into animal body through food chain. In India, DDT residues were found in animal (e.g. cow, goat and buffalo etc.) milk, meat, butter, ghee (Singh and Dhaliwal, 2000) and they also stated that the intake of DDT in cattle occurred mainly through contaminated feeds. Accumulation of DDT and DDE in animal fat was also reported by Harradine and Mc Dougall (1987), Blackman (1992), Willett *et al*. (1993) and Kammerbauer and Moncada (1998).

Correlation between DDT and physico-chemical characteristics of soil and sediment

The correlation co-efficient of physico-chemical characteristics (pH, OM, CEC, sand, silt and clay) of soils and sediments with DDT content was investigated (Table 2). Only organic carbon of soil and clay, organic carbon and CEC contents of sediment showed significant positively correlationship with DDT. Li (1993) found that DDT and BHC increased with decreasing particle size. The adsorption of DDT on clay particles may be related to humic fraction on clay particles. Guzzella (1997) observed a similar significant correlation of sediment concentration of lake, Orta in Italy with organic carbon content. The vast majority of pesticides are non-ionic. For these compounds, organic matter is the only relevant sorbing soil component. The sorption mechanism involved is called by hydrophobic bonding. The more hydrophobic a compound is, the higher is its sorption co-efficient (Schnitzer and Khan, 1978). Adsorption of non polar chlorinated hydrocarbon pesticides by lipid in organic matter as described by Khan (1980). It has been suggested that the adsorption of non-polar pesticides on organic matter is mainly due to pesticide-lipid interaction. Quite generally, adsorption by soils of the non-ionic pesticide is positively correlated with soil organic matter content (Loch, 1991).

Conclusions

DDT has the affinity for binding with clay and organic matter fraction of soil. The concentration of DDT in surface soil and sediment samples of the studied area was negligible. Regular monitoring should be taken into consideration to find out the existence of DDT in different environmental matrices because the small doses in human or other living tissues are reported to have lethal effects.

Acknowledgements

Financial support of the Ministry of Science, Information & Communication Technology is gratefully acknowledged. We thank Dr. Taimur Reza Sharif (PSO), Dr. M. Giasuddin (SO), Dr. Rafiq (SO) of Bangladesh Livestock Research Institute (BLRI) for their skilful technical assistance.

References

Bangladesh Agricultural Research Council (BARC). 1999. Land degradation situation in Bangladesh. Soil Division , Dhaka, Bangladesh

Black, C.A. 1965. Methods of Soil Analysis. American Society of Agronomy, Inc. Publisher, Madison, Wisconsin, U.S.A. 894-895 p.

Blackman, N. 1992. DDT, where has it gone? Rural Resources Interface, Autumn 1992. p. 14-16.

Day, P.R. 1965. Particle fraction and particle size analysis. p. 45-56. In: Methods of Soil Analysis. C.A. Black (ed.). Part 1. American Society of Agronomy, Madison, Wisconsin, USA.

EnviroLogix Inc. 1999. DDT Plate Kit. Catalog. No. EP 020. Portland, USA.

Gee, S.J., B.D. Hammock and J.H. Skerritt. 1995. Diagnostics for plant agrochemical – a meeting of chemistry and immunoassay. p. 243-276. In: New Diagnostics in Crop Sciences. J.H. Skerritt and R. Appels (eds.). CAB International, Wallingford, U.K.

Guzzella, L. 1997. PCBs and Organochlorine pesticides in Lake Orta (Northern Italy) Sediments. *Water, Air and Soil Pollution* 99: 245-254.

Harner, T., J.L. Wideman, L.M.M. Jantunen, T.F. Bidleman and W.J. Parkhurst. 1999. Residues of organochlorine pesticides in Alabama soils. *Environmental Pollution* 106: 323-332.

Harradine, I.R. and K.W. Mc Dougall. 1987. Residues in cattle grazed on land contaminated with heptachlor. p. 70-75. In: Pesticide Seminar held at North Coast Agricultural Institute, Wollongber. B.J. Doyle and K.W. Mc Dougall (eds.). NSW Agriculture and Fisheries: Wollongbar, NSW.

Kammerbauer, J. and J. Moncada. 1998. Pesticides residues assessment in three selected agricultural production system in the choluteca River Basin of Honduras. *Environmental Pollution* 103: 171-181.

Khan, S.U. 1980. Pesticides in the Soil Environment, Elsevier Science Publication Co., Amsterdam, The Netherlands.

Lee, N., J.H. Skeritt and D.P. McAdam. 1995. Hapten synthesis and development of ELISAs for detection of endosulfan in water and soil. *Journal of Agriculture, Food and Chemistry* 34: 1730-1739.

Li, X.G. 1993. Distribution of pesticides in soils-relationship among contents of DDT and BHC, size of soil particle and content of organic matter. *Acta-Pedologica-sinica* 30: 88-93.

Loch, J.P.G. 1991. Effect of soil type on pesticide threat to the soil/ground water environment. p. 291-307. In: Chemistry, Agriculture and the Environment. M.L. Rechardson (ed.). The Royal Society of Chemistry, Cambridge, U.K.

Loganathan, B.G. and K. Kannan. 1994. Global organchlorine contamination trends: an overview. *Ambio* 23: 187-191.

Oudejuns, J.H. 1994. Agro-pesticides properties and functions in integrated crop protection. United Nations Economic and Social Commission for Asia and the Pacific. United Nations, Bangkok. pp. 68-86.

Schnitzer, M. and S.U. Khan. 1978. Soil Organic Matter. Developments in Soil Science. 8, Elsevier, Armsterdam.

Singh, B. and G.S. Dhaliwal. 2000. Pesticide contamination of fatty food commodities. p. 115-190. In: Pesticides and Enviroments. G.S. Dhaliwal and B. singh (eds.). Commonwealth Publishers.

Walkley, A. and I.A. Black. 1934. An examination of the Degtijareff method for determining soil organic matter and aproposed modification of the chromic acid titration method. *Soil Science* 37: 29-38.

White, R.E. and R.S. Kookana. 1998. Measuring nutrient and pesticide movement in soils: benefits for catchment management. *Australian Journal of Experimental Agriculture* 38: 725-43.

Willett, L.B., A.F. O'Donnell, H.I. Durst and M.M. Kurz. 1993. Mechanisms of movement organochlorine pesticides from soils to cows via forages. *Journal of Dairy Science* 76: 1635-1644.