Peer reviewed conference proceedings for papers presented in the 7th International Toxicology Symposium in Africa, 31 August 2015, Johannesburg, South Africa

Pesticide residues in water from rivers and lakes in Lake Tanganyika basin, Tanzania

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The aim of this study was to investigate the types, levels and distribution of pesticide residues in water in Lake Tanganyika basin, Tanzania. Water samples were collected from Kigoma region during April and June and analysed for pesticide residues. The pesticides and metabolites detected were *p,p*'-DDT, *o,p*'-DDT, *p,p*'-DDE and *p,p*'-DDD. The concentrations of total DDT in water were up to 200 and 221 ng/L in lakes and rivers, respectively. The ratios of (*p,p*'- DDE + *p,p*'-DDD)/*p,p*'-DDT indicate recent inputs in most samples. The study reveals that there is recent use of DDT in the region. Continued use of DDT indicates concerns and risks for public and environmental health. The area therefore needs serious environmental monitoring.

Keywords: Pesticides, Water, Lake, River, Tanzania

1. Introduction

The increased use of various types of pesticides in agriculture has led to serious environmental contamination arising from their use. Pesticides have been linked with many health effects and they have serious implications to the environment (WHO 1990; ATSDR, 2002). A variety of agricultural activities are carried out in Lake Tanganyika basin. Different types of pesticides are used to control crop pests, suggesting the possibility of water contamination in the rivers and lakes. Therefore, this study was undertaken to assess the level of pollution due to pesticides.

2. Materials and Methods

Water samples were collected from five sites namely Lake Tanganyika, Luiche River, Malagarasi River, Lake Nyamagoma and the streams at Kalinzi in April and June 2012. From Lake Tanganyika, water samples were collected from two sampling stations at Forodhani and Kibirizi. Samples from Malagarasi River were collected from Malagarasi Bridge in Uvinza district (upstream of the river) and Ilagala (downstream of the river). Samples from Luiche River were collected from the point located five kilometers from where the river enters the Lake. From Lake Nyamagoma samples were collected at Mtegowanoti village in Uvinza district. The lake discharges into Malagarasi River. The samples from Kalinzi were collected from a stream which runs through the coffee farms.

Water samples were collected in 1-litre glass sampling bottles with Teflon caps and preserved with NaCl (100 g each). The samples were kept in a refrigerator at 4 °C until extraction. Water samples were extracted by Liquid-Liquid Extraction method (Åkerblom, 1995) using dichloromethane (60 mL x 3) and dried with anhydrous sodium sulfate (20 g). The extracts were concentrated using a rotary evaporator at 35 °C, solvent changed to cyclohexane/acetone (9:1) and concentrated to 1 mL. Analyses were performed using GC-ECD and confirmed by GC-MS. Analytical quality assurance included analysis of matrix blanks (distilled water) and recovery tests. Blank samples (n = 6) were spiked with standards of all the compounds investigated at concentrations of 0.002 mg/L and 0.005 mg/L and extracted using the same procedures as for the samples. All the blanks did not contain any detectable levels of the analytes. The mean recoveries ranged 87.4–109.6%.

3. Results and Discussion

3.1 Pesticides and Metabolites in Water Samples

The pesticides and metabolites detected in water samples were *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE and *p,p'*-DDD. Although other pesticides like organophosphorus pesticides, pyrethroids and carbamates are used in the study areas, no residues were found. This is because they are highly water soluble and chemically unstable, while organochlorine pesticide residues are stable and therefore highly persistent in the environment (ATSDR, 2002).

3.2 Levels and Distribution of DDT Residues in Water Samples

Table 1 shows the concentrations of DDT and the major metabolites in water samples. In all sampling sites the concentrations of *p, p'*-DDT were higher than those of *o,p'*-DDT indicating contamination by technical DDT (ATSDR, 2002). The concentrations of *p,p'*-DDD were higher than those of *p,p'*-DDE in almost all water samples except those from Ilagala. This suggests that *p,p'*-DDT was dominantly degraded to *p,p'*-DDD under anaerobic conditions. The presence of *p,p'*-DDE is due to degradation of *p,p'*-DDT under aerobic conditions. In case of water samples from Ilagala

collected in April, the concentrations of *p,p'*-DDE were higher than those of *p,p'*-DDD, which implies aerobic degradation of *p,p'*-DDT (ATSDR, 2002).

Table 1: Concentrations of DDT residues in water samples collected in April and June (ng/L)

Sampling sites (points)	SP	*p,p'*-DDE	*p,p'*-DDD	*o,p'*-DDT	*p,p'*-DDT	∑DDT
Malagarasi (2 points)	Apr	5.1	14.0	41.01	56.4	116.5
		4.4	39.6	85.22	90.1	219.3
	Jun	16.03	33.3	85.0	87.0	221.3
		7.3	20.11	47.0	83.31	158
Ilagala (2 points)	Apr	11.1	5.4	6.4	10.3	33.2
		97.22	24.0	11.5	20.6	153.3
	Jun	2.5	13.7	25.1	35.11	76.4
		3.24	12.1	28.0	35.0	78.3
Luiche (2 points)	Apr	14.13	21.0	44.3	61.2	141
		13.0	25.1	52.0	60.0	150.1
	Jun	6.43	19.0	30.63	38.0	94.1
		1.64	12.0	22.4	32.24	68.3
Forodhani (2 points)	Apr	9.0	25.0	60.3	99.0	193
	Jun	4.7	12.6	32	37.3	86.6
		1.6	8.6	13.5	34.0	57.7
Kibirizi (2 points)	Apr	5.6	9.0	25.21	34.4	74.2
		3.51	18.5	29.3	30.1	81.4
	Jun	1.4	11.23	17.1	86.1	116
		10.6	46.0	65.24	78.1	200
Kalinzi (1 point)	Apr	13.1	13.53	27.33	33.32	87.3
L. Nyamagoma (2 points)	Apr	28.2	43.3	47.5	53.0	172
		4.13	10.3	19.6	31.5	65.5

SP = Sampling period; Apr = April; Jun = June

The maximum total DDT concentrations were 221.3 and 153.3 ng/L in Malagarasi and Ilagala samples, respectively. The concentrations of DDT residues were significantly higher at Malagarasi than Ilagala (t = 2.199, p = 0.034), suggesting greater contamination upstream. Also residue concentrations depend on both volume of water and flow rate. At Ilagala station the volume and flow of water were very high compared to Malagarasi bridge station, therefore big volumes of water result in dilution of the concentrations of pesticides. Also Malagarasi bridge is near many agricultural fields where crops are grown while Ilagala is too far, therefore residue concentrations tend to be reduced due to adsorption and evaporation. In samples from Luiche River, the highest concentration of ∑DDT residues was 150 ng/L. The agricultural activities taking place along the rivers could be significant sources of contamination. Contamination might partly be facilitated by the streams which run through the fields and discharge into these rivers. There was significant difference between the mean concentrations of total DDT in Malagarasi and Luiche Rivers (t = 3.58, p = *0.0373*). This is because Malagarasi River is bigger than Luiche River, therefore it has many contamination sources like streams and other small rivers; furthermore it passes through many farms which possibly used the pesticides.

The maximum concentrations of total DDT in samples from Lake Tanganyika at Forodhani and Kibirizi were 193 and 200 ng/L, respectively. There was no significant difference in concentrations of DDT residues between these two points from the lake (t = 0.4798, p = 0.636). Possible sources of contamination might be rivers, streams and runoffs which discharge into the lake from farms and vegetable gardens around the lake. Contamination might also come from neighbouring countries. The highest concentration of total DDT in samples from Lake Nyamagoma was 172 ng/L. Possible sources of contamination might be runoff from tobacco fields near the lake as well as from streams which discharge into the lake. Samples from the stream which runs through coffee fields at Kalinzi had a maximum concentration of total DDT of 87.3 ng/L. This concentration is lower than the concentrations obtained from rivers and lakes, maybe because the stream was small compared to lakes and rivers; it passes through few coffee fields.

The ratios of (*p,p'*-DDE + *p,p'*-DDD) to *p,p'*-DDT ranged from 0.15 to 0.80 in 86.4% water samples, suggesting that new sources of technical DDT existed in the study area. Water samples collected in April from Ilagala and Lake Nyamagoma had ratios ranging from 1.35 to 5.89, indicating input of aged DDT or significant degradation (Mahugija et al., 2015). The results indicate some marked differences in the levels of DDT residues between April (rainy) and June (dry) suggesting differences in input/ application, changes in water volumes and dilution effects. The results indicate moderate level of contamination. There are risks and concerns for public health and the environment because of the fresh application indicated and the compounds are persistent and bioaccumulative.

4. Acknowledgments

We acknowledge Sida-University of Dar es Salaam Food Security Programme (Pesticides and POPs research, Chemistry Department) for sponsorship. We are grateful to Prof Nilufar Nahar and Mr. Nashir Uddin, Dhaka University, Bangladesh for material and technical assistance.

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