Achievements in the Life Sciences 9 (2015) 107–111

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Achievements in the Life Sciences

journal homepage: www.elsevier.com/locate/als

Assessment of Organochlorine Pesticide Residues in Water, Sediments and Fish from Lake Tashk, Iran

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ARTICLE INFO

Available online 30 December 2015

Keywords:
Organochlorine residues
DDT
Soxhlet
GC-ECD
Lake Tashk

ABSTRACT

In this study, the levels of organochlorine (OC) pesticide residues in Lake Tashk have been investigated using water, sediment and fish (carp) samples as a case study to find out the extent of pesticide contamination and accumulation in the lake. Six OC pesticides namely DDT, DDE, lindane, endosulfan, heptachlor and chlordane were analyzed in four sites at four seasons. Water samples were processed using a liquid–liquid extraction technique and gas chromatograph equipped with electron capture detector (GC-ECD). Soxhlet extraction was used for fish and sediment samples followed by clean up and gas chromatograph. DDE was the predominant residue in all the samples analyzed, at the mean concentrations of 0.075 ppb, 8.750 ppb and 4.446 ppb in water, sediment and fish samples, respectively. The lowest levels of OC pesticides were related to heptachlor and chlordane which none of them were found in water samples. Gonban and Midstream sites had the highest and the lowest concentrations of OC pesticides, respectively.

Introduction

Organochlorine (OC) pesticides are among the agrochemicals that have been used extensively for long periods. They have been used widely in agriculture, as well as, in mosquito, termite and tsetse fly control programs (Guo et al., 2008). OC pesticides are characterized by low polarity, low aqueous solubility and high lipid solubility (lipophilicity) and as a result they have a potential for bioaccumulation in the food chain posing a great threat to human health and the environment globally (Afful et al., 2010). Residues and metabolites of many OC pesticides are very stable, with long half lives in the environment (El-Mekkawi et al., 2009). Studies have shown that DDT is still in its highest concentration in biota of some areas. It is a hydrophobic molecule which disrupts ionic channels like Na^+/K^+ pumps in nervous cell membrane leading to automatic stimulation of neurons and involuntary contraction of muscles (Esmaili Sari, 2002).

Many other recent works have indicated the presence of OC residues in surface waters, sediments, biota and vegetations (Darko et al., 2008; Dem et al., 2007; Wang et al., 2007; Imo et al., 2007; Ize-Iyamu et al., 2007). The persistent nature of organochlorine residues in the environment may pose the problem of chronic toxicity to animals and humans via air, water and food intake. Many of these OC pesticides and their metabolites have been implicated in a wide range of adverse human and environmental effects including reproduction and birth defects (Edwards, 1987), immune system dysfunction, endocrine disruptions and cancer (Adeyemi et al., 2008). Fish are used extensively for environmental monitoring (Lanfranchi et al., 2006), because they uptake contaminants directly from water and diet. Generally the ability of fish to metabolize organochlorines is moderate; therefore,

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Peer review under responsibility of Far Eastern Federal University.

http://dx.doi.org/10.1016/j.als.2015.12.003

Table 1
Levels of organochlorine pesticide residues in water samples of Lake Tashk.

Pesticide	Mean (ppb)	Standard deviation (SD)	Range (ppb)	Percentage
DDT	0.028	0.005	0.018–0.038	43
DDE	0.075	0.009	0.045–0.098	87
Chlordane	–	–	–	–
Heptachlor	–	–	–	–
Lindane	0.082	0.022	0.05–0.091	62
Endosulfan	0.068	0.011	0.043–0.085	55

contaminant loading in fish is well reflective of the state of pollution in surrounding environments (Guo et al., 2008). Lake Tashk is a salt lake in Fars Province, southern Iran, about 160 km east of Shiraz and 15 km west of the town of Neyriz. It has around 1.5–2 m depth and surface area is 800 km^2. Tashk fed by the Kor River. Also this lake hosts some globally famous bird species like Dalmatian Pelican and Flamingo (Kafilzadeh et al., 2007).

The determination of OC residues in fish, sediments and water may give indication of the extent of aquatic contamination and accumulation characteristics of these compounds in the tropical aquatic biota that will help in understanding the behavior and fate of these persistent chemicals (Kannan et al., 1995). This work, therefore, seeks to provide baseline information on levels of pesticide residues including DDT, DDE, lindane, endosulfan, heptachlor and chlordane in fish (carp), sediments and surface waters of Lake Tashk through four seasons that will assist in a scientific assessment of the impact of pesticides on public health, agriculture and the environment in Iran.

Materials and Methods

Fish, sediment and water samples were obtained from four various sites namely Dehzir, Tashk, Gonban and Midstream in Lake Tashk. Samplings were conducted seasonally from winter 2013 to autumn 2013 following US-EPA (US-EPA, 2000). Samples were collected from surface parts of the water and sediment. Also, each sampling was carried out in three replicates. A total of 48 samples each of sediments and water were collected randomly. However, fish samples were 14 because of little rainfall in recent years which has caused a decrease in water depth leading to limited dispersal of fish species. All samples collected (water, sediments and fish) were immediately stored in an ice-chest at 4 °C and transported to the laboratory for analysis.

Extraction of OC Pesticides in Water Samples

In the laboratory, using liquid–liquid extraction (LLE) as described in APHA (1975), the total amount of each surface water sample (800 ml) was filtered with Whatman filter paper (i.d. 70 mm) to remove debris and suspended materials and then poured into a 2 l separatory funnel. For the first LLE, the mixture of 100 ml n-hexane and dichloromethane (1:1 *v*/*v*) was added and shaken vigorously for 2 min before two phase separation. The water-phase was drained from the separatory funnel into a 1000 ml beaker. The organic-phase was carefully poured into a glass funnel containing 20 g of anhydrous sodium sulfate through a 200 ml concentrator tube. Following the second and third LLE, the water-phase was poured back into the separatory funnel to re-extract with 50 ml of the same solvent mixture. The extract was concentrated to the volume of 2 ml under a gentle stream of nitrogen using a rotary evaporator and then analyzed with gas chromatography with a micro electron capture detector (GC-μECD) (Siriwong et al., 2009).

Extraction of OC Pesticides in Fish and Sediment Samples

The muscle tissues of the fish samples were ground in a blender to obtain a homogenous composite, while the sediments were air-dried. OC residues in sediments and fish samples were extracted using a Soxhlet extractor (Therdteppitak and Yammeng, 2003). A 10 g sample was placed into a beaker containing 50 g anhydrous sodium sulfate and mixed thoroughly. The sample mixture was transferred to an extraction thimble and placed in a Soxhlet extractor. The mixture was extracted with 150 ml of acetone: n-hexane (20:80 *v*/*v*) at 50 °C for 4 h. The extracts were filtered, concentrated to 1 ml using a vacuum rotary evaporator. Each of the raw extracts was then dissolved in 10 ml hexane and passed through pre-conditioned octadecyl C-18 columns at a rate of 2 ml minG1 to clean up. The column was washed with 1 ml, 30% methanol followed by 1 ml ultrapure water and was

Table 2
Levels of organochlorine pesticide residues in sediment samples of Lake Tashk.

Pesticide	Mean (ppb)	Standard deviation (SD)	Range (ppb)	Percentage
DDT	5.220	1.75	4.182–6.541	72
DDE	8.750	2.43	6.334–10.856	94
Chlordane	0.083	0.05	0.062–0.098	28
Heptachlor	0.088	0.05	0.059–0.096	30
Lindane	6.240	1.27	5.641–8.475	75
Endosulfan	12.475	1.92	9.126–15.263	45