Research Journal of Chemical Sciences _____ ISSN 2231-606X
Vol. **5(9),** 11-18, September **(2015)** *Res. J. Chem. Sci.*

Ecological risks and Circulation of determined Organochlorine Pesticides (OCPs) contamination in lake water and sediments of Ahmedabad, India

Hashmi T.S. and Menon S.K.
Department of Forensic Science, School of Science, Gujarat University, Ahmedabad 380009, Gujarat, INDIA

Available online at: www.isca.in, www.isca.me
Received 9th July 2015, revised 7th August 2015, accepted 10th September 2015

Abstract

Pesticides are chemical substance used to control the pest. In India almost all organochlorine pesticides (OCPs) have been banned, but some farmers and industries are still using it for agriculture purpose. OCPs are very toxic and they may affect the biota and also the human consumers. It used to control the crop pest in agricultural field which affects the yield of depending crops on bee pollination, global fish production as well as human health. We have analyzed samples of water, sediment and fish from different lakes of Ahmedabad city using Gas chromatography (GC) with flame ionization detector (FID).This study reveals that the level of dichlorodiphenyltrichloroethane, (DDT) and hexachlorocyclohexane (HCH) in studied lakes is significantly high. Periodic differences in the concentration of these pesticides were also observed. The concentration of organochlorine was advanced in summer than in the monsoon. So, it is necessary to monitor the concentration level of respected pesticides in different lakes which would be helpful in conservation of our environment.

Keywords: Gas chromatograph, organochlorine pesticides (OCPs), pesticide contamination, water, sediment and fish.

Introduction

Ahmedabad is single in the total of India in stock of ecological flourishing conditions and it is higher to additional cities in the distinction of its memorials. Today Ahmedabad is the viable capital of the Gujarat state and the 7th main city of India, has its individual impalpable charm, combining many old-style elements and the latest international combination. The present city is alienated by the river Sabarmati into two parts, eastern and western Ahmedabad. The old city–eastern Ahmedabad–reproducesaexcellent social and architectural combination of Muslim, Hindu and Jain. Later the fresher areas – western Ahmedabad –industrialized with more modern design of all on the other bank of river. Progress has brought many uninvited alterations to environment with increased number of industries and people. Marine atmosphere of water bodies also concerned due to slightly misconduct and unawareness of public. The growth of new environment problems as a result of this has given increase to new ideas in the field of monitoring and assessment of aquatic environment. Monitoring and assessment run the basic information on the condition of a water bodies. Ahmedabad Urban development Authority (AUDA) approved out a survey of 645 lakes and identified 22 lakes which have been severely tainted. Lakes and water bodies had always been an important part for any cultivation to flourish, but in the modern era, these are in totally deserted state. AUDA proposes to assume works for revival, development of catchments area and enhancement of lakes under the present project. AUDA has commenced work on this lake also through own properties.

Lakes can be willingly polluted by human activity without any apparent signs[1], thus they have long concerned scientific and environmental concentration. Chandolalake was once a lifeline of the city of Ahmedabad in Gujarat. This lake is enclosed by large number of small scale industries and favelas. The waste from the industries and surrounding areas is directly unused into the lake. Isanpurlake is being suffocated, encroached upon by the slums. In place of what could have been a beautiful small lake, lies a black mass of polluted water.

Organochlorine pesticide residues are organic chemical substance used to control the pest for the agriculture purpose. Aquatic atmospheres are mainly affected since pesticides applied to land-based cultivation organizations are eventually approved into water bodies through surface runoff, rivers, and groundwater flow. Therefore, protracted and acute effects of pesticide contamination and bioaccumulation in aquatic flora and fauna are additional plain. Pesticides are a singular form of ecological risk substance in that they are considered to damage living organism. Most of the organochlorine pesticides are determined in the atmosphere and have a capacity to bio-accumulate suggestively concluded food chains. OCPs residues such as DDT, HCH, Endosulfan, Aldrine and Heptachlor remains are broadly disseminated in fresh water bodies, such as pools, river, lakes, basins and estuaries[2-3]. So it is important to examine the concentration level and dispersal of OCPs in aquatic systems. The widespread use of pesticides contributes to significant developments in agriculture yields. However, pesticide pollution of fresh water is producing concern with respect to long-term and low dose possessions of pesticides on public health[4].

Aquatic systems showasignificantpart in human contact to OCPs via food webs. Perugini et al., recommend that 90% of

human exposure to OCPs is concluded food-stuff and that fish and crustaceancharacterize an important source of OCP intake[5]. Therefore, descriptive the remainingabsorption of OCPs in aquatic biota isessential to evaluate their risk to protect natural ecosystems. The present study was an attempt to examine the concentration level and dissemination of OCPs in lake water, its sediments of Ahmedabad city. Work has also been extended to aquatic biota. In this study, we have detected the presence of hexachlorobenzene (HCH) and dichlorodiphenyltrichloroethane (DDT) in sediment, water and fish samples collected from different lakes of Ahmedabad.

Material and Methods

The study area and sampling locations were identified based on the possible potential for water contaminations by pesticides. Water sample collection was done in June 2013, September 2013 and January 2014. Samples were collected during different seasons to study the seasonal variation profile. Water (72), sediment (24) and fish (24) samples collected were analyzed during the study period. The lake water samples collected from midway of the lake (40 cm lower the surface) in high purity glass bottles were elated to the laboratory refrigerated at 4^0C and was analyzed for residues of OCPs. The sediment samplescomposed in the polyethylene gears (approximately 500 g) were elated to the laboratory; shingles, shells and plant matter were removed and the samples were air-dried at room temperature. The air-dried samples were then beached with pestle- mortar and separated to 200-250 BSS mesh size. Fish samples were also collected from each lake in January 2014 (figure-1).

All solvents are pesticide residue (PR) grade and were purchased from SDFCL Fine Che-Limited. Dichloromethane (DCM), acetone, hexane (HPLC grade), sodium chloride (AR grade) were procured from SDFCL Fine Che-Limited. Analytical standards of 4, 4, DDT and HCH were purchased from Sigma Aldrich Laborchemikalien GmbH. The standard solutions (1.0 µg/mL) of individual and the mixture of organochlorine pesticides were prepared in hexane. Millipore Milli-Q purified water was used throughout the experiment.

All the glassware was acid washed and cleansed with distilled water. 10 g NaCl was taken in separating funnel and dissolved NaCl in 1000 ml of water sample, kept separating funnel with stopcock on stand vertically and added 60 ml of DCM (dichloromethane) in separating funnel and shaken the separating funnel for 2-3 min. The organic layer was then separated and passed over anhydrous sodium sulphate bed and composed the extract in a round bottom flask (RB). Repeated the whole process again by adding 2 times 30 ml DCM and passed the whole extract through sodium sulphate bed. Evaporated near to dryness with the help of rotary evaporator. The residue was extracted with acetone hexane mixture (1:9) and again evaporated almost to dryness and made up to 1 ml by adding a mixture of acetone and hexane (1:9) which is then used for GC analysis[6].

For the extraction 10 g sediment samples from each location were used following the procedure (AOAC 1976). In 10 g dried sediment sample added 7 ml 0.2 M ammonium chloride solution. A mixture of 100 ml hexane: acetone (1:1) remained used as a solvent to extract pesticides with overnight shaking for 12 h on reciprocal or wrist action shaker at 180 rpm. The extract was sensibly decanted through activated florisil column (2-3 cm), giving twice wash with25 ml hexane: acetone (1:1) to the sediments. The elute was then washed with 200 ml water and then again aqueous surface was removed with 50 ml hexane. Finally hexane layer was cleaned through 100 ml water and then evaporated to desiccation with a vacuum rotary evaporator. The determined extract was then passed concluded a chromatographic column (30 cm x 10 mm i.d) containing 2 g florisil (lower) and 1 g sodium sulphate (upper) which is pre wetted with hexane: acetone (1:1). OCPs were eluted with 25 ml hexane: acetone (1:1). Solvent was evaporated using rotary evaporator and ultimate volume was accustomed to 5 ml, which is used for GC analysis. All the sediments were analyzed for HCH and DDT[7].

Weighed 20 g of the sample and transferred sample into metal blender. Moisten 40 g granular sodium sulphate with petroleum ether than added to sample. Mixed sample, via rod, allowed to stand for 20 min and mixed once more. Added 100 ml petroleum ether to sample blended for 1 min. Centrifuged the sample for 2 min at ca 2000 rpm to get clear petroleum ether extract. Placed glass wool wad in funnel, overly with 20 g granulated sodium sulphate and located funnel in 250 ml volumetric flask. Mixed sample again with stirring rod, added 100 ml petroleum ether. Transferred 25 ml aliquot to tared 100 ml flat bottom extraction flask, by the help of steam bath to evaporate solvent, leave extra 30 min on steam bath, remove, and then cool. Weigh flask and conclude % fat. For fish containing < 10% fat, transfer 25 ml aliquot to 125 ml K-D concentrator. For fish containing > 10 % fat, take aliquot having not> 200 mg fat. Concentrate to 3 ml on steam bath. Let cool and remove Snyder column. Rinse concentrator with1 ml portion of petroleum ether, viaindividual current of air, concentrate sample to 3 ml for transfer to florisil column.

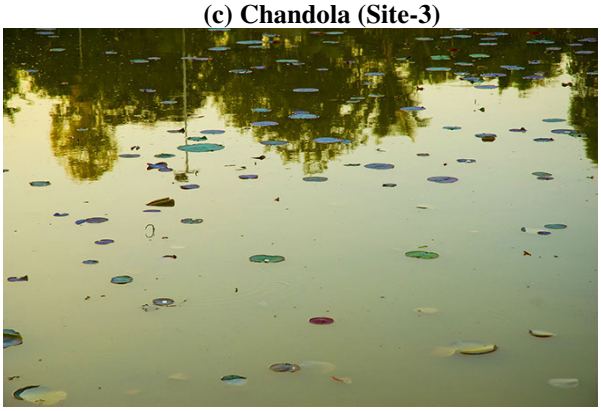
Usage 4 g of florisil accustomed for lauric acid[7]. Add florisil to 300 × 10 mm i.d chromatographic tube and add sodium sulphate to a height of 2 cm over head florisil. Completely open stopcock, tap tube to settle adsorbent and make tube 1 cm above sodium sulphate layer. Add 20-25 ml petroleum ether, as solvent level spreads mark, place 125 ml K-D flask under column. Allocation 3 ml to column, wash tube with 1 ml petroleum ether and wash to column. Solvent level necessity not goes below mark. Temporarily close stopcock if needed. Add 35 ml petroleum ether-combination (94 + 6) and elute PCBs and DDT and its equivalents. When solvent level reaches mark, charge K-D flask, and add 35 ml petroleum ether-ether (85 + 15) to elute mixtures.

(a)Vastrapur (Site-1)

(b) Kankaria (Site-2)

(c) Chandola (Site-3)

(d) Ghodasar (Site-4)



(e) Isanpur (Site-5)

(f) Maleksaban (Site-6)

(g) Nikol (Site-7)

(h) Odhav (Site-8)

Figure-1
Map of water samples collection sites from different lakes of Ahmedabad

Add several granules of caborundum to first concentrator accord Snyder column and sensibly concentrate on water bath. After concentration remove Snyder Column and evaporate solvent under air to proper volume for GC determination. The pesticide residue were analyzed by gas chromatography (GC) and supported by flame ionization detector (FID) and GC software. This detector consents the lower detection of contaminants at trace level concentration in the lower ppm range in the occurrence of a multitude of mixtures extracted from the matrix to which this detector do not respond. Nitrogen was used as the carrier gas and make up gas and the injection technique was in the split mode. Injector temperature was set at 270˚C and a volume of 1 µl of each sample was injected. The column flow was set at 0.7 ml/min and detector temperature was 300˚C. A 30 m 0.25 mm i.e. 0.25 µm film width fused silica capillary column was used for the chromatographic separation of pesticides. The Limit of Quantification (LOQ) and Limit of Detection (LOD) for OCPs were 0.002 µg/l and 0.001 µg/l, respectively.

Results and Discussion

Recent study has been undertaken to identify the level of pesticide residues and accumulation in Ahmedabad Lakes. Basic statistics data and analysis are described in this study; HCH and DDT were detectable in all water, sediments and fish at different sampling sites of lake samples throughout the study period and are summarized in the given table below (table-1).

The solubility of lindane (γ-HCH) in water is 10 mg/L. WHO organizes lindane as "Moderately Hazardous" pesticide. The USEPA (2005) has determinate that lindane does not pollute consumption water in excess of the Agency's level of concern[8]. Maleksaban Lake (S-6), residual concentration of ∑HCH ranged from BDL-1122.42µg/l, BDL-1275.26 ng/g and BDL-689.74 ng/g respectively. In the case of Nikol Lake (S-7), residue of ∑HCH concentration ranged from BDL-119.65µg/l, BDL-224.35 ng/g and BDL-23.01 ng/g respectively. If we compare the residues of organochlorine pesticides (OCPs) between different sampling sites, the site-6 from Maleksaban Lake has maximum concentration of this persistent compound 1263.96 ng/g in sediment whereas the level is 1106.01µg/l in water sample (figure-2).

Table-1
Statistically data of OCPs contamination in surface water, sediments and fish samples of Ahmadabad Lakes, Gujarat, India.

	Water(µg/l)		Sediments(ng/g)		Fish(ng/g)	
Pesticides	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**
Site-1∑HCH	BDL-665.19	662.20±10.13	BDL-755.07	749.72±15.51	BDL-174.78	173.95±12.21
Site-1∑DDT	BDL-208.48	203.27±15.46	BDL-239.33	234.77±11.50	BDL-28.55	27.03±5.69
Site-2∑HCH	BDL-912	896.66±15.01	BDL-921	913.33±8.62	BDL-251.63	241.32±11.25
Site-2∑DDT	BDL-115.58	101.51±14.08	BDL-222	209.33±13.57	BDL-12.36	12.36±0.21
Site-3∑HCH	BDL-692.42	678.02±15.07	BDL-821	810.33±11.59	BDL-210.98	209.84±10.23
Site-3∑DDT	BDL-224.53	205.82±19.06	BDL-411	399±11.53	BDL-14.52	13.52±0.93
Site-4∑HCH	BDL-977.42	962.67±14.56	BDL-998	990.66±7.02	BDL-341.52	339.45±15.23
Site-4∑DDT	BDL-196.28	184.57±10.71	BDL-264	265.33±12.50	BDL-25.42	24.59±1.23
Site-5∑HCH	BDL-802.62	790.24±12.05	BDL-835	814.33±20.50	BDL-241.69	236.85±9.87
Site-5∑DDT	BDL-98.94	85.90 ±13.04	BDL-178	165±13.00	BDL-21.03	20.13±0.87
Site-6∑HCH	BDL-1122.42	1106.01±16.06	BDL-1275.26	1263.96±11.47	BDL-689.74	679.58±15.23
Site-6∑DDT	BDL-186.53	175.82±10.55	BDL-274.42	264.85±9.44	BDL-32.98	32.01±0.04
Site-7∑HCH	BDL-119.65	108.28±12.12	BDL-224.35	211.59±13.12	BDL-23.01	21.05±0.08
Site-7∑DDT	BDL-98.20	110.83 ±12.49	BDL-214.12	206.52±9.89	BDL-42.19	41.85±0.23
Site-8∑HCH	BDL-365.68	352.96±12.58	BDL-474.40	463.03±11.02	BDL-125.69	124.95±5.14
Site-8∑DDT	BDL-298.62	286.25±12.06	BDL-324.38	313.41±10.50	BDL-158.32	158.02±13.02

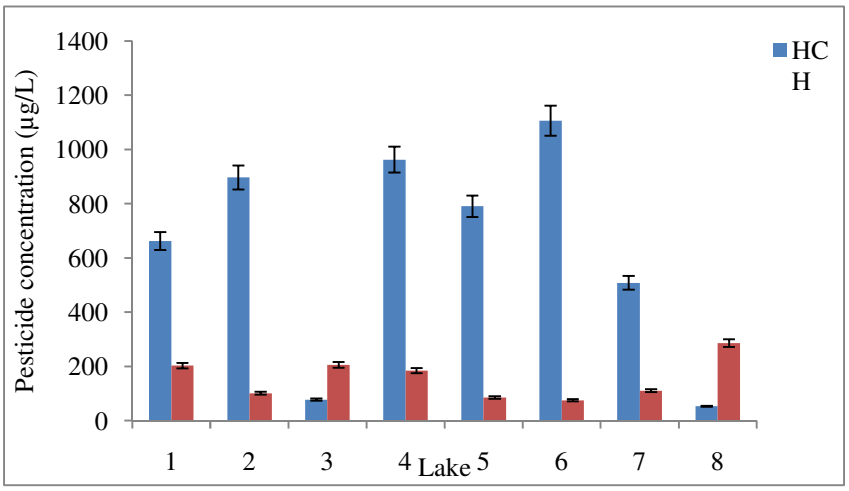


Figure-2
Concentration level of HCH and DDT in water (µg/l) sample sat eight regions of Ahmadabad Lake

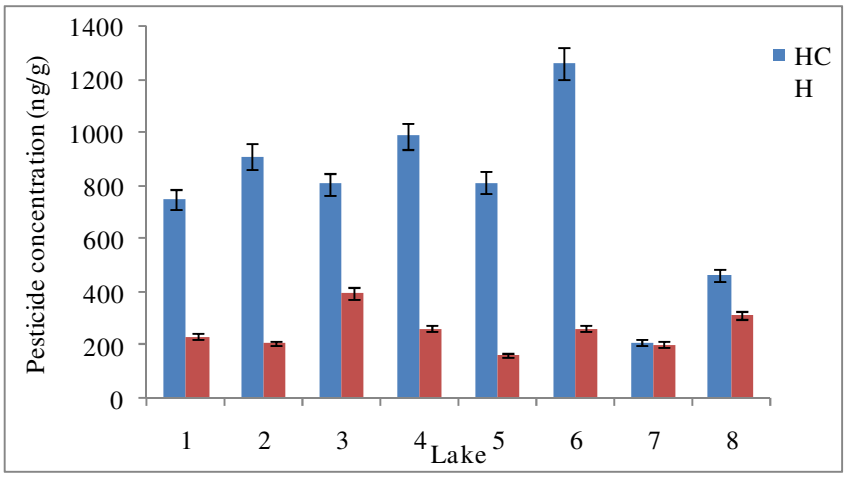


Figure-3
Concentration level of HCH and DDT insediment (ng/g) samples at eight regions of Ahmadabad Lake

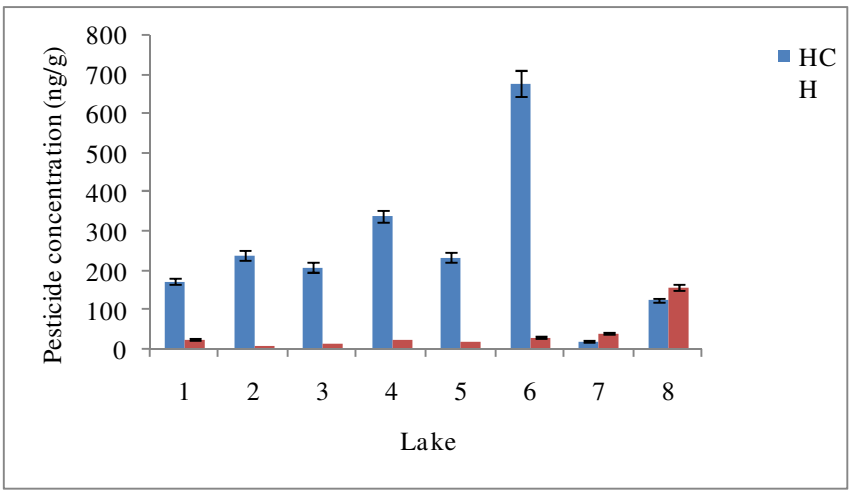


Figure-4
Concentration level of HCH and DDT in fish (ng/g) sample sat eight regions of Ahmadabad Lake

But water sample of the site-7 of Nikol Lake has less concentration of OCPs 217.85µg/l in water where as in sediment sample its level is 438.47 ng/g (figure-2 and 3). In the case of DDT, water, sediment and fish samples collected from Odhav Lake (S-8), showed a residual concentration of ∑DDT ranging from BDL-298.62µg/l, BDL-324.38ng/g and BDL-158.32 ng/g respectively (table-1).

The study has been done mostly for Indian lake like Anasagar of Ajmer (Rajasthan), Keoladeo national park lake, Bharatpur (Rajasthan).The concentration level of OCPs residues detected in the water sample of Anasagar lake were in the range of 125-1174 µg/l and 26-56.2 µg/l of Beta- HCH and pp-DDT respectively[9], this concentration level is lesser than the levels which were found in our study. In water sample of Keoladeo National Park Lake Bharatpur, total residues of HCH and DDT ranged from 0.065-0.199 and 0.014-0.560 µg/l where as in sediment samples it ranged from 0.382-1.924 ng/g and 0.799-14.375 ng/g, respectively which is very low level as compared to our data[10]. Stages of DDT and lindane in water samples of Lake Parishan, Iran ranged between 0.12-0.24µg/l and 0.45-1.50 µg/l respectively[11]. Now water and sediment samples collected from Lake Manyas Turkey, levels of total HCH and DDT ranged from 0.05-0.96, ND-2.56 µg/l and 1.69-7.44, 2.45-8.51 ng/g respectively[12]. The concentration level of DDT ranged from 0.190-4.714 µg/l in samples collected from Manzala Lake, Egypt[13] (table-2).

HCH is extensive pollutant that has come in to the atmosphere by its previous manufacturer and its creation as a by-product during production of a diversity of chlorinated compounds. It is a popular pesticide used by farmers. The report of poisoning due to pesticides in India comes from Madhya Pradesh in 1967-68 where, 12 people were affected and over 12 people died due to high level of HCH. The case study reported of poisoning due to HCH comes from Uttar Pradesh (India) in 1978 where, over 250 people were affected and 4 died[14-15]. DDT has barred for agricultural usage in 1989, but now it is still recycled in the public health sectors for malaria control[16] and by farmers due to lack of public awareness and improper implementation of government policies. DDT has long half-life therefore it is present in the environment till now.

Darko et al. reported the mean concentrations of DDT in water, sediments and fish were 3.64±1.81 ng/g, 4.41±1.54 ng/g and 0.012±0.62 ng/g respectively from Lake Bosomtwiin Ghana, which is less than the levels of lakes of Ahmedabad as per our report[17]. Similarly, Siriwong et al., reported that the stages of DDT and its derivatives in bed-sediments and vertebrates which were 12.05 ng/g and 4.16-57.66 ng/g respectively and was less than the results of analysis of fish samples of the present study[18].

Samples were collected in April 2013, September 2013 and January 2014. As shown from table-3 ∑OCPs in water samples were found higher during summer season as compared to the remaining seasons. During monsoon the concentration of ∑OCPs is less as compared to other season. During the monsoon heavy water flow cause loss of river bed-sediments and its resuspension into the river water column and the contaminants orbed on the residue particles may be diluted by runoff. The water flow during the winter season becomes controlled and river system starts to be stabilized with the settling of eroded deposits whereas during summer the River system is under the stabilized situations but some manmade instabilities or other actions like washing, swimming, boating etc. Thus the biota and aquatic flora and fauna also fluctuates with the changing concentration of organ chlorine pesticides. Same results were reported by Kouzayha et al. for Lebanon's Water Resources[22]. They reported that pesticide concentration follow seasonal patterns, this may be due to timing of agricultural activities and pesticide applications in addition to the runoff condition.

Table-2
Comparison of organochlorine pesticide contamination in sediments of Lake samples sincedifferent locations in the world

Location	Year	∑DDTs	∑HCH	References
Maleksaban lake Ahmadabad, India	2014	264.85	1263.96	Present study
Anasagar lake Ajmer, India	2006-2007	0.026-0.0562[e]	0.125-1.174[a]	(Sharma et al. 2008)[9]
Keoladeo national park lake Bharatpur, India	2000	0.799-14.375[d]	0.382-1.924[c]	(Kathpalet al.2004)[10]
Chaohu Lake, China	2009	0.3-31[d]	0.2-1.8[c]	(Liu et al.2013)[19]
Manzala Lake, Egypt	2005	0.20-5.17[d]	nd-3.42[c]	(Barakatet al.2012)[13]
Dongting Lake, China	2004	0.21-9.59[c]	nd-10.15[b]	(Qian et al.2006)[20]
East Lake, China	2012-2013	0.87-31.6[g]	3.2-201.8[c]	(Yun et al.2014)[21]
Lake Parishan, Iran	2010	4.21-6.18	3.06-14.21	(Farshid et al. 2012)[11]
Lake Manyas,Turkey	1998-1999	2.45-8.51[d]	1.69-7.44[c]	(Erkmen et al.2012)[12]

nd =not detected, [a] β-HCH, [b] Sum ofp,p'-DDE,p,p'-DDD,o,p'-DDT, and p,p'-DDT, [c]Sum of α-,β-,γ-, and δ-HCH, [d] Sum of o,p'-DDE,p,p'-DDE,o,p'-DDD,p,p'-DDD,o,p'-DDT, and p,p'-DDT, [e]pp-DDT, [f]Sum of dichlorobenzophenone,p,p'-DDE,p,p'-DDD, and p,p'-DDT, [g] Sum of p,p'-DDE,p,p'-DDD, andp,p'-DDT, [i] Sum of o,p'-DDT and p,p'-DDT.

Table-3
Concentrations level of Pesticide residues with respect to seasonal variation

Location	OCPs	April (2013) summer	September(2013) monsoon	January (2014) winter
		Mean±SD	Mean±SD	Mean±SD
VastrapurLake (S-1)	∑HCH	2348.58±15.21	536.98±12.321	986.60±10.13
	∑DDT	1253.32±30.25	45.69±5.21	609.82±15.46
Kankaria Lake (S- 2)	∑HCH	1458.69±21.23	214.32±10.21	896.66±15.01
	∑DDT	853.21±20.21	12.32±0.01	201.51±14.08
Chandola Lake(S-3)	∑HCH	1574.25±20.32	214.01±10.21	678.02±15.07
	∑DDT	623.14±21.31	32.14±0.25	205.82±19.06
Ghodasar Lake(S-4)	∑HCH	1712.54±25.32	42.23±2.01	962.67±14.56
	∑DDT	678.45±5.21	23.57±0.03	184.57±10.71
Isanpur Lake(S-5)	∑HCH	1678.25±34.25	238.47±12.03	790.24±12.05
	∑DDT	256.34±13.21	12.32±1.23	85.90±13.04
Maleksaban Lake(S-6)	∑HCH	2136.85±45.63	325.45±16.71	1106.01±16.06
	∑DDT	547.21±20.12	12.36±0.04	175.82±10.55
Nikol Lake(S-7)	∑HCH	469.42±20.32	10.36±0.52	108.28±12.12
	∑DDT	531.02±24.14	-	110.83±12.49
Odhav Lake(S-8)	∑HCH	825.63±23.35	34.23±10.26	352.96±12.58
	∑DDT	789.90±41.32	58.69±32.12	286.25±12.06

Conclusion

This is the first attempt to analyse the organochlorine pesticide concentration in the Lake of Ahmedabad city. HCH and DDT were noticed in all water, sediment and fish samples collected from different sites. Levels were much higher than the concentration found at other lakes of India and abroad. It was also found that the levels of pesticide residues present during summer was very high as compare to other seasons because of the low quantity of water as compared to monsoon, when rain water feeded the lake and concentration levels of all organochloride residue were very low due to dilution by rain water. By this the biota and aquatic flora and fauna of water body got disturb with the changing concentration of organochlorine pesticides. The stages of various organochlorine pesticides were higher in water and sediment samples as equaled to fish. The absorption of the OCPs in water, sediments and fish is considered to be alarming, which is beyond the permissible limit µg/l α-HCH; 0.01 β-HCH;0.04 γ-HCH;2.0 δ-HCH;0.04 o,p-DDT;1.0 and p,p-DDT;1.0 of each pesticide. It will cause the bio-magnification of these pesticides, so this study recommends that further studies should focus on the prospective bio-accumulation of organochlorine pesticides in aquatic biota and risks related with their consumption.

Acknowledgement

We are obliged to Maulana Azad National Fellowship Program for their financial support.

References

1. Oyewale A.O. and Musa I., Pollution assessment of the lower basin of Lakes Kainji/Jebba, Nigeria: heavy metal status of the waters, sediments and fishes, *Environ. Geochem. Health*, **28,** 273-281 **(2006)**

2. Tao S., Li B.G., He X.C., Liu W.X. and Shi L.Z., Spatial and temporal variations and possible sources of dichlorodiphenyltrichloroethane (DDT) and its metabolites in rivers in Tianjin, China, *Chemosphere*, 10-16 **(2007)**

3. Zhou R., Zhu L. and Chen Y., Levels and source of organochlorine pesticides in surface waters of Qiantang River, China, *Environ. Monit.Assess.*, **136,** 277–287 **(2008)**

4. Canbaya H.S., Ogut S. and Yılmazer M., Pesticide Residues Analysis in Lake Water and Sediment Samples from the Golcuk National Park, *Water Resources*, **41(1),** 97–104 **(2014)**

5. Perugini M., Giammarino A., Olivieri V., Guccione S., Lai O.R. and Amorena M., Polychlorinated biphenyls and organochlorine pesticide levels in tissues of caretta from the Adriatic sea, *Dis. Aquat. Organ*, **71,** 155-161 **(2006)**

6. JAOAC, *Official Methods of Analysis*, Arlington VA. USA (**51**), 29 **(1968)**

7. AOAC, Pesticide and Industrial chemical Residues, *Official Methods of Analysis*, Arlington, VA.USA **(970),** 52 **(1976)**

8. Report on toxicology profile for alpha, beta, gamma and delta-hexacholorocyclohexane, In agency for toxic substances and disease registry, U.S. Department of health and human services, **(2005)**

9. Sharma K.C., Charan P.D., and Patni A., Pesticide Contamination in Lake Anasagar of Ajmer, Rajasthan, *12th World Lake Conference*, **(2008)**

10. Kathpal T.S., Rani S., Kumari B. and Prasad G., Magnitude of Pesticidal contamination of sediment and water of Keoladeo National Park Lake, Bharatpur, *Pesticide Research Journal*, **16(2),** 75-77 **(2004)**

11. Kafilzadeh F., Shiva A.H., Malekpour R. and Azad H.N., Determination of Organochlorine Pesticide Residues in Water, Sediments and Fish from Lake Parishan, Iran, *World Journal of Fish and Marine Sciences*, **4(2),** 150-154 **(2012)**

12. Erkmen B., Yerli S.V., Erk'akan F. and Kolankaya D., Persistent organochlorine pesticide residues in water and sediment samples from Lake Manyas, Turkey, *Journal of Environmental Biology*, **34,** 171-176 **(2013)**

13. Barakat A.O., Mostafa A., Wade T.L., Sweet S.T., Sayed N.B., Assessment of persistent organochlorine pollutants in sediments from Lake Manzala, Egypt, *Mar. Pollut. Bull*., **64,**1713–1720, **(2012)**

14. Gupta, P.K., Pesticide exposure- Indian Scène, *Toxicology*, **198,** 83-90 **(2004)**

15. Hashmi T.S. and Menon S.K. Accumulation and distribution of persistent organochlorine pesticide and its contamination in surface water and sediments of Sabarmati River, India, *Journal of advances in environmental health research*, **3(1) ,(2015)**

16. UNEP, Global report on regionally based assessment of persistent toxic substances, Geneva, Switzerland: UNEP Chemicals, **(2003)**

17. Darko G., Akoto O. and Oppong C., Persistent organochlorine pesticide residues in fish, sediment and water from lake Bosomtwi, Ghana, *Chemo.*, **72(1),** 21-24 **(2008)**

18. Siriwong W., Thirakhupt K., Siticharoenchai D., Rohitrattana J., Thongkongown P., Borjan M. and Robson M., DDT and derivatives in indicator species of the aquatic food web of Rang sit agricultural area, Central Thailand, *Ecol. Indic*., **9(5),** 878-882 **(2009)**

19. Liu W.X., He W., Qin N., Kong X.Z., He Q.S., Ouyang H.L. and Xu F.L., The residues, distribution, and partition of organochlorine pesticides in the water, suspended solids, and sediments from a large Chinese lake (Lake Chaohu) during the high water level period, *Environ. Sci. Pollut. Res.,***20,** 2033–2045 **(2013)**

20. Qian Y., Zheng M., Zhang B., Gao L., and Liu W., Determination and assessment of HCHs and DDTs residues in sediments from lake Dongting, China, *Environmental Monitoring and Assessment*, **116,** 157–167 **(2006)**

21. Yun X., Yang Y., Liu M. and Wang J., Distribution and ecological risk assessment of organochlorinepesticides in surface sediments from the East Lake, China, *Environ. Sci. Pollut. Res*., **21,** 10368–10376 **(2014)**

22. Kouzayha A., Ashi A.A., Akoum R.A., Iskandarani M.A., Budzinski H. and Jaber F., Occurance of Pesticide Residues in Lebanon's Water Resources, *Bull. Environ. Contam. Toxicol.,* **91,** 503-509 **(2013)**