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Persistence of Organo-Chlorine Pesticides in Groundwater of Jhansi City, India

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Organochloro pesticides have been analyzed in the groundwater samples collected from different sites. The most commonly used organochloro pesticides of the region were identified and analyzed in the groundwater samples at various site. The estimation of organochloro pesticides was done by gas chromatographic analysis. Among organochloro pesticides analyzed, the sorption decreased in the order of endosulfan > BHC > DDT; however, the leaching order is reverse.

Key Words: Persistence, Organochloro pesticides, Groundwater.

INTRODUCTION

Organochloro pesticides have been dispersed ubiquitously in environment[1] when applied on any field, they can meet a variety of fates. Some may be lost to the atmosphere through volatilization and transported long distance from their sites of application, others are carried away by surface runoff or photodegraded by sunlight. When entering into the soil, pesticides may be taken up by plants or degraded but they may also be transported through the unsaturated zone to groundwater or *via* drains, reach surface water bodies. Consequently, considerable levels of organochloro pesticides have been detected in different components of human environment such as air, water, soil, plants and animals[2].

The fate of a pesticide applied to soil depends largely on its persistence and solubility properties. Once applied to crop land, pesticides may either be taken up by plants[3] or ingested by animals, insects, worms or microorganisms in the soil or may move downward in the soil[4] and either adhere to it or dissolve in water or may vapourize[5] and enter the atmosphere or may breakdown *via* microbial and chemical pathway into other, less toxic compounds[6] or may be leached out[7] of the root zone by rain or irrigation water. Generally the degradation rate decreases and adsorption increases with increasing soil organic matter and clay content. Ninety per cent of all acetanilide loss is due to microbial degradation. This organochloro pesticides are persistent and their negative effect in soil and water long lasting. They are absorbed by crops and subsequently enter the human food chain. There effect may be acute, resulting in mass mortality or chronic, involving changes in survival growth and reproduction[8].

Usages of organochloro pesticides have been prohibited in most of countries but 70 % of banned pesticides are still used in India because of their low cost. In India DDT was banned for use in agriculture in 1985 but still 7500 metric tones per year is used here[9].

The present work was carried out to determine some organochloro pesticide residues in soil and groundwater samples from Jhansi, India.

EXPERIMENTAL

The present study covers the entire urban and suburban region of Jhansi city. After the initially survey of the city and near by agricultural fields, 15 locations were selected for collecting groundwater samples. The sampling locations were classified as agricultural, gardening nursery and landfills areas. The first 3 use organochloro pesticides directly for growing wheat, grams, linsed potato flowers and fruits, but the landfills receive them with solid wastes and agricultural roundoffs.

Groundwater samples were collected from tube wells at 5 different locations amidst and around each site in the study area. Tube-wells were selected away from the dwelling units in such a way as to represent the entire site used for a particular activity. The distance between any 2 tube-wells chosen for study was at least 5 km. In all 75 samples were analyzed.

One litre of ground water sample was collected in a precleaned glass bottle with teflon lined caps from the each jet pump. Samples were kept under refrigeration until analysis. All analyses of a sample were completed within 1 week of sampling. A water sample (500 mL) was taken in 1 L separatory funnel and log NaCl was added to it and was shaken to dissolve NaCl completely. Then 50 mL of 15 % dichloromethane in *n*-hexane was added and the funnel was shaken vigorously for 2-3 min with intermittent pressure release. The separatory funnel was kept undistributed to separate the 2 layers. The lower aqueous layer was drawn into 1 L separatory funnel. The process of partitioning was reported 2 more times using fresh 50 mL portions of 15 % dichloromethane in *n*-hexane. The 3 extracts were combined and dried by passing through an adsorbent (2.5 cm ID and 15 cm 10 ng) containing 5 cm layer of anhydrous Na_2SO_4 over a small pad of glass wool at the bottom. The extracts were concentrated to about 0.5 mL with Kuderna Danish evaporator containing a 3 ball suyder column 3 mL of *n*-hexane was added to the combined extract and concentrated to 0.5 mL again. The process was repeated one more time to remove the final traces of dichloromethane. The residues were finally taken up in *n*-hexane for GLC analysis.

Organochloro pesticides were analyzed using a thermo finnigan trace GC equipped with a Samsung 52x pc. Hpdeskjet 656 c printer, a capillary column Hp 101 (25 mm × 0.2 mm id × 0.2 µm film thickness) with splitling ratio 1:100, an auto sampler and a Ni electron capture detector (^{63}Ni). The operating parameters were carrier gas nitrogen with flow rate 1 mL/min operating temperature-injection port 250, column 195 ºC and detector 300 ºC. The organochloro pesticides were quantified by comparing the samples chromatograms with standards obtained from Aldrich-Sigma.

RESULTS AND DISCUSSION

Organochloro pesticides were the first synthetic insecticides to be developed and of these DDT and BHC are probably the best known. Their advent in 1940s revolutionized global agriculture and was thought that the war with the insects was over once for all. But as per United State National Research Council and FAO experts over 650 species of weeds, insects and fungi have become resistant while 17 of insects have assumed the status of 'super bugs' and are immune to all poisons. Therefore every year the requirement of pesticides in India increase by 20-25 % Andhra Pradesh tops list with 33.6 % followed by Karnataka at 16.2 % and Gujarat 15.0 %. The widespread and sometimes indiscriminate use of organochloro pesticides to destroy disease vectors and to protect crops leads to what proved to be serious environment problems.

TABLE-1
AVERAGE IN ng/L OF ORGANOCHLORINE PESTICIDES RESIDUES IN GROUNDWATER SAMPLES OF JHANSI

Areas	No. of samples	ΣBHC	ΣDDT	Endosulfan
Kocha Bahawar	12	132	302	15
Shivaji Nagar	10	212	331	8
Adarsh Nagar	8	161	259	ND
Nagra	10	46	202	ND
Awas Vikas	5	681	204	ND
Nandan Pura	8	153	252	ND
Antiya Taal	10	302	603	12
Railway Colony	8	733	57	20
C.P. Mission Compound	10	321	309	16
Narayan Bagh	12	292	401	25
B.U. Campus	5	143	212	ND
Rani Laxmi Bai Park	7	201	218	ND
Sipri	10	702	812	56
Khatibaba	5	506	686	11
Veerangana Nagar	5	286	381	21

ND = Not detectable.
*Areas = Kochabhawar to C.P.Mission Compound are Agricultural, Narayan Bagh is Nursery, B.U. Campus and R.L.B. Park are gardening and Sipri to Veerangana are landfills areas.

Technical BHC is largely comprised of 55-70 % α, 5-14 % β, 10-13 % γ and 3-4 % δγ forms. γ-BHC is a very strong insecticides and is called gammaxene, gammane, lindane or 666. Here BHC refers the sum of mainly α, β and forms and is better indicated in Table-2 by ΣBHC. BHC residues were deleted at almost all locations obviously due to its regular use. α was the predominant isomer followed by β and γ-isomer. The β-isomer invariably had the lowest concentration. However, it was more than its normal percentage in technical BHC, indicating its accumulation in the environment. γ-BHC concentrations were well below the limit (3000 ng/L)

specified by the WHO for drinking water quality. Although there is no specified limit for β-BHC, accumulation of this carcinogenic isomer is a cause for concern the mean total BHC concentration was however, less than that found in earlier reports on ground water from urban areas.

TABLE-2
FREQUENCY, MEAN, STANDARD DEVIATION OF THE ORGANOCHLORINE PESTICIDE RESIDUES IN GROUND WATER (ng/L) SAMPLES OF JHANSI

Parameters	Groundwater		Average
	Frequency (%)	Mean ± Standard deviation	
ΣBHC	89.6	310.25 ± 212.18	324.73
ΣDDT	97.6	389.21 ± 186.10	383.27
Endosulfan	43.2	13.76 ± 15.11	12.27

Technical DDT is largely comprised of *p*,*p*′-DDT (~ 80 %) but also of *o*,*p*′-DDT (*ca.* 15 %)[10] and is slowly decomposed to the main metabolites *p*,*p*′-DDE and *p*,*p*′-DDD. In the soil samples ΣDDT ranging from ND-1.82 mg/kg, *p*,*p*′-DDT was dominant component of the DDT family, accounted for an average of 48 % of ΣDDT whereas *p*,*p*′-DDE and *p*,*p*′-DDD accounted for an average of 28 and 33 %, respectively. However in the groundwater *p*,*p*′-DDE was 50 % of ΣDDT whereas *p*,*p*′-DDD and *p*,*p*′-DDT constituted 10 and 40 %, respectively. The DDT residues were detected at almost all the locations. At many places DDT concentration was quite high and even exceeded the WHO limit (100 ng/L).

Endosulfan residues were detected at many locations throughout the year. α-Endosulfan was found in higher concentrations than its β-form. Endosulfan sulfate was not detected in any sample.

The high concentrations of pesticides are obviously due to their extensive use in agricultural. It is estimated that 20,000 Kg of pesticides is used in the region per annum of which organochlorines comprise more than 60 %. The major crops grown in the area are potato, wheat and vegetables. The use of aldrin as antitermite agent in potato crop could account for such high concentration of aldrin in groundwater. Although DDT is banned for use in agricultural, it continues to be used for public health. Despite ban some farmers still use DDT because of its low cost. This has resulted in a high concentration of DDT in groundwater.

A large amount of water is pumped out from the tubewells during each cropping season when water evaporates, non-degradable pesticides remain on the surface. With rains they get incorporated into the subsoil and eventually infiltrate into the ground water. Although most organochlorine pesticides are sparingly soluble in water, they leach to the lower soil profiles under the influence of water moving towards the sub soil. The rapid leaching of pesticides may be attributed to the texture of the soil which is either silt, loam or sandy loam with the organic matter content as low as 0.5 %.

The wells with pesticide residues detected did not cluster together in a single glographic region of the city. The indicates that the pesticides found may not have a single large scale source contamination of the groundwater. The region is having multiple aquifers. The unsaturated zone and shallow aquifers 20-30 m deep mostly composed of silty or sandy loam and are more contaminated than deeper aquifers. Some of the wells contaminated with pesticides were drilled into bedrock and most wells were 5-10 years old. The bedrock in this area is a fractured metamorphic rock. Several hyptheses for the source of these pesticides may be advanced. There could be faults in the well parapets allowing surface water into the wells. These could be large fractures in the bedrock which result in relatively fast flow of groundwater and recharge from surface. It is also possible that the long term usage of these pesticides has allowed the pesticides to leach into the groundwater source despite their unfavourable physical characteristics. The scope of this study did not allow us to determine the mecahnism by which these wells are being contaminated.

These results show the presence of pesticides in groundwater wells from residential areas around agricultural, hotricultural, waste disposal and road side sites. Although only a small percentage of the wells were found to have pesticides residues and the concentrations found below levels of concern, these finding do indicate that pesticide can potentially contaminate the groundwater used by home owners. To illuminate fully the scope of the contamination, further research is necessary. Firstly, a more widespread region wide set of samples would allow us to determine how typical these results are for a community. Secondly, a smaller subset of wells should be monitored on a regular basis. This would allow us to determine if there is a seasonal aspect to the pesticide occurrences. In any case, this research shows the potential for contamination of drinking water and therefore supports the idea to reduce pesticide use when possible.

It is concluded from this work that the level of organochloro pesticides in Jhansi city groundwater is relatrively high and is expected to be much higher in food chains including plants, predators and humans. The illegal use of organochloro pesticides must be immediately stopped. The level of contamination should be regularly monitored at different levels and appropriate measures, must be taken to control pesticide in Jhansi city.

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