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Ground Water Contamination by Organochlorine Insecticide Residues in the Godavari Plain of Nanded district

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Abstract

Residues of several organochlorine insecticides were monitored in the ground water from rural areas in the Godavari river plain of Nanded district for one year (2010-11). Almost all the samples were found to be contaminated with residues of Hexachlorobenzene (HCB) and Dichloro-diphenyl-trichloroethane (DDT). Resides of Aldrin, endosulfan and heptachlor were also detected in large number of samples. The concentrations of aldrin residues greately exceeded the WHO guideline value for drinking water, concentrations of heptachlor and DDT residues also occasionally exceeded the specified limits. Migration of pollutants through ground water recharge with polluted Godawavari River and monsoon rains carrying undegraded residues downwards from the soil surface are thought to be important sources of insecticide contamination of ground water in the region.

Key Words: Groundwater, Godavari Plain of Nanded, insecticides analysis

Introduction

Ground water represents one of the most important sources of potable water all over the world. There has been a steady increase in the use of ground water for human consumption and for irrigation in farmland in semi-arid and arid regions. At present, ground water contamination by persistent organic chemicals has emerged as a major environmental concern because of the difficulty in evaluation the fate and ecotoxicological effects of these pollutants when they are located beneath the water table.

Among various organic and inorganic water pollutants, pesticides are very dangerous and harmful because of their tissue degradation and carcinogenic nature [1]. The term "pesticide" is a composite term that includes all chemicals that are used to kill or control pests. In agriculture, this includes herbicides (weeds), insecticides (insects), fungicides (fungi), nematocides (nematodes), and rodenticides (vertebrate poisons). Pesticides are bioaccumulative and relatively stable, and, therefore, require close monitoring. Lack of proper amenities in many housing societies and apartments has rendered the water unsafe for drinking as well as for domestic purpose. This has resulted in the contamination of ground water supplies with different pesticides and industrial wastes. There is a common misconception among people that groundwater is generally safe for human consumption. However, it is not correct to presume that ground water is generally safe owing to qualitative changes in ground water, especially in the high-density residential areas where sewage and industrial disposal practices are not proper.

Certain pesticides are found to disturb the enzymatic activities of the body which leads to different types of diseases [2]. A list of most commonly used pesticides with acceptable daily intake [3] is given in Table 1 [4]. The various diseases/adverse effects produced due to some commonly used pesticides are listed in Table 2 [4].

Table 1 Some most commonly used pesticides with their acceptable daily intake concentrations.

Pesticide	Maximum acceptable values (µg/l)
Alachlor	20.00
Aldrin/Dieldrin	0.03
Carbofuran	5.00
Chlordane	0.20
DDT	2.00
HCB	1.00
Heptachlor	0.03
Methoxychlor	20.00

Table.2 Most Commonly used pesticides and their health hazards.

Pesticides	Diseases/adverse effects
Aldrin	Attacks the nervous system, convulsion, repeated dosage damages the liver, carcinogenic
BHC	Liver tumour
Captan	Abnormality in the eyes and brain, carcinogenic
Chlordane	Carcinogenic
DDT	Liver damage, carcinogenic, destroys enzymatic activities
Endosulfan	Carcinogenic
HCH	Highly toxic, bone marrow damage, mutagenic, teratogenic, carcinogenic
Heptachlor	Liver damage, carcinogenic
Malathion	Low toxic but sometimes carcinogenic
Methoxychlor	Low toxic but sometimes carcinogenic
Mirex	Carcinogenic

Study area

The Godavari river rises near the Trimbak in the district of Nasik in the Indian state of Maharashtra. The river is approximately 1,465 km long and has a total catchment area of 31 mha. It flows in the eastward direction through the states of Maharashtra and joins the Bay of Bengal in Andhra Pradesh. The principal tributaries of the River Godavari are Penganga, Pranahita, Sabari, Indravati, Manjeera and Manair. It is the second largest river in India. River Godavari is under the serious threat as a result of the growing Urbanization and industrialization. The river has been dying at an alarming rate due to the pollution created by the factories. The main reason behind the pollution of Godavari river is the tiny Nakavaggu rivulet, which joins the Manjira, tributary of the Godavari. Nakavaggu rivulet supports no life at all. Rivulet is surrounded by the highly productive agricultural land, which is polluted by the large number of industries lying near the twin cities of Secunderabad and Hyderabad. However the 72 industries in the Patancheru Industrial area dumping the chemicals and waste into the water are most responsible for the pollution of the river. It has also given rise to some of the major diseases such as lung cancer, leukemia, and liver cancer.

It has been reported that increasing amount of the pesticide residue may be present in the soil and these can ultimately be leached to aquifer levels and contaminate the groundwater or they may be carried away by runoff waters and soil erosion [5-7]. The leachability of the pesticides is measured in terms of the groundwater ubiquity score (GUS). The GUS index [8] can be written as

$GUS = \log (DT_{50}) \cdot [4 - \log(Ka)]$,

where DT_{50} and Ka are persistence and mobility respectively. Bottoni and Funari [9]

Leaching of atrazine in Germany [10] and Denmark [11] was also reported. Contamination of well water by atrazine, alachlor and carbofuran has been found in Switzerland [12]. Atrazine, simazine and cyanazine were determined in wellwater in USA [13]. There are many reports published on groundwater contamination due to pesticides [14-16] all over the world. DDT, HCB, carbamate, Endosulfan etc. [17] are the very common pesticides used in India both in agricultural and public health sectors. Very little monitoring of water pesticides has been done in India. However, some reports have been published on the presence of organochlorine pesticides in some urban water resources near Calcutta [18]. Pesticides enter surface and ground water of Godavari plain primarily as runoff from crops and are most prevalent in agricultural areas. Without proper safeguards pesticides have the potential to seriously threaten many groundwater supplies in the Godavari plain. Approximately 40% of the Nanded population obtains its drinking water from groundwater sources and as much as 75% of the population in agricultural areas uses groundwater as its source of drinking water.

Material and Method

Water samples were collected from Bore Well and Hand Pump (23 Bore Wells and 12 Hand pump) from pre monsoon and post monsoon. Water sample were taken directly from Bore well, Hand pump and filled into 500 ml polyethylene bottles, which were previously acid-washed and rinsed with portions of distilled water and water sample, fitted with tight lids. These samples were analyzed for the presence of organochlorine insecticide residues. Five pesticides were initially selected due to the frequency of their occurrence: Aldrin, endosulfan and heptachlor, Hexachlorobenzene (HCB) and Dichloro-diphenyl-trichloroethane (DDT). According to the EPA they all have been detected in many states, and have the potential to reach levels which exceed health based standards. They are all associated with serious health effects including cancer.

Results and discussion

The detailed chemical analysis of ground water samples collected from Bore Well and Hand Pump have revealed that the samples collected in the vicinity of industries have shown low pH values and high electrical conductivities. The total dissolved solids have increased up to 7010 mg/L, which were 500 mg/L before pollution. Chloride content up to the extent of 4581 mg/L and high concentrations of lead in the range of 0.08-0.14 mg/L were also found in the samples collected from the industrial zone. The geochemical nature of ground water has changed from Ca-HCO_3 type to Ca-Cl_2 type in the process of pollution.

The chemical analysis of water samples collected from Bore Well and Hand Pump in Nanded city have shown nitrate content varying from 0.7 to 420 mg/L and traces to 948 mg/L in pre and post-monsoon periods. The nitrate pollution due to agriculture is further confirmed by the fact that the potassium contents of ground water has been found to be as high as 476 mg/L (Babulgaon), which probably leads to the idea that potassium and nitrate fertilizers are heavily used. Pesticides Actually Present Values in (PAPV) the following places in the Godavari River plain near Nanded recorded highest concentration of them are as follows.

Pesticide	PAPV in **Dhanegaon (µg/l)**	PAPV in **Itwara (µg/l)**	PAPV in **Kautha (µg/l)**	PAPV in **Vishnupuri (µg/l)**	PAPV in **Babulgaon (µg/l)**
Aldrin/Dieldrin	0.04	0.02	0.01	0.02	0.02
Endosulfan	4.00	2.00	1.50	3.00	2.00
Heptachlor	0.03	0.02	0.02	0.01	0.02
HCB	1.00	1.50	1.70	1.70	2.00
DDT	2.00	2.00	2.50	3.00	4.00

The infants consuming high nitrate containing ground water are susceptible to the disease called "Methemoglobenemia". While aldrin and dieldrin were below detection limits, both hexachlorobenzene (HCB) and dichlorodiphenyltrichloroethane (DDT) were traceable in all the water samples.

Conclusion

Presence of endosulfan isomers (α and β), endosulfan sulfate, heptachlor and its metabolites, α-chlordane, γ-chlordane and methoxychlor and predominance of p,p' -DDT among ΣDDT reflects that the quality of ground water in the area has deteriorated to a dangerous proportion making it unfit for drinking and irrigation purposes. The concentrations of HCB and DDT in all the samples were above the permissible limits prescribed by the European Commission Directive for drinking purposes. The disposal of untreated or partially treated effluents in the unlined channels from the industries in the area, especially during the rainy season, has polluted the ground water in the area.

Augmentation of ground water by suitable artificial recharge techniques may help in bringing down the concentrations of insecticides present in the ground water. There is an urgent need to stop the indiscriminate disposal of untreated wastewater in the area to check further deterioration of ground water quality.

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