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Assessment of Pesticide residues in surface waters of Godavari delta, India

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Abstract
The present study investigated the levels of pesticide residues in waters of the Godavari delta of South India. Samples of surface waters were collected randomly from nine stations using grab technique over a period of one year in two different seasons (Rabi and Kharif). The study indicated that the surface waters of Godavari delta were contaminated with pesticides associated with agricultural activities. Detection of pesticides and their residues by Gas chromatography with electron capture detection gave higher concentrations of HCH isomers during pre-monsoon and monsoon indicating their high usage in agriculture. The commonly occurring pesticides were (range, μg L^{-1}) Chlorpyrifos 10.54-30.25; Endosulfan 0.03-0.84; and Monochrotophos 10.25-25.5. Statistical analysis showed that there is significant difference in the concentration of Monocrotophos in Rabi season with respect to Kharif season (at $p<0.05$).

Keywords: Pesticide Residue; Godavari Delta; Rabi and Kharif seasons

1. Introduction
India is an agrarian economic economy and ranks second worldwide in farm output. Agriculture and allied sectors account for about 50% of workforce and 13.7% of gross domestic product (GDP) of the country. Agricultural land constitutes 60.5% of total land area. Ensuring food security for more than 1.2 billion population with existing land resource for cultivation is a herculean task. This necessitates the use of `high yielding variety of seeds, balanced use of fertilizers, proper and timely use of quality pesticides and the use of innovative and highly productive farming techniques. It is estimated that India loses approximately 18% of the crop yield valued at Rs. 900 billion due to pest attack every year [1].

The use of pesticides helps to reduce the loss of crop, provides economic benefits to the farmers, reduces soil erosion and helps in ensuring food security for the nation. It has been estimated that 2.5 million tons of pesticides are being applied worldwide every year and the quantity is keep on increasing year by year [2]. The same trend is observed in India also. In India, Pesticides were used mostly on cotton (45%) followed by rice (22%) crops [3].

Even though there are several benefits (especially with respect to food productivity) in the use of pesticides, the environmental consequences of the widespread use, handling and disposal of pesticides are of great concern due to their toxicity. Pesticides are generally toxic for living organisms and difficult to degrade so that they become long term toxic agents frequently accumulating in certain organs of living beings. The most commonly used pesticides are the organochlorine pesticides and are known to be responsible for several environmental consequences. Organophosphorous pesticides on the other hand degrade rapidly depending on their formulation, method of application, climate and the growing stage of the plant [4, 5]. Pesticide residues reach the water through direct run off, leaching, careless disposal of empty containers, equipment washing etc. It is reported that approximately, three million people are poisoned and 200,000 people are dying every year around the world by pesticide poisoning [6]. Even though some of the pesticides were banned due to their toxic and carcinogenic effects, they are still being used in developing countries [7, 8].

The use of pesticides also represents a water quality risk in agricultural areas since these compounds can spread across the ground and contaminate both surface waters and ground waters [9-11]. Lack of adequate knowledge on the ill effects of indiscriminate use of pesticides in the farmers is the main cause for the presence of substantial quantities of pesticide residues in Indian food and agricultural products.

In Andhra Pradesh, the southern state of India, agriculture provides employment to 65% of the State population. The state alone consumes 24 percent of the total pesticides produced in the country. The pesticide usage in the state is about 0.8 to 1.2 kg/acre. According to Indian Council of Medical Research (ICMR), environmental load of pesticides is about 30 to 70 kg per square meter [12]. The major crop grown in Godavari delta, the rice bowl of southern India, is paddy which is cultivated both in Kharif (June to October) and Rabi (November to April) seasons. There is a paucity of data on the monitoring of pesticides and their residues in the Godavari delta. This study was carried out to investigate the levels of pesticide residues in the surface waters of Godavari delta.

2. Materials and methods

Surface water samples were collected from nine sampling stations, chosen on the basis of agricultural activity, as shown in Figure 1. The geographical location of the sampling sites is presented in Table 1.

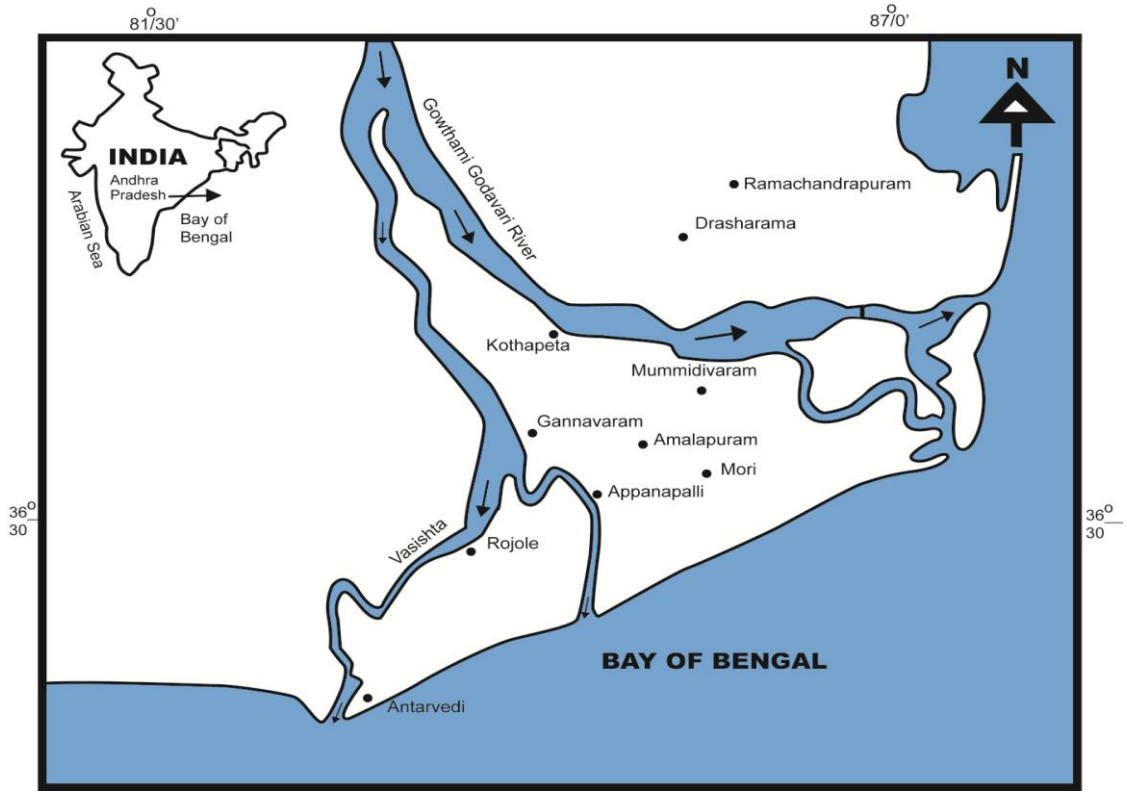

Figure 1: Location map showing the sampling stations

Table-1: Geographical locations of the sampling sites

S. No	GPS location of sampling point	Name of sampling station
1	16°49'14"N 82°3'42"E	Ramachandrapuram
2	16°47'29"N 82°37'4"E	Draksharama
3	16°42'56"N 81°54'2.5"E	Kothapaeta
4	16°38'26"N 82°6'29"E	Mummudivaram
5	16°35'30"N 81°53'26"E	Gannavaram
6	16°34'32"N 82°0'43"E	Amalapuram
7	16°49'14"N 82°3'42"E	Mori
8	16°31'22"N 81°55'24"E	Appanapalli
9	16°28'29"N 81°50'9"E	Rajole

Grab sampling technique was used to collect the surface water samples randomly from ten stations [13]. The sampling was carried out in two different seasons over a period of one year to give a total number of 36 samples. The samples were collected in 2.5 litre glass bottles and were kept cool during transportation and then stored at 4^{o}C, until analysed.

Pesticide residues were analysed by UNEP-IAEA method [14]. They were extracted from surface water samples by solvent extraction.

Samples were collected as per APHA procedure

Soxhlet Extraction of the samples ↓ using hexane and acetone as solvents

15 - 20 ml of raw extract is taken

Treated with ↓ Conc. Sulphuric Acid

approximately 4 ml of final extract is taken

Activated Magnesium silicate Columns ↓ Dried over anhydrous Sodium Sulphate

pesticide residues were analysed by Gas Chromatography

One micro litre each of processed sample was injected into the GC-ECD system 6890 Hewlett-Packard used in a split less mode and equipped with an electron capture detector. HP-5 fused silica capillary column 30 cm × 0.25mm × 0.25 µm (film thickness) was used. Helium was used as the carrier gas at 14 psi. The injector and detector temperatures were maintained at 260^0C and 320^0C respectively. The oven temperature was initially maintained at 90^0C for a period of 2 minutes, ramped to 270^0 C at 5^0C/min (hold time 2 min).

3. Results and discussion

The mean concentrations of pesticide residues during Rabi and Kharif season are presented in Tables 2 and 3 respectively.

Table-2: Mean Concentration of pesticides in water µg L^{-1} during Rabi Season

Pesticide Residue	SAMPLING STATIONS								
	Station -1	Station -2	Station -3	Station -4	Station -5	Station -6	Station -7	Station -8	Station -9
Endosulphan	**0.03**	**0.08**	**0.23**	**0.84**	**0.75**	**0.15**	**0.53**	**0.45**	**0.62**
Chlorpyrifos	**10.54**	**30.25**	**28.15**	**25.18**	**21.68**	**22.19**	**26.5**	**11.16**	**13.58**
Monocrotophos	**15.29**	**10.25**	**13.14**	**11.15**	**19.2**	**18.85**	**17.5**	**16.23**	**21.15**
α-HCH	**ND**	**0.12**	**0.13**	**0.09**	**ND**	**0.03**	**ND**	**0.04**	**0.04**
β-HCH	**0.05**	**0.04**	**ND**	**0.03**	**0.06**	**0.02**	**ND**	**0.03**	**0.04**
γ-HCH	**0.56**	**ND**	**0.51**	**0.46**	**0.54**	**ND**	**0.48**	**0.52**	**0.58**
2,4[1]DDE	**0.05**	**0.19**	**0.29**	**ND**	**0.42**	**0.16**	**0.34**	**0.12**	**0.08**
2,4[1]DDD	**0.21**	**0.45**	**ND**	**0.35**	**0.51**	**ND**	**ND**	**0.29**	**0.32**

ND – Below detection level <0.01 µgL^{-1} / µgKg^{-1}, HCH – Hexachloro cyclohexane,
DDE – Dichloro diphenyl dichloro ethylene, DDD – Dichlorodiphenyldichloroethane

Table-3 Mean Concentration of pesticides in water µg L^{-1} during Kharif Season

Pesticide Residue	SAMPLING STATIONS								
	Station-1	Station-2	Station-3	Station-4	Station-5	Station-6	Station-7	Station-8	Station-9
Endosulphan	**0.0425**	**0.105**	**0.305**	**0.705**	**0.62**	**0.325**	**0.42**	**0.32**	**0.605**
Chlorpyrifos	**11.89**	**20.22**	**21.7**	**20.85**	**14.905**	**17.67**	**26.7**	**10.705**	**14.67**
Monocrotophos	**12.94**	**10.91**	**17.56**	**14.2**	**18**	**11.695**	**12.85**	**21.73**	**22.65**
α-HCH	**ND**	**0.145**	**0.2**	**0.08**	**ND**	**0.08**	**ND**	**0.09**	**0.09**
β-HCH	**0.0425**	**0.095**	**ND**	**0.065**	**0.08**	**0.05**	**ND**	**0.09**	**0.065**
γ-HCH	**0.43**	**ND**	**0.635**	**0.59**	**0.69**	**ND**	**0.41**	**0.56**	**0.27**
2,4[1]DDE	**0.0435**	**0.155**	**0.28**	**0**	**0.455**	**0.195**	**0.28**	**0.17**	**0.07**
2,4[1]DDD	**0.23**	**0.58**	**ND**	**0.415**	**0.425**	**ND**	**ND**	**0.38**	**0.435**

ND – Below detection level <0.01 µgL^{-1} / µgKg^{-1}, HCH – Hexachloro cyclohexane,
DDE – Dichloro diphenyl dichloro ethylene, DDD – Dichlorodiphenyldichloroethane

During Rabi season (November to April), maximum concentration (in μg L^{-1}) of Endosulphan (0.84 & 0.75) was found in stations 4 & 5; Chlorpyrifos (30.25 & 28.15) was found in stations 2 & 3; Monocrotophos (21.15 & 25.5) was found in stations 9 & 10; Σ HCH (0.58) was found in station-4; 2, 4^1 DDE (0.42) was found in station-5; 2,4^1 DDD (0.51) was found in station- 5.

During the Kharif season (June to October), maximum concentration (in μg L^{-1}) of Endosulphan (0.705) was found in station- 4; Chlorpyrifos (26.7) was found in station 7; Monocrotophos (22.65 & 21.73) was found in stations 9 & 8; Σ HCH (0.835) was found in station-3; 2, 4^1 DDE (0.455) was found in station-5; 2, 4^1 DDD (0.58 & 0.435) was found in stations 2 & 9.

Statistical analysis of the results showed that there is a strong correlation between the pesticide residue concentrations in Rabi and Kharif seasons in case of Endosulfan (r = 0.95), Chlorpyrifos (r = 0.85), α-HCH (r = 0.78), 2,4^1DDE (r = 0.94) and 2,4^1DDD (r = -1). T-Test was carried out to determine the significant relationship between pesticide residue concentrations in Rabi and Kharif seasons. There is a significant difference in concentration of Monocrotophos (at $p<0.05$), Chlorpyrifos (at $p<0.08$) and Endosulfan (at $p<0.2$) in Rabi season with respect to Kharif season. No significant differences in the concentrations of α-HCH, β-HCH, γ-HCH, 2,4^1DDE and 2,4^1DDD in Rabi season with respect to Kharif season are observed.

Conclusion

This study indicates that due to the use of excessive pesticides in agriculture, the surface waters in Godavari delta were contaminated with pesticide residues. The concentration of pesticide residues in surface waters was determined by employing the solvent extraction and Gas chromatography. The results indicate the presence of pesticide residues in appreciable quantities in both Rabi and Kharif seasons. In view of the accumulation potential of pesticide residues in food chain, the high concentrations of these contaminates is of great concern.

Due to the paucity of previous data in the study area, the results of present study could not be compared and correlated to determine extent of contamination in the past. Numerical factors also could not be determined for this study area. The present study may however serve as a reference data in the future since regular monitoring of pesticide residues is essential to prevent their excessive buildup in the food chain.

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