AQUACULT Vol. 4 (2), 153-159, 2003 ISSN - 0972 - 2262

Heavy metal and pesticide levels in shrimp culture areas of Nellore (Andhra Pradesh) and Tuticorin (Tamil Nadu)

M. Muralidhar*, B. P. Gupta, K. K. Krishnani and A. Nagavel
Central Institute of Brackishwater Aquaculture, 75, Santhome High Road, R. A. Puram, Chennai - 600 028, India.

(Accepted for Publication - 12th June, 2003)

Abstract

In order to assess the levels or heavy metals and pesticides in shrimp farms, water samples were collected from Kandaleru creek (near Krishnapatnam and Pudiparthi villages), TASPARC ponds and bore wells (Pudiparthi village) and ponds at Krishnapatnam of Nellore District (Andhra Pradesh) during March 1993 and commercial shrimp ponds and sea in Tuticorin area of Tamil Nadu during April 1993. Sediment samples were collected from Kandaleru creek (source and discharge point) and shrimp pond soils of Pudiparthi village. The samples were analysed for heavy metals and pesticides concentration. The concentration of heavy metals and pesticides in water were below detection level except for zinc, mercury and hexachloro cyclohexane (HCH). Zinc was 0.38 mg/l in TASPARC bore well water and in Kandaleru creek water it was 1.35 mg/l. Low level of mercury concentration was noted in sea water at Tuticorin shrimp farm and Krishnapatnam creek water. HCH concentration of 0.002 mg/l was observed in TASPARC pond water. Pond and creek sediment samples registered the natural occurrence of all heavy metals, except cadmium and mercury.

Key words : Pesticides, heavy metals, shrimp culture areas.

Introduction

The wide spread contamination of aquatic ecosystem with heavy metals is the increasing concern of environmental scientists. Heavy metal contaminants in aquatic systems pose a serious environmental hazard because of their persistence and toxicity. Accumulation of heavy metals by organisms, their movement through the food chains to higher trophic levels may adversely affect the entire ecosystem (Vinkour *et al.*, 1980). Numerous studies on heavy metal concentration in waters and bottom sediments of rivers, estuaries and inner continental shelves in overseas countries have highlighted the widespread occurrence of heavy metal contamination (Shimp *et al.*, 1971; Lee, 1975; Nanda and Mohapatra, 1995; Pandey *et al.*, 1995). The aquatic sector is important as it provides substantial food by way of fishing and aquaculture. The coastal aquaculture has taken a new dimension in India with the advent of scientific shrimp farming since last decade.

Toxic effect of organochlorine pesticides on fish has been reported by several workers (Konar, 1981; Kalra and Chawla, 1981). Generally only a small fraction of the pesticide applied hits the target pests while the remaining drifts into the environment. Mass mortality of carps, catfishes and other commercially important fishes was observed due to pesticide pollution in the Punarbhava river of West Dinajpur, West Bengal in 1970 when the paddy fields adjacent to the river were sprayed with the insecticides DDVP, Phosphomidon and Parathion (Konar, 1975).

Among the factors that contribute to the disturbance and imbalance of an ecosystem, the

* Corresponding author

pesticides are noteworthy (Holden, 1973; Dikshit and Dutta, 1973). The residues of pesticides discharged from agricultural land are threatening the aquaculture activity. The runoff from agricultural land is thus main source of gradual pesticide pollution of aquatic environment (Kalra and Chawla, 1981). With increasing use of agrochemicals for crop production the hazard to fish in ponds, rivers and reservoirs also increases. It is now a well-known fact that the aquatic environment is the ultimate sink for all the chemicals and pollutants. The present study was conducted to assess the concentration of heavy metals and organochlorine pesticides in source, pond, effluent and bore well waters.

Materials and Methods

The Study area includes shrimp farms around Kandaleru creek in Nellore District of Andhra Pradesh and Tuticorin area of Tamil Nadu (Fig. 1). Nellore District is endowed with rich fisheries resources of marine, brackishwater and inland water with a coastline of 169 km. Kandaleru creek in Nellore is a flood drain brackishwater creek for almost throughout the year, except at flood times during the north-east monsoon. Shrimp farms have been constructed on both sides of the creek. Both extensive and semi-intensive types of shrimp culture are practiced. TASPARC farm (semi-intensive) near Pudiparthi village and a commercial farm of extensive culture near Krishnapatnam were selected.

The water samples were collected from creek (4 samples), pond (5 samples), effluent (5 samples) and bore well (2 samples) of TASPARC farm; creek (4 samples) and pond (5 samples) of shrimp farm at Krishnapatnam during March 1993 in Nellore District and from sea water, pond and effluent (4 samples from each station) from a commercial shrimp farm in Tuticorin area during April 1993. Sediment samples were collected from semi-intensive farms and adjoining Kandaleru creek (source - 5 samples and discharge point - 5 samples) near Pudiparthi village, Nellore District.

The water samples for heavy metal analysis were preserved by adding one ml of concentrated nitric acid per one litre of sample and the sediment samples were first sun dried and subsequently oven dried. The water and sediment samples were analysed for heavy metals such as mercury, copper, zinc, chromium VI (for water only), total chromium, lead, nickel and cadmium following the standard methods (APHA, 1989). Heavy metals were analysed with atomic absorption spectrophotometer at the Advanced Environmental Laboratory of Tamil Nadu Pollution Control Board, Chennai. Cold vapour atomic absorption technique was used for the estimation of mercury. The sensitivity limits for Cd, Cu, Pb, Ni, Zn, Hg and Cr are 0.005, 0.005, 0.001, 0.005, 0.002, 0.0001 and 0.005 mg/l, respectively.

One litre composite water sample collected from each sampling station was stored in 1.2 litre glass container for the analysis of organochlorine pesticides and transported to the laboratory under low temperature at 4° C in icebox. Samples were preserved in refrigerator until analysed. The water sample was extracted with Dichloromethane and hexane (15:85 v/v) (APHA, 1989). The aqueous layer was discarded and hexane layer was subjected to demoistening and the cleaning process using anhydrous sodium sulphate and 60/100 PR grade florisil activated at 675°C, respectively. The cleaned up extract was concentrated by KD evaporator and analysed by Gas Chromatograph (Chemito 2865) equipped with Electron Capture Detector having Ni^{63} isotope. The glass column used was 6' in length and had an inner diameter of 1/4" packed with 1.5% OV-17+1.95% OV-210 on 80/100 mesh chromosorb WHP. The analysis was recorded by the ORACLE-2 Software programme. Pure and dry nitrogen was used as a carrier gas. The flow rate of N_2 gas was maintained at 60 ml/min. The injector, column and detector temperatures were maintained at 200, 220 and 275°C, respectively. All chemicals used were HPLC grade. Pesticide standards were procured from E. Merek (Dr. Ehrenstorfer,

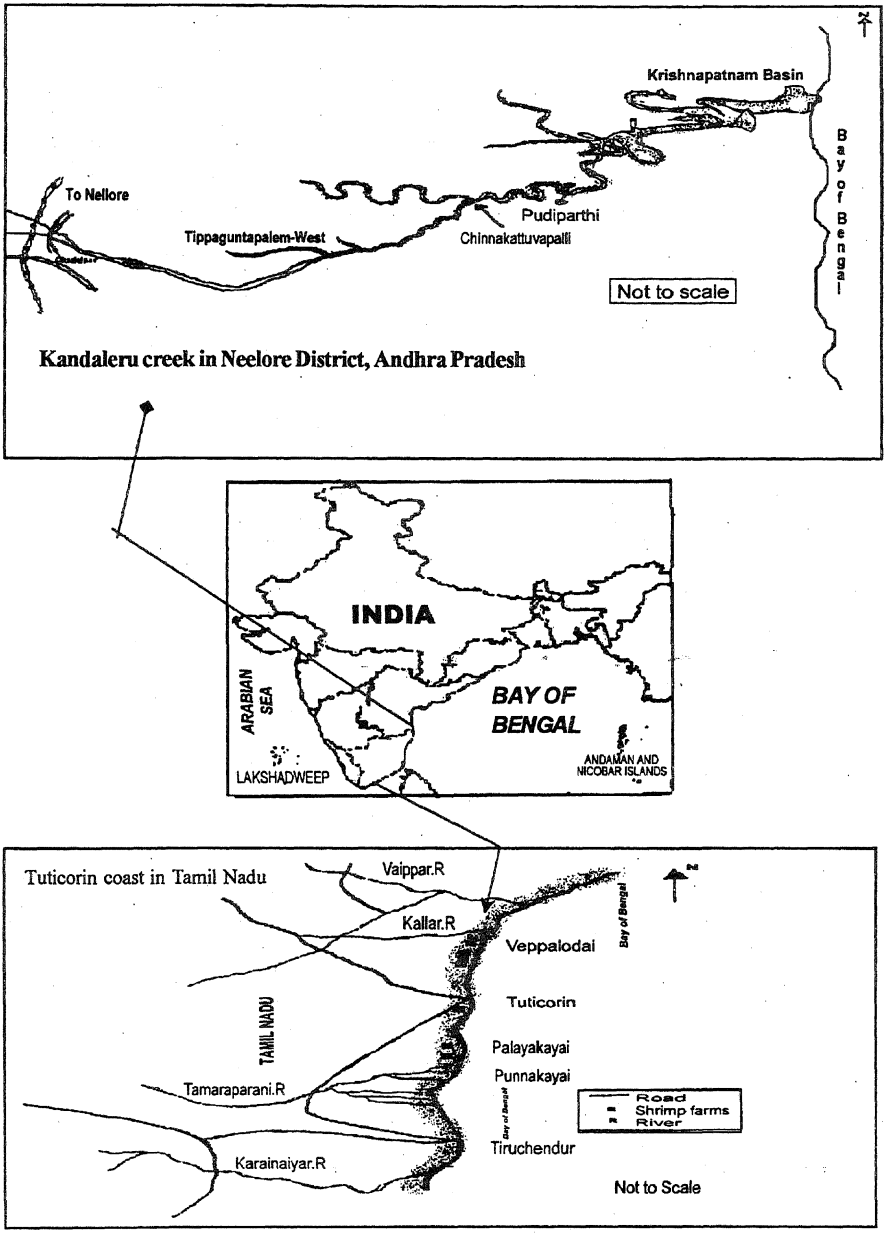

Fig. 1 : Location of study area.

Table 1: Retention times and percent recovery of organochlorine pesticides.

Organochlorine Pesticide		Retention time	Recovery	
		Standard	Level added (µg/l)	(%) Recovery
HCH	α	3.90	4	90
	γ	5.12	4	91
	β	6.01	4	98
Heptachlor		6.45	4	83
DDT		31.95	4	87

Column Condition : 80/100 mesh Chromosorb WHP coated with 1.5% OV-17+1.95% OV-210 packed in a 6' long x 1/4" ID glass column with nitrogen carrier gas at 60 ml/min flow rate. Column temperature held isothermal at 200°C.

Germany). The detection limit of the HCH (1, 2, 3, 4, 5, 6 hexachloro cyclohexane), heptachlor (1, 4, 5, 6, 7, 8, 8-heptachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindene) and DDT (1, 1'-(2,2,2-trichloroethylidene) bis[4-chlorobenzene] is 0.003-0.01, 0.003 and 0.02-0.025 µg/l respectively. Retention times of organochlorine pesticides are given in Table 1. This method was tested by our laboratory using brackishwater collected from coastal areas with known addition at the concentration of 4 µg/l for multi-component sample. The average percentage recoveries from coastal water samples varied from 90 to 98 % for HCH isomers and 83% for heptachlor and 87% for DDT.

Results and Discussion

Heavy metals

The concentration of most of the heavy metals was below detection level (BDL). However, the average zinc content was in detectable levels (Table 2) in TASPARC bore well (0.38 mg/l) and Kandaleru creek (1.35 mg/l) waters. Low-level mercury concentrations were registered in creek water at Krishnapatnam (0.0002 mg/l) and in intake sea water (0.0003 mg/l) of shrimp farm at Tuticorin (Table 3). The mean values of zinc and mercury are found below the Environmental Protection Agency's (EPA) safe limits (MPEDA, 1991) and WHO's standards (Qasim and Sengupta, 1981). Perhaps, this could be due to alkaline nature of waters with high concentration of bicarbonates and total hardness. Calcium and magnesium may reduce the toxicity of metals because of their competition for sites with cationic speciation form of heavy metals (Rai *et al.*, 1981). The concentration of zinc in bore well water is below the safe concentration recommended for potable water (EPA, 1973). The metals are not posing any threat from shrimp culture point of view.

Lethal concentration (96 h LC_{50}) of Cd, Cu and Zn are 150, 1200, 1500 µg/l (Joseph *et al.*, 2001) and using the safe concentration factor 0.01, allowable safe concentrations of these heavy metals are 1.5, 12 and 15 µg/l. Based on the LC_{50} values and derived safe concentrations, heavy metals found in waters were within safe permissible levels (MoEF, 1993). The safe levels of copper, zinc, nickel, cadmium, mercury and total chromium are 25, 100, 5, 2, 0.01 and 1.0 µg/l, respectively.

The concentration of heavy metals in pond and Kandaleru creek sediment samples (average values of source and discharge points) indicated the presence of zinc, lead, copper, chromium and nickel, whereas cadmium and mercury are in below detectable level (Table 4). There is no apparent anthropogenic inputs of heavy metals in these areas, as there is no human settlements or industries nearby. The average values of these metals in pond and creek sediments did not show much difference. Among heavy metals, zinc content was high compared to other metals in pond (158 mg/kg) and creek (162 mg/kg) sediments.

Table 2 : Heavy metal and pesticides concentration (average values with standard deviation) in Kandaleru area, Andhra Pradesh.

Parameter	TASPARC Pond water	TASPARC source water	TASPARC pond effluent	TASPARC bore well water	Kandaleru creek water (Pudiparthi)	Pond water (Krishna-patnam)	Kandaleru creek water (Krishnapatnam)
Heavy metals (mg/l)							
Mercury	BDL	BDL	BDL	BDL	BDL	BDL	0.0002±0.00005
Zinc	BDL	BDL	BDL	0.37±0.06	1.35±0.05	BDL	BDL
Copper	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chromium VI	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Lead	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chromium	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Nickel	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Pesticides (mg/l)							
Heptachlor	BDL	BDL	BDL	BDL	BDL	BDL	BDL
HCH	0.002±0.0004	BDL	BDL	BDL	BDL	BDL	BDL
DDT	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL - Below detection level.

Table 3 : Heavy metal and pesticides concentration (average values with standard deviation) in Tuticorin area, Tamil Nadu.

Parameter	Pond water (Shrimp farm)	Seawater	Effluent water (Shrimp farm)
Heavy metals (mg/l)			
Mercury	BDL	0.0003 ± 0.00005	BDL
Copper	BDL	BDL	BDL
Zinc	BDL	BDL	BDL
Chromium VI	BDL	BDL	BDL
Lead	BDL	BDL	BDL
Chromium	BDL	BDL	BDL
Nickel	BDL	BDL	BDL
Cadmium	BDL	BDL	BDL
Pesticides (mg/l)			
Heptachlor	BDL	BDL	BDL
HCH	BDL	BDL	BDL
DDT	BDL	BDL	BDL

BDL - Below detection level

Table 4: Average values of heavy metals and pesticides (mg/kg, dry weight) with standard deviation in Kandaleru creek and shrimp ponds sediment at Pudiparthi, Nellore, Andhra Pradesh.

Contaminant	Pond sediment	Kandaleru creek sediment*
Heavy metals		
Zinc	158.0±7.8	162.0±8.5
Lead	12.6±1.8	16.9±2.1
Copper	38.2±4.8	32.0±3.9
Chromium	14.1±1.8	12.9±1.1
Nickel	42.0±3.9	46.2±3.1
Cadmium	BDL	BDL
Mercury	BDL	BDL
Pesticides		
HCH	BDL	BDL
DDT	BDL	BDL

*- Average value of source and discharge points in the creek, BDL - Below detection level.

Pesticides

Pesticides residue concentrations were below detection level in water and sediment samples, except for TASPARC pond water, where the HCH residue was 0.002 mg/l. Pesticide residues have been reported from Indian estuaries and coastal areas; particulate matter and sediments of Hoogly estuary have been found to contain HCH and DDT residues (Joshi and Ghosh, 1982). Ahmad *et al.* (1996) reported organochlorines in sediments of Ganga river, which was attributed to the municipal/sewage waste waters originating from residential areas. Dua *et al.* (1996) have detected HCH and DDT in water, sediment and fish in rural ponds of Shahjahanpur (UP).

Pesticide residues have also been reported from many rivers around the world; α-HCH, γ-HCH and PCBs were present in all the samples of Rhine water analysed (Greve, 1972). In Israel, α-HCH and γ-HCH were the most common organochlorine residues in natural water (Kahanovitch and Lahar, 1974). High BHC levels upto 2 µg/l were recorded from the Mississipi river (Laska *et al.*, 1976).

The lethal concentration (96 h LC_{50}) of HCH for crustracean is <10 µg/l (Murthy, 1986) and using the safe concentration factor of 0.1, allowable safe concentration of HCH is <1 µg/l. According to U.S.EPA recommendations, the safe permissible level of HCH for aquatic organisms is 4 µg/l (EPA, 1973), which is about four times higher than the allowable safe limit derived from 96 h LC_{50} of HCH for crustaceans in laboratory toxicity tests. Based on the LC_{50} values, derived safe concentration and USEPA recommendation, HCH found in coastal waters at the present level was within the safe permissible limit for shrimp. The safe levels for HCH, DDT and Heptachlor are 0.41, 0.21 and 1.62 µg/l, respectively in laboratory toxicity tests (Joseph *et al.*, 1999).

The concentration of most of the heavy metals and organochlorine pesticides in the present study area are within the safe limits. The impact of metals and pesticides may not be serious at present but in future, their concentrations may increase due to continuous entry of effluents from industries and may bring about changes in biological spectrum. Hence, the continuous monitoring of the environment is essential. Sometimes wrong conclusions may be drawn from sediment analysis due to strong fluctuations in heavy metal content which is a result of flood water drainage, varying sedimentation rates and non-homogeneous distribution of heavy metals in sediment. In order to determine overall heavy metal pollution, metals concentration should be determined at as many trophic levels as possible in aquatic ecosystem.

Acknowledgements

The authors are thankful to Dr. Mathew Abraham, Director and Dr. K. Alagarswami, former Director of Central Institute of Brackishwater Aquaculture for their encouragement and inspiration.

The authors are grateful to Late Dr. K. O. Joseph, Senior Scientist, CIBA for his contribution in the study. The financial assistance from ICAR, New Delhi (AP Cess Fund) is gratefully acknowledged.

References

Ahmad, S., M. Ajmal and A. A. Nomani : Organochlorines and polycyclic aromatic hydrocarbons in the sediments of Ganga River (India). *Bull. Environ. Contam. Toxicol,* 57 : 749-802 (1996).

APHA : *Standard methods for the examination of water and wastewater.* 17th edition. American Public Health Association, Washington, D. C., USA, 1430p (1989).

Dikshit, T. S. and K. K. Datta : Endrin induced cytological changes in albino rats. *Bull. Environ. Contam. Toxicol.,* 9 : 65-69 (1973).

Dua, V. K., R. Kumari and V. P. Sharma : HCH and DDT contamination of rural ponds of India. *Bull. Environ. Contam. Toxicol.,* 57 : 568-574 (1996).

EPA : *Water quality criteria Series.* EPA-PB-236, 199 : 594 (1973).

Greve, P. A. : Potentially hazardous substances in surface waters. *Sci. Environ.,* 1 : 173 (1972).

Holden, A. V. : Effects of pesticide on fish In : *Environmental pollution by pesticides.* C. A. Edward (ed.). Plenum Press, London, p. 213-253 (1973).

Joshi, H. C. and B. B. Ghosh : Studies on the distribution of organochlorine pesticide residues in the Hoogly estuary. *First National Environ Conf,* ICAR, New Delhi, p. 27 (1982).

Joseph, K. O., B. P. Gupta, K. K. Krishnani and M. Muralidhar : Acute toxicity of selected pesticides to the prawn *P. monodon. Indian J. Fisheries,* 46(1) : 101-105 (1999).

Joseph, K. O., K. K. Krishnani, B. P. Gupta and M. Muralidhar : Acute Toxicity of some heavy metals to Penaied shrimp. *Abst. National Conference on Environment, Biodiversity and Bio-ethics: Current trends and future directions*", Chennai. Pp. 78 (2001).

Kahanovitch, L. and L. Lahar : Occurrence of pesticides in selected water sources in Israel. *Environ. Sci. Toxicol.,* 8 : 762 (1974).

Kalra, R. L. and R. P. Chawla : *Monitoring of pesticide residues in the Indian environment.* Indian Pesticide Industry, Vishvas Publications, Madras (1981).

Konar, S. K. : Pesticides and aquatic ecosystem. Indian J. Fish., 22 : 80-85 (1975).

Konar, S. K. : Pollution of water by pesticides and its influence on aquatic ecosystems. *Indian Rev. Lib. Sci.,* 1 : 139-165 (1981).

Laska, A. L., K. Bartell and J. L. Laseter : Distribution of hexachloro benzene and hexachlorobutadiene in water, sediment and selected aquatic organisms along the Lower Mississipi River, Lousiana. *Bull. Environ. Contam. Toxicol.,* 15 : 535 (1976).

Lee, G. F. : Role of hydrous oxide metals in the transport of heavy metals in the environment. In : *Heavy metals in the aquatic environment,* Pergamon Press, Oxford (1975).

MOEF : Notification - *Ministry of Environment and Forests.* Part A- Effluents, 19th May. (1993).

MPEDA : *Aquaculture Drops for farmers.* IV(11 & 12) : 2 (1991).

Murty, A. S. : *Toxicity of Pesticides to Fish.,* Vol. I & II. CRC Press, Florida (1986).

Nanda, S. and B. C. Mohaptra : Distribution of heavy metals in coastal waters of India. *Fishing Chimes,* 15 : 21-23 (1995).

Pandey, B. K., U. K. Sarkar, M. L. Bhowmik and S. D. Tripathi : Accumulation of heavy metals in soil, water, aquatic weed and fish samples of sewage fed ponds. *J. Environ Biol.* 16(2) : 97-103 (1995).

Qasim, S. Z. and R. Sengupta : *Water pollution and management reviews,* C. K. Varshney (Ed.) South Asian Publishers Pvt. Ltd. Delhi. p. 139 (1981).

Rai, L. O., J. P. Gaur and H. D. Kumar : Phycology and heavy metal pollution. Biol. Rev., 56 : 99-151 (1981).

Shimp, N. F., J. A. Schleicher, R. R. Ruch, D. B. Heck and H. V. Leland : Trace elements and organic carbon accumulation in the most recent sediments of southern lake Michigan, Illinois. *Geological Survey Environmental Geology,* 41 (1971).

Vinkour, W. S., R. M. Goldstein and R. V. Anderson : Bioconcentration patterns of zinc, copper, cadmium and lead in selected fish species from the Fox River, Illinois. *Bull. Environ. contam. Toxicol.,* 24 : 727-734 (1980).