

Acute toxicity levels and ethological responses of *Channa striatus* to fertilizer industrial wastewater

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Abstract: The present paper deals with the toxicity of fertilizer's industrial wastewater on snake head fish *Channa striatus* (Bloch) previously named as *Ophiocephalus* sp., at different concentrations viz., 20, 40, 60, 80 and 100 percent on the behavioural changes and mortality. The exposed fish showed hyperactivity viz., jumping, operculum movement, distance travelling, somersaulting at higher concentration such as 60, 80, and 100 percent within 48 hr. At lower concentrations such as 20 and 40 percent exposed fish showed hyperactivities viz., linear movement and eye movement within 48 hr. The LC₅₀ values of industrial wastewater were also determined viz. 89, 75, 70 and 69 percent at different duration of exposure time i.e. 48, 72, 96 and 120 hr respectively. The obtained data revealed that LC₅₀ value decreased with increase of exposure.

Key word: Acute toxicity, Behavioral changes, Fertilizer's industrial wastewater

Introduction

The rapid industrialization is one of the major cause of water pollution. The discharges of untreated and partially treated wastewater from various industries like chemical, pesticides, fertilizer, pulp and paper and sugar etc., have polluted the aquatic bodies such as river, pond and ditches. In India about two tones wastewater is discharged into aquatic bodies annually from industries (Shaffi, 1981). Discharges of industrial wastewater, cause serious consequence for fisheries resulting in impairment of important function such as respiration and osmoregulation (Kumaraguru, 1995). Aquatic pollution is significant to fisheries and aquaculture industries. The changes of physical, chemical and biological parameters of water alter the behaviour of fishes besides causing mortality. The behavioural changes in fishes has been considered to be sensitive indicator of toxicity by Sharma *et al.* (1993) and among aquatic fauna, fishes are more sensitive to pollutants (Karuppasamy, 1979). A numerous literature is available on the toxicity of fertilizer industrial wastewater on aquatic fauna. Therefore, in the present study attempt has been made to evaluate toxicity of fertilizer industry wastewater and it's effect on ethological response on common edible snake headed fish, *Channa striatus* (Bloch) previously named as *Ophiocephalus* sp. (Chondar, 1999).

Materials and Methods

The wastewater was collected from discharge point from Fertilizer Industry, Phulphur, Allahabad. The live specimen of common edible fish *C. striatus* (Bloch) were collected locally and kept in 60 litre glass aquarium. These fish were treated with potassium permagnate solution (0.5% w/v) for 5 min to remove any dermal adherent. The fish were acclimated in the laboratory (29±1.2°C). Fish were daily fed on dry fish food and pieces of earthworm. In the present study the static acute bioassay study of fertilizer industry wastewater was assessed by the method

given by Sprague (1973). The percentage concentration of industrial wastewater was prepared on volume to volume (v/v) ratio. The percentage concentration of test solution is obtained by using the formula (FAO, 1984), given below :-

$$\text{Volume percent} = \frac{V_E}{V_E + V_{DW}} \times 100$$

Where, V_E = Vol. of effluent, V_{DW} = Vol. of dilution water

The definite acute toxicity test was conducted by selecting a set of 10 fish in each of 5 rectangular 50 litre capacity aquarium, which were filled with different concentration of industrial wastewater viz., 20, 40, 60, 80 and 100 percent respectively. The ethological responses and mortality rate of fish were recorded after 24, 48, 72, 96 and 120 hr. A control set was similarly maintained for comparison. The median lethal concentration (LC₅₀) for 24, 48, 72, 96, 120 hr and its 95% confidence limit were determined by graphic method given by Litchfield and Wilcoxon (1949). Linear regression curve was plotted by taking fertilizer industrial wastewater concentration and percentage mortalities on log and probate scale, respectively, to estimate LC₅₀ value at different time scale (Finney, 1971). The physicochemical characteristics of fertilizer's industrial wastewater were also determined by standard method (APHA, 1998).

Results and Discussion

The data showed percentage mortality and LC₅₀ values with 95% confidence limit for 48, 72, 96 and 120 hr under the exposure of fertilizer industrial wastewater for *C. striatus* to be 89, 75, 70 and 69 percent in Table 1. The relationship between the test concentration of fertilizer industrial wastewater (in the form of LC₅₀) and exposure duration in hour is at shown in Fig. 1.

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Table - 1: Percentage mortality of *Channa striatus* at different concentrations of fertilizer industrial wastewater over a period of 120 hr (10 fish were taken for each concentration)

Exposure time (in hrs)	Concentrations (in %)					LC ₅₀ upper & lower	95% confidence limit
	Control	20	40	60	80		
24	-	-	-	-	-	-	-
48	-	-	-	-	40	60	94-84
72	-	-	20	60	60	60	79-69
96	-	-	40	60	80	70	75-65
120	-	20	40	60	100	69	74-64

(-) Indicate no mortality

Table - 2: Effect of fertilizer industrial wastewater on the behavioural parameters of *Channa striatus* at various exposure durations and concentrations

Parameter	Exposure durations (in hours)																				
	24				48				72				96				120				
	C	20	40	100	C	20	40	100	C	20	40	100	C	20	40	100	C	20	40	100	
Linear movement	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Staying period	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Operculum movement	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Jumping movement	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Somersaling activity	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Equilibrium status	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Movement of fin	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Bottom dwelling	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Distance travelled	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Eye movement	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

(+) Sign indicates the increase or decrease the level of parameters

(-) Sign indicates no detection



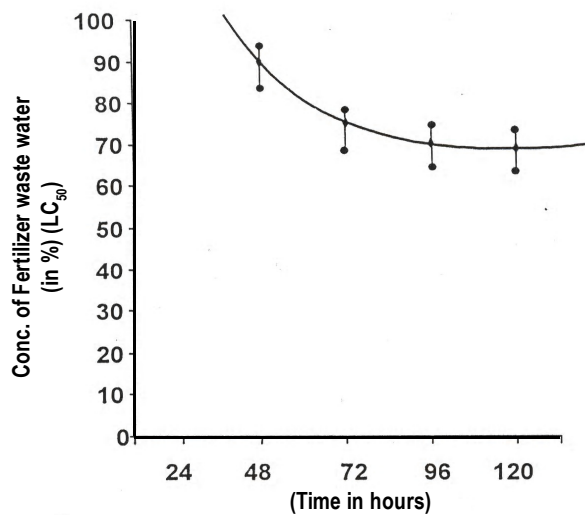


Fig. 1: Toxicity curve showing relationship between median lethal concentration (LC₅₀) of fertilizer industrial wastewater and exposure time for *Channa striatus*

In the present investigation the observation revealed that the mortality rate enhanced with increasing concentration of fertilizer industrial wastewater. For a particular concentration the mortality rate increase with increasing time of exposure. This reflects the regular mode of action, due to harmful chemicals and toxicant of wastewater up to dangerous level that cause fish death. The death of fish could be due to the lethal action of fertilizer industrial wastewater that causes changes in physiological and biochemical process related to cellular metabolic pathway. Birtwell *et al.* (1983) reported that the mortality rate is rapid in fishes in short duration as a result of low dissolve oxygen. Mitz and Giesy (1985) reported the acute mortality of channel fish, *Ictalurus punctatus* (Rafinesque) due to sewage effluent. Earlier workers reported that some other factors are also responsible for mortalities in fishes such as BOD, COD, pH, temp. and DO *etc.*, which were present beyond their prescribed standards (Hingorani *et al.*, 1979; Somanath, 2002). Mallatt (1985) suggested, that the effect of short duration exposure of pollutants on fish gill is responsible for mortality in fish. Moreover, wastewater released from paper mill, sugar industry, fertilizer industry *etc.* are reported to have a large number of toxic chemicals, resulting in mortality of aquatic organisms (Edwards, 1973).

In Table 2 ethological observation of *C. striatus* at different exposure concentration and time duration of fertilizer industrial wastewater are shown. The ethological responses of the fish, *C. striatus* treated with industrial wastewater was found to depend on its concentration and duration of exposure time. Fish were exposed to 20, 40, 60, 80 and 100 percent concentrations of industrial wastewater for different time period of treatment viz., 24, 48, 72, 96 and 120 hr. They show altered behavioural responses, increase in its operculum movement and decrease in bottom dwelling activity. The drastic subsequent increase and

decrease in surface activity such as linear movement, distance travelling, jumping, equilibrium, movement of fins are also observed. The movements of eyes were observed to be very slow. The operculum movement increased considerably with increase in the wastewater concentration. The hypoxic condition in fish causes increase in the breathing rate, which in turn is caused by decreased efficiency in oxygen uptake. Similar observations were also reported for *Gasterosteus aculeatus* (Jones, 1956) and *Mystus kelittius* (Singh and Singh, 1979 ; Stephen *et al.*, 1987). The bottom dwelling activity of *C. striatus* is reduced due to the increased rate of toxicant and chemical uptake from wastewater. The loss of equilibrium status noticed may be due to non functioning of the brain. This observation was also reported in *C. puntatus* exposed to in nickel and zinc by Saxena *et al.* (1981). The ethological responses in fish are extremely sensitive to toxicant, therefore the ethological responses are the most sensitive parameter for measuring the neurotoxicity as suggested by Doving (1992).

On the other hand we have concluded that the fertilizer industrial wastewater possess higher concentration of toxicant. So in the present investigation to determine the degree of pollutant toxicity and ethological responses would prove a useful as well as rapid method for evaluating toxicity of fertilizer industrial wastewater. Thus it is concluded that the *C. striatus* are sensitive to fertilizer industrial wastewater stress.

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References

- APHA.: Standard methods for the examination of water and wastewater, 20th Edn. American public health association, Washington, DC. pp. 2005-2605 (1998).
- Birtwell, I.K., G.L. Greer, M.D. Nassichuk and I.H. Rogers: Studies on the impact of municipal sewage discharged onto an intertidal area within the Fraser river estuary. British Columbia. Canadian technical report of fisheries and aquatic science, 1170, Department of Fisheries Oceans B.C. (1983).
- Chondar, S.L.: Biology of fin fish and shell fish. SCSC publisher, Howrah, India. p. 435 (1999).
- Doving, K.B.: Assessment of animal behaviour as method to indicate environmental toxicity. *Comp. Biochem. Physiol.*, **100**, 247-252 (1992).
- Edwards, C.A.: Environmental pollution by pesticides. Plumer Publishing Co. Ltd., London, New York. p. 542 (1973).
- FAO.: Meeting on the toxicity and bioaccumulation of selected substance in marine organisms. FAO fisheries report, No. 334 Rovinj, Yugoslavia, 5-9 Nov. FIR/R334 (1984).
- Finney, D.T.: Probit analysis. 3rd Edn. Cambridge University Press, London (1971).
- Hingorani, H.G., A.D. Diwan and N. Chandrasekaran Naidu: Oxygen consumption in fish, *Labeio rohita* under exposure to different concentration of industrial effluents. *Comp. Physiol. Ecol.*, **4**, 272-276 (1979).
- Jones, F.R.H.: The behaviour of minnows in relation to light intensity. *J. Exp. Biol.*, **33**, 271-281 (1956).



- Karuppasamy, P.: Pollution and fish mortality in Chaliger river, Mavoor (near Calicut). *Fish Surv.*, **7**, 11-13 (1979).
- Kumaraguru, A.K.: Water pollution and fisheries. *Ecol. Environ. Cons.*, **1**, 143-150 (1995).
- Litchfield, J.R. and F. Wilcoxon: A simplified method of evaluating dose effect experiments. *J. Pharm. Exp. Ther.*, **96**, 99-113 (1949).
- Mallatt, J.: Fish gill structure changes induced by toxicants and other irritants: A statistical review. *Can. J. Fish Aquat. Sci.*, **42**, 630-648 (1985).
- Mitz, S.V. and J.P. Giesy: Sewage effluent biomonitoring: 1. Survival, growth and histopathological effects in channel cat fish. *Ecotoxicology*, **10**, 22-39 (1985).
- Saxena, O.P., A. Parashari and R.S. Yadav: Toxicity of a few heavy metals to freshwater fish *Channa punctatus*. *J. Ichthyol.*, **1(1)**, 37-40 (1981).
- Shaffi, S.A.: Mercury toxicity, biochemical and physiological alterations in nine freshwater teleosts. *J. Toxicol.*, **8**, 187-194 (1981).
- Sharma, B., M.D. Ram, S. Lata and K. Gopal: Carbaryl induced alterations in the biogenic amines in various part of the brain of *Clarias batrachus*, a fresh water fish. *Toxicol. Environ. Chem.*, **38**, 95-99 (1993).
- Singh, S.R. and B.R. Singh: Changes in oxygen consumption of siluroid fish *Mystus vittatus* put to different concentration of some heavy metal salts. *Indian J. Exp. Biol.*, **17**, 274-276 (1979).
- Somanath, V.: Toxicity of tannery effluent to some aquatic animals. *J. Ecotoxicol. Environ. Monit.*, **12(4)**, 277-284 (2002).
- Sprague, J.B.: The ABC's of pollutant bioassay using fish biological method for assessment of water quality. ASTM STP 528. *Am. Soc. Test Materials*. pp. 6-30 (1973).
- Stephen, M.A.R., A.G. Murugesan and M.A. Haniffa: Toxicity of industrial effluent of the fresh water cat fish *Mystus kelitius*. *Curr. Sci.*, **14**, 733-735 (1987).