© 2012 Triveni Enterprises
Vikas Nagar, Lucknow, INDIA
editor@jeb.co.in
Full paper available on: www.jeb.co.in

J. Environ. Biol.
33, 167-171 (2012)
ISSN: 0254-8704
CODEN: JEBIDP

Assessment of the toxicity of waste water from a textile industry to *Cyprinus carpio*

Author Details

H. Roopadevi	Department of Environmental Science, Bangalore University, Bangalore - 560 056, India
R.K. Somashekar (*Corresponding author*)	Department of Environmental Science, Bangalore University, Bangalore - 560 056, India e-mail: h.roopadevi@gmail.com

Publication Data

Paper received:
1 October 2010

Revised received:
10 December 2010

Accepted:
21 April 2011

Abstract

Static, short-term, acute toxicity tests were performed over a period of 96 hrs using different concentrations of influent and effluent of textile industry waste water with the objective of evaluating their acute toxicity on fresh water fish, *Cyprinus carpio* (common carp). The LC_{50} 24, 48, 72 and 96 hr of influent and effluent were 25.9, 21.10, 15.66, 11.11% (v/v) and 63.18, 54.89, 48.62, 36.04% (v/v), respectively. The acute toxic unit TUa values for 24, 48, 72, 96 hr for influent and effluent are 3.85, 4.73, 6.38, 8.99 and 1.58, 1.82, 2.05, 2.77, respectively. Correspondingly, the TF was found to be 1, 1.22, 1.65 and 2.33 for influent, and for effluent 1, 1.15, 1.29 and 1.75. Total efficiency of the treatment was 69.16% and the safe concentration of effluent is set to be 3.60%. These data are highly useful in establishing limits of acceptability by the aquatic animals. The need to introduce toxicity evaluation assay for confirming the quality of effluent from the point view of effective environmental safe limits and to ensure integrity of aquatic environment, is stressed.

Key words

Cyprinus carpio, Toxicity evaluation, Textile effluent, Toxicity factor, Acute toxic unit

Introduction

Aquatic systems are exposed to a number of pollutants emanating from industries, sewage treatment plants, drainage from urban and agricultural areas. Industrial effluents are possibly the most important single source of contaminates to aquatic environment (Bryan and Langston, 1992). Some toxicants contained in the industrial effluents have been reported to be toxic, depending on the dose and exposure duration (Yusuff and Sonibare, 2004), and they can impart serious damage to aquatic life (Vinodhini *et al*., 2009). There have been several reported cases of fish mortality due to the discharge of industrial effluents from several industries into the receiving water bodies (Das, 2003; Adewoye and Lateef, 2004; Adewoye *et al*., 2005). The pollutants build up in the food chain are responsible for the adverse effects and finally death of aquatic organisms (Ogundiran *et al*., 2010). Textile industries are the major sources of pollution due to the nature of their operations which require high volume of water that eventually results in higher wastewater generation (Nemerow, 1978). Uptake of textile effluents through food chain in aquatic organisms may cause various physiological disorders like hypertension, sporadic fever, renal damage, cramps *etc.* (Karthikeyan *et al*., 2006).

Physico-chemical parameters are generally used for evaluation of effluent quality. However, these parameters alone cannot give a quantitative measure of the impact of pollution. Toxicity evaluation is an important and cost effective tool in wastewater quality monitoring as it provides the complete response of test organisms to all the compounds in a cumulative way (Somashekar *et al*., 1985; Tisler and Koncan, 1999) and are more useful in regulating toxic chemicals and also to determine the long and short term impacts of discharge on the aquatic life of the receiving body of water and ground water table (Kohn, 1980). Also, the studies are highly useful for determining the safe concentration of waste water to be discharged in to aquatic water bodies (Bobmanuel *et al*., 2006). This in turn, could pave way to establish limits and levels of their acceptability by the living organisms. Therefore, the ultimate aim of toxicity evaluation is to predict the acceptable levels of toxicants in the environment to the biota. To understand whole effluent toxicity (WET) using fish, toxicity test endpoint tool used in compliance monitoring is called toxic units. The test end points are converted to a number and a measure of toxicity in an effluent is determined by the acute toxic unit (TUa). It is a reciprocal of the effective concentration and indicates higher TUa, the greater toxicity. It is helpful to translate concentration based toxicity data into unit (US-EPA, 2000). Chukwuand and Okhumale (2009) suggested the TF for relative potency measurements in acute toxicity of binary mixtures of petroleum products using Nile tilapia fingerlings. Furthermore, Chukwu and Okpe (2006) evaluated the toxicity of inorganic fertilizer under various salinity regimes on *Tilapia guineensis* employing TF.

The *Cyprinus carpio* fish having commercial importance is a known bioindicator used in the toxicological tests (ISO 7346/1 (1984), USEPA, 2002). This test is recommended as a general standard test by Environmental Protection Act (EPA, 1986) for discharge of pollutants from the industrial operations (Schedule-I), and general standard for discharge of effluent to inland surface water, public sewer on land for irrigation and marine coastal areas (schedule-VI). The objective of this study was to evaluate the acute toxicity of the effluent and influent (Sri Srinivasa Textile Industry, Bangalore) exposed in different concentration to *Cyprinus carpio.*

Materials and Methods

Source of fish and test media: Healthy common carp, irrespective of sex were obtained from National Centre for Fisheries, Bhadra River project, Shimoga, Karnataka state and transported to the laboratory using standard procedure. They were acclimatized to laboratory conditions in well aerated dechlorinated tap water for 15 days in glass aquaria (120X60X70 cm) with oxygenation by aerators at 25 ± 2°C, maintained with thermostat. The water was changed once in 5 days and filter was adjusted to remove the metabolic wastes. Diseased fish or fish showing any abnormal behavior were removed from the aquaria as soon as possible. Where the mortality exceeded 5% during the process, the entire batch was discarded. The fish were provided with commercial diet. After acclimatization, those with average length of 8.5 cm and an average weight of 7.0 g were selected for the study.

The influent (before treatment) and effluent (after final treatment) samples used for the study were collected from Sri Srinivasa Textile Industry, Bangalore during February to May, 2009. The discharges from different processes include dye, chrome dye, indigo dye and vegetable dyes. The effluents are treated in the industry premises to reduce contaminants.

Bioassays: Thirty five litre capacity plastic cans were used to collect influent (5 cans) and effluent (5 cans) samples from the textile industry and transported immediately to the laboratory and stored in a cold room. Preliminary screening test was carried out to ascertain the range of toxicity of the test media before the actual bioassay. Acute static toxicity tests were performed in accordance with APHA (2005). For the determination of LC_{50}, different concentrations (sample and diluent water) of influent and effluent were prepared using dechlorinated tap water. A total of 70 fishes of *C.carpio* were exposed including control as triplicates (10 fishes per replicate) per treatment. The concentration of influent sample used were 5, 10, 15, 20, 25, 30% (v/v) and control, since it was found to be much toxic than effluent sample as confirmed by preliminary test. The effluent samples were used at 20, 30, 40, 50, 60 and 70% and control. Observations were made after 24, 48, 72, 96 hr intervals. The feeding was suspended 24 hr before start and throughout the experiment. Fish status and behavior along with water temperature, pH, dissolved oxygen and conductivity were monitored through the course of experiment. The physico-chemical parameters of the tap water were estimated according to APHA (2005). The number of dead fish within 96 hr post-exposure was recorded.

Physico-chemical analysis: Influent and effluent samples from the industry were collected simultaneously and separately into 2 l clean plastic cans and taken for physico-chemical analysis following standard procedure (APHA, 2005). Samples were preserved using preservatives as required, separately (for BOD, heavy metals, Total residual chlorine, sulphide and oil and grease estimation).

Statistical analysis: LC_{50} and their corresponding 95% confidence intervals were calculated by probit analysis (SPSS 7.5 version). The TF were calculated using ratio of 24 hr LC_{50} of a sample to LC_{50} values of samples at different time intervals (48, 72 and 96 hr) (Chukwu and Okpe, 2006). Safe concentration was obtained by multiplying the lethal concentration values with an application factor of 0.1 (Bobmanual *et al.,* 2006). Acute toxic unit (TUa) and total efficiency of effluent treatment unit was calculated (USEPA, 2000) as follows:

$$TUa = 100/LC_{50}\% \ (v/v)$$
$$E = (TUai - TUae)/TUai * 100$$

Where TUai = Influent TUa; TUae = Effluent TUa; E = Efficiency.

Results and Discussion

There were not many variations in the physical and chemical characteristics of dilution water used for test for parameters such as pH, total hardness, dissolved oxygen and alkalinity. The pH of influent sample was highly alkaline side, dark blue colored and exhibited pungent smell, whereas the effluent sample was slightly alkaline and grey colored with unpleasant smell. The concentrations of COD, BOD, suspended solids, dissolved solids, chloride, chromium, were high (Table 1). The result of bioassay, however implicated the effluent to be unsafe to fishes. The influent and effluent characteristics did not met the (EPA, 1986) standards for cotton textile and dye and dye intermediate effluent and FEPA (1991) specification of safe limit for effluent discharge into any categories of water bodies.

However, when the test samples were administered to experimental tanks, various stressful behaviors like erratic swimming, increased activity, inconsistent jumping were observed in *Cyprinus carpio* exposed to both influent (above 25% concentration) and effluent (above 50% concentration). These behavioral responses of fish is in response to toxicants present in the sample at different duration of exposure and the prevailing specific environmental conditions as opined by Bobmanuel *et al.* (2006). This also signifies respiratory impairment, an out come of the impact of the waste water on the gills of fish as observed by Adewoye *et al*. (2005). There was gradual loss of equilibrium and eventually 100% mortality at 96

Table - 1: Physico-chemical parameters of influent and effluent from Sri Srinivasa Textile Industry

Parameters	Influent	Effluent	Standard limits	
			EPA (1986)*	FEPA (1991)**
Temperature (^oC)	39	28	-	-
Colour	Dark blue	Grey	-	-
Odour	Pungent	Unpleasant	-	-
pH	11.2	8.1	5.5-9	6-9
COD (mg l^{-1})	993	539	-	-
BOD (mg l^{-1})	780	144	150	50
Suspended solids (mg l^{-1})	328	114	100	30
Dissolved solids (mg l^{-1})	5682	3938	-	-
Conductivity (mmhoscm^{-1})	8.4	5.9	-	-
Cr (mg l^{-1})	0.38	0.32	2	-
Cd (mg l^{-1})	0.01	BDL	-	<1.0
Zn (mg l^{-1})	0.05	0.05	-	<1.0
Cu (mg l^{-1})	0.31	0.02	-	<1.0
Pb (mg l^{-1})	0.09	0.09	-	<1.0
Chloride (mg l^{-1})	2600	1200	-	-
Total residual chlorine (mg l^{-1})	Nil	Nil	-	-
Sulphide (mg l^{-1})	8.0	Nil	2	-
Phosphate (mg l^{-1})	0.15	Nil	-	-
Oil and grease (mg l^{-1})	Nil	Nil	10	10
Bioassay	Not confirmed	Not confirmed	90% survival of fish	-

*Environment Protection Act, 1986, India.
**Federal Environmental Protection Agency, 1991.
Values are the average of triplicate samples.

Table - 2: Mortality details of common carp *C. carpio* exposed to various concentrations of influent and effluent at different duration

Concentration (%)	24 hr			48 hr			72 hr			96 hr		
	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3
Influent												
0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	0	1	1	2	2	2	3	3	3
10	0	1	1	1	1	1	2	3	3	4	4	4
15	2	2	1	3	2	2	3	4	4	5	5	5
20	3	2	3	4	4	4	5	5	4	6	6	7
25	5	6	5	6	7	7	7	7	8	8	8	8
30	8	7	7	8	8	8	9	9	9	10	10	10
Effluent												
0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	1	0	0	1	1	0	2	2	1
30	0	0	1	1	0	1	1	1	1	3	3	3
40	0	1	1	1	2	1	3	3	4	4	5	4
50	3	2	2	3	4	3	4	5	4	8	8	7
60	6	5	5	5	5	5	6	6	6	9	9	9
70	7	7	6	9	9	9	9	10	9	10	10	10

R = Replicate

hr occurred at higher concentrations *viz*., 30 and 70% of influent and effluent, respectively. This could be a consequence of depletion of energy in the body of the exposed animals and an indication of impairment of carbohydrate metabolism wherein organisms that could not tolerate the contaminants enter into a state of coma and subsequent death (Ogundiran *et al*., 2010). The responses recorded for the fish in this study are similar to those reported by Danielly de paiva magalhaes *et al.* (2007) and Chukwuand and Okhumale (2009). Such an anomaly was not observed in the control set maintained under identical experimental condition and the fish did not show symptoms of restless behaviors.

Table - 3: Relative acute toxicity of influent and effluent of textile industry on *Cyprinus carpio*

Exposure duration (hr)	LC_{50} (95% confidence limit v/v)	Slope ± S.E	DF	Probit equation	TUa	TF	Safe concentration	Total efficiency (%)
				Influent				
24	25.907 (19.297 – 63.413)	3.597±0.640	4	-5.085+3.597x	3.859	1.00	2.59	-
48	21.104 (14.950 – 38.975)	3.392±0.538	4	-4.492+3.392x	4.738	1.22	2.11	
72	15.663 (08.296 – 29.902)	2.432±0.415	4	-2.905+2.432x	6.384	1.65	1.56	
96	11.117 (03.333 – 17.994)	2.383±0.403	4	-2.492+2.382x	8.995	2.33	1.11	
				Effluent				
24	63.189 (58.052 – 71.649)	6.792±1.213	4	-12.231+6.792x	1.582	1.00	6.31	59.00
48	54.895 (42.794 – 89.919)	6.051±0.901	4	-10.526+6.051x	1.821	1.15	5.48	61.56
72	48.625 (39.168 – 63.512)	5.146±0.736	4	-08.681+5.146x	2.056	1.29	4.86	67.79
96	36.044 (27.830 – 43.832)	5.268±0.682	4	-08.201+5.268x	2.774	1.75	3.60	69.16

S.E = Standard error, D.F = Degree of freedom, TUa = Acute toxicity unit, TF = Toxicity factor

The results of mortality analysis of influent against *Cyprinus carpio* yielded the derived toxicity indices values (LC_{50}) ranging from 11.11% (v/v) at 96 hr to 25.90% (v/v) at 24 hr, while for the final treated effluent, the values ranged between 36.04% (v/v) and 63.18% (v/v) at 96 and 24 hr, respectively (Table 3). The lethal concentrations (LC_{50}) were inversely proportional to duration of exposure. The TF for the treated effluent for 96 hr (with LC_{50} value of 36.04%) was 1.33 times less than the influent for 96 hr (with LC_{50} value of 11.11%). The mortality rate of *C. carpio* remained directly proportional to duration of exposure, concentration and toxicity factor as observed in Catfish hybrid by Gabriel and Okey (2009) and TUa (Pool *et al.*, 2009). The acute toxicity units (Pool *et al.,* 2009) obtained for influent were higher than effluent, thus showing that influent is more toxic to Carp as compared to effluent. Influent had mildly acute toxic (2-10 acute toxic unit)) at all exposed duration. On the other hand effluent was negligibly acute toxic (1-2 acute toxic unit) at 24 and 48 hr and mildly acute toxic (2-10 acute toxic unit) at 72 and 96 hr. The TUa obtained for effluent at 96 hr (2.77) was 3.24 times less than the influent for 96 hr (8.99) which indicates, the effluent was 2.77 times and influent was 8.99 times more toxic than an acceptable discharged effluent under US-EPA (2000) NPDES permitted discharges. The total efficiency of the treatment was 69.16%, the safe dischargeable concentration of effluent was set to be 1.11% (v/v) for influent and for effluent, 3.60% (v/v) which is highly useful in establishing limits of acceptability by the aquatic animals. It is observed that the treated textile effluents impart toxicity in common carp and therefore the present level of treatment of effluent prior to discharge appears insufficient.

Acknowledgments

The first author thanks the Karnataka State Pollution Control Board for deputation to higher studies and laboratory facilities.

References

Abdel-Moneim, A.M., N.M. Abou Shabana, S.E.M. Khdre and H.H. Abdel-Kader: Physiological and histopathological effects in catfish (*Clarias lazera*) exposed to dyestuff and chemical wastewater. *Int. J. Zool. Res.,* **4**, 189-202 (2008).

Adewoye, S.O., O.O. Fawole and O.D. Owolabi: Toxicity of cassava a waste water effluents to African catfish: *Clarias gariepinus*. *Ethiop. J. Sci*., **28**, 189-194 (2005).

Adewoye and A. Lateef: Evaluation of the microbiological characteristics of Oyun river – A polluted river in North-central Nigeria. *Pollut. Res*., **23**, 587-591 (2004).

Anonymous: The Environment protection and pollution control manual. Karnataka law journal publication, Bangalore, India, 30-50, (2000).

APHA: Standard methods for the examination of water and waste water. 20th Edn. APHA, AWWA, WPCF, Washington, USA (2005).

Bobmanuel, N.O.K., U.U. Gabriel and I.K.E. Edweozor: Direct toxic assessment of treated fertilizer effluent to *Oriochromis niloticus, Clarias gariepinus* and Catfish hybrid (*Heterobranchus bidorsalis*♂ *X Clarias* garepinus♀). *African J. Biotech*., **5**, 635-642 (2006).

Bryan, G.W. and W.J. Langston: Bioavailability, accumulation and effects of heavy metals in sediments with special reference to United Kingdom estuaries: A review. *Environ. Pollut*., **76**, 89-131 (1992).

Chukwu, L.O. and H.A Okpe: Differential response of *Tilapia guineensis* fingerlings to inorganic fertilizer under various salinity regimes. *J. Environ. Biol*., **27**, 687-690 (2006).

Chukwuand, L.O. and B.O. Okhumale: Mode of joint action response to binary mixtures of three refined petroleum products by Nile tilapia, *Oreochromis niloticus* fingerlings. *Sci. Res. Essay,* **4**, 806-811 (2009).

Danielly de paiva magalhaes, Rodolfo Armando da cunha, Jose Augusto Albuquerque Dos Santos, Daniel For sin buss and Darcilio Fernandez Batista: Behavioral response of Zebra fish, *Danio rerio,* Hamilton 1822 to sub lethal stress by sodium hypo chloride ecotoxicological assay using an image analysis biomonitoring system. *Ecotoxicol*., **16**, 417-422 (2007).

Das, M.K.: Fish health management in inland fisheries-A comprehensive study. *Environ. Ecol.,* **21**, 72-78 (2003).

FEPA: Federal Environmental Protection Agency.S.1.8 National environmental Protection [Effluent discharge Limitation]. (1991).

Gabriel, U.U. and I.B.Okey: Effect of aqueous leaf extracts of *Lepidagathis alopecuroides* on the behaviours and mortality of hybrid cat fish (*Heterobranchus bidorsalis*♂ *X Clarias gariepinus*♀) fingerlings. *Res. J. Appl. Sci. Eng. Tech.,* **1**, 116-120 (2009).

ISO 7346/1: Water quality- Determination of acute lethal toxicity of substances to a freshwater fish (Brachydanio rerio Hamilton-Buchanan (Teleostei, Cypinidae) – Part 1: Static method (1984).

Karthikeyan, S., M. Jambulingam, P. Sivakumar, A.P. Shekhar and J. Krithika: Impact of textile effluents on fresh water fish *Mastacembelus armatus* (Cuv. and Val). *E-J. Chem*., **3**, 303-306 (2006).

Kohn, G.K.: Bioassay as a monitoring tool. *Residue Rev.,* **76**, 99-129 (1980).

Nemerow, N.L.: Industrial water pollution: Origins, characteristics and treatment. Addison-Wesley, Massachusetts. p. 738 (1978).

Ogundiran, M.A., O.O. Fawole, S.O. Adewoye and T.A. Ayandiran: Toxicological impact of detergent effluent on juvenile of African catfish (*Clarias gariepinus*) (Buchell 1822). *Agric. Biol. J. N. Am*., **1**, 330-342 (2010).

Pool, E.J., J.A. Klaasen and Y.P. Shoko: The environmental toxicity of *Dicerothanmus rhinocerotis and Galenia africana. African J. Biotech.,* **8**, 4465-4468 (2009).

Somashekar, R.K., M.R. Gurudev and Siddaramaiah: Somatic cell abnormalities induced by dye manufacting industry waste waters in *Allium cepa*. *Cytologia,* **50**, 129-134 (1985).

Tisler, T. and J. Zagorc Koncan: Toxicity evaluation of water from pharmaceutical industry to aquatic organisms. *Wat. Sci. Tech*., **39**, 71-76 (1999).

US-EPA: Understanding and accounting for method variability in whole effluent toxicity application under the national pollutant discharge elimination system. EPA 833-R-00-003 (2000).

US-EPA: Methods for measuring the acute toxicity of effluents and receiving waters to fresh water and marine organisms. EPA-821-R-02-01 (2002).

Vinodhini, R. and Narayanan: The impact of toxic heavy metals on the hematological parameters in common carp (*Cyprinus carpio* L.). *Iran. J. Environ. Hlth. Sci. Eng.*, **6**, 23-28 (2009).

Yusuff, R.O. and J.A. Sonibare: Characterization of textile industries effluents in Kaduna, Nigeria and pollution implications. *Global Nest: Int. J*., **3**, 212-221 (2004).