International Journal of Zoology Studies
ISSN: 2455-7269
Impact Factor: RJIF 5.14
www.zoologyjournals.com
Volume 3; Issue 6; November 2018; Page No. 19-27

Impact of Industrial Effluent on the Changes in Behaviour and Bodyweight of a Freshwater fish Tilapia, *Oreochromis mossambicus* (Peters)

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Abstract
One must continue to anticipate increasing density of urban population with all the problems of air, water pollution and waste disposal from the local area industrial estate Antharasanahalli Tumakuru, Karnataka, India. Located near Tumakuru town discharge of heavy industrial effluent into aquatic environment from various sources even below permissible levels creates health hazards in aquatic organisms. Short term definitive test by static renewal bioassay method was conducted to determine the acute toxicity (LC_{50}) of industrial effluent and freshwater fish fingerlings were exposed to different concentrations of industrial effluent 15ml/L for 96hrs, 30ml/L for 96hrs, 60ml/L for 96hrs and 120ml/L for 96hrs were selected for acute study on fish Tilapia, *Oreochromis mossambicus* procured from Fisheries Research and Information Centre (Inland) Hebbal, Bangalore, Karnataka, India. The size of the fish will be (3 ± 0.21 g; 3 ± 0.25 cm) and duration of the study will be 1, 5, 10 & 15 days respectively. The present study shows that behaviour condition of the fishes were varies and symptoms dictated like irregular, erratic and darting swimming movements, hyper excitability, capsizing, attaching to the surface, restlessness, difficulty in breathing, loss of equilibrium and gathering around the ventilation filter and the bodyweight of the fishes also decreases slowly up to 15 days of time period. This present investigation shows that impact of industrial effluent on the changes in behaviour and bodyweight of a freshwater fish, Tilapia, *Oreochromis mossambicus*. The results of the study evidenced that effluent is toxic and thus, it has led to the altered fish physiology. However the exact mechanism through which this is achieved needs to be studied further.

Keywords: Industrial effluent, Antharasanahalli industrial area, Behaviour, Bodyweight & Tilapia, *Oreochromis mossambicus*

Introduction

Water is the most significant component for the existence of life on the earth. It is distributed in environment in different forms such as river water, rain water, mineral water and spring water etc., In this world today human population suffering lots of water problems day by day and some of the disputes from mankind on this type of habitat due to scarcity of water because dense population, utilization of river, lakes, ponds, streams etc. for different type of industrial as well as agricultural purpose, pollution is a serious issue in recent times, the natural resources of water bodies such as rivers, ponds, lakes and seas are polluted with a variety of solid and liquid wastes causing a great damage to the aquatic ecosystems. The two most important processes that effect the global environment are the resource production and the waste disposal. A proper balance between these two is necessary for a healthy biosphere. Although, certain resources are often created for some useful purpose, on actual use some such resources contaminate and pollute the environment. Besides, every human society, be it rural or urban, industrially or technologically advanced, disposes certain by-products and waste products into the environment (Patro L 2006) [41].

Industrial effluents are a complex mixture of number of chemical constituents and have very high oxidation potential inside the aquatic ecosystems. The effluent causes great damage to water quality as well as aquatic flora and fauna. Hence, there are capable of producing harmful effects even lethal and sub-lethal concentrations. The effluent generated is dumped into fresh water rivers housed along the bank of rivers. Tannery industry effluent contains several complex organic & inorganic components like Sulphides (Sodium sulphide, Sodium hydrosulphite & Calcium hydrosulphide), Sodium chloride, Cyanides, dimethyl amines, Chromium sulphate salts, oil, grease, alum salts & suspended solids. They are mainly absorbed through the gill and the effect is accumulative other substance like Boron, Chloride & Sulphides. The release of effluent without proper treatment into natural water bodies and ecosystems increases health risk for human beings and environmental pollution. It is not possible to eliminate all mutagens &carcinogens in environment (Gurinder *et al.* 2015) [22]. The aquatic environment is to heavy and diverse pollutants load, particularly in the highly industrialized and urbanized regions. There is much concern over possible effects of these pollutants on aquatic life (Verma *et al.* 1978) [52].

Heavy metals are the major source of water pollution as it eradicates the economically important species either indirectly through breaking the biological chains or directly produces toxic stress by means of chemical changes in water. As a result, large scale mortality of fishes has been observed due to discharge of heavy metal pollution into natural water resources (Srivastava A. K & Srivastava A. K 1994) [49].

Fishes are very sensitive to a wide variety of toxicants in water, various species of fish uptake and accumulate many toxicants such as heavy metals (Herger *et al.* 1995) [27]. The accumulation of heavy metals in tissues thus causes many physiological, histological and other freshwater fauna by influencing the activities of several enzymes and metabolites (Nagarathnamma and Ramamurthi R 1982) [37]. The change in the behaviour and physiology of fish indicates the deterioration of water quality, since; fish are the biological indicators of water quality. Hence, the present study was under taken to evaluate the aquatic toxicity of Cadmium Chloride with special emphasis on behavioural aspects of the freshwater teleost, *C. carpio* exposed to lethal and sub-lethal concentrations of commercial grade heavy metal Cadmium chloride and Cadmium has gained wide interest in the scientific community in recent years due to its potential human health hazards (Shivaraj *et al.* 2015) [48].

In natural aquatic ecosystems, environmental toxicants discharged from various sources causes determental effects on important features such as metabolism, growth, reproduction & ultimately the survival of the fish become very difficult (Adams *et al.*1992) [1], (Benejam L *et al.* 2008) [5]. Environmental pollution resulting from industrial effluents and agricultural activities has become a global issue because of the extent damage caused to the aquatic ecosystems and the disruption in the natural food change, by several agricultural practices such as insecticidal and herbicidal application. The increasing population is generating a stress on resources, resulting in the excessive use of organophosphorus pesticides and fertilizers to meet the demand. These substances ultimately pollute the aquatic environment and causes severe damage to the aquatic life especially the non- target species (Venkateshwarlu *et al.* 2016) [51].

Rapid urbanization and industrialization in India has resulted in the substantial increase in the liquid waste (spent wash or effluent) which is traditionally discharged in the open land or into nearby natural water, causing a number of environmental problems including threat to plants and animal lives present in that environment. These industrial pollutants alter the natural condition of aquatic medium that causes behavioral changes as well as morphological imbalance of aquatic organisms (Yadav *et al.*2007) [54]. Toxicity study is important to find out safe concentration as well as toxicant limit, so there will be least harm to aquatic fauna in future. The acute toxicity test is short term exposure to the test organisms under the laboratory condition. The mortality of the test animal is the most detectable response to find out the LC_{50} Concentration of experimental organisms (Ishi S.S and Patil R.D 2017) [30]. Physicochemical water quality parameters affect the survival, growth, reproduction and distribution of aquatic animals directly or indirectly (Patoine A 2002) [40], (Freund J.G *et al.*2007) [19], (Gupta *et al.*2012) [21], (Leduc A.O *et al.*2013) [31], (Perkin *et al.*2016) [42]. Among them, water p^H plays a crucial role. Its roles and the effects of extreme water p^H value on fish have been widely studied and reviewed (Underhay *et al.*1997) [50], (Ikuta K *et al.*1999) [29], (Baldigo *et al.*2001) [4], (Scott D M *et al.*2005) [46], (Aride and Ivoke N 2007) [3], (Henrique and Arid 2007) [25], (Oliveira *et al.*2008) [39], (Bolner *et al.*2014) [6]. It is well accepted that a suitable p^H range for fish is 6.5 to 9.0 (Zweig R.D 1999) [55]. However, different species have different p^H tolerance and fish at different life stages also exhibits different responses to water p^H value (Lolyd R *et al.*1964) [33], (Lopes J.M 2001) [34], (Heydarnejad *et al.*2012) [28]. Such variations of fish tolerance to different p^H indicate that p^H changes in their natural habitat could greatly affect their survival and growth. Anthropogenic activities such as agricultural runoff, deforestation and sewer over flow all have major influence on water p^H of the aquatic ecosystem.

In this present investigation the studies on impact of industrial effluent on the changes in behaviour and bodyweight of a freshwater fish, Tilapia, *Oreochromis mossambicus*. There is wide lacuna in this field of industrial effluent toxicity on freshwater fishes prompted to take up this investigation further. In this work the survey of literature reflects that, the industrial effluent affects a wide range of non-target organisms such as fishes and other aquatic organisms. No information was available on the direct effect of the effluent of the industry on freshwater fishes. The effluents of the industry leach and enter into neighbouring ponds and contaminated the ponds, where this Tilapia fish (*Oreochromis mossambicus*) was mass cultured. Hence, this venture was designed for instant information on the issue. In outlook of the foregoing account the present investigation was projected to understand the impact of lethal concentration of industrial effluent on the freshwater fish, Tilapia, *Oreochromis mossambicus* with the following goals.

Materials and Methods

Collection of carp, and their maintenance

The collection of carp, from Fisheries Research and Information Center (Inland) Hebbal, Bangalore, Karnataka, India, provided healthy and active 1 month old Tilapia, *Oreochromis mossambicus* fingerlings (3 ± 0.21 g; 3 ± 0.25 cm). Large aerated crates were used to transport fish to the laboratory. Before investigation fish were maintained for 30 days in large cement tanks (22 × 12 × 5 feet). Further, carp (50 fingerlings) were acclimatized to laboratory conditions for 20 days at 22 ± 2 ºC in 100 L glass aquaria (120 × 45 × 80 cm) containing dechlorinated tap water of the quality used in the test. Characteristics of the water were determined by following the methods (APHA 2005) [2].

Physico-Chemical Parameters (Methods Followed)

In this present investigation, the physico-chemical parameters of water such as temperature, pH, Dissolved oxygen, Carbon dioxide, hardness, Total alkalinity, Conductivity, Specific gravity, Chlorinity, Calcium and Sodium were estimated during the course of the study according to the standard protocols APHA international guideline.

Experimental Toxicant

Industrial Effluent containing some of the macro and micro toxic elements, so we choose as a toxic substance based on the some of the literature survey. This Industrial effluent was procured from the local area industrial estate Antharasanahalli Industrial Area, Tumakuru, Karnataka, India. For this study the treatment of industrial effluent was found suitable for the exposure based on the available literature survey.

Acute toxicity test

The acute toxicity (96 hr LC_{50}) of Industrial effluent for the freshwater fish, Tilapia, *Oreochromis mossambicus* was determined in the laboratory using the semi-static method in (OECD 1992) [38]. The carp (10 fingerlings in 20 L of test medium in each replicate) were exposed to varying concentrations of industrial effluent with two replicates for each concentration along with the control sets. Test medium was renewed for every 24 hr with their respective test concentrations of the toxicant without aeration. Mortality was recorded every 24 hr and the dead fish were removed when observed, every time noting the number of fish death at each concentration up to 96 h for estimation of acute toxicity (LC_{50}). Time of exposure was the repeated measure factor while treatment (concentration and control) was the second factor. The LC_{50} was calculated using probit analysis (Finney O. J 1953) [17], which has been recommended by OECD guideline as an appropriate statistical method for toxicity data analysis (Lilius H 1994) [32]. After linearization of the concentration response curve by logarithmic transformation of concentrations (log^{+2}), 96 hr LC_{50} with 95% confidence limits and slope function were calculated to provide a consistent presentation of the toxicity data.

Experimental design and test concentrations

In this experiment lethal concentration of industrial effluent 15ml/L for 96hrs, 30ml/L for 96hrs, 60ml/L for 96hrs and 120ml/L for 96hrs were selected for acute study. Each replicates possessed 10 fish in 20 L of the test medium and two replicates group -1 (control) and group-2 (treated) were maintained for each concentration and control. Tilapia, *Oreochromis mossambicus* were exposed to both the test concentrations for 15 days of time period but 96hrs for each group were exposed the concentration levels of each groups were 15, 30, 60 & 120ml/L increased up to the mortality arises in this level of exposure and were allowed to recover in toxicant free medium for seven days. In this experimental periods test medium was renewed daily followed by addition of respective test concentrations of industrial effluent only up to day 15 without aeration, respectively.

Results

Water quality analysis

Table 1: Daily/Weekly Wise Water quality Analysis Report: For Stock Fishes Acclimatization Period.

S. No.	Parameter Name	Units	Tank Control 1	Tank Treated 2	Mean± SD
01	Temperature	^{0} C	23.9	23.8	23.85^0 C
02	P^H	mg/L	7.8	8.3	8.05 mg/L
03	Dissolved oxygen	mg/L	82.6	81.7	82.4 mg/L
04	Carbon dioxide	mg/L	18.3	19.0	18.6 mg/L
05	Hardness of water	mg/L	120	118	119 mg/L
06	Total alkalinity	mg/L	21.2	21.1	21.15 mg/L
07	Conductivity	µS/cm	< 10	< 10	< 10 µS/cm
08	Chlorinity/Chloride	mg/L	44.4	45.0	44.9 mg/L

- In this part of experimental work all the water quality related parameters were carried out based on the APHA guidelines this table-1 indicates that average mean values of the standards at the time of acclimatization period.

First exposure: 1, 2, 3 & 4 day exposure-control groups

Table 2: It indicates that Bodyweight and Behavioural Toxicological Symptoms appear to be normal in day-1, 2, 3 & 4 Control group of *Oreochromis mossambicus.*

Dose Concentrations/ Days/hrs	Number Of fishes	Bodyweight in gms Day-1	Body weight in gms Day-2	Body weight in gms Day-3	Body weight in gms Day-4	Behavioural Toxicological Symptoms Day-1 to Day-4
0ml/L/ Day-1, 2, 3 & 4/ 24, 48, 72 & 96 hrs	01	1.8	1.9	2.2	2.3	N
	02	2.1	1.5	2.1	1.2	N
	03	1.9	1.9	1.9	1.6	N
	04	2.0	1.1	2.2	1.6	N
	05	2.0	2.1	2.3	2.1	N
	06	1.9	1.2	1.9	1.9	N
	07	1.5	1.7	1.8	1.8	N
	08	1.7	1.9	1.9	2.2	N
	09	1.6	1.5	1.6	2.3	N
	10	2.0	1.9	1.6	2.3	N

There is no significance in the present table and N-Normal

First exposure: 1, 2, 3 & 4 day exposure-treated groups

Table 3: It indicates that Bodyweight and Behavioural Toxicological Symptoms appear

Dose Concentrations/ Days/hrs	Number Of fishes	Bodyweight in gms Day-1	Body weight in gms Day-2	Body weight in gms Day-3	Body weight in gmsDay-4	Behavioural Toxicological Symptoms Day-1 to Day-4
15ml/L/ Day-1, 2, 3 & 4/ 24, 48, 72 & 96 hrs	01	1.7	1.6	1.9	2.5	N
	02	2.3	2.3	2.3	1.9	N
	03	1.6	1.7	2.4	2.3	N
	04	1.9	1.9	2.3	2.1	N
	05	1.9	2.4	1.9	1.7	N
	06	2.4	2.1	1.7	2.1	N
	07	1.8	1.5	2.3	2.1	N
	08	1.9	1.5	1.9	1.8	N
	09	1.9	2.2	2.4	2.1	N
	10	2.3	1.8	1.8	1.7	N

To be normal in day-1, 2, 3 & 4 Treated group of *Oreochromis mossambicus.* There is no significance in the present table and N-Normal

Second exposure: 1, 2, 3 & 4 day exposure-control groups

Table 4: It indicates that Bodyweight and Behavioural Toxicological Symptoms appear to be normal in day-1, 2, 3 & 4 Control group of *Oreochromis mossambicus.*

Dose Concentrations/ Days/hrs	Number Of fishes	Bodyweight in gms Day-1	Body weight in gms Day-2	Body weight in gms Day-3	Body weight in gms Day-4	Behavioural Toxicological Symptoms Day-1 to Day-4
0ml/L/ Day-1, 2, 3 & 4/ 24, 48, 72 & 96 hrs	01	2.1	2.3	2.5	2.5	N
	02	2.4	2.1	2.5	2.2	N
	03	1.9	2.5	1.8	2.7	N
	04	2.3	1.7	2.3	2.8	N
	05	2.3	1.9	1.9	2.2	N
	06	2.1	1.7	2.7	2.1	N
	07	2.1	2.5	2.8	2.7	N
	08	1.7	2.2	1.9	2.2	N
	09	2.1	2.9	2.5	1.8	N
	10	1.9	2.1	2.7	1.9	N

There is no significance in the present table and N-Normal

Second exposure: 1, 2, 3 & 4 day exposure-treated groups

Table 5: It indicates that Bodyweight and Behavioural Toxicological Symptoms appear

Dose Concentrations/ Days/hrs	Number Of fishes	Bodyweight in gms Day-1	Body weight in gms Day-2	Body weight in gms Day-3	Body weight in gms Day-4	Behavioural Toxicological Symptoms Day-1 to Day-4
30ml/L/ Day-1, 2, 3 & 4/ 24, 48, 72 & 96 hrs	01	2.1	2.1	2.5	2.5	N
	02	1.9	2.5	2.5	2.2	N
	03	2.5	2.3	2.1	2.7	N
	04	2.6	2.7	2.7	2.8	N
	05	2.3	1.9	2.2	2.2	N
	06	2.4	2.3	2.7	2.1	N
	07	2.4	1.7	2.1	2.7	N
	08	2.1	1.7	2.5	2.2	N
	09	2.3	2.3	2.2	1.8	N
	10	1.9	1.8	2.2	1.9	N

To be normal in day-1, 2, 3 & 4 Treated group of *Oreochromis mossambicus.* There is no significance in the present table and N-Normal

Third exposure: 1, 2, 3 & 4 day exposure-control groups

Table 6: It indicates that Bodyweight and Behavioural Toxicological Symptoms appear to be normal in day-1, 2, 3 & 4 Control group of *Oreochromis mossambicus.*

Dose Concentrations/ Days/hrs	Number Of fishes	Bodyweight in gms Day-1	Body weight in gms Day-2	Body weight in gms Day-3	Body weight in gms Day-4	Behavioural Toxicological Symptoms Day-1 to Day-4
0ml/L/ Day-1, 2, 3 & 4/ 24, 48, 72 & 96 hrs	01	2.1	2.1	2.5	2.4	N
	02	2.5	1.9	1.9	2.4	N
	03	2.3	2.5	2.3	1.9	N
	04	2.7	2.6	2.1	1.8	N
	05	1.9	2.3	1.7	2.2	N
	06	2.3	2.4	2.1	2.1	N
	07	1.7	2.4	2.1	2.5	N
	08	1.7	2.1	1.8	2.3	N
	09	2.3	2.3	2.1	2.5	N
	10	1.8	1.9	1.7	2.5	N

There is no significance in the present table and N-Normal

Third exposure: 1, 2, 3 & 4 day exposure-treated groups

Table 7: It indicates that Bodyweight and Behavioural Toxicological Symptoms appear

Dose Concentrations/ Days/hrs	Number Of fishes	Bodyweight in gms Day-1	Body weight in gms Day-2	Body weight in gms Day-3	Body weight in gms Day-4	Behavioural Toxicological Symptoms Day-1 to Day-4
60ml/L/ Day-1, 2, 3 & 4/ 24, 48, 72 & 96 hrs	01	2.5	2.5	2.4	2.4	Irregular, Erratic and darting swimming movements, Hyper excitability, Capsizing, Attaching to the surface, Restlessness, Difficulty in breathing, Loss of equilibrium and Gathering around the ventilation filter
	02	2.3	1.9	2.4	2.4	
	03	2.6	2.3	1.9	1.9	
	04	2.4	2.1	1.8	1.8	
	05	2.5	1.7	2.2	2.2	
	06	2.1	2.1	2.1	2.1	
	07	2.2	2.1	2.5	2.5	
	08	2.3	1.8	2.3	2.3	
	09	2.5	2.1	2.5	2.5	
	10	2.4	1.7	2.5	2.5	

To be normal in day-1, 2, 3 & 4 Treated group of *Oreochromis mossambicus.* There is significance in the present table and some of the Behavioural symptoms occur

Fourth exposure: 1, 2, 3 & 4 Day exposure-control groups

Table 8: It indicates that Bodyweight and Behavioural Toxicological Symptoms appear to be normal in day-1, 2, 3 & 4 Control group of *Oreochromis mossambicus.*

Dose Concentrations/ Days/hrs	Number Of fishes	Bodyweight in gms Day-1	Body weight in gms Day-2	Body weight in gms Day-3	Body weight in gms Day-4	Behavioural Toxicological Symptoms Day-1 to Day-4
0ml/L/ Day-1, 2, 3 & 4/ 24, 48, 72 & 96 hrs	01	2.5	2.4	1.8	2.5	N
	02	1.9	2.4	7.3	2.3	N
	03	2.3	1.9	2.2	2.6	N
	04	2.1	1.8	3.2	2.4	N
	05	1.7	2.2	5.1	2.5	N
	06	2.1	2.1	3.4	2.1	N
	07	2.1	2.5	4.3	2.2	N
	08	1.8	2.3	3.5	2.3	N
	09	2.1	2.5	3.2	2.5	N
	10	1.7	2.5	1.6	2.4	N

There is no significance in the present table and N-Normal

Fourth exposure: 1, 2, 3 & 4 day exposure-treated groups

Table 9: It indicates that Bodyweight and Behavioural Toxicological Symptoms appear

Dose Concentrations/ Days/hrs	Number Of fishes	Bodyweight in gms Day-1	Body weight in gms Day-2	Body weight in gms Day-3	Body weight in gms Day-4	Behavioural Toxicological Symptoms Day-1 to Day-4
120ml/L/ Day-1, 2, 3 & 4/ 24, 48, 72 & 96 hrs	01	2.5	1.8	2.5	2.5	Irregular, Erratic and darting swimming movements, Hyper excitability, Capsizing, Attaching to the surface, Restlessness, Difficulty in breathing, Loss of equilibrium and Gathering around the ventilation filter
	02	1.9	7.3	1.9	2.3	
	03	2.3	2.2	2.3	2.6	
	04	2.1	3.2	2.1	2.4	
	05	1.7	5.1	1.7	2.5	
	06	2.1	3.4	2.1	2.1	
	07	2.1	4.3	2.1	2.2	
	08	1.8	3.5	1.8	2.3	
	09	2.1	3.2	2.1	2.5	
	10	1.7	1.6	1.7	2.4	

To be normal in day-1, 2, 3 & 4 Treated group of *Oreochromis mossambicus.* There is significance in the present table and some of the Behavioural symptoms occur

First exposure: periods
Day-1 to Day-4 Control Groups
Normal fish

In this present investigation control fishes maintained a fairly compact school, covering about one third of the bottom during the first five days of the 15 days experiment time period. By fifth day, the school became less compact covering up to two-third of the tank area in stock. Fishes were observed to scrap the bottom surface inside the aquarium. When these fishes were frightened, they instantly formed a school that was maintained briefly and this aquatic species they were highly sensitive to light and moved to the bottom of the tank when light was passed into the tank/aquarium. Except a less response to form a dense school towards the end of the study, no other astonishing behaviour symptoms and morphological signs was observed in this test system.

In this present investigation fishes were exposed normal tap water media dose concentration will be 0ml/L, used as a control group there is no change in all the part of the exposure replicates groups like 1-control and 1-treated but we concentrated on both the groups up to the period of 96 hrs, it represents the following table - 2 which indicates the body weight and behavioural activity will be remains same, there is no morphological anomalies found and this shows that the fishes are in normal condition.

Day-1 to Day-4 Treated Groups

In this present study fishes were exposed industrial effluent and dose concentration will be 15ml/L, which I selected this concentration based on review of literature survey and in this study we used as a control group there is no change in all the part of the exposure replicates groups like 1-control and 1-treated but we concentrated on both the groups up to the period of 96 hrs, it represents the following table - 3 which indicates the body weight and behavioural activity will be remains same, there is no other changes found in this 96 hrs exposure period and finally this shows that the fishes are in normal condition.

Second exposure: periods
Day-1 to Day-4 Control Group

In this present investigation fishes were exposed normal tap water media dose concentration will be 0ml/L, used as a control group there is no change in all the part of the exposure replicates groups like 1-control and 1-treated but we concentrated on both the groups up to the period of 96 hrs, it represents the following table - 4 which indicates the body weight and behavioural activity will be remains same, there is no morphological anomalies found and this shows that the fishes are in normal condition.

Day-1 to Day-4 Treated Group

In this present study fishes were exposed industrial effluent and dose concentration will be 30ml/L, which I selected this concentration based on review of literature survey and in this study we used as a control group there is no change in all the part of the exposure replicates groups like 1-control and 1-treated but we concentrated on both the groups up to the period of 96 hrs, it represents the following table - 5 which indicates the body weight and behavioural activity will be remains same, there is no other changes found in this 96 hrs exposure period and finally this shows that the fishes are in normal condition.

Third exposure: periods
Day-1 to Day-4 Control Group

In this present investigation fishes were exposed normal tap water media dose concentration will be 0ml/L, used as a control group there is no change in all the part of the exposure replicates groups like 1-control and 1-treated but we concentrated on both the groups up to the period of 96 hrs, it represents the following table - 6 which indicates the body weight and behavioural activity will be remains same, there is no morphological anomalies found and this shows that the fishes are in normal condition.

Day-1 to Day-4 Treated Group

In this present study fishes were exposed industrial effluent and dose concentration will be 60ml/L, which I selected this concentration based on review of literature survey and in this study we used as a control group there is no change in all the part of the exposure replicates groups like 1-control and 1-treated but we concentrated on both the groups up to the period of 96 hrs, it represents the following table - 7 which indicates the body weight which slowly changes the behavioural activity will be found during exposure time period like irregular, erratic and darting swimming movements, hyper excitability, capsizing, attaching to the surface, restlessness, difficulty in breathing, loss of equilibrium and gathering around the ventilation filter, and finally no gross pathological lesions were found throughout the experimental period. Hence, this study shows that there are some of the behavioural symptoms found due to the stress and finally this industrial effluent is toxic to all the aquatic species.

Fourth exposure: periods

Day-1 to Day-4 Control Group

In this present investigation fishes were exposed normal tap water media dose concentration will be 0ml/L, used as a control group there is no change in all the part of the exposure replicates groups like 1-control and 1-treated but we concentrated on both the groups up to the period of 96 hrs, it represents the following table - 8 which indicates the body weight and behavioural activity will be remains same, there is no morphological anomalies found and this shows that the fishes are in normal condition.

Day-1 to Day-4 Treated Group

In this present study fishes were exposed industrial effluent and dose concentration will be 120ml/L, which I selected this concentration based on review of literature survey and in this study we used as a control group there is no change in all the part of the exposure replicates groups like 1-control and 1-treated but we concentrated on both the groups up to the period of 96 hrs, it represents the following table - 9 which indicates the body weight changes and slowly changes the behavioural activity will be found during exposure time period like irregular, erratic and darting swimming movements, hyper excitability, capsizing, attaching to the surface, restlessness, difficulty in breathing, loss of equilibrium and gathering around the ventilation filter Hence, this study shows that there is a some of the behavioural symptoms found due to the stress, and finally this industrial effluent is toxic to all the aquatic species.

Discussion

The migration of the fish to the bottom of the tank following the addition of industrial effluent, clearly indicates the avoidance behaviour of the fish as observed in trout which was reported by (Christensen G. M 1975) [10], (Das *et al.*2004)[11] have observed the avoidance nature by rainbow trout and Atlantic salmon on exposure to four pollutants viz., Alkyl benzene, Sulfonate (AVS), Phenol chlorine and Kraft pulp effluent reported by (Hartwell 1989)[24], (David 1995) [12] in various species of fish. It has been also reported by (Folmar 1976) [18] that Rainbow trout can detect and avoid copper sulphate, dalapon, 2, 4-D (DMA), xylene and acrolein. When abate was applied to river Oti in Ghana to control similum larvae, fish found at that site were observed to show avoidance reaction (Henry *et al.*1986) [26].

Disruption of schooling behaviour of the fish, due to the lethal and sub lethal stress of the toxicant, results in increased swimming activity, and entails increased expenditure of energy. A change in the normal physiological and bio-chemical aspects in the treated fish in the present study could be attributed to the disruption of the schooling behaviour of the fish, which in turn leads to hyper activities as suggested by (Evans 1993) [16], (Weis *et al.* 1974) [53] have reported that cadmium has a marked effect on the schooling behaviour of the Atlantic silverside. Loss of such behaviour following heavy metal exposures has been observed by (Drummond *et al.*1986) [15]. The erratic swimming of the treated fish indicates loss of equilibrium. It is likely that the region in the brain which is associated with the maintenance of equilibrium should have been affected (Drummond *et al.*1986) [15]. Loss of equilibrium and erratic swimming are reported in blue gills exposed to dursban (Mehrle *et al.*1975) [35]. Excited and erratic movements were observed by (Rao 2003) [43], (Henry *et al.*1986) [26]. Increase in fin "flickers" observed in the treated fish is not uncommon (Drummond *et al.* 1986) [15]. These behavioural changes were seen in the present investigation also.

The Chronic exposure of fin fish to alchlor was found to induce surfacing phenomenon of fish as pointed out by (Hansen 1972) [23], (Drummond 1986) [13], have recorded similar observation in fathead minnow treated with different chemical groups. The increased ventilation rate by rapid, repeated opening and closing of the mouth and opercular coverings accompanied by partially extended fins (coughing) was observed in the present study. This could be due to clearance of the accumulated mucus debris in the gill region for proper breathing as suggested by (Drummond 1978) [14], cough and yawns seem to be a more extreme effort to do the same (Cairns 1982) [8]. Similar situation was observed by (Carlson 1982) [9] in the bluegill, Lepomismacrochirus (Schaumburg 1967) [45] have noticed a direct relationship between the frequency of coughing and the time of exposure in rainbow trout. Coughing frequency in Coho salmon was increased, with increasing concentration of nickel (Bull *et al.*1974) [7].

The hyper-excitability of the fish in the lethal and sub lethal exposure of Cadmium may probably be hindrance in the functioning of the enzyme AChE in relation to nervous system as suggested by the authors (Shakul Hameed and Vadamalai 1986) [47]. In this part of the study it leads to accumulation of acetylcholine which is likely to cause prolonged excitatory post synaptic potential. This may first lead to stimulation and later cause a block in the cholinergic system. Heavy metal exposure evident into hyperactivity of muscles in *Blunt-nose minnow* (Mount 1996) [36], (Grant and Mehrle 1970) [20]. According to (Sambasiva Rao and Chandrashekara Rao 1987) [44], (David 1995) [12] behavioural patterns are also influenced by bio-chemical changes at the tissue level. The significant alterations observed in the bio-chemical constituents of gill, liver and muscle in the present investigation corroborate with the above view that bio-chemical change at the tissue level of the dosed fish contribute to the abnormal behaviour of the fish.

Conclusion

The Present toxic study concluded that, in this toxic exposure periods the results were evidenced that the industrial effluent is highly toxic to the aquatic species and devastatingly affected behavioural responses of Tilapia, *Oreochromis* *mossambicus*. Industrial effluent depicted terrible impact on bodyweight and behaviour affects. The results were seen to be valuable tool that should be incorporated to a battery of biomarkers to maximize the confidence with which eco-toxicologists and environmental toxicologists assess impacts of toxic pollution in the aquatic environment.

Acknowledgements
We are thankful to my beloved guide and my parents for their assistance and guidance during my Project work.

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