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Lethal Limits and Respiration in the Cichlid Fishes, *Tilapia zillii, Sarotherodon galilaeus, S. melanotheron* and *Oreochromis niloticus* Exposed to Effluent from Chemistry Department Laboratories.

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ABSTRACT: In this study, the lower and upper lethal limits, LC_{50} and respiration of the freshwater cichlid fishes, *Tilapia zillii, Sarotherodon galilaeus, S. melanotheron* and *Oreochromis niloticus* exposed to effluents from Chemistry Department Laboratories were investigated. The mixing of the effluents produced a reduction in pH and dissolved oxygen and a fairly constant temperature and salinity of the media, while the toxicity of the effluents increased. The LC_{50} values after 24 and 48-h exposure in the effluent media were 0.24% and 0.21% for *T. zillii*; 0.26% and 0.24% for *O. niloticus*; 0.25% and 0.23% for *S. galilaeus;* 0.27% and 0.26% for *S. melanotheron,* respectively. The effect of chemical effluent on the rate of respiration of the treated cichlids produced lower rates of oxygen consumption in the order of *S. galilaeus>O. niloticus>S. melanotheron>T. zilili* in the highest concentration of the effluent. The results obtained from this study have shown that the effluents from Chemistry Department Laboratories are not treated as they produced respiratory impairment and physiological dysfunction in the exposed fish. It is suggested that proper treatment of these effluents be carried out before being discharged into the surrounding stream. @ JASEM

Investigations were made on the impact of chemical effluent from laboratories of the Chemistry Department, University of Ibadan, Nigeria on the lethal limits and respiration of the freshwater cichlids, *Tilapia zillii, Sarotherodon galilaeus, S. melanotheron* and *Oreochromis niloticus*. These species are delicacies in Nigeria and are cultured in large numbers in Awba Lake located near to the effluent discharge site of the Department of Chemistry laboratories, University of Ibadan and Eleyele reservoir, Ibadan. It had been observed that chemical effluents such as mercury, sulphuric acid), ferrous sulphate, aluminium, zinc, magnesium, manganese, chromium, vanadium, silicon, sulphur, chlorine, arsenic, Iron, lead, Nickel, copper and a host of others by manufacturing factories and industries are rampantly seeped in minute quantity into the surrounding streams thereby polluting the water (Odukoya, 2000). In the same vein, raw effluents from the chemistry laboratories of University of Ibadan, Nigeria are being indiscriminately discharged into the surrounding stream because the laboratories do not have clean up technology as at the time of this research. Increasing volumes of the chemical effluent discharges go directly into this stream and perhaps through leaching and mixing of the chemical effluents into nearby Awba Lake. Heavy metals in the environment have been known to have deleterious effects on plants and animals including humans. The presence of metals in river and stream water leads to accumulation of these metals in fish and other aquatic organisms (Prabu and Handy, 1977) and is subsequently passed to the consumer with adverse consequences on health (Fosset, 1980; Waldron, 1980). The objective of this study therefore was to evaluate the effects of the chemistry laboratory effluent on the lethal limits and oxygen consumption of *Tilapia zillii, Sarotherodon galilaeus, S. melanotheron* and *Oreochromis niloticus* which are cultured in large populations in Awba Lake which serves the University of Ibadan and Eleyele reservoir and the South-east of Ibadan.

MATERIALS AND METHODS

Live and healthy juvenile specimens of *Tilapia zillii* (1.15± 1.02g), *Sarotherodon galilaeus* (1.23±1.12 g), *S. melanotheron* (1.25±0.32g) and *Oreochromis niloticus* (2.15±0.51g) were used for this study. For each species, four hundred and fifty juveniles were procured from uncontaminated Oyo State Fish Farms, Agodi Secretariat, Ibadan, transported in oxygenated pvc bags to the laboratory and acclimated for 15 days in three holding glass tanks (50 litres) half filled with dechlorinated one day old tap water. Feeding was administered twice (morning and evening) daily using fish food of 35% crude protein at 3% fish body weight. Faecal samples were siphoned out every six hours, while the entire used water was changed every day. Renewable static bioassay method of FAO (1986) was employed to carry out the toxicity test. Mixing the freshly collected effluent from the discharge site with the media made the desired concentrations of the effluent. Five specimens of each species were used for a range finding test and this showed the interval between the highest test concentration of the effluent at which 90% to 100% fish mortality occurred and the lowest concentration at which 0% to10% mortality occurred within one hour of exposure (Sprague, 1973).

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Data from this exploratory test range were used to select five definitive concentrations of 0.17, 0.21, 0.24, 0.29 and 0.35% of the effluent. Twenty fish in triplicate were exposed in each concentration of the 10-litre media for 48-h period. Controls were maintained in all the experiments. Both experimental and control fish were starved of food during the toxicity test. Dose mortality responses of the different cichlids in the various concentrations were recorded. Lethal concentration values at which 50% fish mortality occurred (LC_{50}) for 24 and 48-h were calculated by probit analysis of Finney (1980). Respiratory rates of the treated and control fish were measured after 48-h exposure with Fry's respirometer. Relationships between the rates of respiration and the effluent concentrations were estimated and the corresponding regression equations calculated with the method of least square. The physico-chemical parameters of the test media and control which were measured included temperature using standard thermometer, pH using pH meter, salinity using salinometer and dissolved oxygen (DO) using DO digital probe.

RESULTS

The physico-chemical parameters of the test media are given in Table 1. Values of temperature (26.5±0.01^o C) and salinity (172±0.04 ‰) were fairly constant, while the most variable values of physico-chemical parameters occurred in dissolved oxygen (4.3±0.01-6.2±0.04 ml/l) and pH (3.5±0.05-7.5±0.03). Salinity values significantly ($P<0.05$) increased from the control to the highest concentration (0.35%), but dissolved oxygen and pH values decreased in the like manner. The 24 and 48-h LC_{50} values including the lower and upper limits of the effluent for the different cichlids are presented in Table 2. The LC_{50} values for *T. zillii* were 0.24% (24-h) and 0.21% (48-h); *O. niloticus* were 0.26% (24-h) and 0.24% (48-h); *S. galilaeus* were 0.25% (24-h) and 0.23% (48-h); and *S. melanotheron* were 0.27% (24-h) and 0.26% (48-h). The respiratory rates of all the cichlid fishes decreased from that of the control as the concentrations of the effluent increased in their respective media (Table 3). Rates of oxygen consumption in *T. zillii* were between 0.114±0.01 and 0.032±0.00, the corresponding values for *O. niloticus* were 0.142±0.01 and 0.038±0.02, *S. galilaeus* were 0.118±0.01 and 0.040±0.00, and *S. melanotheron* were 0.126±0.01 and 0.037±0.01. The regression equations showing the relationships between the rates of respiration (cm^3 O_2/ g /h) (Y) and the effluent concentrations (%) (X) used where Y= -3.0246, X= +2.0324 for *T. zillii*; Y= -3.0231, X= +2.0318 for *O. niloticus*; Y= -3.0141, X= +2.0326 for *S. galilaeus* and Y= -2.7724, X= +2.0435 for *S. melanotheron*.

Table 1: Mean physico-chemical parameters of the test media

Effluent Concentrations (%)	Dissolved Oxygen (cm^3/l)	pH	Salinity (‰)	Temperature ^{o}C
0.0 (Control)	6.2±0.04	7.5±0.03	0.168±0.04	27.2±0.02
0.17	5.2±0.02	4.6±0.05	0.172±0.04	26.5±0.01
0.21	5.1±0.02	4.2±0.05	0.174±0.07	26.5±0.02
0.24	4.8±0.03	3.8±0.04	0.178±0.04	26.5±0.04
0.29	4.6±0.02	3.7±0.02	0.182±0.04	26.5±0.03
0.35	4.3±0.01	3.5±0.05	0.188±0.02	26.5±0.01

Table 2: Lethal limits of effluent (%) for the different cichlid fishes

Fish Species	24h LL	24h UL	24h LC_{50}	48h LL	48h UL	48h LC_{50}
Tilapia zillii	0.21	0.27	0.24	0.19	0.28	0.21
Oreochromis niloticus	0.24	0.29	0.26	0.23	0.28	0.24
Sarotherodon galilaeus	0.21	0.29	0.25	0.18	0.27	0.23
Sarotherodon melanotheron	0.26	032	0.27	0.25	0.33	0.26

Key: LL= lower limit; UL= upper limit

Table 3: The rate of respiration / oxygen consumption (cm^3O_2/g/h) of cichlid fishes exposed to different concentrations of chemistry laboratory effluent

Effluent Concentrations (%)	*Tilapia zillii*	*Oreochromis niloticus*	*Sarotherodon galilaeus*	*Sarotherodon melanotheron*
0.0 (Control)	0.114±0.01	0.142±0.01	0.118±0.01	0.126±0.01
0.17	0.101±0.02	0.120±0.02	0.106±0.02	0.111±0.02
0.21	0.085±0.02	0.096±0.01	0.088±0.02	0.084±0.02
0.24	0.068±0.01	0.0774±0.02	0.071±0.02	0.066±0.01
0.29	0.053±0.01	0.049±0.01	0.056±0.01	0.050±0.02
0.35	0.032±0.03	0.038±0.02	0.040±0.02	0.037±0.01

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DISCUSSION

A sharp decline in pH and dissolved oxygen and a fair rise in salinity might have influenced stress of the fishes. The most pronounced stress of the cichlids caused by the effluent was the reduction in pH of the medium owing to the presence of mercuric acid and possibly sulphuric acid. A change in pH following the discharge of an acid effluent would modify the toxicity of other poisons already present, while a reduction of pH below 4 would lead to mortality of many animals as a result of acidamia causing bicarbonate loss in the body fluid (Alabaster and Lloyd, 1980). The lethal concentration at which 50% of the experimental fish died (LC_{50}) after 24 and 48-h exposure showed *T. zillii* (0.24% 24-h and 0.21% 48-h) as the most vulnerable of the cichlids to the effluent, while *S. melanotheron* with the values of 0.27% 24-h and 0.26% 48-h was the most tolerant. The reason for this might be due to differences in their physiology, which permits different detoxification process. Longer exposure periods in effluent concentration above 0.35% adversely affected the survival rates of the fish. Symptoms of toxicosis of the effluent on fish were evident by their feeble movements and the coagulation of the precipitate of mercuric salts on the mucus and gills. Thereafter, the margin of fin membranes turned whitish and red patches appeared on the opercula and on the base of the pectoral fins. Similar symptoms of toxicosis were documented in some fish species of Lake Vanern exposed to mercury effluents (Lindestrom, 2001).

The respiratory rates of the four cichlid fishes showed varied oxygen consumption in the various concentrations of the chemistry laboratory effluent. Rates of oxygen consumption of *Labeo rohita* in various concentrations of industrial effluent showed a decrease with an increase in the concentration of the effluent and this was explained as due to hypoxia induced by the presence of effluent and also due to high concentrations of heavy metals (Hingorani *et al*., 1979). Vijayamohanan and Suryanarayanan (2000) further documented similar result with specific mentioning of the heavy metals that apart from sulphuric acid, titanium, aluminium, zinc, manganese etc caused hypoxia in *Etroplus maculates* and *E. suratensis* exposed to effluents from a titanium dioxide factory. In this experiment, the effect of chemical effluent on the rate of respiratory of the treated cichlids produced lower rates of oxygen consumption in the order of *S. galilaeus*>*O. niloticus*>*S. melanotheron*>*T. zilli* in the highest concentration of the effluent. This showed that an inverse relationship existed between the oxygen consumption of the fish and the concentration of the effluent used. Davis (1975) opined that the decrease in dissolved oxygen in the presence of some toxicants enhance the lethal effects of the toxicants to fish and that the low dissolved oxygen levels producing metabolic stress can lower the ability of the fish to resist toxicants as well as increase the rate of toxicant uptake via elevated ventilatory water flow. This opinion had been documented in *Gambusia affinis* exposed to aqueous extract of *Parkia biglobosa* (Fafioye, 2002), in *O. niloticus* and *S. galilaeus* exposed to herbicides Primextra and Gramoxone (Fafioye and Jeje, 2000) and in *Clarias gariepinus* exposed to *Parkia biglobosa* and *Raphia vinifera* (Fafioye *et al.*, 2004). It is therefore evident that chemical effluents produce metabolic stress in fish.

Conclusively, this study reveals the impact of chemical effluents from Department of Chemistry laboratory on the survival and metabolism of freshwater fish found in the vicinity of the effluent discharge site. It is suggested that appropriate precautionary measures must be put in place to checkmate the possible leaching and mixing of the effluents into the nearby Awba and Eleyele reservoirs where these edible cichlids are cultured in large populations.

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