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Short communication

TOXICITY OF CASSAVA WASTEWATER EFFLUENTS TO AFRICAN CATFISH: *CLARIAS GARIEPINUS* (BURCHELL, 1822)

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ABSTRACT: The relative lethal and sublethal toxicity of cassava wastewater effluents from a local food factory were investigated on *Clarias gariepinus* fingerlings using a renewable static bioassay. The physico-chemical characteristics of the cassava wastewater effluents showed a number of deviations from the standards of the Federal Environmental Protection Agency (FEPA) on the guidelines for effluent discharges. Considering the pollutants of the effluent, cyanide (CN) is suspected to be primarily responsible for the toxicity, although synergistic effect of other pollutants cannot be ruled out. At each exposure, in the two tests, the test-organisms showed signs of serious stress, swimming pattern changed and mortality increased over relatively small increase in concentration. The LC_{50} for lethal and sublethal tests were 0.024 mgl^{-1} and 0.0064 mgl^{-1}, respectively. The differences observed in the mortalities and bioconcentration of metals in fish muscles of varying concentrations were significant ($p<0.05$). It is suggested that deposition of cassava wastewaters into aquatic environments may impair the natural population size while the consumption of fish from such environment is deleterious.

Key words/phrases: Bioconcentration, *Clarias gariepinus*, effluent, toxicity, wastewater

INTRODUCTION

Man in an attempt to alleviate food scarcity and poverty has developed a fast changing technology, which has led to upsurge of agricultural practices, industrialization and food production. These practices have worsened water and other forms of environmental pollution thus creating health hazards to man and other living organisms.

Various substances released from modern complex human societies and entering water may produce alterations in survivability of aquatic organisms residing within such a polluted environment because they are highly toxic. Thus fishes are unenviable position of being within a constantly changing ecosystem which may have sometimes altered their physiology, biochemistry or induced changes in their bodies resulting in increased susceptibility to other disease agents and death (Brungs *et al*., 1977/1978). Reish and Oshida (1987) reported that effluents might contain toxicants that are harmful to living organisms because of their detrimental effect on tissues, organs and biological processes.

The effect of toxicants could either be lethal or sublethal (Stanley, 1992). Many laboratory studies have demonstrated that lethal effects occur rapidly and are clearly defined, often fatal and rarely reversible. Various authors (Chukwu, 1991; Nwaedozie, 1998; Adewoye and Fawole, 2002a) have reported the effects of industrial effluents against aquatic life by means of short-term bioassay. Sublethal concentrations of toxic pollutants may disrupt the behaviour of organisms and this may in turn reduce the fitness of a natural population. The swimming performance of fish may be reduced owing to a reduction in oxygen uptake as has been described for sublethal concentrations of pulpwood fibre (Macleod and Smith, 1966). Subacute concentrations of DDT caused changes in the orientation and behaviour of the fish, *Therapon jarbua* (Lingaraja *et al*., 1979).

Bradley and Morris (1986) reported that increased environmental burdens of metals and

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acids in lakes were potentially stressful to local fisheries. For instance, fish populations may be lost from lakes, apparently because of reproduction failures. Moreover, fish have a great capacity to accumulate heavy metals from polluted water thus it is hazardous to consume fish indiscriminately. Adeyemi *et al*. (1996) stressed that fish species concentrate metals in their tissues in various levels.

This paper focuses on the behavioural response, mortality rates of *Clarias garepinus* fingerlings subjected to lethal and sublethal concentrations of cassava wastewaters and the extent of the bioaccumulation of the pollutants in their tissues.

MATERIALS AND METHODS

Samples of Cassava wastewater effluents were collected from cassava processing factory in Ora, Ogbomoso, Nigeria. The samples were thoroughly mixed prior to refrigeration in the laboratory (Reish and Oshida, 1987) and their physicochemical characteristics were subsequently determined following the procedure of WHO (1988).

Fingerlings of *Clarias gariepinus* were collected from the Ministry of Agriculture, Fisheries Division, Ilorin, Nigeria. The test organisms were transported in a sealed oxygenated polythene bag which contained freshwater from the farm. The specimens were kept in large aquaria with well aerated and dechlorinated borehole water for fourteen (14) days to accilimatize them to the laboratory conditions. During acclimatization, the fish were fed once a day with dry pelleted feed containing 35% crude protein (Pearson, 1975) at a rate of 5% body weight. Feeding was discontinued 24 hours prior to the commencement of the experiments. Before the bioassay started, ten acclimated fingerlings were introduced into each tank containing different concentrations of the wastewater effluents with two replicates. Control experiments were also set up in replicates with dechlorinated water and ten fingerlings each.

Acute tests

Five varying concentrations: 0.025, 0.030. 0.040, 0.050 and 0.060 $mg1^{-1}$ of the cassava wastewater effluents were used according to Adewoye and Fawole (2002b) and the control were in replicates. The experiments were monitored for 96 hours exposure. Behavioural responses and mortalities of test organisms were monitored for a period of 96 hours.

Subacute tests

Five varying concentrations: 0.004, 0.007, 0.010, 0.013 and 0.016 $mg1^{-1}$ of the wastewater effluents were also used based on Adewoye and Fawole (2002b). Each treatment and control was in replicates. The experiment was undertaken for two weeks, behavioural responses of the test organisms and moralities were monitored.

Dead fingerlings from the two tests were removed and kept in refrigerator prior to metal analysis of fish muscles. The analysis of selected metals was carried out using Pye Unicam Atomic Absorption Spectrophotometer (AAS) and WHO (1988) procedures. Data were statistically analysed using Analysis of variance (ANOVA) and Duncan Multiple Range Test.

RESULTS

Table 1, shows the physicochemical characteristics of cassava wastewater effluents from the local food factory used in this study. The lowest parameter recorded was chromium (0.60 $g1^{-1}$) while the highest was BOD (185 $mg1^{-1}$). All the parameters, however, showed deviation from FEPA (1991) specifications for maximum limit allowed for effluent discharge into water bodies for all categories of industries, except chromium and cadmium.

At each exposure time abnormal behaviour such as restlessness, loss of equilibrium and erratic movement were observed as soon as the media started to act on the test organisms. The affected fish became very weak, gasping for air and died in increasing numbers at relatively small increase in concentration (Table 2a and b). However, normal behaviours were observed in the control groups. The LC_{50} values for the lethal and sublethal tests were found to be 0.024 $mg1^{-1}$ and 0.006 $mg1^{-1}$, respectively (Figs 1 and 2).

Table 1. Physico-chemical characteristics of cassava wastewater effluents.

Parameters	Cassava Wastewaters mg l^{-1}	FEPA (1991) Specifications (mgl^{-1})
pH	11.5	6.9
Dissolved Oxygen (DO)	0.74	5.0
Biological Oxygen Demand (BOD)	185	50
Total Suspended Solids (TSS)	87	30
Temperature	36	<40
Oil and grease	12.5	10
Alkalinity	52.5	45
Iron (fe^{2+})	2.92	1.0
Cadmium (Cd)	0.82	<1.0
Chromium (Cr)	0.60	<1.0
Sulphide (S_2)	2.35	0.2
Nitrate ($N0_3$)	22.2	20
Cyanide (CN)	0.84	20
Lead (Pb)	1.95	<1.0
Copper (Cu)	1.12	<1.0
Zinc (Zn)	1.27	<1.0
Chloride (Cl)	13.47	NA

*NA = Not available

Table 2a. Percentage mortality of *C. gariepinus* at lethal concentration of cassava wastewaters.

Concentration mgl^{-1}	Number of death at 96 hrs.				
	Replicates			Total	%
	I	II	III	mortalities	mortality
Control	0	0	0	0	0.0
0.025	6	6	6	18	60.0
0.030	7	7	8	22	73.3
0.040	8	4	8	8	80.0
0.050	8	9	9	26	86.7
0.060	10	10	9	29.3	96.7

Table 2b. Percentage mortality of *C. gariepinus* at sublethal concentrations of Cassava wastewater effluents.

Concentration	Number of deaths in 14 days				
	Replicates			Total	%
	I	II	III	mortalities	mortalities
Control	0	0	0	0	0.0
0.004	3	4	4	11	36.7
0.007	5	5	6	16	53.5
0.010	6	7	7	20	66.7
0.013	8	8	8	24	80.0
0.016	8	9	9	26	86.7

The analysis of variance (ANOVA) indicated significant differences ($p<0.05$) in the bioaccumulation of metals in the muscle of the fish at the two exposures, this was confirmed by Duncan's Multiple Range Test (Tables 3a and 3b).

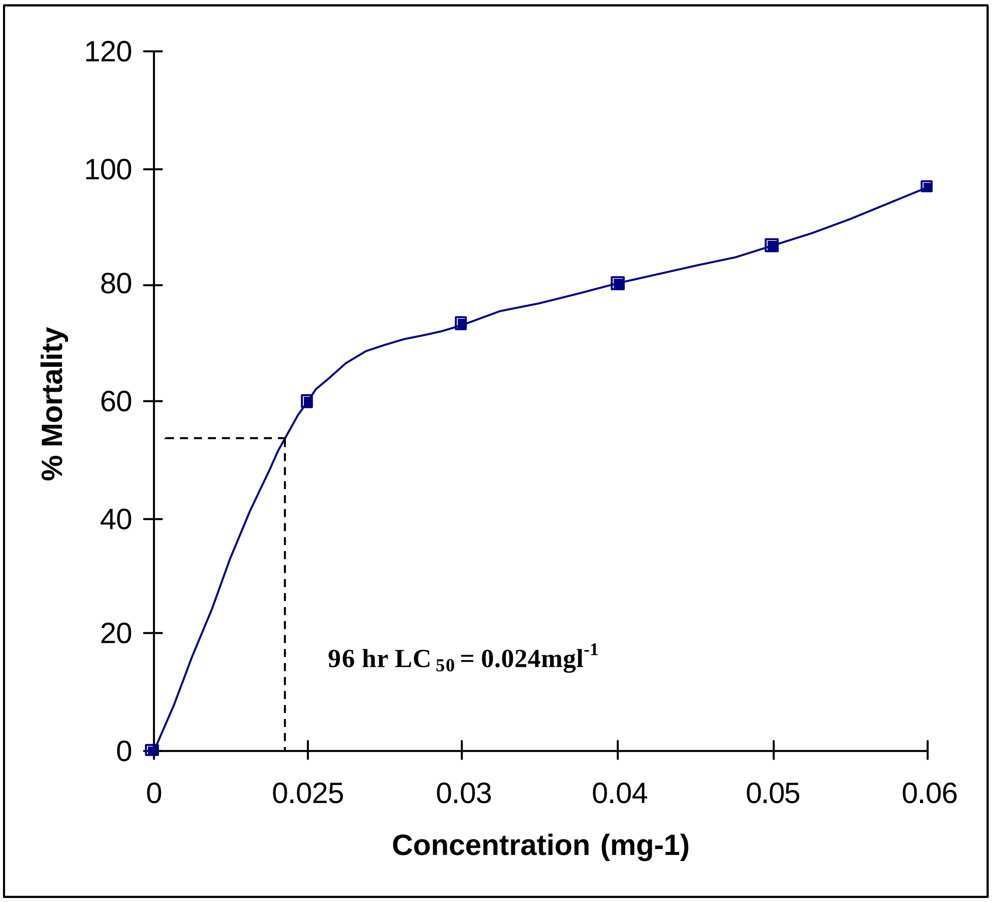

Fig. 1. The 96 hr LC_{50} of *C. gariepinus* at varying concentration of cassava wastewater.

Table 3a. Level of concentration of selected metals in the muscle of fish subjected to lethal concentration of cassava wastewater effluents.

Parameters concentration (mg/1-)	Fe	Zn	Pb	Cd	CN
Control	0.63d	0.51c	ND	ND	ND
0.025	3.61a	1.37b	2.66a	0.20d	0.14b
0.030	3.31a	1.71a	2.31b	0.21b	0.15b
0.040	3.01a	1.74a	2.51a	0.16d	0.17b
0.050	1.97b	1.76a	2.61a	0.63b	0.11b
0.060	1.80b	1.85a	2.45a	0.45bc	0.20ab
0.070	1.26bc	1.92d	2.38b	0.94a	0.34a

Means having the same alphabets are not significantly different (P = 0.05). ND = Not detected.

Table 3b. Level of concentration of selected metals in the muscle of fish subjected to lethal concentration of cassava wastewater effluents.

Parameters concentration (mg/1-)	Fe	Zn	Pb	Cd	CN
Control	0.63c	0.51c	ND	ND	ND
0.004	3.75a	1.02ab	1.67b	0.15b	0.09b
0.007	3.71a	1.07ab	2.02b	0.23b	0.11ab
0.010	3.68a	1.13ab	2.32a	0.16d	0.19a
0.013	3.65ab	1.20a	2.12a	0.32a	0.22a
0.016	3.62ab	1.34a	2.23a	0.30a	0.17a

Means having the same alphabets are not significantly different (P = 0.05). ND = Not detected.

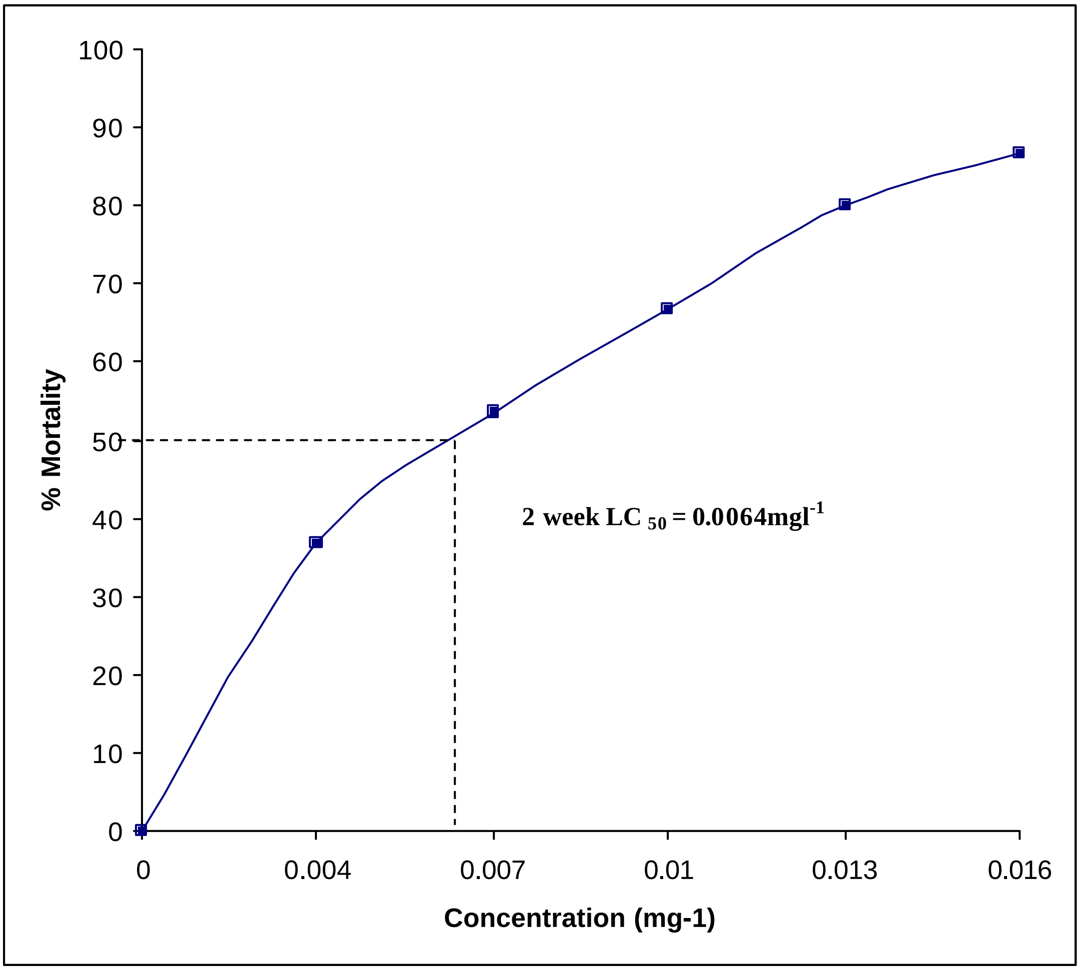

Fig. 2. Two-Weeks LC_{50} *C. gariepinus* at varying concentration of cassava waste water.

DISCUSSION

The physicochemical characteristics of the cassava wastewater effluents showed a number of deviations from FEPA (1991) specifications for maximum limit allowed for effluent discharge into water bodies. Although, the concentration of chromium and cadmium in the effluents fell within FEPA (1991) standard, their residual effects may affect organs like the gills, liver, brain, kidney and genital organs. The low dissolved oxygen (DO) and high biochemical oxygen demand (BOD), total suspended solids (TSS) and cyanide content of the cassava wastewater effluents could be attributed to the level of organic load in the wastewater thus providing a medium for biodegradation activities of anaerobic bacteria whose end product is foul smell (Adewoye and Fawole, 2002b). Consequently, the behavioural responses observed in the two tests prior to mortality was a result of depleted oxygen content recorded as a result of the high BOD and suspended solids. When organic matter content is abnormally high in an aquatic environment, the BOD increases and the oxygen content reduces, this further disrupts the behavioural responses of the organisms and eventually reduces the fitness of a natural population (Jones, 1964; Manson, 1991). The toxicity of the cassava wastewater effluents could be attributed to the presence of cyanide, though the synergistic effects of other pollutants could be a contributing factor. Cyanide was observed to be extremely toxic and it contributed to mortalities even at a low concentration.

The LC_{50} values of 0.02 $mg1^{-1}$ and 0.0064 $mg1^{-1}$ recorded for lethal and sublethal concentration, respectively is an indication that at extremely low concentration of cassava wastewater effluents discharged into water bodies may impair the physicochemical status of the water. This might in turn reduce or alter the population size of the fish. A stressed biological population is characterized by reduction in diversity and population biomass (Patrick, 1973; Nwadiaro, 1990; Nwankwo, 1998). The observed sharp increase in mortality as the concentration of the test solution increased suggest mortality to be a factor of concentration and this explains the variation observed in the tests. This is similar to the observation of Kreutzweiser *et al*. (1994) and Adewoye and Fawole (2002a and b) that mortality rates increased over a small increase in concentration of wastewater. The significant differences ($p<0.05$) observed in the bioaccumulation of metals in the muscles of the fish subjected to both lethal and sublethal tests suggest that accumulation of metals in muscles also depends on concentration. Variations in the accumulation of metals could arise from factors which may be dependent on different ion accumulation in the species and or fish habitat (Adeyemi *et al*., 1996).

The present investigation proved convincingly that cassava wastewater effluents contain pollutants that are deleterious to a natural fish population. In developing countries like Nigeria, there is need to give attention to industrial waste management as a result of sharp improvement in the manufacturing performance. The indiscriminate discharge of wastes can not only be attributed to lack of proper education on waste disposal but also to inadequate functioning of environmental monitoring groups. The local, state and federal environmental protection agencies should not rule out the hazardous effects of the wastewaters from small scale industries especially local food producing factories. However, it is imperative that all tiers of government should enforce the proper treatment and disposal of wastewaters by the industries before they are discharged into waters.

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