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# Concentration of Electrolyte Reserves of the Juvenile African Catfish *Clarias gariepinus* (Burchell, 1822) Exposed to Sublethal Concentrations of Portland Cement Powder in Solution

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**Abstract.** The study investigated the effect of sublethal concentrations (39.10, 19.55, 9.87 and 0.00 mg/l) of Portland cement powder in solution on the electrolyte reserves (sodium, potassium, calcium, chloride and inorganic phosphorus) in the serum, liver and kidney of the juvenile African catfish *Clarias gariepinus* after a 15 day exposure period. The basic function of the determined electrolyte reserves in the body lies in controlling fluid distribution, intra and extra cellular acidobasic equilibrium, maintaining osmotic pressure of body fluid and normal neuro-muscular irritability. The result revealed significant ($P<0.05$) changes in serum sodium, potassium, calcium and chloride and insignificant ($P>0.05$) changes in inorganic phosphorus. Sodium, calcium, chloride and inorganic phosphorus and potassium were significantly ($P<0.05$) and insignificantly ($P>0.05$) different in liver and kidney, respectively. Ipso-facto, the effector organs *viz:* liver and kidney of teleost species – *Clarias gariepinus* which are primarily responsible for regulating water and ionic movement between external and internal milieu of fishes are susceptible to deleterious effects of Portland cement powder thus sublethal concentration (39.10 mg/l) of Portland cement powder in solution after a 15 day exposure has been most toxic and debilitating to the test fish.

**Keywords:** portland cement, electrolyte reserves, serum, liver, kidney, *Clarias gariepinus*.

## Introduction

Though involved in the developmental structure of any country in the modern world but cement industry generates dust/aerosol during its operations. Portland cement also known as hydraulic cement is composed of tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetracalcium aluminoferate and gypsum with trace constituents like potassium oxide, sodium oxide, chromium compound and nickel compound (Mindess and Young, 1981). Use of these important ingredients of concrete and mortar as well, cannot be avoided in building construction. Cement and most of its constituents have been found to be toxic to living organisms in the environment (Adamu and Audu, 2008; Adamu and Kori-Siakpere, 2008; Akinola *et al.*, 2008; Khattak *et al.,* 2005, Fatima *et al.,* 2001; Hansen, 1998).

The development and severity of the injury caused by the cement dust on plants or animals depend besides the concentration of the pollutant, also on the duration of exposure to the pollutant, the species and its stage of development as well as the environmental factors conducive to the accumulation of the cement dust in the organism, which makes it susceptible or resistant to injury (Heather, 2003).

According to Musa and Omoregie (1999), fish are intimately associated with an aqueous environment and physical and chemical changes in the environment are rapidly reflected as measureable physiological changes in the fish.

Electrolyte reserves are the ions balance that change within certain limits depending on metabolic activities caused by some environmental factors such as pollution. In fresh water fishes, blood and electrolyte concentrations are regulated by interacting processes, such as absorption of electrolyte from the surrounding medium through active mechanism mainly at the gills and through selective re-absorption of electrolytes from urine. Any alteration in one or more of these processes results in a change in the plasma electrolyte composition. These ions play vital role in several body functions. The monovalent ions, sodium, potassium and chloride are involved in neuromuscular excitability, acid base balance and osmotic pressure (Verma *et al.*, 1981), whereas divalent ions such as calcium and magnesium facilitate neuromuscular excitability, enzymatic reaction and retention of membrane permeability. Inorganic phosphate acts as a major cytoplasmic buffer and is the basis of energy exchange (Aurbach *et al.*, 1985).

Despite the fact that cement production leads to the formation of aerosols which invariably reach the aquatic system, no detailed study has been reported on its sublethal effect on concentration of the electrolyte reserves of fish. Therefore, the present study seeks to determine the sublethal effect of Portland cement powder in solution on the concentration of

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the electrolyte reserves of the juvenile African catfish, *Clarias gariepinus*. *Clarias gariepinus* occupies a position within a food chain leading to man. It is widely available and abundant and thus amenable to laboratory testing. It is genetically stable and thus a uniform population can be tested. Further it can be produced artificially.

## Materials and Methods

**Experimental fish.** Juveniles of the African catfish *Clarias gariepinus* (Burchell, 1822) of the same brood-stock and mixed sex were obtained from Asaba Fish Farm in Igbide, Delta State, Nigeria. The mean length and weight of fish were 16.35±0.23 cm and 28.07±0.45 g, respectively. The fish were transported in an oxygenated bag to the laboratory (Animal and Environmental Biology Laboratory, Delta State University, Abraka, Nigeria) and placed in a large plastic aquarium of 60 l capacity with well aerated borehole water to acclimatize for ten (10) days during which they were fed with commercial feed (Durantee feed) to avoid starvation. After acclimatization, the fish were transferred to the experimental plastic aquaria, ten (10) fish per 40 l aquarium in replicate thus twenty (20) fish per concentration.

**Preliminary investigation.** The following concentrations of Portland cement powder in solution (Dangote Portland cement powder, Nigeria) were used for the range finding test: 156.40, 78.20, 39.10, 19.55, 9.78, 4.89 and 2.45 mg/l. The tests were conducted on five (5) *Clarias gariepinus* juveniles per concentration of Portland cement powder in solution with replications, including the control with 0% Portland cement powder in solution. Based on the result of the range finding test, the definitive concentrations of 39.10, 19.55, 9.87 and 0.00 (control) mg/l of Portland cement powder in solution were prepared and replicated for the experimentation.

**Experimental procedure.** Forty (40) litres of aquaria were maintained throughout the exposure period. Ten (10) juveniles were placed in each 40 litres plastic aquarium with one replication. Well-aerated borehole water was used during acclimatization and exposure periods. Fish were fed with commercial feed during acclimatization period of 8.00, 14.00 and 18.00 h. In order to monitor the level of the toxicant and dissolved oxygen, the effect of evaporation and ammonia concentrations during experimentation, the toxicant was changed daily. The exposure period lasted for 15 days during which some water quality parameters were monitored at 5 days intervals using the method described by APHA (1998). The experiment was conducted at the mean water temperature of 25±2.00 °C, dissolved oxygen of 7.22±0.04 mg/l, pH and total alkalinity of 6.94±0.23 and 10.08±0.32 mg/l, respectively. A total of twelve (12) fish from each concentration were sacrificed for electrolyte reserve analyses. Blood was collected from the sacrificed fish by the method described by Kori-Siakpere (1998) and placed in lithium heparin test tubes. Serum was obtained from the blood using a Pasteur pipette after centrifuging with Centurion 1000 series (centrifuge model 1020D.E) at 3,000 rpm for 5 mins (Ogbu and Okechukwu, 2001). Thereafter, liver and kidney were obtained from the fish, homogenized separately using laboratory mortar and pestle and extractants was prepared by adding 2 ml of 10% sucrose solution (Mahobia, 1987). The preparations were then centrifuged separately at 3,000 rpm for 20 mins. Supernatant was transferred to a 2 ml microcentrifuged tube for the determination of electrolyte reserve concentration immediately. These measurements were determined in accordance to the procedure of Cromatest kit (Cromatest Linear Chemicals, Barcelona, Spain). Thereafter, the absorbance (A) was recorded using a spectrophotometer (UV-7504 spectrophotometer, Surgi Friend Medicals, England).

**Data analysis.** The data was first analyzed using a single factor (concentration) ANOVA after which individual means were compared using Tukey HSD multi-sample correction / test. Control values obtained at the beginning and the end of the 15 day exposure were not significantly different and were therefore combined as one control. In all cases, differences were considered statistically significant at $P<0.05$. Statistical analysis was carried out using NCSS statistical programme. All the data is presented as mean ± standard error.

## Results and Discussion

Results relating to the levels of sodium (Fig. 1), potassium (Fig. 2), calcium (Fig. 3), chloride (Fig. 4) and inorganic phosphorus (Fig. 5) in the serum, liver and kidney of African catfish (*Clarias gariepinus*) after 15 days exposure to sublethal concentrations of portland cement powder in solution are presented as follows.

**Sodium.** It was observed that sodium levels in serum and liver significantly ($P<0.05$) decreased during 15 days exposure period as compared to the control, while sodium level in kidney increased significantly ($P<0.05$). Concentration of Portland cement powder in solution, 39.10 mg/l, caused the reported significant difference. Statistical analysis revealed that sodium concentration was the most significant in the liver, less in the kidney and least in the serum of the test fish after 15 days exposure.

**Potassium.** The level of serum potassium in the fish, after 15 days exposure, revealed a significant ($P<0.05$) decrease when compared to the control. However, the level of potassium in the liver and kidney exhibited insignificant ($P>0.05$) decrease. Concentration of Portland cement powder in solution, 39.10 mg/l, caused the reported significant difference.

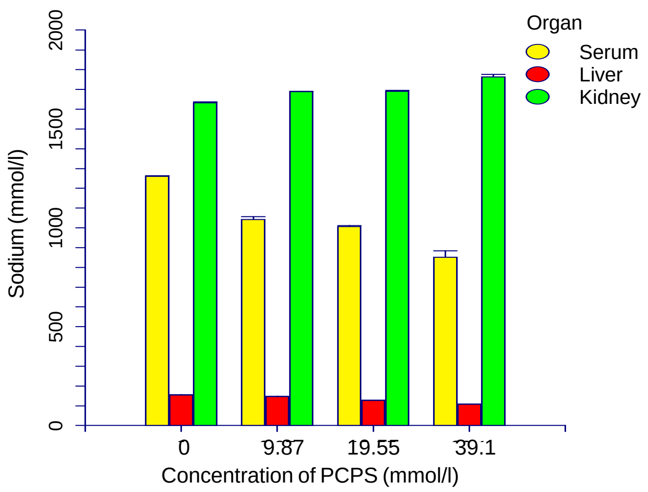


**Fig. 1.** Mean and standard error values of sodium of the exposed *Clarias gariepinus*.

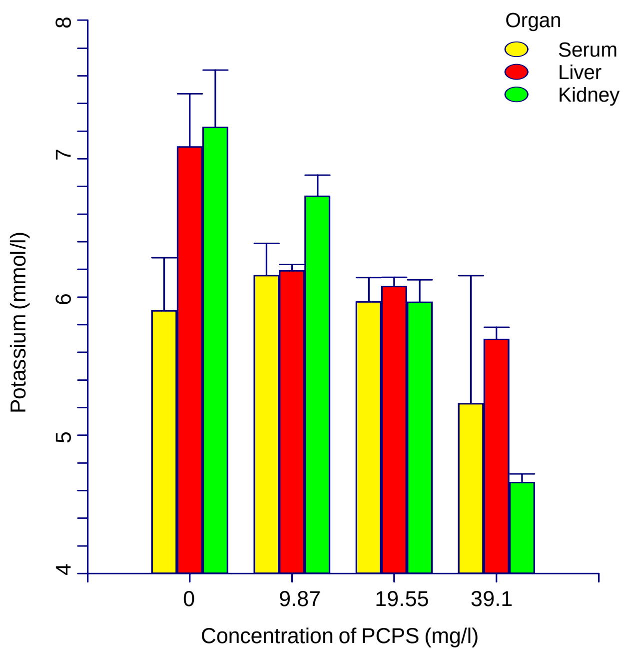


**Fig. 2.** Mean and standard error values of potassium in the exposed *Clarias gariepinus*.

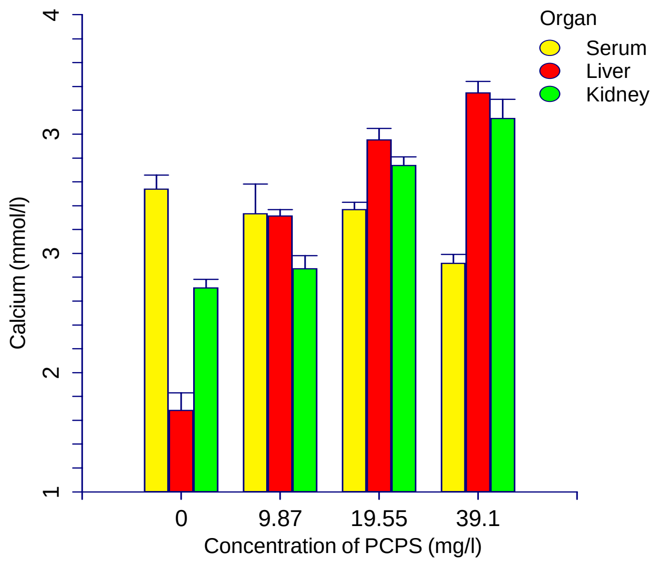


**Fig. 3.** Mean and standard error value of calcium in the exposed *Clarias gariepinus*.

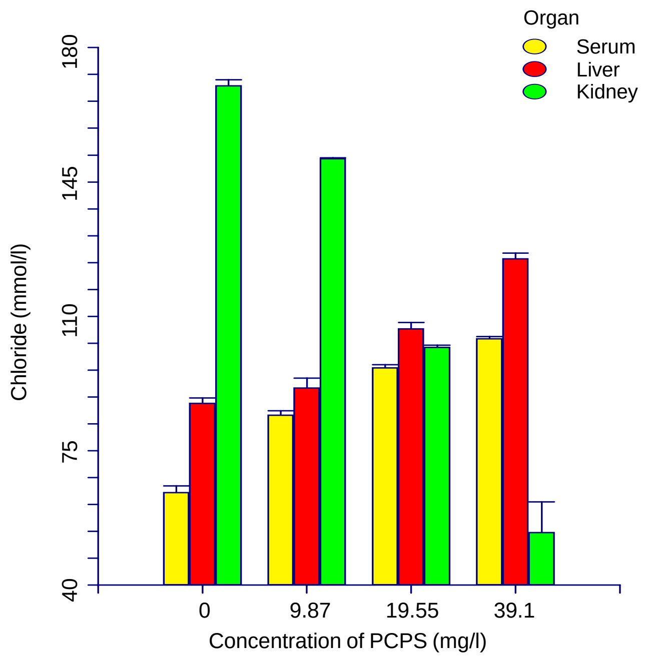


**Fig. 4.** Mean and standard error values of chloride in the exposed *Clarias gariepinus*.

Statistical analysis revealed that the potassium concentration was the most significant in the serum, less in the kidney and least in the liver of the test fish.

**Calcium.** The level of calcium in serum and liver of the exposed fish insignificantly (P>0.05) decreased while the levels of the liver and kidney calcium increased significantly (P<0.05) when compared to the control. Concentration of Portland cement, 39.10 mg/l, caused the significant difference, whereas statistically, calcium concentration was the most significant in the liver, less in the kidney and the least in the serum of the test fish.

**Chloride.** The level of serum chloride insignificantly (P>0.05) increased, while the levels of the liver and kidney chloride significantly (P<0.05) increased and decreased, respectively. Concentration of Portland cement, 39.10 mg/l, caused the significant difference. Statistically, the chloride concentration was the most significant in the liver, less in the kidney and the least in the serum.

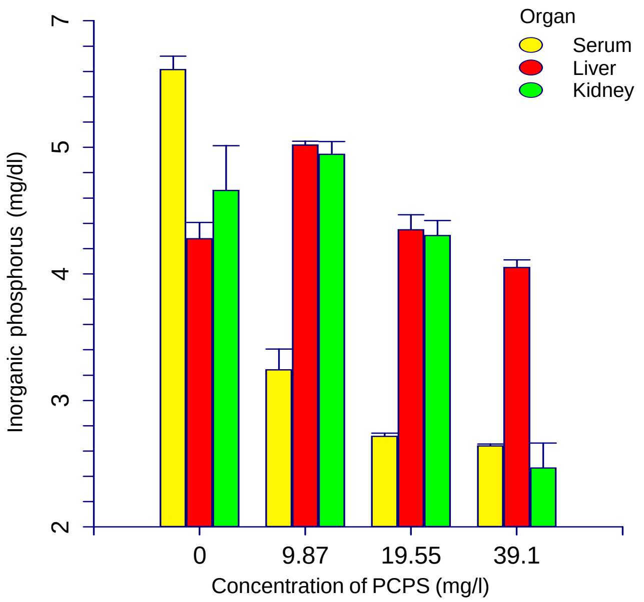


**Fig. 5**. Mean and standard error values of inorganic phosphorus of the exposed *Clarias gariepinus*.

**Inorganic phosphorus.** The concentration of inorganic phosphorus in the liver insignificantly (P>0.05) decreased, while in serum and kidney, significantly (P<0.05) increased and decreased, respectively. Portland cement concentration, 39.10 mg/l, caused the significant difference. Statistical analysis revealed the inorganic phosphorus concentration to be the most significant in the kidney, less in the serum and least in the liver of the test fish.

The result of water quality parameters used in the study were within the optimal range, required by *Clarias gariepinus* as reported by Viveen *et al.*, (1985). Oleru (1984) reported that traces of copper and chromium in cement dust played an important role in disturbing various metabolic processes. Akinola *et al.* (2008) reported high levels of calcium, silicon, zinc, aluminum and iron in the rats exposed to cement dust in Sagamu as compared to the unexposed rats. Chronic exposure to Portland cement powder in solution has been reported to cause reduction in TLC, PCV, TEC, Hgb and ESR in fish (*Oreochromis niloticus*) (Adamu and Audu, 2008). Adamu and Kori-Siakpere (2008) reported significant alterations in nitrogenous waste products and tissue aminotransferases in catfish *Clarias gariepinus* exposed to sublethal concentrations of Portland cement powder in solution.

Sodium is the chief regulator of osmotic pressure of the body fluid. It initiates and maintains the rate of heart beat and excites involuntary muscles and nerves. Mazon *et al.* (2002) reported, significant decrease in the concentration of plasma sodium in *P. scrofa*, exposed to lethal and sublethal concentrations of copper. In addition, Pelgrom *et al.* (1995) observed marked decrease in plasma $Na^+$ concentrations in *Oreochromis mossambicus* exposed to copper concentrations for 6 days. Stouthart *et al.* (1995) reported reduced total sodium concentration in larvae of *Cyprinus carpio* exposed to chromium.

In the present study a significant decrease was observed in serum sodium concentration in *Clarias gariepinus* exposed to the highest concentration of Portland cement powder in solution after 15 days. This decrease might reflect sodium influx rate which may be due to ion loss as a result of complete failure of osmoregulatory processes. The mechanism of osmoregulatory disruption by metals normally involves inhibition of $Na^+/K^+$ ATPase enzymes in gills and perhaps in the gut, as well. Therefore, Portland cement powder in solution might inhibit gill $Na^+/K^+$ ATPase in *Clarias gariepinus* causing disruption of sodium regulation. The increase in kidney sodium concentration may reflect decreased urinary excretion of sodium due to renal tubular dysfunction or reduced intestinal absorption which might be the cause of the observed decline and increase in sodium concentration in serum and kidney, respectively.

Potassium is the main intracellular cation involved in several physiological functions *viz*, nerve and muscle function, acid-base balance and osmotic pressure. Swarnlata (1995) reported an increase in the concentration of potassium in blood and spleen and a decrease in kidney, liver, muscle and brain of *Clarias batrachus* after 15 days of treatment with carbaryl. Similar findings were observed in the present study. The decreased concentration of potassium observed in the test fish may be attributed to cell damage in the gills and kidneys as revealed by the histopathological examination of *Oreochromis niloticus* exposed to Portland cement powder in solution (Adamu *et al.*, 2008). Disturbed potassium regulation might be due to an impaired active reabsorption of potassium in renal tubules.

Calcium is of great importance in blood coagulation and as regulator of permeability of cell membrane to water and inorganic ions. It also contributes to the maintenance of the membrane potential as well as the development of action potential in muscles and nerves. Hypocalcemia was recorded in the serum of the test fish *Clarias gariepinus*. Koyama and Itazawa (1977) showed a relationship between renal damage, hypocalcemia and skeletal deformities in cadmium-treated carp. Seemingly the persistent hypocalcemia observed may be due to defective intestinal calcium absorption or to impaired calcium reabsorption in the renal tubules accompanied by neuro-muscular hyperexcitability and cramp conditions. Similarly, the hypocalcemia observed may be attributed to diffusional losses caused by increased permeability of gill epithelium to water and ions (Adamu *et al.*, 2008).

Chloride ions along with sodium and potassium play an important role in neuromuscular excitability, acid-base balance and osmotic pressure of the body. There was an insignificant increase in serum chloride concentration and significant increase and decrease in liver and kidney chloride, respectively. It was however, noted that as the concentration of sodium in the serum and liver decreased there was a corresponding increase in chloride concentration. The inability of the kidney to perform the function of re-absorption due to damage may have been responsible for the decrease and increase in concentrations of chloride recorded in kidney and liver, respectively.

The inorganic phosphate acts as a major cytoplasmic buffer and is the basis of energy exchange. A non-significant decrease in serum phosphorus reported in this study may have resulted from decreased oxidative metabolism and lowered ATP production due to the ability of the Portland cement powder to inhibit the enzymes involved in electron transport chain, affecting the phosphorylating capacity of mitochondria. The decrease in the concentration of inorganic phosphorus may be linked to redistribution of electrolytes between intracellular and extracellular compartments and/or impairment of renal function.

## Conclusion

The study shows that the liver and the kidney, which are primarily responsible for regulating water and ionic movement between external and internal milieu of fishes, are susceptible to deleterious effects of Portland cement powder in teleost species. The result further confirms that Portland cement powder in solution as high as 39.10 mg/l is pathogenic and toxic to the test fish.

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