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Muscle, blood plasma and liver electrolytes of juvenile and adult freshwater catfish, *Clarias gariepinus* in response to treatment with detergent (Linear alkylbenzene sulfonate)

George ADI and Uedeme-Naa B

Abstract
On exposure of sodium ion (Na^+), potassium ion (K^+), calcium ion (Ca^{2+}), chloride ion(Cl^-), hydrogen carbonate ion (HCO_3^-) in the muscle, blood plasma and liver of juvenile and adult freshwater catfish, *Clarias gariepinus* to 10.00, 20.00, 30.00, 40.00 and 50.00mg/l of detergent for 30 days, it was observed that sodium ion respectively dropped below control at 10.00, 20.00 and 50.00mg/l by 8.17, 11.20 and 11.29% and was higher than control at 30.00 and 40.00mg/l by 37.37 and 14.79% in the muscles of juvenile fish while in adult fish, it was noted that LAS, caused a significant increase ($P<0.05$) of sodium ion in the muscles of specimen (*C. gariepinus*) by 17.08% at 10.00mg/l, 38.07% at 20.00mg/l, 54.06% at 30.00mg/l, 55.27% at 40.00mg/l and 64.04% at 50.00mg/l with increase in concentration. Potassium ion significantly decreased in both life stages with increase in concentration except at 50.00mg/l in juvenile fish where it was raised above control by 21.41% (62.37±10.25). Potassium ion peaked at 30.00mg/l with 40.40% in adult fish and that of adult peaked at 50.00mg/l with 40.24% below control. Linear alkyl benzene sulfonate significantly raised calcium ion in juvenile fish by 32.60% at 10.00mg/l, 90.43% at 20.00mg/l, 106.20% at 30.00mg/l, 145.74% at 40.00mg/l and 228.60% at 50.00mg/l while in adult fish calcium ion was similar as control in the muscle at 10.00 and 20.00mg/l and respectively less than control by 18.78, 51.75 and 58.32% at 30.00, 40.00 and 50.00mg/l as concentration improved. At 10.00 and 20.00mg/l, chloride ion was elevated above control in juvenile fish by 86.26 and 69.97% and below control by 0.02, 0.45 and 23.93% while in adult fish it was 0.70% less than control at 10.00 and 40.00mg/l. It was detected that hydrogen carbonate ion concentration in juvenile fish was the contrary of that in adult fish in that there was a steady decline below control by 5.93, 6.67, 13.33, 8.33 and 25.00% in juvenile fish and raised above control by 7.60, 11.10, 17.54, 36.61 and 53.80% in adult fish as concentration improved.

Keywords: Sodium ion (Na^+), potassium ion (K^+), calcium ion (Ca^{2+}), chloride ion(Cl^-), hydrogen carbonate ion (HCO_3^-), Linear alkyl benzene sulfonate

Introduction
Detergents are molecules that are amphiphilic in nature with a hydrophobic hydrocarbon tail and a hydrophilic head assemblage. It is the hydrophile on the head assemblage that defines the detergent as anionic, cationic, nonionic or amphoteric, all of which may be used in detergent preparations. Cationic in characteristic and cause damage to the outer membrane and promote their own intracellular uptake and entry (Russell 2001 and Holah *et al*, 2002) [44, 41]. There are two kinds of detergents with different features: phosphate detergents and surfactant detergents. Detergents that contain phosphates are extremely caustic, and surfactant detergents are very toxic. The differences are that surfactant detergents are used to boost the wetting, foaming, dispersing and emulsifying properties of detergents. Phosphate detergents are used in detergents to unstiffen hard water and help suspend dirt in water (Siposova *et al*, 2017) [42]
Sudiana (2004) [43] explained that an increase in LAS concentrations that go beyond cell capacity (lysosomes) will cause disturbance of cell metabolism. This led to a decrease in LAS degradation and may even lead to cell death. Furthermore, the side effects of LAS and ABS presence that surpass the natural degradation capacity are polluted environments that can cause damage to ecosystem components. Further, Russell (2001) [40] explained surfactant as a detergent component that can cause environmental problems. The stable foam formation in the river is highly undesirable because it blocks the transformation of the oxygen-mass from air to

water. Hydrophilic constituents of toxic surfactants will endanger the survival of aquatic animals and bacteria in water. According to KEP / 51 /MENLH / 2004, the concentration of surfactants in waters is 1 mg / l. Detergents also add another problem to aquatic life by lowering the surface tension of the water. Organic chemicals such as pesticides and phenols are then much more easily absorbed by the fish. A detergent concentration of only 2 ppm can cause fish to absorb double the amount of chemicals they would normally absorb, although that concentration itself is not high enough to affect fish directly.

The effects of surfactants on gill osmoregulatory function were studied by monitoring the changes in the activity of the gill Na^{+}- K^{+} ATPase. It was reported by many workers that low concentrations of surfactants activated this membrane-bound enzyme while high concentrations had an inhibitory effect. The effects of syndets like Idet 5L and Swanic 6L (SLS) on ATPase activity was studied by Verbost *et al.* (2007) [24] in the fish *Channa punctatus*. They exposed the animals to sub lethal levels of these syndets for 25 and 50 days. The analysis of the enzyme activity revealed that enzyme inhibitions were highest in the gill and brain homogenates for oligomycin-sensitive Mg^{2+} ATPase with pronounced effects (65%) after 50 days of exposure to 7.5 ppm of Swanic. Fish exposed to lower concentrations showed an insignificant activation of Na -K ATPase and Mg^{2} ATPasc in the gills. A similar study on in vivo responses of ATPase was done on *Mystus vitrofus* (Verbost *et al.*, 2007) [24] exposed to Swascofix (alkyl benzene sulfonate). The brain, gill, liver and kidney tissues were sampled. After a period of 60 days the highest inhibition was noted in the brain followed by gill, kidney and liver and it was observed that low concentrations in some cases enhanced the activity. Trump *et al.* (2009) [36] also reported enhanced Mg^{2+}- Ca^{2+} ATPase activity in the microsomal fraction of the bovine brain cortex treated with sodium deoxycholate and Lubrol-WX. The ATPase is concerned with the active transport of sodium ions out of the cell and potassium ions into the cell. Hence it is fundamental to functions like regulation of cell volume and electrolyte balance.

Naturally, the liver of fish can be considered a target organ to pollutant and alterations in its structure can be significant in the evaluation of fish health. This is because there is usually a good relationship between structural distortion and function (Myers *et al*., 1998) [26]. Hinton *et al*., 1992 [22] noted that the liver exhibits the effects of a variety of environmental pollutants. Therefore, the imparts of xenobiotics such as detergents on liver function may be of interest to the environmentalists. The liver plays primary role in the metabolism and excretion of xenobiotic compounds with morphological alterations occurring in some toxic conditions (Rocha and Monteiro, 1999) [25]. Contamination of aquatic phase by detergent has been reported in aquatic organisms such as fishes (Adham *et al*., 2002; Adewoye *et al*., 2005; Ogundiran *et al.*, 2007 and Ogundiran *et al*., 2009) [31 30, 20, 21]. Pollutants build up in food chains and are responsible for the adverse effects and death in aquatic organisms (Farkas and Dickhoff, 2002) [18]. Fishes are widely used to evaluate the health of aquatic ecosystem and physiological changes serves as biomarkers of environmental pollution (Knock *et al*., 1996) [15].

Many of the reports available on surfactants detergent toxicity are related to the effects of anionic surfactants during exposure periods of 15 minutes to 30 days (Jain *et al*., 2011; Santanu, 2013 and Rejeki *et al*., 2006) [14, 29, 23]. Effects on olfactory responses, respiration and gill physiology were the most frequently monitored (Chevalier *et al*., 2012) [35]. It was found that concentrations greater than 0.1 ppm were sufficient to elicit characteristic physiological responses (Skelton, 2001) [39]. The blocking effects of cationic and anionic (ABS) compounds were noted on the olfactory epithelium of Atlantic Salmon at 1ppm (Bernet *et al.*, 2004) [32]. No effects were observed for non-ionics. It was also found that in many of the cases these effects were reversible (Omotoso and Fagbero (2005) [19]. Effects on feeding pattern/feeding rate were studied in presence of surfactants (Baskaran, *et al*., 2012) [33]. Probably due to olfactory disturbances, it was observed that feeding rate in the presence of detergents was reduced (Nurnberg, 2012) [27]. The feeding rates were decreased at 0.25, 0.38 and 1.1 ppm. The fishes were found to move towards the feed, swallowed it, tried to chew for 3- 4 sec but ejected the food matter out of the buccal cavity. Swallowing and regurgitation continued 3- 4 times, whereas the control fishes rushed towards the food and swallowed it quickly. Respiration was largely affected in the presence of surfactants. The respiratory rate was increased in *Lepomis machrochirus* at concentrations above 1.56 ppm when exposed to alkyl ethoxylates (Jensen *et al.* 2001) [13]. The detergent exposure (oil spill dispersants) was found to induce conditions

similar to hypoxia. There was an increase in heart rate and ventilation volume (Nero *et al*., 1978) [28] and concomitant bradycardia in fish- *Tautogolabrus adspersus* (cunner fish) exposed to nonionic Triton X-lO0, Tween 20 and the anionic sodium lauryl sulfate. Bradycardia so induced was sustained during the exposure period and was reversible. All the surfactants tested produced the same response differing only in the threshold concentrations. This rapid reversibility showed that the effect was the result of a reversible action on a peripheral site /sensory receptor of the gill epithelium.

Developmental abnormalities were caused by surfactants to a large extent (Fukuda, 2012) [17]. Studies on fat head minnows, *Tilapia*, *poecilia* etc. revealed that hatching, growth and larval survival were affected at linear alkyl benzene sulphonate (LAS) concentrations of 0.25-11 ppm for 90 days. Non ionics like C_{12}-C_{13} alcohol ethoxylates also created disturbances in development by interfering with growth, hatching and larval development when the exposure period was 90 days. Cationics like dimethyl ammonium chloride and tri methyl ammonium chloride were found to affect the developmental stages of fat head minnows when exposed for 28 days. Similar data regarding surfactant toxicity are also available for invertebrates like sea urchins, sponge, star fish among others (Olson 1996, Smith *et al.*, 2006, Boyer *et al*., 2006) [16, 37, 34]. Smith *et al*., 2001[38] stated that developmental stages of fishes were especially sensitive to surfactants.

Materials and Methods

Experimental fish: Healthy *Clarias gariepinus* juveniles (mean weight, 246.30± 14.12g SD; mean length 16.15±1.40cm SD and adults (mean eight, 850.00± 10.22g SD**;** mean length 29.20± 7.12 cm SD.**)** were obtained from a diseased free fish farm and held in the laboratory of Fisheries and aquatic Environment Department, Rivers State University, in some aquaria of 25 -30L capacity. Specimens were acclimated 7 days to the time of experiment. During and after the period, fish were fed with pelleted diet containing 42% crude protein once per day at 2% body weight for juvenile fish and 2% body weight for adult.

Preparation of test solution: Series of trial test to prepare chronic detergent solution for the experiment was carried out using Santanu (2013) [29] method. Eventually, the final definitive point of 50.00mg/l was reached where for juvenile and adult fish, any quantity of detergent that exceeded 50.00mg/l resulted in to erratic swimming, jumping or death. At this point the decision of 10.00, 20.00, 30.00, 40.00 and 50.00 mg/l were reached. Based on the definitive test result, juveniles and adults of *Clarias gariepinus* were exposed to 10.00, 20.00, 30.00, 40.00 and 50.00 mg/l detergent solution for 30 days. Six treatments with five replicates, control inclusive were considered in this work. A total of 150 juveniles and 30 adults at the rate of 5 juveniles and 1 adult per aquarium and feeding was maintained as at the acclimation period. The toxicant and test water was renewed after every 24 hours interval to maintain the toxicant strength.

Sample Collection: Fish were killed with a blow on the head after blood collection and dissected in order to collect samples (0.5g) of gill, liver, kidney, muscle and spleen tissues with the aid of penknife. Sample was macerated with pestle and mortar. To prepare samples for electrolyte, 5ml of de-ionized water was used. After the addition of this diluent, the samples were centrifuged at the rate of 300 rounds per minutes for 10 minutes. The supernatants were then removed and stored in plain bottles at – 4 ºC for analysis.

Statistical test: Data were subjected to analysis of variance (ANOVA). Duncan Multiple Range Test (DMRT) to test for difference between different levels of treatments and to separate means where applicable. Test of significance was at 95% probability.

Results

Sodium ion respectively dropped below control at 10.00, 20.00 and 50.00mg/l by 8.17, 11.20 and 11.29% and raised above control at 30.00 and 40.00mg/l by 37.37 and 14.79% in the muscles of juvenile fish while in adult fish, it was noted that detergent, caused a significant increase (P<0.05) of sodium ion in the muscles of *C. gariepinus* by 17.08% at 10.00mg/l, 38.07% at 20.00mg/l, 54.06% at 30.00mg/l, 55.27% at 40.00mg/l and 64.04% at 50.00mg/l with increase in concentration. Potassium ion significantly decreased in both juvenile and adult fish with increase in concentration except at 50.00mg/l in juvenile fish where it was raised above control by 21.41% (62.37±10.25). In juvenile fish, potassium ion peaked at 30.00mg/l with 40.40% while that of adult peaked at 50.00mg/l with 40.24% below control. Detergent significantly raised calcium ion in juvenile fish by 32.60% at 10.00mg/l, 90.43% at 20.00mg/l, 106.20% at 30.00mg/l, 145.74% at 40.00mg/l and 228.60% at 50.00mg/l while in adult fish calcium ion was same as control in the muscle at 10.00 and 20.00mg/l and respectively less than control by 18.78, 51.75 and 58.32% at 30.00, 40.00 and 50.00mg/l as concentration increased. At 10.00 and 20.00mg/l, chloride ion was raised above control in juvenile fish by 86.26 and 69.97% and below control by 0.02, 0.45 and 23.93% while in adult fish it was 0.70% less than control at 10.00 and 40.00mg/l. It was observed that hydrogen carbonate ion concentration in juvenile fish was the reverse of that in adult fish in that there was a steady decrease below control by 5.93, 6.67, 13.33, 8.33 and 25.00% in juvenile fish and increase above control by 7.60, 11.10,17.54,36.61 and 53.80% in adult fish as concentration increased (Table 1and 2, Fig. 1).

Detergent decreased sodium ion in plasma electrolyte of juvenile fish (Table 3 and 4, Fig. 2) by 32.38% at 10.00mg/l, 27.25% at 20.00mg/l, 10.94% at 30.00mg/l, 4.08% at 40.00mg/l and 1.07% at 50.00mg/l and raised that of adult fish by 10.81, 40.09,48.42, 57.43 and 67.72% with increase in concentration. At 10.00, 30.00 and 40.00mg/l, potassium ion respectively dropped in blood plasma by 28.44, 0.41 and 11.38% and was raised at 20.00 and 50.00mg/l by 19.96 and 9.31% while in adult fish, it was significantly raised by 25.55, 45.37,69.60, 93.83 and 118.06% as concentration increased. In juvenile fish, calcium ion was raised above control at all the concentrations except at 10.00mg/l where it was insignificantly lower than control by 0.49% whereas in adult fish, it was equal to control with increase in concentration. Chloride and hydrogen carbonate ions were all raised on exposure to detergent in the plasma, except at 40.00 and 50.00mg/l in chloride ion where it dropped respectively by 4.96 and 6.75% and hydrogen ion at 10.00mg/l by 37.89%. In adult fish, chloride and hydrogen carbonate ions were significantly raised (P<0.05) above control with increase in concentration.

Generally, sodium, chloride and hydrogen ions in the liver of juvenile fish (Table 5, Fig.3) dropped and that of potassium and calcium ions were raised with increase in concentration. Jn the adult fish, it was observed that all the electrolytes under consideration except that of sodium decreased with increase in concentration (Table 6, Fig.3)

Discussion

The present investigation shows that prolonged exposure of *Clarias gariepinus* juveniles and adult to detergent (alkyl benzene sulfonate) in water induces a variety of anomalies in the sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl^-) and hydrogen carbonate (HCO_3^-) ions. There was a significant (P<0.05) alterations in the electrolytes of both life stages of *C. gariepinus* when compared with control. The significant dose-dependent alterations in all the electrolytes observed in both life stages exposed to detergent indicate that the fish were severely physiologically affected. This alteration also suggests that the toxicant have altered the cell membrane permeability by causing ionic variation due to ionic imbalance in the muscular activity of the experimental animal (Inyang *et al*., 2016 and Bhanu, 2016) [7, 10]. This is in corroboration with this work in that sodium (Na^+) in the muscle of juvenile fish drastically dropped at 10.00, 20.00 and 50.00mg/l and raised at 30.00 and 40.00mg/l whereas in the adult fish it was raised in all the concentrations which peaked at 50.00mg/l with 64.04% above control and least at 10.00mg/l. Sodium ion levels in all freshwater fishes are higher than Ca^{2+} according to stages of fish of this work were higher than calcium ions. It is an essential electrolyte in plasma and is found in bound state with plasma proteins (Bansal *et al*., 2009) [2]. It is needed by erythrocytes to maintain their functional entity. Calcium ion in fish is used as a powerful tool in the assessment of health of fish and environment in which they inhabit. It helps in clotting of blood, takes part in contraction of muscles, controls the excitability of nerves and also is involved in certain hormone activity (Ip, *et al*., 2001) [1]. In contrast to sodium ion, the lower values of calcium ion concentrations were observed in treated fish compared to control. It was suggested that the experimentally stressed fish tried to control excitability of nerves and has lost integration of voluntary muscles (Ip, *et al*., 2001) [1]. In juvenile fish, potassium ion dropped between 10.00 and 40.00mg/l and was raised at 50.00mg/l by 21.41%; calcium ion was raised in all the concentrations and peaked at 50.00mg/l by 228.60%; chloride ion fluctuated between 10.00 and 50.00mg/l while hydrogen carbonate ion decreased with concentration when compared with control. Also, potassium, calcium, chloride ions in the muscle of adult fish dropped and that of hydrogen carbonate ion increased with increase in concentration. As such, elevation or decline in values may lead to hyper or hypo function in the blood plasma, muscle and liver Inyang *et al*., 2016. Adamu and Francis, 2008 [12] reported that the significance variation in the electrolytes among the different experimental group suggests damage in the selected organs of the fish. This agrees with this work in that in the liver of juvenile fish, detergent caused the decrease in sodium, chloride and hydrogen carbonate ions and raised that of potassium and calcium whereas, in the liver of adult fish, potassium, calcium, chloride and hydrogen carbonate decreased and that of sodium ion raised with increase in concentration when compared with control. In the plasma of adult fish, sodium, potassium, chloride and hydrogen carbonate ions were raised above control except calcium ion which was same as control, while in juvenile fish, sodium ion decreased with increase in concentration and that of potassium, calcium, chloride and hydrogen ions fluctuated with increase in concentration when compared with control. Prolong exposure could lead to alteration of genetic makeup, social behavior or death (Adamu and Francis, 2008) [12]. The variation inclination in sodium content in the liver and calcium in both muscle and plasma in this study is comparable to the work of Ogamba, *et al*. 2015 [5], Ogamba, *et al*. 2018 [4] , Inyang, *et al*. 2016 [7], Inyang and Patani (2015) [8] and Uedeme-Naa and George, 2019 [45]. However, the higher concentration of potassium and sodium in the liver could be related to their role in detoxification. Usually, electrolytes aid in the maintenance of ionic balance to improve normal function of the cells (Bhanu, 2016) [10]. Specifically, sodium and potassium are important extra cellular fluids that are very useful for the transportation of ATP (Inyang, *et al*., 2015; Erhunmwunse, and Ainerua, 2014; Bhanu, 2016) [9, 6, 10]. Some specific function of electrolytes are maintenance of heart contraction and involuntary muscles and other metabolic activities (sodium) Erhunmwunse, and Ainerua, 2014 [6], intracellular physiological (nerve and muscle) functions, acid-base balance and osmotic pressure, enzymatic transfer of phosphate from ATP to pyruvic acid (Muralidharan, 2014 [11], potassium - blood coagulation (Ogubunka and Ike-Obasi, 2018 [3], Adamu and Francis, (2008) [12] and regulation of permeability in the cell membrane (calcium) Adamu, and Francis, 2008 [12].

Table 1: Electrolytes in the Muscles of *C. gariepinus* Juveniles Exposed to Jumbo Detergent for 30 Days (Mean ± SD).

Conc.(mg/l)	Na^+(mg/l)	% Control	K^+(mg/l)	% Control	Ca^{2+}(mg/l)	% Control	Cl^-(mg/l)	% Control	HCO_3^- (mg/l)	% Control
0.00	465.00±28.86^{a}	100	51.37±12.49^{ab}	100	9.51±3.46^{a}	100	57.51±16.11^{ab}	100	15.00±2.88^{b}	100
10.00	427.00±15.16^{a}	-8.17	42.37±16.35^{b}	-17.52	12.61±3.41^{ab}	+32.60	107.12±35.75^{c}	+86.26	14.11±1.44^{b}	-5.93
20.00	412.51±12.88^{a}	-11.20	36.37±11.31^{a}	-29.20	18.11±7.21^{ab}	+90.43	97.75±12.61^{b}	+69.97	14.00±2.44^{b}	-6.67
30.00	638.75±59.21^{b}	+37.37	30.62±8.61^{a}	-40.40	19.61±6.21^{ab}	+106.20	57.50±12.64^{ab}	-0.02	13.00±1.71^{ab}	-13.33
40.00	533.75±11.08^{ab}	+14.79	42.25±11.72^{b}	-17.75	23.37±6.25^{b}	+145.74	57.25±12.71^{ab}	-0.45	13.75±2.50^{ab}	-8.33
50.00	412.50±12.88^{a}	-11.29	62.37±10.25^{c}	+21.41	31.25±7.31^{c}	+228.60	43.75±12.91^{a}	-23.93	11.25±3.16	-25.00

Means within the same column with different superscripts (a,b,ab,c) differ significantly ($P<0.05$)

Key: **Na^+**= Sodium ion, **K^+** = Potassium ion, **Ca^{2+}**= Calcium ion, **Cl^-** = Chloride ion, **HCO_3^-** = Hydrogen carbonate ion, mg/l = Milligram per liter.

Table 2: Electrolytes in the Muscles of *C. gariepinus* Adults Exposed to Jumbo Detergent for 30 Days (Mean ± SD)

Conc. (mg/l)	Na^+ (mg)	% Control	K^+ (mg/l)	% Control	Ca^{2+} (mg/l)	% Control	Cl^- (mg/l)	% Control	HCO_3^- (mg/l)	% Control
0.00	189.50±7.63^{a}	100	42.25±9.22^{c}	100	6.07±3.46^{b}	100	35.75±7.60^{a}	100	128.25±2.88^{a}	100
10.00	218.50±6.69^{ab}	+17.08	37.50±9.12^{b}	-11.24	6.07±3.41^{b}	0.00	35.50±6.50^{a}	-0.70	138.00±1.44^{a}	+7.60
20.00	261.50±8.60^{ab}	+38.07	30.75±8.11^{ab}	-27.22	6.07±7.21^{b}	0.00	35.75±7.00^{a}	0.00	142.50±2.44^{ab}	+11.10
30.00	292.00±7.52^{ab}	+54.06	28.25±7.89^{ab}	-33.14	4.93±6.21^{ab}	-18.78	35.75±5.03^{a}	0.00	150.75±1.71^{b}	+17.54
40.00	294.25±7.62^{ab}	+55.27	28.00±6.05^{a}	-33.75	2.93±6.25^{a}	-51.75	35.50±6.33^{a}	-0.70	179.00±2.50^{ab}	+36.61
50.00	310.50±8.43^{b}	+64.04	25.25±6.09^{a}	-40.24	2.53±7.31^{a}	-58.32	35.75±7.43^{a}	0.00	197.25±3.16^{c}	+53.80

Means within the same column with different superscripts (a,b,ab,c) differ significantly ($P<0.05$).

Key: **Na^+**=Sodium ion, **K^+** =Potassium ion, **Ca^{2+}**=Calcium ion, **Cl^-**=Chloride ion, **HCO_3^-** = Hydrogen carbonate ion, mg/l=Miligram per liter.

Table 3: Electrolytes in the Plasma of *C. gariepinus* Juveniles Exposed to Detergent for 30 Days (Mean ± SD)

Conc. (mg/l)	Na^+ (mg/l)	% Control	K^+ (mg/l)	% Control	Ca^{2+} (mg/l)	% Control	Cl^- (mg/l)	% Control	HCO_3^- (mg/l)	% Control
0.00	116.50±6.57^{b}	100	9.67±1.21^{b}	100	10.27±6.71^{a}	100	181.50±28.40^{a}	100	2.51±1.01^{a}	100
10.00	78.25±5.31^{a}	-32.38	6.92±3.21^{a}	-28.44	10.22±1.19^{a}	-0.49	296.00±56.70^{b}	+63.09	1.56±0.16^{a}	-37.89
20.00	84.75±10.18^{a}	-27.25	11.60±2.19^{c}	+19.96	10.40±4.21^{a}	+1.27	298.25±76.07^{b}	+64.32	3.00±0.51^{b}	+19.52
30.00	103.75±15.88^{b}	-10.94	9.63±1.61^{b}	-0.41	20.02±6.14^{b}	+94.94	276.50±94.20^{b}	+52.34	3.25±0.81^{b}	+29.46
40.00	111.75±19.15^{b}	-4.08	8.57±2.95^{b}	-11.38	21.52±6.14^{b}	+109.54	172.50±29.55^{a}	-4.96	4.00±0.74^{c}	+59.36
50.00	115.25±19.90^{b}	-1.07	10.57±2.64^{c}	+9.31	24.54±6.22^{b}	+138.95	169.25±33.05^{a}	-6.75	4.01±0.81^{c}	+59.76

Means within the same column with different superscripts (a,b,c) differ significantly ($P<0.05$).

Key: Na^+=Sodium ion, K^+ =Potassium ion, Ca^{2+}=Calcium ion, Cl^-=Chloride ion, HCO_3^- = Hydrogen carbonate ion, mg/l=Miligram per liter.

Table 4: Electrolytes in the Plasma of *C. gariepinus* Adults Exposed to Jumbo Detergent for 30 Days (Mean ± SD)

Con. (mg/l)	Na^+ (mg/l)	% Control	K^+ (mg/l)	% Control	Ca^{2+} (mg/l)	% Control	Cl^- (mg/l)	% Control	HCO_3^- (mg/l)	% Control
0.00	111.00±7.23[a]	100	11.35±1.21[a]	100	4.50±0.13[a]	100	194.25±3.07[a]	100	150.50±5.00[a]	100
10.00	123.00±8.00[ab]	+10.81	14.25±3.32[ab]	+25.55	4.50±0.13[a]	0.00	205.50±3.34[a]	+5.79	174.75±7.87[a]	+16.11
20.00	155.50±5.43[ab]	+40.09	16.50±2.19[ab]	+45.37	4.50±0.13[a]	0.00	220.00±4.00[ab]	+13.26	185.50±4.98[ab]	+7.14
30.00	164.75±6.55[b]	+48.42	19.25±1.61[ab]	+69.60	4.50±0.13[a]	0.00	243.00±2.56[ab]	+25.09	199.75±6.54[ab]	+32.70
40.00	174.75±6.61[b]	+57.43	22.00±2.95[b]	+93.83	4.50±0.13[a]	0.00	246.00±3.06[ab]	+26.64	203.00±5.97[b]	+34.88
50.00	185.50±712[c]	+67.72	24.75±6.64[c]	+118.06	4.50±0.13[a]	0.00	260.50±5.07[b]	+34.15	203.00±4.32[b]	+34.88

Means within the same column with different superscripts (a,b,ab,c) differ significantly (P<0.05).
Key: **Na^+**=Sodium ion, **K^+** =Potassium ion, **Ca^{2+}**=Calcium ion, **Cl^-**=Chloride ion, **HCO_3^-** = Hydrogen carbonate ion, mg/l=Miligram per liter.

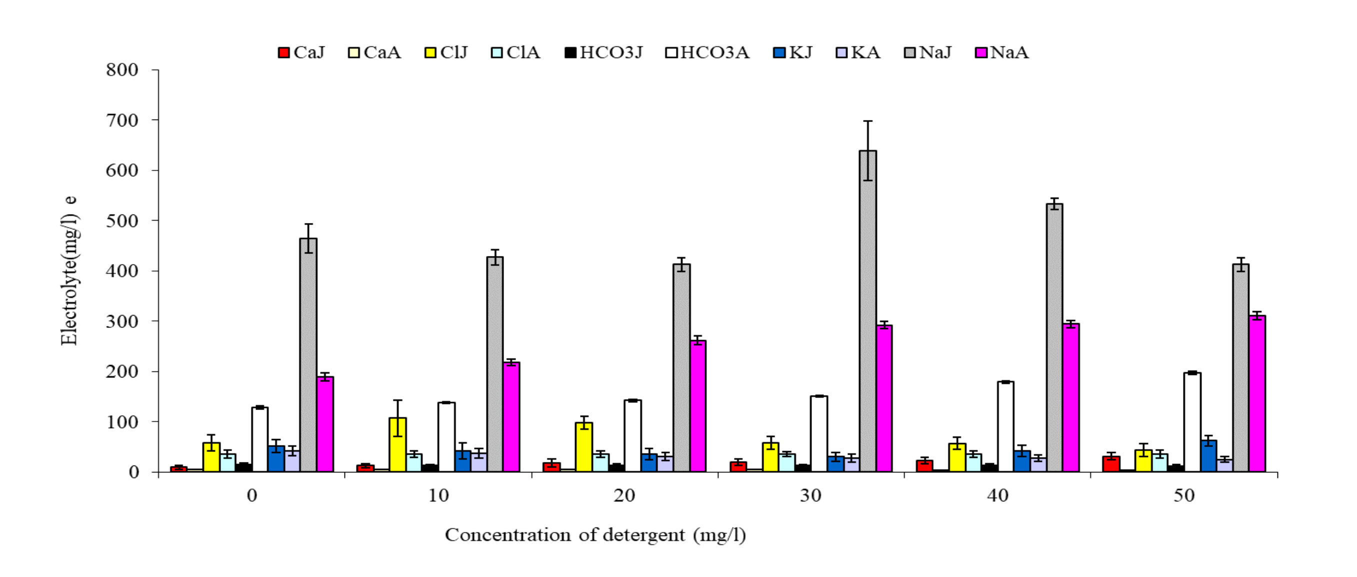

Fig 1: Comparative levels of selected electrolytes in the muscles of juvenile and adult *C. gariepinus* exposed to detergent for 30 day (Mean ± SD)

Key: CaJ=Calcium ion in juvenile, CaA=Calcium ion in adult, ClJ=Chloride ion in juvenile, ClA=Chloride ion in adult, HCO_3J=Hydrogen carbonate ion (bicarbonate ion) in juvenile, HCO_3A=Hydrogen carbonate ion (bicarbonate ion) in adult, KJ=Potassium ion in juvenile, KJ=Potasium ion in adult, NaJ=Sodium ion in juvenile, NaA=Sodium ion in adult.

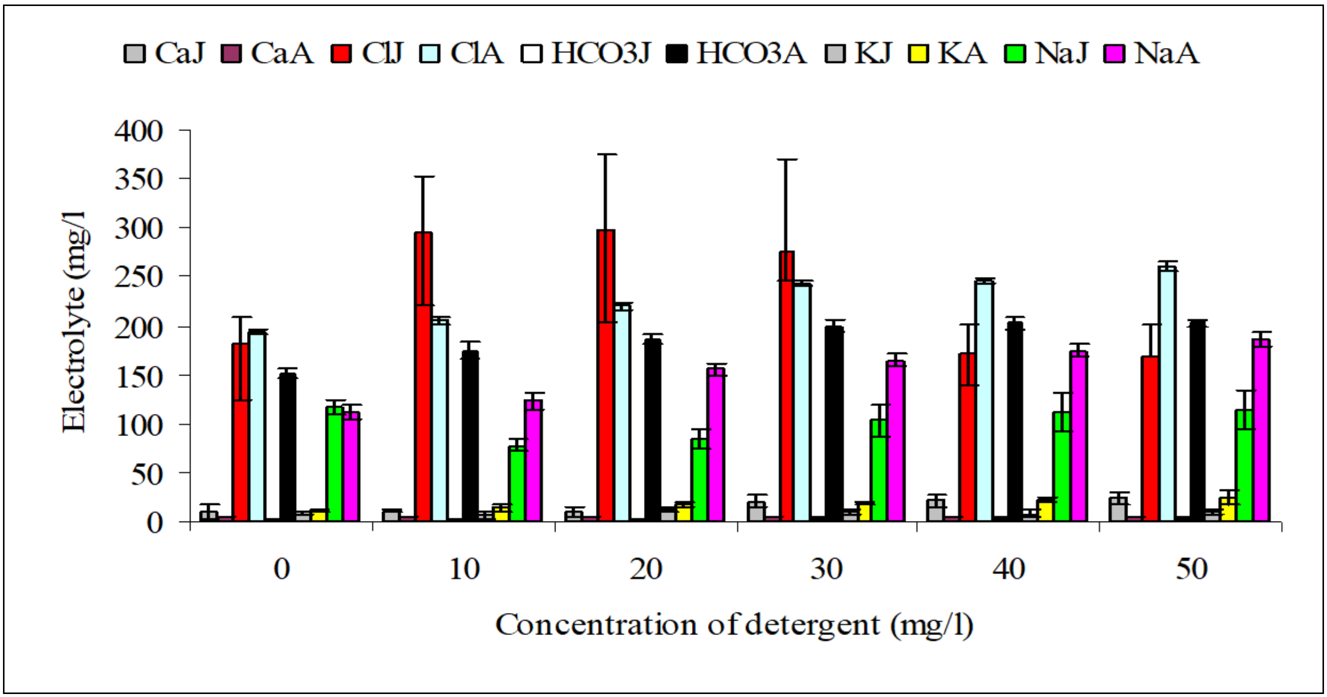

Fig 2: Comparative levels of electrolytes in the plasma of juvenile and adult *C.gariepinus* exposed to jumbo detergent for 30 days (Mean ±SD)

Key: CaJ=Calcium ion in juvenile, CaA=Calcium ion in adult, ClJ=Chloride ion in juvenile, ClA=Chloride ion in adult, HCO_3J=Hydrogen carbonate ion (bicarbonate ion) in juvenile, HCO_3A=Hydrogen carbonate ion (bicarbonate ion) in adult, KJ=Potassium ion in juvenile, KJ=Potasium ion in adult, NaJ=Sodium ion in juvenile, NaA=Sodium ion in adult

Table 5: Electrolytes in the Liver of *C. gariepinus* Juveniles Exposed to Detergent for 30 Days (Mean ± SD)

Conc. (mg/l)	Na^+ (mg/l)	% Control	K^+ (mg/l)	% Control	Ca^{2+} (mg/l)	% Control	Cl^- (mg/l)	% Control	HCO_3^- (mg/l)	% Control
0.00	360.00±23.09[c]	100	44.12±9.61[a]	100	6.51±0.11[a]	100	267.00±34.29[c]	100	18.75±1.44[b]	100
10.00	359.00±17.32[c]	-0.28	44.75±11.62[a]	+1.43	8.01±3.12[a]	+23.04	142.12±30.11[b]	-46.77	17.51±0.01[b]	-6.61
20.00	355.00±5.77[c]	-1.39	46.21±9.62[a]	+4.74	9.51±0.37[a]	+47.08	143.31±31.11[b]	-46.33	17.51±0.01[b]	-6.61
30.00	317.00±17.07[b]	-11.94	50.25±8.71[b]	+13.89	11.12±5.96[b]	+70.81	138.37±30.52[b]	-48.18	13.75±1.44[a]	-26.67
40.00	310.00±10.01[b]	-13.89	51.50±14.88[b]	+16.73	22.01±12.89[c]	+238.10	112.51±31.61[ab]	-57.86	13.75±1.48[a]	-26.67
50.00	307.00±9.57[a]	-14.72	57.75±11.83[b]	+30.89	31.25±7.21[c]	+380.18	43.75±17.51[a]	-83.61	13.25±1.43[a]	-29.33

Means within the same column with different superscripts (a,b,ab,c) differ significantly (P<0.05).
Key: Na^+=Sodium ion, K^+ =Potassium ion, Ca^{2+}= Calcium ion, Cl^-= Chloride ion, HCO_3^- = Hydrogen carbonate ion, mg/l=Milligram per liter.

Table 6: Electrolytes in the Liver of *C. gariepinus* Adults Exposed to Detergent for 30 Days (Mean ± SD).

Conc. (mg/l)	Na^+ (mg)	% Control	K^+ (mg/l)	% Control	Ca^{2+} (mg/l)	% Control	Cl^- (mg/l)	% Control	HCO_3^- (mg/l)	% Control
0.00	145.50±5.00[a]	100	27.50±1.09[b]	100	6.83±3.02[b]	100	31.50±5.00[a]	100	207.00±4.01[b]	100
10.00	166.75±5.01[a]	+14.60	26.25±1.05[b]	-4.55	6.83±3.02[b]	0.00	30.70±5.05[a]	-2.54	201.50±3.98[b]	-2.66
20.00	186.50±4.00[a]	+28.18	24.00±1.00[a]	-12.72	6.13±2.76[b]	-10.25	31.00±4.12[a]	-1.58	199.75±3.32[ab]	-3.50
30.00	235.50±6.00[ab]	+61.86	24.00±1.00[a]	-12.72	4.75±2.22[ab]	-10.45	30.70±4.32[a]	-2.54	105.00±2. 89[a]	-49.30
40.00	268.75±6.07[b]	+84.71	24.00±1.00[a]	-12.72	3.67±2.50[a]	-46.27	31.00±5.00[a]	-1.58	105.00±1.98[a]	-49.27
50.00	341.75±7.02[c]	+134.88	24.00±1.00[a]	-12.72	2.13±0.32[a]	-68.96	30.75±5.03[a]	-2.38	105.00±1.98[a]	-49.30

Means within the same column with different superscripts (a,b,ab,c) differ significantly (P<0.05).
Key: Na^+=Sodium ion, K^+ =Potassium ion, Ca^{2+}=Calcium ion, Cl^-=Chloride ion, HCO_3^- = Hydrogen carbonate ion, mg/l=Miligram per liter.

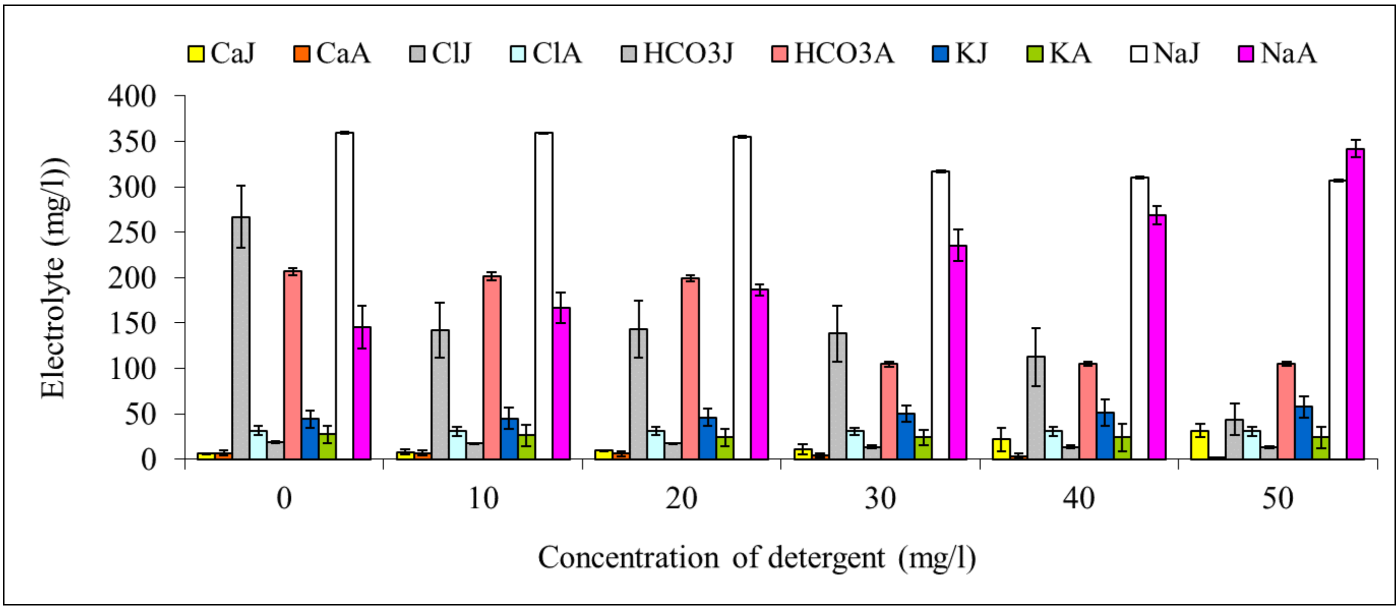

Fig 3: Comparative levels of electrolytes in the liver of juvenile and adult *C. gariepinus* exposed to jumbo detergent for 30 days (Mean ± SD)
Key: CaJ=Calcium ion in juvenile, CaA=Calcium ion in adult, ClJ=Chloride ion in juvenile, ClA=Chloride ion in adult, HCO_3J=Hydrogen carbonate ion (bicarbonate ion) in juvenile, HCO_3A=Hydrogen carbonate ion (bicarbonate ion) in adult, KJ=Potassium ion in juvenile, KJ=Potasium ion in adult, NaJ=Sosdium ion in juvenile, NaA=Sodium ion in adult

Conclusion

This study assessed the outcome of detergent (linear alkylbenzene sulfonate) on selected electrolytes as sodium ion (Na^+), potassium ion (K^+), calcium ion (Ca^{2+}), chloride ion (Cl^-), hydrogen carbonate ion (HCO_3^-) in some vital organs of *Clarias gariepinus*, a common Niger Delta wetland fish. The significant variations in the electrolytes content in this study implies that incessant dumping of detergents and industrial wastes in our waters have the potency of directly or indirectly altering the general physiology of fish and other aquatic resources. To check this, reasonable restraints backed up by law must be meted to those in the habit of discarding untreated wastes into our water bodies.

References

1. Ip YK, Chew SF, Randall DJ. Ammonia toxicity, tolerance, and excretion. Fish Physiol. 2001; 20:109-148.
2. Bansal S, Lindenfeld J, Schrier RW. Sodium retention in heart failure and cirrhosis. Circulation Heart Failure. 2009; 2:370-376.
3. Ogubunka SO, Ike-Obasi JC. Variations of Some Electrolytes in the Plasma of Black Jaw Tilapia (*Sarotherodon melanotheron*) Exposed to Some Pesticides in the Laboratory. Journal of Fisheries and Livestock Production. 2018; 6:4.
4. Ogamba EN, Izah SC, Nabebe G. Effects of 2, 4-Dichlorophenoxyacetic acid in the electrolytes of blood, liver and muscles of *Clarias gariepinus*. Nigeria Journal of Agriculture Food and Environment. 2018; 11:23-27.
5. Ogamba EN, Izah SC, Numofegha K. Effects of dimethyl 2, 2-dichlorovinyl phosphate on the sodium, potassium and calcium content in the kidney and liver of *Clarias*

gariepinus. Research Journal of Pharmacology and Toxicology. 2015; 1:27-30.

6. Erhunmwunse NO, Ainerua MO. Effect of Glyphosate Herbicide (360g/l) On Some Biochemical Electrolytes of Exposed Africa Catfish. Journal of Environmental Science. Toxicology and Food Technology. 2014; 8:27-29.
7. Inyang IR, Thomas S, Izah SC. Activities of Electrolytes in Kidney and Liver of *Clarias gariepinus* Exposed to Fluazifop -P-Butyl. Journal of Biotechnology Research. 2016; 2(9):68-72.
8. Inyang IR, Patani DE. Haematological aberrations and electrolyte Stabilization in *Heterobranchus bidorsalis* induced by rhonasate 360SL containing glyphosate. Nigerian Journal of Agriculture, Food and Environment. 2015; 11:28-31.
9. Inyang IR, Okon NC, Izah SC. Effect of glyphosate on some enzymes and electrolytes in *Heterobranchus bidosalis* (a common African catfish). Biotechnological Research. 2015; 2:161-165.
10. Bhanu AP. Cypermethrin induced alterations in electrolytes in the blood and tissues of *Cyprinus carpio*. International Journal of Technical Research and Applications. 2016; 4:248-250.
11. Muralidharan L. Impact of Fenthion on Ionic Regulation in the Blood of Freshwater Fish, *Cyprinus carpio* (Linn). IOSR Journal of Environmental Science, Toxicology and Food Technology. 2014; 8:63-70.
12. Adamu MK, Francis OA. Concentration of electrolyte reserves of the juvenile African catfish *Clarias gariepinus* (Burchell, 1822) Exposed to sublethal concentrations of portland cement powder in solution. Pakistan Journal of Science and Industrial Research. 2008; 51:323-328.
13. Jensen KM, Korte JJ, Kahi MD, Pasha MS, Ankley GT. Aspects of basic reproductive biology and endocrinology in the fathead minnow (*Pimephales promelas*). Toxicological Pharmacology. 2001; 128:127-141.
14. Jain V, Mishra KD, Madhuri S, Pandey G. Linear alkyl benzene sulfonate, a detergent induced toxicity on the gill of *Puntius ticto* fish**.** International Resourse Journal of Pharmacology. 2011; 2(10):76-78.
15. Knock G, Triendi M, Hofer R. Seasonal pattern of metal accumulation in Arctic char (*Salvelinus alpinus*) from an Oligotrophic Alpine lake related to temperature. Journal of Fishery and Aquatic Science. 1996; 53:780-78.
16. Olson KR. Scanning electron microscopy of the fish gill. In: Fish morphology: Horizon of New research. Edited by Munshi, J.S.D. and Dutta, H.M. Science publishers, Inc. U.S.A, 1996.
17. Fukuda Y. Specific reactions of goldfish gills exposed to linear Alkyl benzene sulphonate. Japanese Journal of Ichthyoogyl. 2012; 30:268-274.
18. Farkas LC, Dickhoff WW. The Parrsmolt Transformation and Seawater adaptation in salmonids. Aquaculture. 2002; 21:1-37.
19. Omotoso FO, Fagbero OA. A comparative study on the toxicity of three commercial detergents on the survival of the Nile Tilapia, *Oreochromis niloticus*, Journal of Agricultural Resource and Development. 2005; 4(2):139-147.
20. Ogundiran MA, Fawole OO, Adewoye SO. Effects of Soap and Detergent Effluents on the Heamatological Profiles of *Clarias gariepinus*. Science Focus. 2007; 12(1):84-88.
21. Ogundiran MA, Fawole OO, Adewoye SO, Ayandiran TA. Pathogenic lesions in the gill structures of *Clarias gariepinus* exposed to sublethal concentration of soap and detergent effluents. Journal of Cell and Animal Biology. 2009; 3(5):78-82.
22. Hinton DE, Baumann PC, Gardner GR, Hawkins WE, Hendricks JD, Murchelano RA *et al*. Histopathologic biomarker. In Biomarkers: Biochemical, Physiological and Histological markers of Anthropogenic Stress. Edited by Huggett, R.J., Kimerle, R.A., Mehrle Jr, P.M. and Bergman, H.L. Lewis publishers, 1992.
23. Rejeki S, Desrina A, Mulyana AR. Chronic. Effects of Surfactant detergent - Linear Alkyl-Benzene Sulfonate (LAS) On the Growth and Survival Rate of Sea Bass (*Lates calcalifer* Bloch) Larvae, Journal of Coastal Development**.** 2006; 95**(**35):496-599
24. Verbost PM, Flik G, Lock RAC, Wendelaar Bonga SE. Cadmium inhibition of Ca^{2+} uptake in rainbow trout gills. American Journal of Physiology. 2007; 253:216-221.
25. Rocha E, Monteiro RAF. Histology and Cytology of fish liver; A review, In: Saksena D.N. (ed.), Ichthyology: Resent Research advances. Science Publishers. Enfield, New Hampshire. 1999, 321-344.
26. Myers MS, Johnson LL, Olson OP, Sther CM, Homess BH, Collier TK *et al*. Toxicopathic hepatic lesions as biomarkers of chemical contaminants exposure and effects in marine bottom fish species from the north east and pacific coast. U.S.A., Maine Pollution Bulletin. 1998; 37:92-113.
27. Nurnberg HW. Pollutants and Their Ecotoxicological Significance. John Wiley and Sons, New York. 2012, 321-325.
28. Nero V, Farwell A, Lister A, Van der Kraak G, Lee IEJ, *et al*. Gill and liver histopathological changes in yellow perch (*Perca flavescens*) and goldfish (*Carassius auratus*) exposed to oil sands process-affected water. Ecotoxicological Environmental Safety. 1978; 63(3):365-377.
29. Santanu Sarma. Effect of sub-lethal exposure of detergent on transamination in the liver of *Heteropnustes fossilis*. International Journal of Pure and Applied Bioscience. 2013; 1(5):36-41.
30. Adewoye SO, Fawole OO, Owolabi OD, Omotosho JS. Toxicity of cassava waste water effluents on African Catfish (*Clarias gariepinus).* Ethiopian Journal of Science. 2005; 28(7):189 -194.
31. Adham KG, Hamed SS, Ibrahim HM, Saleh RA. Impaired functions of Nile Tilapia, *Oreochromis niloticus* from polluted water. Acta Hydrochemical et Hydrobiological. 2002; 5(3):162-173.
32. Bernet D, Schmidt-Posthaus H, Wahli T, Burkhardt-Holm P. Evaluation of two monitoring approaches to assess effects of waste water disposal on histological alterations in fish. Hydrobiology. 2004; 524:53-66.
33. Baskaran P, Gopalakrishna SG, Sathiyabama B. Impact of commercial detergent (Nirma) on feeding energetic and protein metabolism in the fresh water teleost fish *Oreochromis mossambicus.* Journal of Ecotoxicology and Environmental Monitoring. 2012; 1(1):31-40.
34. Boyer JL, Swartz J, Smith N. Biliary secretion in Elasmobranchs. II. Hepatic uptake and biliary excretion of organic anions. American Journal of Physiology. 2006; 230:974-981.

35. Chevalier C, Gauthier L, Moreau G. Histophathological and electron microscopic studies of gills of brook trout, *Salvelinns foniinotis*, from acidified lakes. Canadian Journal of Zoology. 2012; 63:2062-2070.
36. Trump BF, McDowell EM, Arstila A. Cellular reaction to injury. In: Principles of pathobiology, 3 Ed. Edited by Hill, R.B. and La Via, M.F. Oxford University Press, New York. 2009, 20-111.
37. Smith CE, Peck TH, Klauda RJ. Hepatomas in Atlantic tomcod (*Microgadus tomcod)* Walbaum collection in the Hudson River estuary in New York. Journal of Fish Diseases. 2006; 2:313-319.
38. Smith Z, Castro VI, Fracto L. Evaluation of fish quality from muscle protein, International Journal of Environmental Chemistry. 2001; 6(1):209-218.
39. Skelton P. A Complete study on the Freshwater Fishes of Southern Africa. Struik Publishers, 2001.
40. Russell AD. Antibiotic and Biocide resistance in bacteria: comments and conclusions. J Appl Microbiol Symp Supp. 2002; 92:1715-1735.
41. Holah JT, Taylor JH, Dawson DJ, Hall KE. Biocide use in the food industry and the disinfectant resistance of persistent strains of *Listeria monocytogenes* and *Escherichia coli*. J Appl Microbiol Symp Supp. 2002; 92:1115-1205.
42. Siposova K, Kozar T, Musatov A. Interaction of nonionic detergents with the specific sites of lysozyme amyloidogenic region─ inhibition of amyloid fibrillization. Colloids and Surfaces B: Biointerfaces. 2017; 150:445-455.
43. Sudiana IM, Peraan KM, Lumpur AK, Perombakan TD. Detergen Alkyl Sulfonat Linear dan Benzena Alkyl Sulfonat. Berkala Penelitian Hayati. LIPI, 2004.
44. Russell AD. Mechanisms of bacterial insusceptibility to biocides. Am J Infect Control. 2001; 29:259-261.
45. Uedeme-Naa B, George ADI. The implications of linear alkylbenzene sulphonate on selected enzymes in the muscle and plasma of two life stages of *Clarias gariepinus*. Journal of Biological Series. 2019; 2(3):100-106.