

TOXICITY OF SODIUM THIOSULPHATE TO TEST THE BEHAVIORAL ACTIVITIES AND LC₅₀ ON AFRICAN CATFISH (*Clarias gariepinus*) JUVENILES

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Abstract

The effect of Sodium thiosulphate on juveniles of African catfish C. gariepinus juveniles, with mean body weight of $18.29 \pm 1.00g$ was evaluated after 96 hours. Effects on behavioural activities, mortality and ventilation were observed. Mortality increased with increase in concentration. The LC₅₀ of the Sodium thiosulphate was determined to be 18g/1L for C. gariepinus juveniles. The gill showed filament degeneration, mild sub-mucosal congestion and erosion at the mucosal epithelium in some region of the secondary papillae, the kidney showed space formation and fragmentation of nuclear chromatin. Mild hemorrhage of the interstitium, severe congestion of hemorrhage at renal interstitium. Vacuole formation and congestion of renal vessel. The result shows that the highest concentration (20g/l) of Sodium thiosulphate is toxic to fish and can cause degradation of organs and death of C. gariepinus juveniles in aquatic water bodies.

Introduction

Sodium Thiosulphate or Hypo (Na₂S₂O₃)

Water quality is an important factor in the production process and expansion of intensive aquaculture systems (Bullock *et al*, 1997, Summer Felt *et al.*, 1997). Current methods for the disinfection of water, which reduce bacterial loading in water supplies and/or avoid blooms of potentially pathogenic of microorganisms, include treatments with antibiotics, ozone, filtration, Sodium thiosulphate, heat, and ultraviolet radiation. One of such method of disinfection is chlorination.

Water pollution has become a serious problem in aquaculture and in the environment. Only a few chemicals have been ecologically tested in Nigeria for safety in spite of their environmental and ecological impact. Recently, The Federal Government of Nigeria is emphasizing the need for adequate environmental protection in any technological and socio-economic development or endeavours by strictly asking industrial operator to sustainably manage the disposal of chemical into the natural environment (DPR, 2002).

Sodium thiosulphate is a chemical used for renal diseases, anti-fungal agent, during chemotherapy, in both film and photographic paper processing, to remove chlorine and ammonia from water environment and is generally used for the purpose (Browman *et al.*, 1980). Generally, the overdose of some chemicals causes death of the fish due to destruction of gill epithelia (Slabber and Morgan, 1982). It induces symptoms of slow suffocation, dizziness, cluster together, paralysis, destruction of gills lamellae and mucus cell depletion in several freshwater fishes; various researcher have reported on the effects of chemicals on aquatic

organisms (Jiraunghkoorskul *et al.*, 2002) the environmental factors such as P^H , turbidity, alkalinity, dissolved oxygen. Temperature and conductivity influence the rate of reaction of the very high dose of Sodium thiosulphate applying to the water or the lethal effects on the aquatic organisms (Fagbenro, 2002).

Resorts on the toxicity of Sodium thiosulphate and heavy metals to the African mud fish, the fish is of high economic value perhaps comparable to salmon Gardner of the temperate region. The latter fish has been the subject of many researches on effect of heavy metals. *C.gariepinus* has therefore been exposed in toxicity trials to Sodium thiosulphate in the laboratory water in order to determine the toxic dose limit of Sodium thiosulphate in soft water.

Grubbs and Ladshaw (1991) reported Sodium thiosulphate as best dechlorinating agent after testing the effectiveness of several chemical dechlorinating agents because it gave off no poisonous gasses, mixed readily with water, less likely to overdose effluent which could cause oxygen depletion in the receiving stream, instant reaction with chlorine and low initial capital investment.

Chlorine although toxic to fish, chlorinated water treated with Sodium thiosulphate be used to hold aquatic animal immediately since the Sodium thiosulphate is not toxic, but over-treatment may be dangerous though to test the effectiveness of treatment with sodium thiosulphate, fish were added to the aquarium immediately after the chemical was used.

Chlorine and ammonia are the most significant water pollutants in fresh and marine water (Felding, 1992 and Tash *et al.*, 1996). Chlorine has being found to affect various aquatic animals. Animals have been found to accumulate it in a variety of tissue (Du Preez and Van Uren, 1992) In fresh water invertebrates chlorine was known to affect hydro mineral balance or gill function in Crabs (Silvestre *et al.*, 2002) and hemacyanin function (Prasad *et al.*, 1995), more also in fish chlorine and ammonia can also cause damage to gill, liver and kidneys of the fish. (Fisher-scheriet *al.*, 1991).

Oxidative stress in aquatic organisms, principally fish, has great importance for environmental and aquatic toxicology. Because oxidative stress is induced by many chemicals, including some pesticides, these contaminants may stimulates reactive oxygen species and alteration in antioxidant systems, pro-oxidant factor actions in fish can be used to assess pollution of specific areas or worldwide marine pollution (Uneret *al.*, 2006 and SlcniNovaet *al.*, 2009). Non-enzymatic antioxidants such as α -tocopherol (vitamin E), ascorbic acid (vitamin C) β -carotene (vitamin A), flavonoids (quercetinrutinetc).

Justification

Fish are quite susceptible to Sodium thiosulphate and their continuous exposure to higher concentration of Sodium thiosulphate may reduce the resistance of fish against parasitic infections. In order to reduce the stress of Africa catfish (*C. gariepinus*) during the application of Sodium thiosulphate into the water body, the usage of this chemical must be minimal is because excess of Sodium thiosulphate in the water can lead to pollution of the aquatic body and inhibit enzyme activities. (Dorn *et al.*, 1997) and cause oxygen stress, thereby causing various ecophysiological disorders in fish and other aquatic fauna (Bakirel *et al.* 2005; Saxena *et al.* 2005). Therefore, this study was initiated to give baseline information on the toxicity of Sodium thiosulphate to *C. gariepinus* juveniles in order to know how to apply the chemical in water, being discharged to surface water body.

Objective of the Study

The specific objectives of the study are to identify the physiological changes in *C. gariepinus* juveniles exposed to different concentrations of Sodium thiosulphate after 96 h exposure and determine the LC₅₀ of Sodium thiosulphate on *C. gariepinus* juveniles;

Material and Methods

Experimental Fish

Three hundred (300) healthy unsexed *Clarias gariepinus* juveniles (18.29± 1.00g) were purchased from the Federal University of Technology (FUTA) Fish Farm and transported to the Department of Fisheries and Aquaculture laboratory for the experiment. The *C. gariepinus* juveniles were acclimatized in the laboratory conditions for 72 hours prior to the commencement of the experiment using plastic tanks (47cm x33cmx33cm) filled with 10 litres of clean fresh water. The fishes were not fed for 72 hours prior to the commencement of the experiment in order to avoid possible pollution of water as a result of metabolic waste discharge from the fish, so as to reduce production of ammonia from the fish.

Experimental Design

Twelve plastic tanks were used. The plastic tanks were washed thoroughly and then filled with 10 litres of water. All the plastic tanks were labelled. The *C. gariepinus* juveniles were weighed with electronic scale (Mettler Toledo PB8001) and distributed randomly in duplicate treatments. 10 juveniles per tank were so distributed.

Collection of Sodium Thiosulphate

The Sodium thiosulphate with batch Number 00011 was purchased from Matadon Dafon Pharmaceutical Company, Akure and was stored in a cool dry place before the commencement of the experiment.

Range-finding Test

The range finding test was carried out to determine the toxicity on *C. gariepinus* juveniles to serve as preliminary test to determine the level of Sodium thiosulphate to be used in a definitive test. For the range finding test, a control and five test treatments in duplicates were used. The control and five test concentration in duplicates of 200 g, 250 g, 300 g, 350g, and 400g of Sodium thiosulphate per 10L of water were used. The *C. gariepinus* were stocked in each plastic tank for 72 hours prior to the introduction of the Sodium thiosulphate to the water from each tank. The range finding test lasted for 96 hours and observations were made at three to four hours interval. The reaction of the fish were monitored and recorded.

Definitive Test

The result obtained from the range finding test provides a guide for the concentrations to be used in definitive test. Five varying concentrations of Sodium thiosulphate representing five treatments in duplicates and a control were administered to *C. gariepinus* juveniles (10 per each treatment). The concentrations of Sodium thiosulphate used were 12g, 14g, 16g, 18g, and 20g per 1L of water in experimental plastic tanks.

Dissolution of Sodium Thiosulphate

Sodium thiosulphate was completely dissolved in a litter of water and later mixing up with the 9L left in the experimental plastic tank and there were treatments A, B, C, D and E each in duplicates, while treatment F serves as the control.

Distribution of *C. gariepinus* Juveniles

Ten (10) *C. gariepinus* juveniles were introduced into each of the experimental plastic tanks. The duration of the experiment was 96 hours.

Fish Behaviour

The behavioural activities of *C. gariepinus* juveniles after exposure to different concentrations of *Sodium thiosulphate* were critically observed. The number of dead fishes in each concentration was counted after 24 hours; mortality rate was the criteria used for assessing the toxicity.

Water Parameter Determination

The p^H, dissolved oxygen, temperature and conductivities were determined, and their readings were recorded every 24 hours until 96 hours (duration of the experiment) using methods described by APHA (1989).

The pH readings of both the treatments and control solution were measured using a pH MVC2602 dipping the electrode into each solution and the readings were recorded.

Dissolved Oxygen

Oxygen levels of both the treatment and control solution were measured using oxygen meter YS1550DO by inserting the electrode into each solution for about five minutes and the readings were recorded.

Temperature

The temperature was measured using temperature meter YS1550DO. The thermometer was calibrated in °C and dipped into the solution for five minutes to achieve a stable reading before it was recorded.

Conductivity

The conductivity of both the treatment and control solution were measured using the conductivity meter by dipping the electrode into the solutions for five minutes in order to achieve a stable reading before it was recorded.

Weighing of Experimental Fish

Average weight of fish was determined immediately after acclimatization using an electronic meter balance (Model Ja-410).

Biological Data

In the course of the experiment, some observations were also made, apart from monitoring and recording fish mortality. They were recorded in the test; changes in behaviour, erratic swimming, and loss of reflex.

Statistical Analysis

Results obtained were subjected to one way analysis of variance (ANOVA) and New Duncan's Multiple range Test was used to separate means using statistical Package for Social Sciences (SPSS) version 13.0.

Results

Fish response to sodium thiosulphate during the range-finding test

During the range finding tests, *C. gariepinus* juveniles exposed to different test concentrations displayed certain physiological responses in different levels of concentrations Sodium thiosulphate. The introduction of Sodium thiosulphate caused abnormal body

movement being displayed as the level of tolerance of *C. gariepinus* juveniles was exceeded in each treatment of the test concentration: the physiological changes noticed was based on different concentrations of Sodium thiosulphate.

The physiological effects of Sodium thiosulphate concentrations on the *C. gariepinus* juveniles noticed during the range-finding test were summarised in (Table 1). The result showed a sharp response of erratic swimming, insensitivity to external stimuli, rapid opercula movements and, at a point, all the juveniles settled at the bottom of the experimental tank.

The abnormal behaviour physically noticed in the response of *C. gariepinus* juveniles to different treatments of Sodium thiosulphate increases with increasing concentration (Table 3.1). It was also revealed from the results that the time taken by the juveniles to die with the Sodium thiosulphate ranges from 5–48hrs. At higher concentration of Sodium thiosulphate (200–400g), the effects are higher, decreasing progressively at lower concentration of Sodium thiosulphate. Total mortality (i.e. 100%) was recorded within 5hrs at the highest concentration (400g), there was total mortality within 48hrs at the lowest concentration (200g), (Table 1). There was no discoloration or deformity noticed on the body of the fish exposed to varying test concentrations of Sodium thiosulphate when compared with the control treatment (Table 1).

Table 1: Body Physiology of *Clarias gariepinus* Juveniles Exposed to Varying Concentrations of Sodium thiosulphate in the Range Finding Test

Concentration of Sodium Thiosulphate (G)	Control Treatment 0.0	200	250	300	350	400
Change in behaviours	—	+	+	+	+	+
Hyperventilation	—	+	+	+	+	+
Erratic Swimming	—	+	+	+	+	+
Loss reflex	—	+	+	+	+	+
Percentage of Mortality	—	100%	100%	100%	100%	100%
Discoloration Deformity	—	—	—	—	—	—

Key

+ = Indicates presence of particular observation with increase concentration

— = Indicates absence of any physical observation with increase concentration

Observation of *Clarias gariepinus* juveniles exposed to sodium thiosulphate concentrations in definitive test

The result obtained from the definitive test revealed that *C. gariepinus* exposed to Sodium thiosulphate at different concentrations changes in opercula rate, insensitivity to external stimuli, erratic swimming, change in behaviour, and discoloration. The death of the fish was confirmed by their floating or failure to respond to prodding even when touched with a pair of forceps. The numbers of such fish specimens were two fish per each plastic tank and removed from the test media to prevent contamination of the whole media and kept in deep freezer for the analysis.

Table 2 shows the number of *C. gariepinus* juveniles that died within 96hours at different concentrations: (12g, 14g, 16g, 18g and 20g). The LC₅₀ 96hours was 18g/1L that is

the value that shows 50% mortality of test organisms within the experimental period of 96 hours at concentration was 18g/1L.

Table 2. Effects of Sodium thiosulphate on the Body Physiology and Behaviour of *Clariasgariepinus* Juveniles Exposed to Various Concentrations in the Definitive Test

Hours	24 hours						48 hours						72 hours						96 hours					
Concentration of Sodium Thiosulphate (G)	00, 120, 140, 160, 180, 200						00, 120, 140, 160, 180, 200						00, 120, 140, 160, 180, 200						00, 120, 140, 160, 180, 200					
Insensitivity to External Stimuli	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+
Rapid Opercular Movements	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+
Erratic Swimming	-	-	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+
Discoloration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Change in Behaviour	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+

⁺ Indicates presence of particular observation

⁻ Indicates absence of physical observation

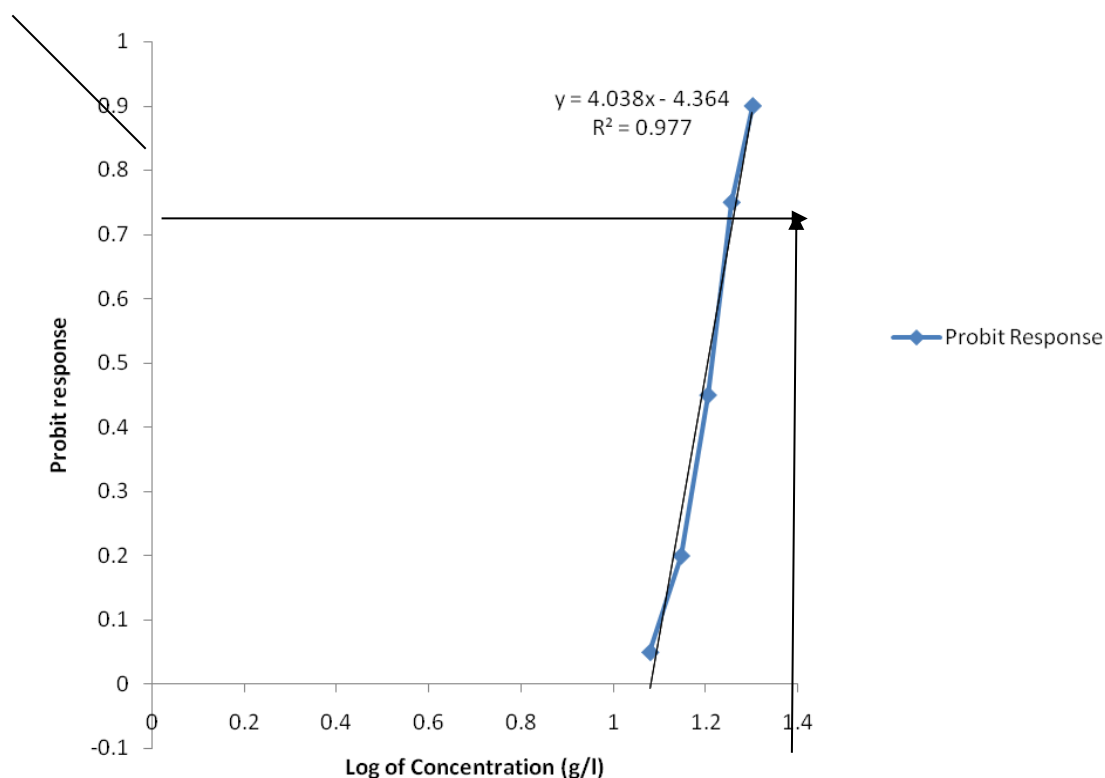


Figure 1: 96 Hours LC_{50} of *Clarias gariepinus* juveniles exposed to different concentration of Sodium thiosulphate.

Toxicity

The 96hours LC_{50} values obtained for fish exposed to sodium thiosulphate are presented in fig 3.1. The result showed the effect of sodium thiosulphate, as a toxicant, on mortality of *C. gariepinus* juveniles for a period of 96hours. It was observed that total mortality(100%) occurred at the highest concentration (20g/1L), no mortality at concentration 12g/1L and the control tank while partial mortality occurred at other concentrations (14g/1L=30%, 16g/1L=40%, 18g/1L (1.26g/l)=50% and 20g/1L=100%). The 96hours LC_{50} value was obtained at 18g/1L (1.26g/l) concentration. The values are shown bellow in (table 3)

Table 3: Mortality and Survival Level of Juveniles in Treatment

Cell Counts and Residuals							
	Number	Concentrations	Number of Subjects	Observed Responses	Expected Responses	Residual	Probability
PROBIT	1	12.000	10	0	.417	-.417	.042
	2	14.000	10	3	1.638	1.362	.164
	3	16.000	10	4	4.104	-.104	.410
	4	18.000	10	5	7.005	-2.005	.701
	5	20.000	10	10	8.994	1.006	.899
	6	.000	10	0	.000	.000	.000

Water Quality Parameters

The mean values obtained for the water quality parameter of the test media throughout the period of the experiments. The p^H (7.21-7.00), temperature (26.0-26.1°C), dissolved oxygen (5.05-6.19mg/L) and conductivity (244.00-570.00cm³) showed slight fluctuation value throughout the experiment. All the values are presented in Table 4.

Temperature

A slight variation occurs in the temperature (26.0-26.1°C) as the concentration of sodium thiosulphate increases. After 96hours of the experiment, the significant difference has no effect on the temperature from the control to the highest concentration (Table 4).

Dissolved Oxygen

A little change occurs in the dissolved oxygen (5.05-6.19mg/l) decreases value across the treatment with increase concentration value (5.05-6.19mg/l) of the toxicant when compared to control value (4.60-5.07mg/l) After 96hours of the experiment, the significant difference has no effect on the dissolved oxygen from the control to the highest concentration as shown in Table 4.

pH

Variation occurs in the pH (7.00-7.21) as the concentration of sodium thiosulphate increases. After 96hours of the experiment, there was a significant difference in the pH (6.26-6.59) from the control to the highest concentration. The figures were showing in (table 4).

Conductivity

As the concentration of *sodium thiosulphate* used increased, variation occur in the conductivity. After 96hours of the experiment, there was a significant difference in the conductivity from the control (18.61-19.50/cm³) to the highest concentration (244.00-570.00/cm³) as shown in Table 4.

Table 4: Water Quality Parameters of the Water Obtained during Exposure of *Clarias gariepinus* Juveniles to Different Concentration of Sodium thiosulphate during 96hrs Experiment

Period of Exposure	Parameters	Controls	12g/1L	14g/1L	16g/1L	18g/1L	20g/1L
00hours	DO (mg/L)	4.60±0.04	4.76±0.02	5.02±0.03	5.20±0.03	4.84±0.40	5.07±0.06
	Temp (°C)	27.6±0.2	27.5±0.1	27.1±0.02	27.1±0.05	26.9±0.02	26.9±0.00
	pH	6.26±0.02	6.26±0.02	6.33±0.02	6.33±0.20	6.34±0.04	6.59±0.06
	Conductivity	19.50±0.04	19.80±0.07	19.47±0.04	19.47±7.50	19.36±0.05	18.61±0.01
24hours	DO (mg/L)	9.20±0.07	8.58±0.04	8.41±0.03	8.48±0.00	8.26±0.00	8.15±0.03
	Temp (°C)	26.3±0.01	26.4±0.10	26.4±0.02	26.4±0.03	26.4±0.00	26.2±0.30
	pH	6.86±0.23	6.47±0.03	6.60±0.01	6.67±0.04	6.69±0.02	6.79±0.02
	Conductivity	213.50±2.50	313.00±0.20	318.00±0.10	340.50±1.50	344.00±0.60	394.00±0.04
48hours	DO (mg/L)	6.87±0.06	6.44±0.01	6.13±0.05	5.95±0.06	5.83±0.03	5.72±0.40
	Temp (°C)	26.5±0.00	26.8±0.04	26.8±0.23	27.0±0.02	26.9±21.00	26.8±0.03
	pH	4.56±0.29	7.13±0.03	7.19±2.50	7.20±0.02	7.60±0.05	7.72±0.02
	Conductivity	225.50±11.50	401.50±0.04	405.50±0.06	438.00±0.00	467.00±0.27	552.00±0.01
72hours	DO (mg/L)	6.50±0.02	6.19±0.05	6.10±0.00	5.83±0.01	5.57±0.04	5.17±0.02
	Temp (°C)	26.42±0.01	26.70±0.06	26.8±0.29	26.68±0.05	26.67±0.03	26.66±0.08
	pH	7.21±0.08	7.19±0.07	7.16±0.02	7.20±0.06	7.24±0.02	7.19±3.00
	Conductivity	231.50±11.50	414.50±0.08	404.50±0.01	445.50±0.07	480.00±0.10	564.00±0.16
96hours	DO (mg/L)	6.19±0.04	5.97±0.03	5.81±0.08	5.77±0.07	5.47±0.08	5.05±0.00
	Temp (°C)	26.1±0.05	25.9±0.02	26.0±0.04	25.9±0.01	25.9±0.03	26.0±0.02
	pH	7.21±0.21	7.20±0.10	7.18±0.05	7.13±0.20	7.09±0.07	7.00±0.03
	Conductivity	244.00±7.00	422.00±0.20	418.00±0.21	453.00±0.03	484.50±6.00	570.00±0.60

Mean ± SE

Discussion

Behavioural Changes

Stressful behaviours of exposed *C. gariepinus* juveniles such as hyperventilation, regular visit to the surface to gulp in air, restlessness, erratic swimming, convulsion, loss of reflex and lastly death in this study agrees with the finding of Omitoyin *et al.* (2006) who exposed *C. gariepinus* juveniles to grammahyachloxcyclohexane, and Chindah *et al* (2004) who exposed *Cyprinionwatsoni* to copper. Hypersensitivity is considered as a primary and principal sign of nervous system failure due to pesticide poisoning which affect physiological and biological activities Matsumura, (1975). Furthermore, this agrees with Akinbulumo (2004) who reported that *C. gariepinus* juveniles exposed to synthetic anaesthesia exhibited loss of reflex and moulting discoloration.

Physico-chemical Parameter of Water

The physico-chemical parameters of the test solutions that fluctuated slightly during the bioassays, although, it did not affect fish mortality, since they were above the acceptable range (4.67-5.07 mg/l for dissolved oxygen, 26.1-26.0°C for temperature, 7.21-7.00 for pH and 244-570 cm³ for conductivity) recommended for rearing and culture of most tropical fishes, including the African catfish and this could be due to the environmental changes during the experimental period, and this must be within tolerance range as suggested by Mackereth (1963). The Sodium thiosulphate with the higher concentration in the water body will be toxicant to hinder the fish from utilizing the available oxygen in their environment. This agrees with Thomas and Rice (2005) who suggested that increased opercula movement may be caused by decreased efficiency in oxygen uptake or transport; thus, the rapid opercula movement displayed by *C. gariepinus* juveniles in this study is an indication of reduced oxygen uptake.

Toxicity

The study was to determine the toxicity of Sodium thiosulphate on *C. gariepinus* juveniles. LC₅₀ value obtained for the test was 18g/1L. Several toxicity levels for different toxicants were reported by different authors. 4.57% was reported as the 96h LC₅₀ of petroleum refinery effluent to *Chironomus tetanus* (Chronomid larvae) by Pagenkof (1983). The results obtained from this study established a limit (not exceeding 18g/1L) on the usage of sodium thiosulphate in aquatic environment, in other to remove or reduced the ammonia, chlorine and Iodine.

Conclusion

The higher the concentrations of Sodium thiosulphate in to the water bodies increasing health hazard and then the environmental pollution will occur.

The 96 -hr LC₅₀ of Sodium thiosulphate administered to *C. gariepinus* juveniles in water was 18g/1L. Such stressors may prevent the fish from growing to its maximum size, expected in a conducive and stress-free environment. The Sodium thiosulphate is therefore capable of reducing or removing the ammonia and chlorine from the water bodies. The result showed that the higher concentrations of the Sodium thiosulphate may be toxic to aquatic organisms depending on the concentration of Sodium thiosulphate dissolved in water bodies.

Recommendation

The Sodium thiosulphate were used to treat water which are toxic to the fish but with this research showed that with the addition of Sodium thiosulphate, the fish farmer can reduce

the quantity required for rearing fish and not to make the use of the water inevitable for farmers

References

- Amoregie, E., Ufodike, E. B. C., Onwuliri, C. O. E. and Bullock et al. (1997). Effects of water soluble fractions of crude oil on carbohydrate reserves of *Oreochromis niloticus* (L). *Journal of Aquatic Sciences*, 2; 1-7.
- Bouck, G. and Summer Felt et al. (1997). Water quality considerations and criteria for high-density fish culture with supplemental oxygen. America Fisheries Society Bethesda M. O. pp. 372-385.
- Chindah, A. C.; F. D. Sikoki, and I. Vincent-Akpu, (2004): Toxicity of an organophosphate pesticide (Chlorpyrifos) on a common Niger Delta wetland fish – *Tilapia guineensis* (Blecker 1862): J. A. ppl. Sci. Environ. Mgt., 8(2): 11 – 17.
- Department of Petroleum Resources (DPR) (2002): Environmental guideline and standards for the petroleum industries in Nigeria (EGASPIN) Revised Edition. pp203-210
- European Parliament Regulation (EC) No 648 2004 of the European Parliament and of the Council of 31 March, 2004 on *Sodium thiosulphate*. EC No 684 /2004, in officiate *Journal of the European Union*, 08 April 2004. pp75-80.
- Fagbenro, O.A (2002): Tilapia: fish for thought. Inaugural Lecture Series 32, delivered at Federal University of Technology Akure. 77pp.
- Fagbenro .O.A. and S.J. Davies (2002): Use of soyabeem flour (dehulled) so went-extracted soyabeen) as a fishmeal substitute in practical diet for African catfish. *C.gariepinus* (Burchell 1822): Growth, Feed utilisation and digestibility. *Journal of Applied Technology* 1764-69.
- Fisher-Scheri, M. (1991): Manual of Tropical Veterinary Parasitology. CAB International, Wolling Ford, Oxon UK. 473.
- Mackereth, F. J. H. (1963): Some methods of water analysis for Limnologists. *Freshwater Biological Association Publication* No. 21. 70 pp.
- Matsumura, F. (1975): Toxicology of insecticides. 2nd Edn. Plenum Press NY. pp. 503.
- Omitoyin, B. O. E. K.; Ajani, B. T.; Adesina; C. N. F.; Okuagu, and Uneret *al.* (2006): Toxicity of lindane (gamma hexachlorocyclohexane) to *Clarias gariepinus* (Burchell 1822): W. J. Zool; 1:57 63.
- Safriel, O. and Bruton, M.N. (1984): A cooperative aquaculture research programme for South Africa. South African National Scientific programmes Report 89. CSIR, Pretoria, pp79.
- Saxena, P. S.; Sharman, V.; Suryavathi, R.; Griver, P.; Soni, S.; Kumar and Sharma, K. P. (2005): Effect of an acute and chronic toxicity of sodium thiosulphate on the freshwater fish, *Gambusia affris* J. *Environ. Biol.*, 47, 119 – 124.
- Thomas, A.A. and Rice, B.A. (2005): “Increase Opercula Rates of pink Salmon (*Onchorynchus gorbuscha*) Fry after Exposure to the Water Soluble Fraction of Prudhoe Bay Crude Oil”, *Journal of Fish Resources Board Canada*, pp. 2221-24
- United State Environmental Protection Agency-USEPA (1985): Drinking water criteria document for sodium thiosulphate (final draft). Environmental criteria and Assessment office. Climannati, off: Environmental Protection Agency, EPA 600/x-84/190-1. pp 220-230.