FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 11, June, 2026, pp 94 – 102
DOI: https://doi.org/10.33003/fjs-2026-1011-5073

Evaluation of Toxicity of Three Car Wash Detergents (Morning Fresh, Mama Lemon and 2Sure) on Catfish (*Clariasgariepinus Juveniles)* Using ANOVA and Survival Analysis

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Received: 22 Jan. 2026
Accepted: 12 Feb. 2026
Published: 10 July 2026

ABSTRACT
This study evaluated the acute toxicity of three commonly used liquid detergents—Morning Fresh, 2-Sure, and Mama Lemon—on juveniles of *Clariasgariepinus* over a 96-hour exposure period. A static bioassay method with graded concentrations (0.015625–0.5%) was employed, and mortality responses were analyzed using descriptive statistics, survival curves, and one-way ANOVA at $\alpha = 0.05$. Results showed a clear concentration-dependent decline in fish survival across all detergents, with higher concentrations producing faster mortality rates. Survival curve analysis indicated that 0.5% concentration had the lowest LT50 (16 h) and LT90(~86 h), while lower concentrations did not reach LT90 within 96 hours. However, ANOVA results across all replicates and detergents consistently showed no statistically significant difference between group means ($p = 0.176 > 0.05$; F <Fcrit). Despite the lack of statistical significance, observable biological effects indicate that detergent effluents pose ecological risks to aquatic organisms. The study highlights the need for regulation of detergent discharge into aquatic systems and recommends further toxicological evaluation using more sensitive analytical methods.

Keywords: Acute Toxicity, Detergents, Surfactants, *Clariasgariepinus*, Bioassay, Aquatic Pollution

INTRODUCTION

Surfactants are synthetic organic chemicals used in detergents, personal care and household cleaning. These compounds usually comprise 10%-18% of granular and liquid detergents and are the largest ingredient of the 20-25 compounds used in these products (Richtler and Knaut, 1988).

Morning fresh, Mama lemon and 2sure are liquid detergent used mostly by road side carwash. In Owerri, the Imo State capital and many other Nigerian cities and the hinterlands, the establishment of car wash outfits are now on the increase probably because of paucity of white-collar jobs amongst our youths. The effluents (waste water) from these car wash outfits empty into water bodies in their proximity via gutters and urban drains and thus, could pollute them in especially, Sub-Saharan Africa where there are little or no prohibitions for violators. Liquid detergents are known to reduce surface tension in water and allow aqueous solutions to spread and penetrate more easily. Unfortunately, these same characteristics could adversely affect aquatic lives such as altering the properties of a fish's gills. According to Ndu (2004), such alterations could change the fish's normal uptake of ions from the water. Toxic effects of any pollutant must certainly come into play once their safe limits are exceeded irrespective of intention, source or mode of the pollutant's entry into the water medium. Even non-target organisms can be affected (Wan, 1989a; Wan *et al*; 1994a). The dose is the primary determinant of the safety of a substance. Therefore it is the dose, not the substance itself, which makes the substance poisonous (Klein, 1996).

Morning fresh, Mama Lemon and 2sure effluents from car wash outlets in and around Owerri and other cities in Nigeria ultimately enter into nearby water bodies through gutters and urban drains and thus, could pollute them. Water bodies being the main habitat for Catfish (*Clariasgariepinus*) have been inundated with different kinds of liquid detergent effluents whose toxicities are yet to be ascertained. It is known that inorganic pollutants could exert unfavorable effects on aquatic biota, and these liquid detergent wastes may not be exceptions. The effects of inorganics on resident aquatic organisms range from altering fish's gill, through tainting of the fish's body to bioaccumulation of the toxicant in fish tissues, among others. Nonetheless, these liquid detergents wastes continue to be generated and introduced into the medium, especially in the face of an ever-increasing human populations and infrastructural development in the city. Unfortunately, the possible toxic effects of these inorganic pollutions have not been investigated in our local environment, against its increasing use and increasing introduction of newer brands by manufacturers. The many harmful domestic, agricultural, scientific, and industrial products and wastes generated by man, finding their ways into our delicate environment could ultimately enter our body systems or those of our plants and animals as xenobiotic. These toxicants are capable of causing us health and other related problems. Bioassay tests could be conducted well on time to determine the potency of these xenobiotic ever before they are introduced into the market or to permit their continual distribution to the population or releases to the environment. Findings from this research could therefore be of public health relevance to both individual and corporate stakeholders. This research therefore is an attempt to close this gap in knowledge through evaluation of the toxicity of three commonly used car warsh detergents (*morning fresh, mama lemon and 2sure*) on the catfish (*clariasgariepinus)* juveniles in Owerri, Imo state, Nigeria.

MATERIALS AND METHODS

Study Area

The study Area is Owerri, Imo State; South Eastern Nigeria. It lies within latitudes 5^0 22' and $5^0$39' and longitudes 6^0 08' and $06^0$41'

Acquisition and Acclimation of Fish Specimen

Healthy specimens of the African catfish, *Clariasgariepinus* of mixed sex and brood stock (mean weight= 9.42 ± 0.2g and mean length= 6.30 ± 0.1cm) were purchased from a fish farm in Owerri, Imo State, Nigeria.

The choice of *Clariasgariepinus* was made because of its ability to withstand stress and its high commercial value in Imo State in particular and Nigeria in general. They were thereafter transported to serene private apartment at Awaka, Owerri North LGA where they were kept in a large plastic bowl of about 140 litres capacity containing 70litres of clean borehole water. They were maintained in the Apartment for a minimum period of two weeks for acclimation during which period they were fed 3 times daily morning, afternoon and night with commercial fish pellets. Three-quarters of the water were changed every morning at feeding time to reduce constant dirt as a result of the feed pellets and the fish feces. However, feeding were discontinued 24 hours before commencement of definitive experiment.

Determination of Physicochemical Properties of Diluents Water

The temperature, Dissolved Oxygen (DO) and pH of experimental water were continuously determined *in-situ* with a pre-calibrated HANNA HI 9828 P^H/ORP/EC/DO meter.

Active Ingredients in Toxicants

Car wash detergents essentially contain linear alkylbenzene sulphonates and fragrance formulations. The specific chemical compositions of the toxicants used in this study are shown in Table 1.

Table 1: Chemical Compositions of the Three (3) Car Wash Detergents Used as Toxicant in 96-Hours Bioassay

Car wash Detergents		
2surefresh	**Morning Fresh**	**Mama Lemon**
Aqua, linear Alkyl benzene sulfonate (LABS), Sodium Laureate, sulfate, magnesium sulfate, glycerine, perfumes, Disodium EDTA, methyl dibromoGlutaronitrile	water, Sodium, Laureth, Sulphate, Cocamidoprophyl, Betaine, Xylenesulfonate, Poloxamer, 188, Fragrance, Tetrasodium, EDTA, DMDM, Hydrantoin, Methylchloroisothiazolinone, Methylisothiazolinone, CI59040, CI42090.	Sodium Benzoate, EDTA-2NA, Kathon CGSLES-260, P-77 Surfactant, NA2S04, and Lemon Fragrance.

Range-Finding Test

Ten fish of approximately same sizes were distributed randomly into each of 5 plastic aquaria containing 70litres of water. Graded concentrations (5,4,3,2and 1%) of each of the toxicants (2sure, mama lemon and morning fresh) were serially added to the aquaria and the set-ups allowed to stand for 96 hours. Observations for death of fish would be made after 1, 2, 4,8,16,24,48,72, and 96 hours.

Definitive 96-hour Static Bioassay

Definitive graded concentrations of 0.5, 0.25, 0.125, 0.0625, 0.03125, 0.015625 and 0.00% (control) for each toxicant were constituted in 6 aquaria containing 70 litres of diluents water. Twelve fish specimens were added to each of the aquarium. Replicate aquaria were also established and the set-up observed for mortalities after 1, 2, 4, 8, 16, 24, 72 and 96 hours.

Death were ascertained when fish did not react to gentle poke with a glass rod and were immediately removed to avoid decay and contamination. Loss of equilibrium, vigorous movement of gulping of air and other behavioral patterns were also observed for fish in each plastic aquaria.

The tes fish were not fed to avoid remnants of uneaten food from contaminating the water thereby increasing mortality rates.

Statistical Analysis

The median lethal concentration (LC50) values of the toxicants were determined using arithmetic, logarithmic, and probit analytical methods. One-way Analysis of Variance (ANOVA) was employed to examine whether significant differences existed among the mean survival rates of fish exposed to the various concentrations of the toxicants. Where significant variations occurred, post-hoc mean plots were used to identify the pattern of differences between treatment groups at a significance level of $P < 0.05$. In addition, pair wise comparisons between survival rates at different toxicant concentrations were carried out using the Student's t-test at a 95% confidence interval.

ANOVA Calculation

i. *Summary Table:*

For each group. For column 1 and Column 2. Count, n = number of observations. Sum, $\sum x$, Average (Mean) $\bar{\bar{X}} = \frac{\sum x}{n}$, and Variance, $S^2 = \frac{\sum_{n=1}^{n}(x_i - \bar{\bar{X}})}{n-1}$

Table 2: Summary Table

Central Tendency	Count n	Sum $\sum$	Average $\bar{\bar{X}}$	Variance S^2
Column 1	n	$\sum x$	$\bar{\bar{X}} = \frac{\sum x}{n}$	$S^2 = \frac{\sum_{n=1}^{n}(x_i - \bar{\bar{X}})}{n-1}$
Column 2	n	$\sum x$	$\bar{\bar{X}} = \frac{\sum x}{n}$	$S^2 = \frac{\sum_{n=1}^{n}(x_i - \bar{\bar{X}})}{n-1}$

ii. ANOVA Calculation

Assumes, *Group 1 -→$n_1, \bar{\bar{X}}_1$ and *Group 2 --→$n_2, \bar{\bar{X}}_2$, *while* *Total Observation -→$N = n_1 + n_2$

Step 1: Grand Mean, $X_G = \frac{\sum X_1 + \sum X_2}{N}$

Step 2: Sum of Square SS

a. Between Groups SS_B, $S_B = n_1(X_1 - X_G)^2 + n_2(X_2 - X_G)^2$

b. Within Group SS_W, $SS_W = (X_1 - X_1)^2 + (X_2 - X_2)^2$
Or You can also use variance shortcut,
$SS_W = (n_1 - 1)S_1^2 + (n_2 - 1)$

c. Total Sum of Square, $SS_T = SS_B + SS_W$

Step 3: Degrees of Freedom Df

*Between Groups, $df_B = k - 1$

- Within Groups, $df_W = N - k$
- Total, $df_T = N - 1$

Step 4: Mean Squares MS

*Between Groups, $MS_B = \frac{SS_B}{df_B}$

* Within Groups, $MS_W = \frac{SS_W}{df_W}$

Step 5: F-Statistic, $F = \frac{MS_B}{MS_W}$

Step 6: P-Value

- Obtained from F-distribution table or Software using. $F(df_B, df_W)$

Step 7: F-critical (F_{Crit})

- From F-table at chosen significance level (Usually $\alpha = 0.05$)

Table 3: Final ANOVA Table Format

Source	SS	df	MS	F	P-Value	F-Crit
Between Groups	SS_B	df_B	MS_B	F	0.176	4.13
Within Groups	SS_W	df_W	MS_W	F		
Total	SS_T	df_T				

RESULTS AND DISCUSSION

Results of Fish Response

The response of fish exposed to different concentrations of the toxic liquid soaps was monitored under a mean room temperature of 24.3 ± 0.2°C throughout the experimental period.

The toxicants used in this study were:

i. Morning Fresh Liquid Soap
ii. 2-Sure Liquid Soap
iii. Mama Lemon Liquid Soap

These are commercial brand names, while their chemical compositions are presented in Table 1.

The raw experimental data obtained from the fish responses to Morning Fresh Liquid Soap under different concentrations and replicates are presented in Tables 4, 7, and 8.

Table 4 presents the fish survival response to Morning Fresh Liquid Soap in Replicate 1 across different exposure periods and concentrations.

Table 4: Morning Fresh Liquid Soap Replicate 1

Concentration (%)	Time in hours								
	1	2	4	8	16	24	48	72	96
0.5	12	12	8	7	6	5	4	3	0
0.25	12	12	9	8	7	6	5	3	1
0.125	12	12	10	9	8	7	6	5	2
0.0625	12	12	10	9	9	8	8	5	3
0.03125	12	12	11	10	8	8	7	6	4
0.015625	12	12	12	10	9	8	7	6	5
Control	12	12	12	12	12	12	12	12	12

The results indicate that fish mortality increased with increasing concentration and exposure time. The highest concentration (0.5%) produced the fastest decline in fish survival, while lower concentrations showed relatively slower mortality rates. The control experiment maintained complete survival throughout the 96-hour period, indicating that mortality observed in the treated groups resulted from the toxic effect of the soap.

Table 5 presents the summary statistics for Morning Fresh Liquid Soap Replicate 1. Column 1 recorded a mean survival value of 6.67 with a variance of 14.12, while Column 2 recorded a higher mean value of 8.22 and a lower variance of 8.65. This suggests that fish survival was more stable in Column 2 compared to Column 1.

Table 5: Morning Fresh Liquid Soap Replicate 1 Summary Table

Central Tendency	Count n	Sum $\sum$	Average $\bar{X}$	Variance S^2
Column 1	18	120	6.67	14.12
Column 2	18	148	8.22	8.65

Step by Step ANOVA Calculation

Step 1: Grand Mean

$\bar{\bar{X}}_G = \frac{120 + 148}{36} = 7.44$

Step 2: Sum of Squares

Between Groups SSB

$SS_B = 18(6.67 - 7.44)^2 + 18(8.22 - 7.44)^2$

$SS_B = 18(0.5929) + 18(0.6084) = 21.78$

Within Groups (SSW)

$SS_w = (18\text{-}1)(14.12) + (18\text{-}1)(8.65)$

$SS_w = 17(14.12) + 17(8.65)$

$SS_w = 240.04 + 147.07 = 387.11$

Total SST

$SS_T = SS_B + SS_W = 21.78 + 387.11 = 408.80$

Step 3: Degrees of Freedom

Between

$df_B = 1$

Within

$df_w = 36 - 2 = 34$

Total

$df_r = 35$

Step 4: Mean Squares

Between

$MS_B = \frac{21.78}{1} = 21.78$

Within

$MS_W = \frac{387.11}{34} = 11.39$

Step 5: F-Statistic

$F = \frac{21.78}{11.39} = 1.91$

Step 6: P-Value

P = -.176

Step 7: F-Critical (α = 0.05)

F_{Crit} = 4.13

Table 6: Final ANOVA Table

Source	SS	df	MS	F	P-Value	F-Crit
Between Groups	21.78	1	21.78	1.91	0.176	4.13
Within Groups	387.11	34	11.39			
Total	408.89	35				

ANOVA Interpretation

The ANOVA analysis conducted for Morning Fresh Liquid Soap Replicate 1 produced an F-value of 1.91, which was less than the critical F-value of 4.13. Similarly, the p-value obtained (0.176) was greater than the significance level of 0.05.

Since: $F = 1.91 < F_{Crit} = 4.13$

$P = 0.176 > 0.05$

This indicates that there was no statistically significant difference between the compared groups.

However, the experiment was conducted in additional second replicate and their raw data responses were shown in Tables 7 and 8.

Table 7: Morning Fresh Liquid Soap Replicate 2

Concentration (%)	Time in hours								
	1	**2**	**4**	**8**	**16**	**24**	**48**	**72**	**96**
0.5	12	12	9	8	7	6	5	3	1
025	12	12	10	9	8	8	7	4	2
0.125	12	12	10	10	9	8	7	5	3
0.0625	12	12	10	10	9	9	8	6	3
0.03125	12	12	11	11	10	9	8	7	4
0.015625	12	12	11	11	11	10	8	7	4
Control	12	12	12	12	12	12	12	12	12

Table 8: Morning Fresh Liquid Soap Replicate 3

Concentration (%)	Time in hours								
	1	**2**	**4**	**8**	**16**	**24**	**48**	**72**	**96**
0.5	12	12	10	9	7	6	5	3	0
025	12	12	11	10	9	8	6	5	2
0.125	12	12	10	9	9	8	8	7	3
0.0625	12	12	11	10	10	9	9	8	4
0.03125	12	12	12	10	10	9	9	7	4
0.015625	12	12	12	11	10	10	9	8	5
Control	12	12	12	12	12	12	12	12	12

In the same vain the experiment of adding toxicants (2-Sure) into fish aquarium was also carried out in replicates 1, 2 and 3 in certain concentrations of 0.5 %, 0.25, 0.125, 0.0625, 0.03125, 0.015625, and 0% (control) respectively. Their responses are shown in tables 9 to 11.

The introduction of different doses of toxicants (2-sure) into the aquarium is as presented in Tables 9 – 11

Table 9: 2-Sure Liquid Soap Replicate 1

Concentration (%)	Time in hours								
	1	**2**	**4**	**8**	**16**	**24**	**48**	**72**	**96**
0.5	12	12	12	12	10	8	6	4	1
025	12	12	12	12	11	9	8	6	2
0.125	12	12	12	12	12	10	9	6	2
0.0625	12	12	12	12	12	12	10	8	3
0.03125	12	12	12	12	12	12	10	8	3
0.015625	12	12	12	12	12	12	11	9	4
Control	12	12	12	12	12	12	12	12	12

Table 10: 2-Sure Liquid Soap Replicate 2

Concentration (%)	Time in hours								
	1	**2**	**4**	**8**	**16**	**24**	**48**	**72**	**96**
0.5	12	12	12	12	12	11	8	5	2
025	12	12	12	10	10	9	8	4	2
0.125	12	12	12	11	10	9	8	5	3
0.0625	12	12	12	12	11	10	9	6	3
0.03125	12	12	12	12	12	12	10	8	3
0.015625	12	12	12	12	12	12	11	10	4
Control	12	12	12	12	12	12	12	12	12

Table 11: 2-Sure Liquid Soap Replicate 3

Concentration (%)	Time in hours								
	1	**2**	**4**	**8**	**16**	**24**	**48**	**72**	**96**
0.5	12	12	12	11	10	8	7	5	1
025	12	12	12	11	11	9	8	7	2
0.125	12	12	12	12	11	10	9	8	4
0.0625	12	12	12	12	12	11	11	8	4
0.03125	12	12	12	12	12	12	11	9	4
0.015625	12	12	12	12	12	12	12	10	5
Control	12	12	12	12	12	12	12	12	12

Finally, In the same vain the experiment of the effecting fish with toxic liquid soap was also carried out with Mana Lemon liquid soap in replicate 1, 2 and 3 in certain concentration of 0.5 %, 0.25, 0.125, 0.0625, 0.03125, 0.015625, and 0% (control).

Different concentrations of toxicant (Mama Lemon) were presented in Tables 12 – 14

Table 12: Mama Lemon Liquid Soap Replicate 1

Concentration (%)	Time in hours								
	1	**2**	**4**	**8**	**16**	**24**	**48**	**72**	**96**
0.5	12	12	12	12	11	10	9	8	3
025	12	12	12	12	12	11	10	8	3
0.125	12	12	12	12	12	12	10	8	4
0.0625	12	12	12	12	12	12	11	10	6
0.03125	12	12	12	12	12	12	11	10	6
0.015625	12	12	12	12	12	12	11	11	7
Control	12	12	12	12	12	12	12	12	12

Table 13: Mama Lemon Liquid Soap Replicate 2

Concentration (%)	Time in hours								
	1	**2**	**4**	**8**	**16**	**24**	**48**	**72**	**96**
0.5	12	12	12	12	10	10	8	6	2
025	12	12	12	12	11	10	9	6	3
0.125	12	12	12	12	12	11	10	7	3
0.0625	12	12	12	12	12	11	11	8	4
0.03125	12	12	12	12	12	12	11	10	6
0.015625	12	12	12	12	12	12	12	11	6
Control	12	12	12	12	12	12	12	12	12

Table 14: Mama Lemon Liquid Soap Replicate 3

Concentration (%)	Time in hours								
	1	**2**	**4**	**8**	**16**	**24**	**48**	**72**	**96**
0.5	12	12	12	11	10	9	8	6	4
025	12	12	12	11	11	10	9	8	4
0.125	12	12	12	12	11	11	10	7	4
0.0625	12	12	12	12	12	11	11	8	5
0.03125	12	12	12	12	12	11	11	9	5
0.015625	12	12	12	12	12	12	11	10	6
Control	12	12	12	12	12	12	12	12	12

Table 15: Summary Table of Analysis of Variance (ANOVA)

S/No	Type of Liquid Soap	Interpretation of ANOVA Results	Remarks/comment
1	MORNING FRESH LIQUID SOAP Replicate 1	F= 2.413 <Fcrit = 4.13, P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2
2	MORNING FRESH LIQUID SOAP Replicate 2	F= 1.85 <Fcrit = 4.13, P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2.
3	MORNING FRESH LIQUID SOAP Replicate 3	F= 2.22 <Fcrit = 4.13, P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2.
4	2-Sure Liquid Soap Replicate 1	F= 1.174 <Fcrit = 4.13, P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2.
5	2-Sure Liquid Soap Replicate 2	F= 0.613 <Fcrit = 4.13: P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2.
6	2-Sure Liquid Soap Replicate 3	F= 2.031 <Fcrit = 4.13, P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2.
7	Mama Lemon LIQUID SOAP, Replicate 1	Since F= 0.8603 <Fcrit = 4.13, P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2.
8	Mama Lemon LIQUID SOAP, Replicate 2	F= 1.221 <Fcrit = 4.13, P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2.
9	Mama Lemon LIQUID SOAP, Replicate 3	F= 1.112 <Fcrit = 4.13, P = 0.176 > 0.05.	There is no significant Difference between column 1 and Column 2.

The ANOVA Summary tables and final ANOVA tables for all soap types and replicates. In all cases, the calculated F-values were lower than the critical F-value (4.13), while the p-values were greater than 0.05. This generally indicates that there were no statistically significant differences among the compared treatment groups at the 95% confidence level.

Graphical Presentation of Fish Response on Different Liquid Soaps

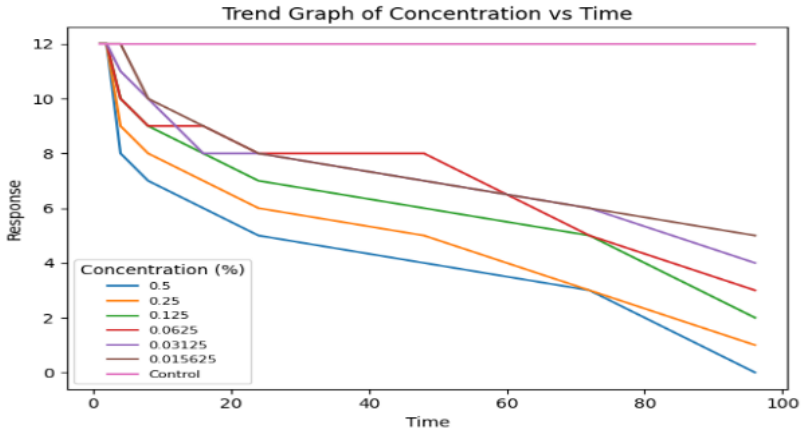

Figure 1: Trend Graph of Fish Response for Morning Fresh Liquid Soap (Replicate 1)

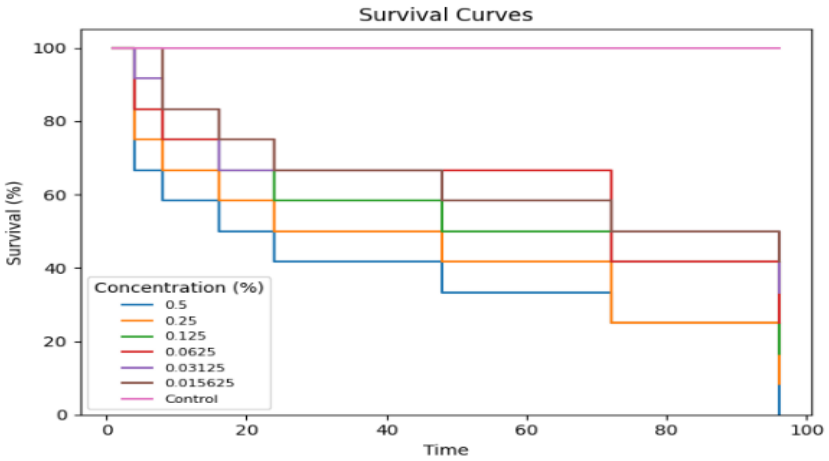

Figure 2: Survival Curve of Fish Response for Morning Fresh Liquid Soap (Replicate 1)

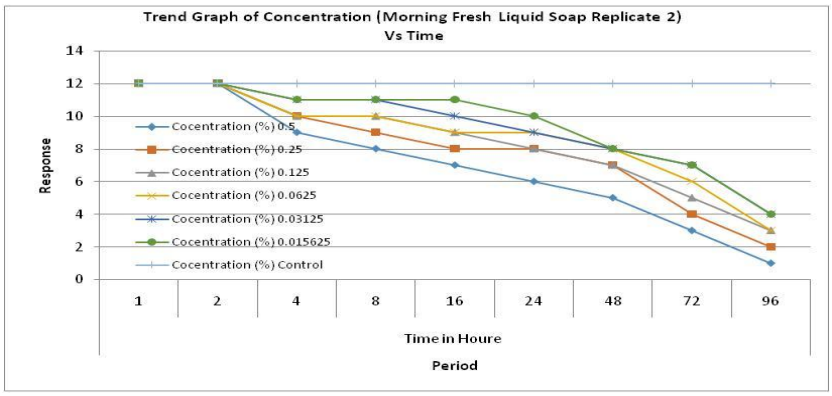

Figure 3: Trend Graph Representation of Fish Survival Response Over Time at Different Concentrations of Morning Fresh Liquid Soap (Replicate 2)

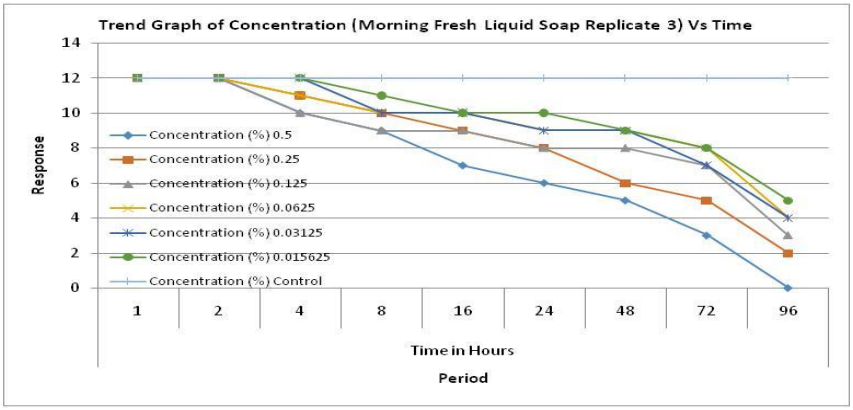

Figure 4: Trend Graph Representation of Fish Survival Response Over Time at Different Concentrations of Morning Fresh Liquid Soap (Replicate 3)

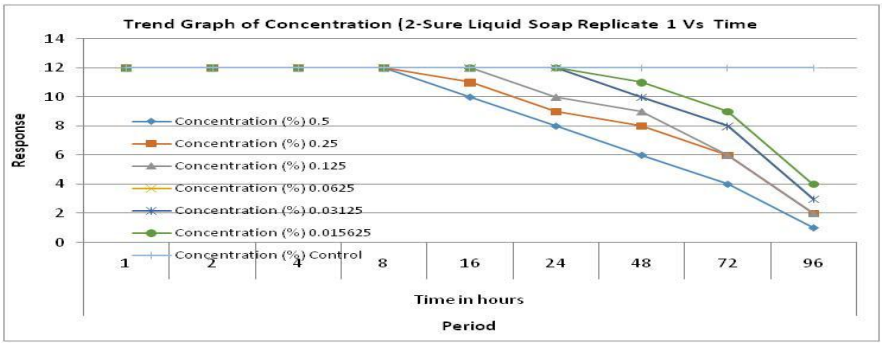

Figure 5: Trend Graph Representation of Fish Survival Response Over Time at Different Concentrations of 2-Sure Liquid Soap (Replicate 1)

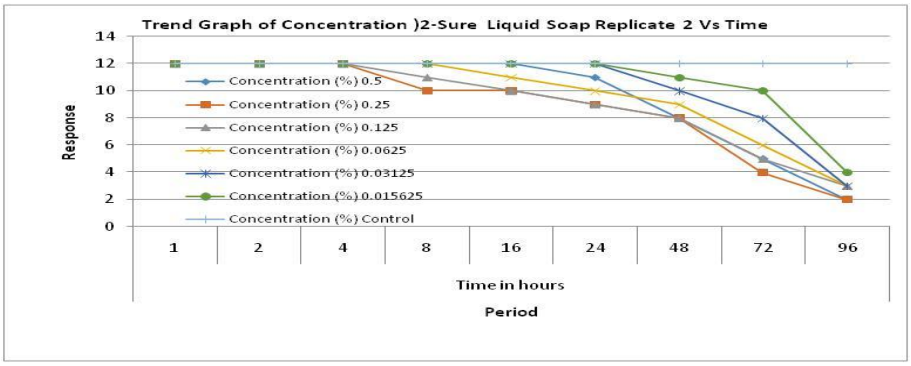

Figure 6: Trend Graph Representation of Fish Survival Response Over Time at Different Concentrations of 2-Sure Liquid Soap (Replicate 2)

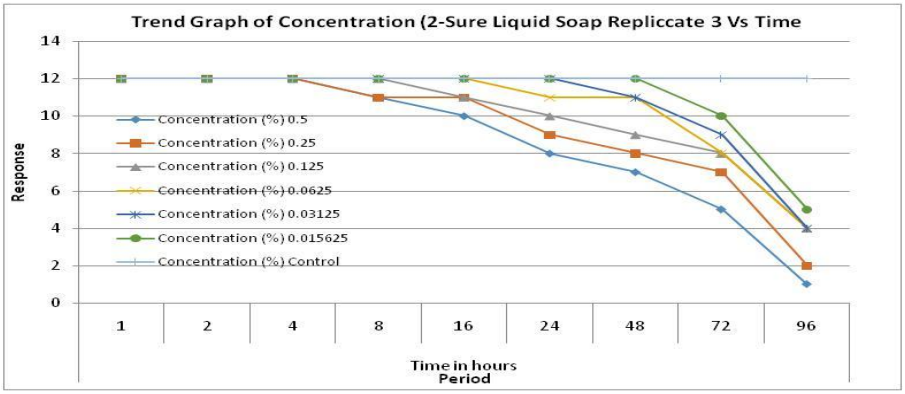

Figure 7: Trend Graph Representation of Fish Survival Response Over Time at Different Concentrations of 2-Sure Liquid Soap (Replicate 3)

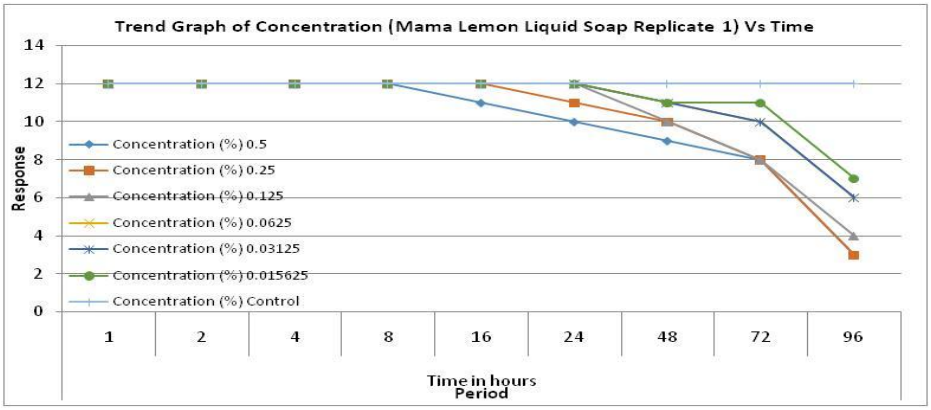

Figure 8: Trend Graph Representation of Fish Survival Response Over Time at Different Concentrations of Mama Lemon Liquid Soap (Replicate 1)

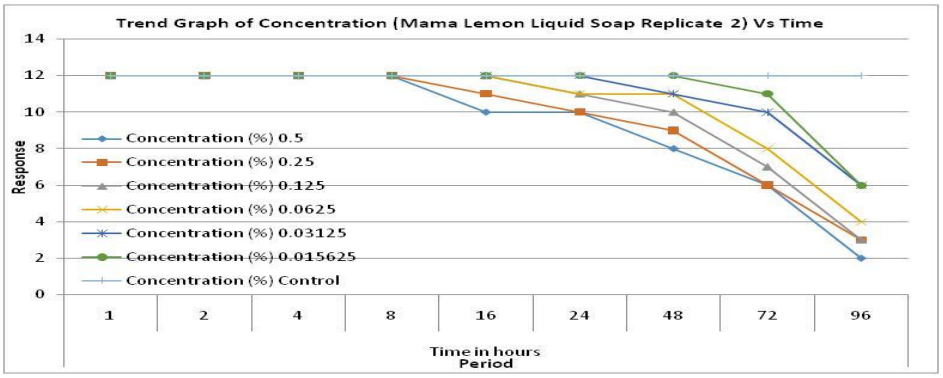

Figure 9: Trend Graph Representation of Fish Survival Response Over Time at Different Concentrations of Mama Lemon Liquid Soap (Replicate 2)

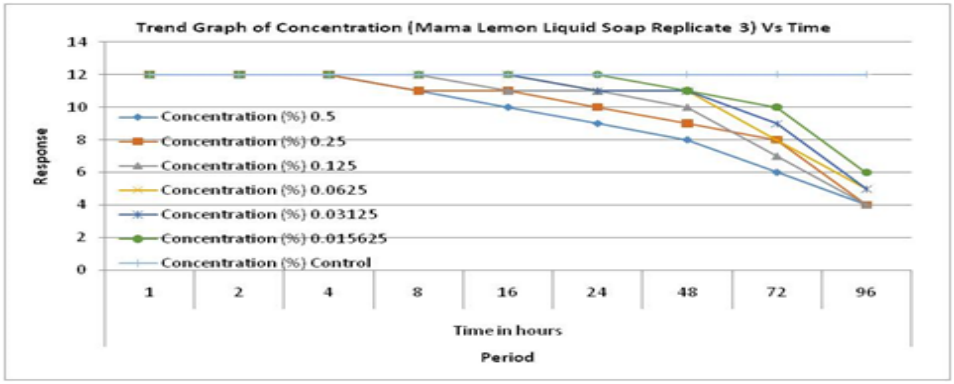

Figure 10: Trend Graph Representation of Fish Survival Response Over Time at Different Concentrations of Mama Lemon Liquid Soap (Replicate 3)

Discussion

The results of this study demonstrate a clear toxicological pattern in which increasing concentrations of detergents led to progressive reductions in survival rates of *Clariasgariepinus.* This aligns with established toxicological principles that toxicity is dose-dependent (Klein, 1996). The rapid mortality observed at 0.5% concentration, particularly in Morning Fresh, confirms the high potency of surfactant-rich effluents.

The trend graphs and survival curves further reinforce this pattern. The steep decline in survival at higher concentrations indicates acute toxicity, while gradual declines at lower concentrations suggest sub-lethal stress effects. The control groups maintaining 100% survival validate that mortality was due to the toxicants rather than experimental conditions (Ogbuagu & Iwuchukwu, 2014; Arojojoye, Nwaechefu, Adeosun & Samuel,2022). Despite these observable differences, the ANOVA results revealed no statistically significant differences between compared group means across all detergents and replicates ($p = 0.176 > 0.05$; $F < Fcrit$). This apparent contradiction between biological trends and statistical outcomes may be attributed to:

High within-group variability

Limited sample size

Grouping structure of the ANOVA (columns rather than concentrations)

Such findings are not uncommon in ecotoxicological studies, where biological relevance may exist even in the absence of statistical significance (Wan et al., 1994a).

Comparatively, Morning Fresh exhibited the highest toxicity, followed by 2-Sure, while Mama Lemon showed relatively lower toxicity. This variation likely reflects differences in chemical composition, particularly the concentration of linear alkylbenzenesulfonates (LABS), known to disrupt fish gill function and ion regulation (Ndu, 2004).

The observed behavioral changes—such as erratic movement, air gulping, and loss of equilibrium—are consistent with respiratory distress and neurotoxicity, commonly reported in fish exposed to surfactants. These effects can impair ecological fitness even when mortality is not immediate.

Importantly, the findings support concerns that untreated car wash effluents discharged into urban drains and water bodies can adversely affect aquatic ecosystems, especially in regions with weak environmental regulation.

CONCLUSION

This study demonstrates that liquid detergents commonly used in car wash operations in Owerri exert concentration-dependent toxic effects on Clarias gariepinus juveniles. Although the ANOVA showed no statistically significant differences among treatment groups, survival patterns and LT_{50} estimates revealed that increasing detergent concentrations resulted in more rapid fish mortality, indicating that these detergents pose potential ecological risks to aquatic ecosystems. To mitigate these effects, regulatory agencies should enforce wastewater discharge standards, car wash operators should adopt effective effluent treatment systems and biodegradable detergents, and environmental awareness should be strengthened.

ACKNOWLEDGEMENT

We sincerely thank the Federal Government through Tertiary Education Trust Fund (TETFUND) and the Management of Federal Polytechnic Nekede, Owerri for the opportunity given to us to participate in the institutional Based Research (IBR).

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