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Original Research Article

Effect of Sublethal Concentrations of Commercial Detergents on the Protein Content of Selective Freshwater Fishes

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ABSTRACT:
Freshwater fishes are the primary and cheapest sources of protein for humans. The quality and quantity of protein generally determine the nutritive value of the fishes. These values are progressively worsening due to the environmental contaminants that appear in aquatic habitats. Nutritive values of protein in the tissues of fish are inversely proportionate to the total of pollutants that appear in aquatic habitats. Detergents are one of the major toxicants that rapidly contaminate lakes, rivers, ponds, streams, and creek bodies. Hence the present study aimed to determine the effect of sublethal concentrations of commercial detergents (Surf Excel, Ariel, Rin, and Nirma) on the protein content of freshwater fishes, Indian Carp (*Catla catla*), Rohu (*Labeo rohita*), Catfish (*Clarias gariepinus*) and Tilapia (*Oreochromis niloticus*). The protein contents were determined in the fish tissues of muscles, liver, and gills at different time exposure of 24, 48, 72, and 96 hours. The results show the quantity of all tissue proteins significantly decreased with an increase in concentrations of all four detergents and exposure time. Based on the findings, we suggest that random discharge of detergents into water bodies should be averted.

Keywords: Commercial Detergents, Protein Content, Freshwater Fishes, Detrimental Effects

INTRODUCTION

For more than two decades, there is rapid economic development and urbanization throughout the world, which creates enormous changes in the water ecosystems due to the accumulating pollutants and xenobiotics. Commercial household and Domestic detergent are some of the key contaminants with the highest impact globally as it is used annually for three billion kilos (Fowler et al., 2017). These products are eventually discharged into

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water bodies and affect the ecosystem, which is chronically exposed to the plant, animal, and human systems (Kasumyan, 2019; Sobrino-Figueroa, 2018).

A detergent is a multifaceted structure of the chemical substances, produced by the surfactant. They are divided into three broad classes namely, nonpolar (eg. Tween 80, alkyl polyglycosides, and Triton X), cationic (eg. ethoxylated alcohols, cetyl trimethyl ammonium chloride, and benzalkonium chloride) and anionic (eg. alkyl lauryl sulfonate, alkylbenzene sulfonate, and dodecylbenzene sulfonate). Furthermore, detergents comprise additive compounds, including, bleaching agents, preservatives (sodium sulfate), foam stabilizers, builders, corrosion inhibitors, water softeners (perborates, carbonates, poly-phosphates, and silicates), brightening colorants, anti-redeposition agents, enzymes, dyes, perfumes, and other minor elements, which eliminate dirt, stain, and provide a fragrant odor and great impression (Day et al., 2019; Desel, 2019; Lal et al., 1983; Pettersson et al., 2000; Sobrino-Figueroa, 2013; Warne and Schifko, 1999).The compositions of commercial detergents are generally confidential, however, the amounts of the ingredients are about 15 percent surfactant, 30 percent of combined poly-phosphate and silicate, 20 percent sodium sulfate, 20 percent sodium perborate, 0.5 percent enzymes, 0.1 percent fluorescent colorant (Pettersson et al., 2000). Currently, these detergents are swiftly popular as they can be routinely used in the household washing device, impart softness, resilience to fabrics, moderate irritant to eyes and skins, and prove decent elimination through the water (Belsito et al., 2002; Desel, 2019).

Regrettably, the synthetic composition of detergents (15 percent) is only biodegradable which depends on the surfactants. Hence, most detergents are accumulated as pollutants and eliminated as such into water bodies. An earlier study has indicated that the quantities of these synthetic compounds in aquatic ecosystems range from 0.001 to 10 mg/litre (Pettersson et al., 2000; Sobrino-Figueroa, 2013). The detergents and their byproducts are highly harmful to aquatic life at ranges from 0.08 to 300 mg/litre. High toxic effects of these surfactants and bleaching agents that cause potentially harmful to aquatic life (Sobrino-Figueroa, 2013).

The aquatic toxicity and the impact of detergents have been explored by many researchers for the last two decades (Cedervall et al., 2012; Lopes et al., 2017; Sobrino-Figueroa, 2018; Zimmermann et al., 2009); and the impacts of the surfactants have been well-established. The anionic detergents cause the following detrimental effects to the aquatic organisms, particularly in the fishes(a) inhibit esterases and phosphatases resulting in the nerve receptor alterations cause a deficit in thermoregulation and feeding behavior; (b) changes in the membrane permeability due todisparities in the composition of phospholipids;(c) membrane alterations inhibit the functions of transport proteins,(d)changes in the gills epithelial tissue generate respiratory glitches in several fishes and mollusks, and (e) elevated bioaccumulation of detergents eventually cause celllysis resulting in the demise of aquatic sensitive animals (Pettersson et al., 2000; Sobrino-Figueroa, 2018; Sobrino-Figueroa, 2013).

Moreover, anionic surfactants induce oxidative stress, lipid peroxidation, DNA damage, and inflammatory mechanisms (Sobrino-Figueroa, 2013). Previous studies have evidenced that alkylbenzene sulfonate, a surfactant, is accumulated in the Shrimp Palaemonetes (Renaud et al., 2014), which generally produces noteworthy changes in the aquatic life by Physico-chemical changes in the water through the accumulation of phosphates resulting in eutrophication (Quevedo and Paganini, 2018). Cationic surfactants are also highly harmful to aquatic life. Studies have reported that alkylphenols, and ethoxylates, well-known cationic surfactants, play as significant endocrine disruptors and embryo-destructive agents in fish(Kierkegaard et al., 2020; Vaughan and van Egmond, 2010; Ying, 2006). Commercial detergents containing additives have also cause detrimental effects to humans and aquatic organisms (Trüeb, 2007). Synthetic detergents containing enzymes produce the noxious effects that cause cellysis in aquatic organisms resulting in tissue injury (Al-Ghanayem and Joseph, 2020).

Earlier investigations have been performed on various commercial synthetic detergents and their impacts on aquatic life including, several microalgae (Azizullah et al., 2011; Azizullah et al., 2013; Singh and Patidar, 2020), Cladocerans (Pedrazzani et al., 2012; Pettersson et al., 2000), Polychaetes (Uc-Peraza and Delgado-Blas, 2015), the gastropod (Cossi et al., 2020; Lebreton et al., 2021) and acute and chronic organ toxicity on various fish species (Fiorelini Pereira et al., 2017; Lopes et al., 2017; Saxena et al., 2005; Sobrino-Figueroa, 2018; Sobrino-Figueroa, 2013). The investigations on the commercial detergents are limited and few earlier reports have been reported on native fish species in our nation. Hence, the present study aimed to determine the effect of sublethal concentrations of commercial detergents (Surf, Ariel, Rin, and Nirma) on the protein content of freshwater fishes, Indian Carp (*Catla catla*), Rohu *(Labeo rohita*), Catfish (*Clarias gariepinus*) and Tilapia (*Oreochromis niloticus*).

MATERIALS AND METHODS

Detergents

Four commercial detergents (Surf Excel, Ariel, Rin, and Nirma) were purchased from the local markets and their active ingredients of each detergent were listed in Table 1, based on the data presented on the packaging and the related Material Safety Data Sheets. From each detergent, the test solutions were prepared and used for the toxicity bioassays. The solution was generally prepared as fresh on the same day. The pH of the solution was between 7.2 and 8.2.

Table 1: Commercial detergents and their ingredients

Surfactant and additives present in the detergents*			
Surf Excel	**Ariel**	**Rin**	**Nirma**
Cleaning agents (anionic and nonionic surfactants, enzymes), water softeners (sodium carbonate and sodium aluminosilicate), fabric whitener, sodium perborate, anti-redeposition agent, perfume, washer protection agent (sodium silicate), and processing aids (sodium sulfate).	Surfactant agent (alkyl lauryl sulfonate, lauryl dimethyl hydroxyethyl ammonium), water softeners (sodium triphosphate, sodium silicate), anti-redeposition agents, bleaching agents (sodium carbonate, peroxides), preservatives (sodium sulfate), brightening pigments, enzymes, dyes, and perfumes	Cleaning agents (anionic surfactants-sodium alkylbenzene sulfonate), nonionic surfactants (alcohol ethoxylate), enzymes, water softeners (sodium carbonate and sodium aluminosilicate), fabric whitener, sodium perborate monohydrate, anti-redeposition agent, perfume, washer protection agent (sodium aluminosilicate), and processing aids (sodium Sulfate).	Surfactant agent (Alkylbenzene sulfonate), water softeners (sodium phosphate, sodium silicate), Soda Ash, anti-redeposition agents, glycerin, preservatives (sodium sulfate), brightening pigments, enzymes, dyes, and perfumes

*Information obtained in the package detergents and their safety data sheets.

Freshwater fishes

The freshwater fishes, Indian Carp (*Catla catla,* Family: Cyprinidae), Rohu *(Labeo rohita,* Family: Cyprinidae), Catfish (*Clarias gariepinus,* Family: *Clariidae)*, and Tilapia (*Oreochromis niloticus,* Family: Cichlidae) were collected from the unpolluted area of the Jederpalayam dam, located at Kabilarmalai village of Namakkal District. Fishes were chosen for the study according to the weight between 15 to 25g, and size/length between 12 cm to 15 cm and were transported to the laboratory for acclimatization. The fishes were acclimatized in the lab conditions for 7 days and were maintained in a glass tank according to methods of the American Public Health Association (APHA)(Young et al., 2005). The adapted fishes were used for the toxicity study. Static renewal bioassay tests were used to determine the acute toxicity study of the detergents.

Toxicity bioassay

For the toxicity bioassay, the Lethal concentration 50 values for 96 h were assessed by the earlier method (Litchfield and Wilcoxon, 1949). According to the earlier standard method, each species of the experimental fishes were exposed to sub-lethal concentration (1/3rd and 2/3rdof LC50) of all four detergents as per recommendations for various exposure times (24, 48, 72, and 96 hours) (Konar, 1969). Each species of the fishes was exposed to six concentrations of each of the detergents, which were placed in 10 litre glass containers, in triplicate. The control group of fishes was also kept at the same time without exposure to the detergent (Burress, 1975). Each assay was repeated at least three times. Bioassays were kept at room temperature (27±1°C), 12h light and 12h dark of photoperiods, and dissolved oxygen greater than 4 mg/litre. The water with the different concentrations of detergents was changed every 24h. the mortality of the fish was monitored. After 96 h exposure, control and experimental fishes were sacrificed, and collected the tissues of muscles, liver, and gills for quantification of proteins using Folin-Phenol reagent (Lowry et al., 1951).

Statistical analysis

The values were shown as Mean ± SD. The data were analyzed using one way-ANOVA and group means were compared with Duncan's multiple comparison test (DMRT) with 95% confidence. For the statistical analysis, the SPSS software package was used.

RESULTS

The effects of sublethal concentrations of four commercial detergents, Surf Excel, Ariel, Rin, and Nirma on protein contents in muscles, liver, and gills of Indian Carp (*Catla catla*) are exhibited in Table 2. Exposure of 1/3rd and 2/3rd sublethal concentrations of Surf Excel (i.e., 6.67 and 13.34 mg/litre), Ariel (5.56, 11.12 mg/litre), Rin (6.5, 13.0 mg/litre), and Nirma (7.783, 15.67 mg/litre) significantly reduced the protein content in muscles, liver, and gills of Indian Carp at 48, 72 and 96h of exposure when compared to control. The higher sublethal concentration of detergents reduced higher protein content when compared to low sublethal concentration.

The effects of sublethal concentrations of four commercial detergents, on protein contents in muscles, liver, and gills of Rohu (*Labeo rohita*) are exhibited in Table 3. Exposure of 1/3rd and 2/3rd sublethal concentrations of Surf Excel (i.e., 6.5, 13.0 mg/litre), Ariel (7.783, 15.67 mg/litre), Rin (6.67 and 13.34 mg/litre), and Nirma (5.56, 11.12 mg/litre) significantly decreased the protein content in muscles, liver, and gills of Rohu at 48, 72 and 96h of exposure when compared to control. The elevated sublethal concentration of detergents reduced high protein content when compared to low sublethal concentration.

Table 2: Effects of sublethal concentrations of detergents on protein content in muscles, liver, and gills of freshwater fish, Indian Carp (*Catla catla*)

Conc. mg/lit	Muscle (mg/g)				Liver (mg/g)				Gills (mg/g)			
	24h	48h	72h	96h	24h	48h	72h	96h	24h	48h	72h	96h
Surf Excel												
Control	23.52±3.48[a]	24.89±3.65[a]	25.21±4.78[a]	25.98±4.27[a]	38.45±4.67[a]	38.89±4.86[a]	39.67±4.82[a]	39.88±4.56[a]	5.13 ± 1.38[a]	5.44 ± 1.68[a]	5.78 ± 1.89[a]	5.97 ± 1.44[a]
6.67	21.78±3.97[a, b]	20.68±3.67[b]	17.38±2.86[b]	15.55±2.89[b]	37.46±4.38[a]	35.56±3.78[a, b]	32.55±4.13[b]	29.49±3.76 [b]	4.34 ± 1.58[b]	3.31 ± 0.49[c]	2.99 ± 0.88[b]	2.14 ± 0.55[b]
13.3	20.56±2.48[b]	18.47±3.65[b, c]	14.58±2.45[c]	12.39±2.48[c]	34.78±3.87[b]	31.78±3.89[b]	25.87±3.78[c]	23.67±3.69[c]	3.83 ± 0.68[c]	3.09 ± 0.35[b, c]	2.41 ± 0.33 [b,c]	1.98 ± 0.48[c]
Ariel												
Control	24.67±4.13[a]	24.98±3.76[a]	25.45±4.23[a]	25.88±3.85[a]	36.88±4.82[a]	37.48±4.77[a]	38.48±3.98[a]	39.42±3.54[a]	6.38 ± 1.48[a]	6.95 ± 1.38[a]	7.17 ± 2.12[a]	7.36 ± 2.11[a]
5.56	22.58±3.63[b]	20.29±2.55[b]	17.36±3.87[b]	15.54±2.88[b]	33.12±3.99[b]	31.54±4.22[b]	29.44±3.68[b]	28.64±3.22[b]	4.89 ± 1.76[b]	3.78 ± 0.87[b]	3.14 ± 0.99[b]	2.78 ± 0.48[b]
11.12	20.92±3.77[b, c]	18.52±2.64[c]	14.33±3.88[b]	11.22±1.89[c]	31.34±3.77[c]	29.46±4.27[c]	24.55±3.44[b]	24.88±3.53[c]	3.99 ± 0.48[b, c]	2.98 ± 0.58[b, c]	2.15 ± 0.83[c]	1.44 ± 0.47[c]
Rin												
Control	25.82±3.24[a]	25.99±3.43[a]	26.15±4.56[a]	26.88±4.34[a]	37.33±3.85[a]	37.32± 3.57[a]	38.56±3.99[a]	39.44±3.83[a]	5.44 ± 1.48[a]	6.13 ± 1.79[a]	6.89 ± 2.58[a]	7.23 ± 1.89[a]
6.5	22.55±3.98[a, b]	21.33±3.98[b]	18.43±3.54[b]	15.32±2.56[b]	34.29±3.88[a, b]	32.83±3.55[b]	30.46±3.22[b]	28.99±3.66[b]	4.78 ± 1.43[a, b]	3.99 ± 0.57[b]	3.11 ± 0.66[b]	2.24 ± 0.62[b]
13.0.	20.55±3.68[b]	17.44±3.65[c]	13.54±2.79[c]	11.34±1.86[c]	32.83±3.57[b]	30.46±3.93[b]	24.75±3.68[c]	22.49±2.39[c]	3.19 ± 0.47[b]	2.88 ± 0.46[c]	2.34 ± 0.22[c]	1.68 ± 0.14[c]
Nirma												
Control	25.47±3.67[a]	25.78±4.12[a]	25.99±3.78[a]	26.34±4.86[a]	38.12±4.69[a]	38.63±4.17[a]	38.88±3.58[a]	39.56±4.78[a]	5.22 ± 1.58[a]	5.98 ± 1.47[a]	6.45 ± 1.47[a]	6.86 ± 2.01[a]

7.783	23.67±3.78$^{a, b}$	21.49±2.89^{b}	19.56±3.97^{b}	16.45±2.18^{b}	35.78±4.67$^{a, b}$	33.74±4.86^{b}	32.49±3.22^{b}	29.57±3.78^{b}	4.86 ± 1.56^{b}	3.57 ± 0.98^{b}	2.98 ± 0.75^{b}	2.11 ± 0.46^{b}
15.67	21.68±2.86^{b}	18.39±2.56$^{b, c}$	15.39±2.58^{c}	13.55±2.47$^{b, c}$	34.89±3.98$^{a, b}$	30.22±3.98^{b}	25.88±3.67^{c}	24.99±3.87^{c}	3.11 ± 0.68^{c}	2.46 ± 0.59c	2.01 ± 0.43^{c}	1.86 ± 0.11^{c}

Values are expressed as Means ± SD. The values not sharing a common superscript vary significantly at $p<0.05$, Duncan's Multiple Range Test (DMRT)

Table 3: Effects of sublethal concentrations of detergents on protein content in muscles, liver, and gills of freshwater fish, Rohu (*Labeo rohita*)

Conc. mg/lit	Muscle (mg/g)				Liver (mg/g)				Gills (mg/g)			
	24h	**48h**	**72h**	**96h**	**24h**	**48h**	**72h**	**96h**	**24h**	**48h**	**72h**	**96h**
Surf Excel												
Control	22.41 ±3.37^{a}	23.78 ±3.54^{a}	24.11±4.67^{a}	24.87 ±4.16^{a}	37.34 ±4.56^{a}	37.78 ±4.75^{a}	38.56 ±4.71^{a}	38.77 ±4.45^{a}	4.02 ± 1.27^{a}	4.33 ± 1.57^{a}	4.67 ± 1.76^{a}	4.86 ± 1.33^{a}
6.50	20.67 ±3.86$^{a, b}$	19.57 ±3.56^{b}	16.16 ±2.75^{b}	14.44 ±2.78^{b}	36.35 ±4.27^{a}	34.45 ±3.67$^{a, b}$	31.44 ±4.02^{b}	28.38 ±3.65 ^{b}	3.23 ± 1.47^{b}	2.25 ± 0.38^{c}	1.88 ± 0.77^{b}	1.03 ± 0.44^{b}
13.0.	19.45 ±2.47^{b}	17.36 ±3.54$^{b, c}$	13.47 ±2.34^{c}	11.28 ±2.37^{c}	33.67 ±3.76^{b}	30.67 ±3.78^{b}	24.76 ±3.67^{c}	22.56 ±3.58^{c}	2.72 ± 0.57^{c}	2.08 ± 0.24$^{b, c}$	1.31 ± 0.22 ^{b,c}	0.87 ± 0.37^{c}
Ariel												
Control	23.56 ±4.02^{a}	23.87 ±3.65^{a}	24.34 ±4.12^{a}	24.77 ±3.74^{a}	35.77 ±4.71^{a}	36.37 ±4.66^{a}	37.37 ±3.87^{a}	38.31 ±3.43^{a}	5.27 ± 1.37^{a}	5.84 ± 1.27^{a}	5.06 ± 2.01^{a}	6.25 ± 2.12^{a}
7.783	21.47 ±3.52^{b}	19.18 ±2.44^{b}	16.25 ±3.76^{b}	14.43 ±2.77^{b}	32.01 ±3.88^{b}	30.43 ±4.11^{b}	28.33 ±3.57^{b}	27.53 ±3.11^{b}	3.78 ± 1.65^{b}	2.67 ± 0.76^{b}	2.03 ± 0.88^{b}	1.67 ± 0.37^{b}
15.67	19.81 ±3.66$^{b, c}$	17.41 ±2.53^{c}	13.22 ±3.77^{b}	10.11 ±1.76^{c}	30.23 ±3.66^{c}	28.35 ±4.16^{c}	23.34 ±3.33^{b}	23.77 ±3.42^{c}	2.88 ± 0.37$^{b, c}$	1.76 ± 0.36$^{b, c}$	1.04 ± 0.65^{c}	0.49 ± 0.36^{c}
Rin												
Control	24.71 ±3.13^{a}	24.88 ±3.32^{a}	25.04 ±4.45^{a}	25.77 ±4.23^{a}	36.22 ±3.85^{a}	37.32± 3.46^{a}	37.45 ±3.88^{a}	38.33 ±3.72^{a}	4.33 ± 1.37^{a}	5.02 ± 1.68^{a}	5.78 ± 2.47^{a}	6.12 ± 1.78^{a}
6.67	21.44 ±3.87$^{a, b}$	20.22 ±3.87^{b}	17.32 ±3.43^{b}	14.21 ±2.45^{b}	33.18 ±3.77$^{a, b}$	31.72 ±3.44^{b}	29.35 ±3.11^{b}	27.88 ±3.55^{b}	3.67 ± 1.32$^{a, b}$	2.88 ± 0.46^{b}	2.01 ± 0.55^{b}	1.13 ± 0.51^{b}

13.3	19.44±3.57^{b}	16.33 ±3.54^{c}	12.43 ±2.68^{c}	10.23 ±1.75^{c}	31.72 ±3.46^{b}	29.35 ±3.82^{b}	23.64 ±3.57^{c}	21.38 ±2.28^{c}	2.08 ± 0.36^{b}	1.77 ± 0.35^{c}	1.23 ± 0.11^{c}	0.57 ± 0.03^{c}
Nirma												
Control	24.36 ±3.56^{a}	24.67 ±4.01^{a}	24.88 ±3.67^{a}	25.23 ±4.76^{a}	37.01 ±4.58^{a}	38.52 ±4.06^{a}	37.77 ±3.47^{a}	38.45 ±4.67^{a}	4.11 ± 1.47^{a}	4.87 ± 1.36^{a}	5.34 ± 1.36^{a}	5.75 ± 2.09^{a}
5.56	23.56 ±3.67$^{a, b}$	20.38 ±2.78^{b}	18.45 ±3.86^{b}	15.34 ±2.07^{b}	34.67 ±4.56$^{a, b}$	32.63 ±4.75^{b}	31.38 ±3.11^{b}	28.43 ±3.67^{b}	3.75 ± 1.45^{b}	2.46 ± 0.87^{b}	1.87 ± 0.64^{b}	1.01 ± 0.35^{b}
11.12	20.57 ±2.75^{b}	17.28 ±2.45$^{b, c}$	14.28 ±2.47^{c}	13.44 ±2.36$^{b, c}$	33.78 ±3.87$^{a, b}$	29.11 ±3.87^{b}	24.77 ±3.56^{c}	23.88 ±3.78^{c}	2.01 ± 0.57^{c}	1.35 ± 0.48^{c}	1.01 ± 0.32^{c}	0.75 ± 0.01^{c}

Values are expressed as Means ± SD. The values not sharing a common superscript vary significantly at $p<0.05$, Duncan's Multiple Range Test (DMRT)

Table 4: Effects of sublethal concentrations of detergents on protein content in muscles, liver, and gills of freshwater fish, Catfish (*Clarias gariepinus*)

Conc. mg/lit	Muscle (mg/g)				Liver (mg/g)				Gills (mg/g)			
	24h	48h	72h	96h	24h	48h	72h	96h	24h	48h	72h	96h
Surf Excel												
Control	24.63 ±3.59^{a}	25.90 ±3.76^{a}	24.32 ±4.89^{a}	24.09 ±4.38^{a}	39.56 ±4.78^{a}	39.90 ±4.97^{a}	40.78 ±4.93^{a}	40.99 ±4.67^{a}	6.24 ± 1.49^{a}	6.55 ± 1.79^{a}	6.89 ± 1.90^{a}	6.08 ± 1.55^{a}
6.67	22.89 ±3.08$^{a, b}$	21.79 ±3.78^{b}	18.49 ±2.97^{b}	16.66 ±2.90^{b}	38.57 ±4.49^{a}	36.67 ±3.89$^{a, b}$	33.66 ±4.24^{b}	30.50 ±3.87^{b}	5.45 ± 1.69^{b}	4.42 ± 0.61^{c}	4.01 ± 0.99^{b}	3.03 ± 0.66^{b}
13.3	21.67 ±2.59^{b}	19.58 ±3.76$^{b, c}$	15.69 ±2.56^{c}	13.50 ±2.59^{c}	35.89 ±3.98^{b}	32.89 ±3.09^{b}	26.98 ±3.89^{c}	24.78±3.80^{c}	4.94 ± 0.79^{c}	4.12 ± 0.46$^{b, c}$	3.42 ± 0.44$^{b, c}$	2.09 ± 0.59^{c}
Ariel												
Control	25.78 ±4.24^{a}	25.08 ±3.87^{a}	26.56 ±4.34^{a}	26.99 ±3.96^{a}	37.99 ±4.93^{a}	38.59 ±4.88^{a}	39.59 ±3.09^{a}	40.53 ±3.65^{a}	7.49 ± 1.71^{a}	8.017 ± 1.49^{a}	8.28 ± 2.23^{a}	8.47 ± 2.22^{a}
5.56	23.69 ±3.74^{b}	21.40 ±2.66^{b}	18.47 ±3.98^{b}	16.65 ±2.99^{b}	34.23 ± 4.11^{b}	32.65 ±4.33^{b}	30.55 ±3.79^{b}	29.75 ±3.33^{b}	5.90 ± 1.87^{b}	4.89 ± 0.98^{b}	4.25 ± 1.01^{b}	3.89 ± 0.59^{b}
11.12	22.03	19.63	15.44	12.33	32.45	30.57	25.66	25.99	5.11 ±	4.01 ±	3.26 ±	2.55 ±

	±3.66[b, c]	±2.75[c]	±3.99[b]	±1.91[c]	±3.88[c]	±4.38[c]	±3.55[b]	±3.64[c]	0.49[b, c]	0.69[b, c]	0.94[c]	0.58[c]
Rin												
Control	26.93 ±3.35[a]	27.01 ±3.53[a]	27.26 ±4.67[a]	27.99 ±4.45[a]	38.44 ±3.96[a]	38.43 ± 3.68[a]	39.65 ± 4.99[a]	40.55 ±3.94[a]	6.55 ± 1.69[a]	7.24 ± 1.90[a]	7.90 ± 2.69[a]	8.34 ± 1.09[a]
6.50	23.66 ±3.09[a, b]	22.44 ±3.09[b]	19.54 ±3.64[b]	16.43 ±2.67[b]	35.40 ±3.99[a, b]	33.94 ±3.66[b]	31.57 ±3.33[b]	30.09±3 .77[b]	5.89 ± 1.54[a, b]	5.09 ± 0.68[b]	4.22 ± 0.77[b]	3.35 ± 0.73[b]
13.0.	21.66 ±3.79[b]	18.55 ±3.76[c]	14.65 ±2.80[c]	12.45 ±1.97[c]	33.94 ±3.68[b]	31.57 ± 4.04[b]	24.86 ±3.79[c]	23.57 ±2.50[c]	4.30 ± 0.58[b]	3.99 ± 0.57[c]	3.45 ± 0.33[c]	2.79 ± 0.25[c]
Nirma												
Control	26.58 ±3.78[a]	26.89 ±4.32[a]	27.09±3 .89[a]	27.45 ±4.97[a]	39.23 ±4.80[a]	39.74 ±4.28[a]	39.98±3 .69[a]	40.65 ±4.89[a]	6.33 ± 1.69[a]	7.09 ± 1.58[a]	7.56 ± 1.58[a]	7.90 ± 2.12[a]
7.783	24.78 ±3.89[a, b]	22.51 ±2.91[b]	20.67 ±3.09[b]	17.56 ±2.29[b]	36.89 ±4.78[a, b]	34.85 ±4.97[b]	33.51 ±3.33[b]	30.68 ±3.98[b]	5.97 ± 1.67[b]	4.68 ± 0.88[b]	4.09 ± 0.86[b]	3.22 ± 0.57[b]
15.67	22.79 ±2.97[b]	19.50 ±2.67[b, c]	16.50 ±2.69[c]	14.66 ±2.58[b, c]	35.91 ±3.98[a, b]	31.33 ±3.09[b]	26.99 ±3.78[c]	25.01 ±3.98[c]	4.22 ± 0.79[c]	3.57 ± 0.70[c]	3.12 ± 0.54[c]	2.97 ± 0.22[c]

Values are expressed as Means ± SD. The values not sharing a common superscript vary significantly at $p<0.05$, Duncan's Multiple Range Test (DMRT)

Table 5: Effects of sublethal concentrations of detergents on protein content in muscles, liver, and gills of freshwater fish, Tilapia (*Oreochromis niloticus*)

Conc. mg/lit	Muscle (mg/g)				Liver (mg/g)				Gills (mg/g)			
	24h	48h	72h	96h	24h	48h	72h	96h	24h	48h	72h	96h
Surf Excel												
Control	25.74 ±3.70[a]	26.91 ±3.87[a]	27.43 ±4.90[a]	28.10 ±4.49[a]	40.67 ±4.89[a]	41.19± 5.08[a]	41.89 ± 5.04[a]	42.10 ±4.78[a]	7.35 ± 1.50[a]	7.66 ± 1.90[a]	7.90 ± 2.01[a]	8.19 ± 1.66[a]
7.783	23.90 ± 4.19[a, b]	22.80 ±3.89[b]	19.50 ± 3.08[b]	17.77 ± 3.02[b]	39.68 ±4.50[a]	38.78 ±3.90[a, b]	34.77 ±4.35[b]	31.72 ±3.98 [b]	6.58 ± 1.70[b]	5.52 ± 0.71[c]	5.11 ± 1.01[b]	4.36 ± 0.77[b]
15.67	22.78 ±2.60[b]	20.69 ±3.87[b, c]	16.70 ±2.67[c]	14.61 ±2.70[c]	36.90 ± 4.09[b]	33.90 ± 4.02[b]	27.09 ±3.90[c]	25.79 ±3.91[c]	5.02 ± 0.79[c]	5.11 ± 0.57[b, c]	4.62 ± 0.55[b, c]	3.28 ± 0.70[c]

Ariel												
Control	26.89 ±4.35^{a}	27.12 ±3.98^{a}	27.67 ±4.46^{a}	28.10 ± 4.17^{a}	39.10 ± 5.14^{a}	39.70 ±4.99^{a}	40.70 ± 4.20^{a}	41.64 ±3.76^{a}	8.60 ± 1.70^{a}	9.27 ± 1.60^{a}	9.39 ± 2.34^{a}	9.58 ± 2.33^{a}
5.56	24.70 ±3.85^{b}	22.51 ±2.77^{b}	19.58 ± 3.19^{b}	17.76 ± 3.11^{b}	35.34 ± 4.11^{b}	33.76 ±4.44^{b}	31.66 ±3.90^{b}	30.86 ±3.44^{b}	7.02 ± 1.98^{b}	5.90 ± 0.44^{b}	5.26 ± 0.95^{b}	4.90 ± 0.70^{b}
11.12	23.14 ±3.99$^{b, c}$	20.74 ±2.85^{c}	16.55 ±3.57^{b}	13.44 ±1.95^{c}	35. 54 ±3.99^{c}	31.68 ±4.49^{c}	26.77 ±3.66^{b}	27.01 ±3.75^{c}	6.22 ± 0.70$^{b, c}$	5.05 ± 0.70$^{b, c}$	4.37 ± 0033^{c}	3.66 ± 0.69^{c}
Rin												
Control	28.04 ±3.46^{a}	28.22 ±3.65^{a}	28.37 ±4.68^{a}	29.12 ±4.58^{a}	39.55 ± 4.34^{a}	39.54 ± 3.79^{a}	40.71 ± 4.11^{a}	41.66 ± 4.05^{a}	7.66 ± 1.71^{a}	8.26 ± 1.91^{a}	9.01 ± 2.70^{a}	9.46 ± 1.95^{a}
6.67	24.77 ± 4.04$^{a, b}$	23.55 ± 4.10^{b}	20.46 ±3.76^{b}	17.54 ±2.78^{b}	36.51 ± 4.01$^{a, b}$	35.05 ±3.77^{b}	32.68 ±3.44^{b}	31.01 ±3.88^{b}	6.90 ± 1.66$^{a, b}$	6.22 ± 0.79^{b}	5.33 ± 0.88^{b}	4.46 ± 0.84^{b}
13.3	22.77 ±3.80^{b}	19.66 ±3.87^{c}	15.76 ±2.92^{c}	13.56 ± 2.08^{c}	34.06 ±3.79^{b}	32.68 ± 4.12^{b}	26.97 ±3.90^{c}	24.72 ±2.51^{c}	5.32 ± 0.69^{b}	5.01 ± 0.68^{c}	4.56 ± 0.44^{c}	3.80 ± 0.36^{c}
Nirma												
Control	27.69 ±3.89^{a}	27.90 ±4.35^{a}	28.22 ±3.90^{a}	28.56 ±4.52^{a}	40.34 ±4.91^{a}	40.85 ±4.33^{a}	41.01 ±3.70^{a}	41.78 ±4.90^{a}	7.44 ± 1.70^{a}	8.20 ± 1.69^{a}	8.67 ± 1.69^{a}	9.08 ± 2.23^{a}
6.50	25.89 ±3.90$^{a, b}$	23.71 ± 3.02^{b}	21.78 ± 4.29^{b}	18.67 ±2.30^{b}	37.90 ±4.89$^{a, b}$	35.96 ± 5.08^{b}	34.71 ±3.44^{b}	31.79 ±3.90^{b}	7.08 ± 1.78^{b}	5.79 ± 1.10^{b}	5.20 ± 0.97^{b}	4.33 ± 0.68^{b}
13.0.	23.80 ± 3.08^{b}	20.52 ±2.78$^{b, c}$	17.61 ±2.80^{c}	15.77 ±2.69$^{b, c}$	37.02 ± 4.20$^{a, b}$	33.44 ± 4.20^{b}	28.01 ±3.89^{c}	27.22 ± 4.09^{c}	5.33 ± 0.80^{c}	4.68 ± 0.72^{c}	4.23 ± 0.65^{c}	4.08 ± 0.33^{c}

Values are expressed as Means ± SD. The values not sharing a common superscript vary significantly at $p<0.05$, Duncan's Multiple Range Test (DMRT).

The effects of sublethal concentrations of four commercial detergents, on protein contents in muscles, liver, and gills of Catfish (*Clarias gariepinus*) are exhibited in Table 4. Exposure of 1/3rd and 2/3rd sublethal concentrations of Surf Excel (i.e., 6.67 and 13.34 mg/litre), Ariel (5.56, 11.12 mg/litre), Rin (6.5, 13.0 mg/litre), and Nirma (7.783, 15.67 mg/litre) significantly decreased the protein content in muscles, liver, and gills of Catfish at 48, 72 and 96h of exposure when compared to control. The increased sublethal concentration of detergents reduced excessive protein content when compared to low sublethal concentration.

The effects of sublethal concentrations of four commercial detergents, on protein contents in muscles, liver, and gills of Tilapia (*Oreochromis niloticus*) are exhibited in Table 5. Exposure of 1/3rd and 2/3rd sublethal concentrations of Surf Excel (i.e., 7.783, 15.67mg/litre), Ariel (5.56, 11.12 mg/litre), Rin (6.67 and 13.34 mg/litre), and Nirma (6.5, 13.0 mg/litre) significantly decreased the protein content in muscles, liver, and gills of Tilapia at 48, 72 and 96h of exposure when compared to control. The higher sublethal concentration of detergents reduced extreme protein content when compared to low sublethal concentration.

DISCUSSION

In the present study, the protein contents in muscles, liver, and gill are significantly reduced with an increase in the concentration of all four detergents and exposure time. It implies that protein could be exploited in the tissues for energy production or deactivation of enzymes involved in the protein synthesis(Roy, 1988). The mechanism of protein exploitation in the tissue or protein synthesis inhibition may be combated due to the extra energy demand during the detergent stress environments (Pettersson et al., 2000). During the exposure of any toxicity settings, fishes require high energy to manage the situations, thus, the rapid results of proteolysis. Furthermore, the enzyme that participates in the protein synthesis is inactivated because of the effects of high concentrations of detergent. The current findings are consistent with the findings of earlier investigators(Al-Ghanayem and Joseph, 2020; Azizullah et al., 2011; Azizullah et al., 2013; Cedervall et al., 2012; Fowler et al., 2017).

Due to the detergent stress environment, fish opercular and swimming activities can be elevated, which need extra glucose and oxygen for the generation of rising energy demands (Kasumyan, 2019). During these stress conditions, the intake of food and oxygen would be deprived and unable to generate the required amount of glucose in the blood. Hence, this shortfall of glucose can be achieved from the tissue reservoirs, glycogen, fat, and finally proteins (Al-Ghanayem and Joseph, 2020; Singh and Patidar, 2020; Sobrino-Figueroa, 2018; Tasaki et al., 2017). Earlier, similar findings were performed in the detergent toxicity with two fishes, *Oreochromis mossambicus* and *Cyprinus carpio*, which demonstrated a significant reduction in glycogen and protein content (Coutinho and Gokhale, 2000). The protein content is significantly reduced during the detergent-exposed fishes. This is because the high environmental stress drives the fishes to transport muscle protein to the bloodstream, which aids to compensate for certain acidosis conditions caused by the accretion of lactic acid(Tasaki et al., 2017). An increase in the concentration of commercial detergent reduces the contents of tissue glycogen, protein, and fat with high exposure time. This substantial reduction is because of the high metabolic rate and reduction in feeding patterns (Lopes et al., 2017; Pedrazzani et al., 2012). Furthermore, stress-induced tissue proteolysis, glycolysis, and lipolysis contribute high concentration of free amino acids, glucose, glycerol, and fatty acids in the blood and combat the high demands of energy (Ganesan et al., 1989).

The detergents are generally noxious compounds, creates injuries to the lining of buccal cavity epithelium and gills, resulting in limited consumption of the food and deprived uptake of oxygen (Day et al., 2019; Sobrino-Figueroa, 2018). Furthermore, Detergents can be readily absorbed by the gills and intestine and readily transported into the portal blood circulation of the fish(Zimmermann et al., 2009). The toxicity can be due to the higher concentrations of surfactants, silicates, bleaching agents, enzymes, and dyes (Azizullah et al., 2013; Lal et al., 1983). Additionally, it was evidenced that the toxicity of the detergents increases when the temperature rises(Tasaki et al., 2017). These findings strongly suggest that native fish species are more sensitive to synthetic detergents. Thus, commercial detergents and xenobiotics are highly noxious to aquatic life.

CONCLUSION

The four commercial detergents (Surf Excel, Ariel, Rin, and Nirma) were analyzed in this investigation and had different LC50 values depends upon the species of the fish. The most sensitive fishes were also varied based on the treatment of the detergents. Freshwater fishes are the key and cheapest sources of protein in which the nutritive values of the proteins mainly exist in the muscles of fishes. However, in the present study, there were significantly decreased protein contents with an increased in detergent concentrations and exposure time. It implies that the quantity of nutritive values progressively worsens due to the exposure of detergents. These synthetic products in natural waters can rapidly contaminate aquatic life. Nowadays, the treatment of wastewater is inadequate, and the usages of detergents often discharge into the water bodies resulting in potential adverse effects to the aquatic environment. Hence, we suggest that the appropriate measures and ought to create a biodegradable detergent that is urgently required to lessen the threat and protects the existence of aquatic life.

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