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Toxic effects of insecticides on *Oreochromis niloticus* and *Puntius gonionotus*

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ABSTRACT

The study was conducted to determine the toxicity of insecticide (Sumithion and Nogos) to two species of fish namely tilapia (*Oreochromis niloticus*) and thai sarputi (*Puntius goniontus*). A total of about 150 fishes of each variety were collected for each test. Fishes taken for the study were spawn and fingerling of *O. niloticus* and fingerlings of thai sarputi. Ten glass aquaria (50cm x 26cm x 28cm) ft were used for the purpose. The concentrations of Sumithion and Nogos required for LD_{0}, LD_{50}, and LD_{100} at 48 hours were found to vary widely with the species and size of the fish. The ranges of LD_{0}, LD_{50}, and LD_{100} values recorded were 1 ppm to 6 ppm, 1.85 ppm to 8.8 ppm and 4 ppm to 12 ppm respectively for Sumithion, and 4 ppm to 10 ppm, 7.35 ppm to 13.6 ppm and 10 ppm to 16 ppm respectively for Nogos. The safe application rates of Sumithion and Nogos were also found to vary from species to species and the ranges recorded were 0.46 ppm to 4.4 ppm for Sumithion and 2.94 ppm to 8.50 ppm for Nogos. Of the two species, *P. gonionotus* was found to be more resistant to toxicity of insecticides than *O. niloticus*. Between the two size groups of *O. niloticus* spawn was found to be very susceptible to toxic effect of insecticides than the fingerlings. However, between the two insecticides Sumithion was found to be more toxic to fish than Nogos.

INTRODUCTION

Bangladesh, historically a land of fish, as it has vast in land water resources like rivers, canals, ponds, haors, baors, reservoirs, submerged paddy fields etc which furnishes us with 80% of the total fish production in our country. However, the production per unit area is very low as compared to other advanced countries. This low productivity is the result of a variety of factors which are both natural and man- made. Among the man- made factors, indiscriminate use of insecticides is the vital one.

Available insecticides which are used in the paddy fields and other crops in our country are generally classified into three major groups viz. inorganic, synthetic organic and natural organic. The inorganic pesticides include Mercurials, Borates and Flourides. The synthetic organic compounds include chlorinated hydro carbons (eg. DDT, chloroden, Di-eldrin and Heptachlore etc), Organophos phorus (eg. Diazinon, Melathion, Dimecron and Sumithion etc), carbamate compounds (eg. carbaryl, Mypsin, Marshal, Carbafuran and padan etc), pyrethroids (eg. Ripcord, Simbush, Desis, Sumisidin, Sumi-alpha etc.) and the natural organic compounds include rotenon, pyrethrum and Nicotine etc.

These synthetic insecticides and pesticides are also reported to have residual toxicity which affects aquatic food chain (Hagen & Larsen, 1979). Contamination of the water supply by insecticide and chemical is a known cause of fish mortality (Karim, 1975). Mortality of fish due to the use of insecticides was also reported to in several instances. The mortality of many of the species of fish was sometimes the result of direct exposure to the insecticides, but more often death was due to the bio-magnification of the insecticide through the food chain & deposition of the same in body fat. Considering the above realities, this study was undertaken to determine the safe level of concentration of Sumithion and Nagos in case of tilapia, to find out the effect of above insecticides on the physico- chemical qualities of water and to observe the behavioral responses of tilapia in different concentrations of the selected insecticides.

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MATERIALS AND METHODS

Two insecticides eg, Sumithion and Nogos were used for the experiment. Two species of fish namely tilapia (*Oreochronis niloticus*) and thai sarputi (*Puntius goniontus)* were collected for the study. A total of about 150 fishes of each variety were collected for each test. Fishes taken for the study were spawn and fingerling of *O. niloticus* and fingerlings of thai sarputi.

Experiments

Ten glass aquaria (50cm×26cm×28cm) were used for the purpose. The other equipments used in the experiment were thermometer, micropipette, glass, jars, conical flask etc. Air compressor was used for the aeration of acclimatization tank through flexible plastic tubes and air stones. Dissolved oxygen meter and pH meter were used for the determination of physico-chemical parameters such as pH, dissolved oxygen (DO) and temperature etc. The aquaria were first cleaned and washed thoroughly by the tap water and then set in the laboratory. They were arranged in pair for each treatment to regulate error. All the aquaria were filled up with ten liters of tap water. Among them two were used as controls. Three different sets of concentrations of sumithion used in the experiment for spawn, fingerlings of tilapia (*O. niloticus*) and thai sarputi (*P. gonionotus*). The set were A (1.0, 2.0, 4.0 and 6.0 ppm), B (2.0, 4.0, 6.0 and 8.0 ppm) and C (6.0, 8.0, 10.0 and 12.0 ppm). The concentration of Nogos used for tilapia and thai sarputi were 4.0, 6.0, 8.0, 10.0 and 10.0, 12.0, 14.0 and 16.0 ppm respectively. The number of replication in each case was two.

In the test aquaria, desired concentrations of insecticides were poured carefully and mixed gently with a glass rod. Ten fishes were released into each of the ten aquaria containing different concentrations of the insecticides as well as the control ones. No food was supplied to the fishes during the test period of 48 hours.

After the release of test fishes into the test solution, biological behavior reactions and other changes in the body of the fishes with respect to its contaminated environment was observed and recorded properly.

Toxicity tests

Static test method was used to test the toxicity of the insecticides. Various lethal doses (mortalities determined within 48 hours) of the insecticides for the test fishes were LD_{100}, LD_{50} and LD_0 representing 100, 50 and 0 percent, respectively. The LD_{100} and LD_0 values were determined directly from bio-assays test. The LD_{50} values were calculated by straight line graphical interpolation method for 24 and 48 hours after Sharma et al. (1981). The Safe Application Rate (SAR) for Nogos and Sumithion on fishes were determined with the help of the methods described Basak and Konar (1977).

RESULTS AND DISCUSSIONS

Survival of fishes under different concentrations of insecticide

The percentages of survival of *O. niloticus* and *P. gonionotus* for different hours in different concentrations of Sumithion and Nogos have been shown in Tables 1, 2, 3. The fishes were tested in different concentrations for 48 hours. But the survival percentages were shown only upto the concentration where cent percent mortality of each species occurred in 48 hours. The tested fishes showed their response differently in different concentrations of the insecticides in different hours. The tested fishes in control did not show any sign of abnormality and survived well during the period of experiment. The tested fishes showed various signs of distress and abnormality in the experimental aquaria after the application of insecticides in different concentrations.

Table 1
Toxic effects of Sumithion on the spawn of *O. niloticus* for 12, 24, 36 and 48 hours under different concentrations.

Hours	Different concentrations of Sumithion (ppm)				
	Control	1	2	4	6
	No. of survived fish (%)				
12	10 (100)	10 (100)	9 (90)	4 (40)	1 (10)
24	10 (100)	10 (100)	8 (80)	2 (20)	0 (0)
36	10 (100)	10 (100)	6 (60)	1 (10)	0 (0)
48	10 (100)	10 (100)	4 (40)	0 (0)	0 (0)

Table 2
Toxic effects of Sumithion on the fingerlings of *O. niloticus*.

Hours	Different concentrations of insecticide (ppm)				
	Control	2	4	6	8
	No. of survived fish (%)				
12	10 (100)	10 (100)	10 (100)	10 (100)	4 (40)
24	10 (100)	10 (100)	10 (100)	9 (90)	2 (20)
36	10 (100)	10 (100)	10 (100)	7 (70)	1 (10)
48	10 (100)	10 (100)	9 (90)	4 (40)	0 (0)

Table 3
Toxic effects of Sumithion on the fingerlings of *P. gonionotus* (sarputi) for 12, 24, 36 and 48 hours under different concentrations.

Hours	Different concentrations of Sumithion (ppm)				
	Control	6	8	10	12
	No. of survived fish (%)				
12	10 (100)	10 (100)	10 (100)	10 (100)	10 (100)
24	10 (100)	10 (100)	10 (100)	9 (90)	4 (40)
36	10 (100)	10 (100)	9 (90)	6 (60)	3 (30)
48	10 (100)	10 (100)	7 (70)	2 (20)	0 (0)

Table 4
Toxic effects of Nogos to fingerlings of *O. naloticus* for 12, 24, 36 and 48 hours under different concentrations.

Hours	Different concentrations of Nogos (ppm)				
	Control	4	6	8	10
	No. of survived fish (%)				
12	10 (100)	10 (100)	10 (100)	10 (100)	8 (80)
24	10 (100)	10 (100)	10 (100)	8 (80)	4 (40)
36	10 (100)	10 (100)	10 (100)	6 (60)	2 (20)
48	10 (100)	10 (100)	9 (90)	3 (30)	0 (0)

Table 5
Toxic effects of Nogos to fingerlings of *P. gonionotus* for 12, 24, 36 and 48 hours under different concentrations.

Hours	Different concentrations of Nogos (ppm)				
	Control	10	12	14	16
	No. of survived fish (%)				
12	10 (100)	10 (100)	10 (100)	10 (100)	8 (80)
24	10 (100)	10 (100)	10 (100)	10 (100)	4 (40)
36	10 (100)	10 (100)	10 (100)	8 (80)	3 (30)
48	10 (100)	10 (100)	9 (90)	4 (40)	0 (0)

Most of the fishes came to the surface due to suffocation within a short time of application of insecticides especially in aquaria with concentrated doses. Gradually they lost their balance, became paralyzed and finally settled down to the bottom of the aquaria. Sharma et al. (1981) also reported similar findings as recorded in the present study. The concentrations of Sumithion required for cent percent survivability of spawn and fingerling of *O. niloticus* and fingerling of *P. gonionotus* recorded for 48 hours were 1, 2 and 6 ppm, and for 24 hours were 1, 4 and 8 ppm respectively (Tables 1, 2, 3). But for Nogos the concentrations required for cent percent survivability at 24 hours and 48 hours were found to be 6 ppm and 4 ppm respectively for *O. niloticus*, and 14 ppm and 10 ppm respectively for *P. gonionotus* (Tables 4, 5). The concentrations of Sumithion required for cent percent mortality at 48 hours recorded were 4 ppm, 8 ppm and 12 ppm for spawn and fingerling of *O. niloticus* and fingerling of *P. gonionotus* respectively (Tables 1, 2, 3). Whereas, for Nogos the concentrations recorded for cent percent mortality of fingerling of *O. niloticus* and *P. gonionotus* at 48 hours were 10 ppm and 16 ppm respectively (Tables 4, 5). The above findings clearly indicated that among the tested fishes *P. gonionotus* was more resistant to insecticides. This finding also agrees with the finding of Samina (1993). However, between the two size groups of *O. niloticus*, fingerlings were found to be more resistant than spawns.

Lethal dose

The LD_{50} values required for 24 hours and 48 hours were determined for both Sumithion and Nogos. The values were found to vary widely with the tested fishes. Corresponding to LD_{50}, the values for LD_0 and LD_0 were also found to vary remarkably with the tested fishes. The LD_0 values of Sumithion recorded for tested fishes were found to vary from 1 to 6 ppm with the highest value in *P. gonionotus* and lowest of the same in spawn of *O. niloticus* (Figure 1, 2, 3). For Nogos, the values of the same recorded were 4 ppm and 10 ppm for *O. niloticus* and *P. gonionotus* respectively (Figure 4, 5).

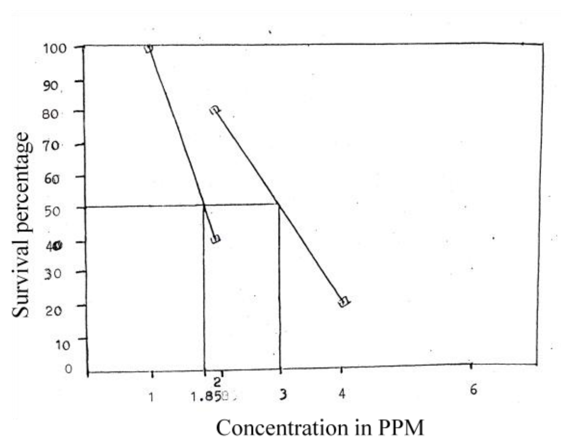


Figure-1
Median Tolerance Limit (TLM) for spawn of *O. niloticus* for Sumithion on 24 and 48 hours.

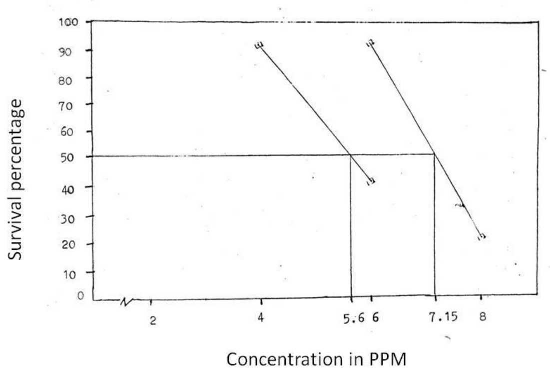


Figure 2
Median Tolerance Limit (TLM) for fingerlings of *O. niloticus* for Sumithion on 24 and 48 hours.

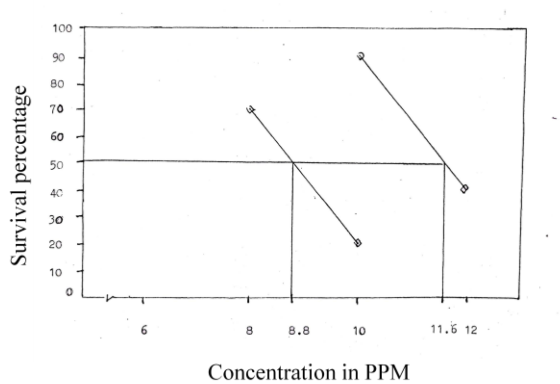


Figure 3
Median Tolerance Limit (TLM) for fingerlings of *P. gonionotus* for Sumithion on 24 and 48 hours.

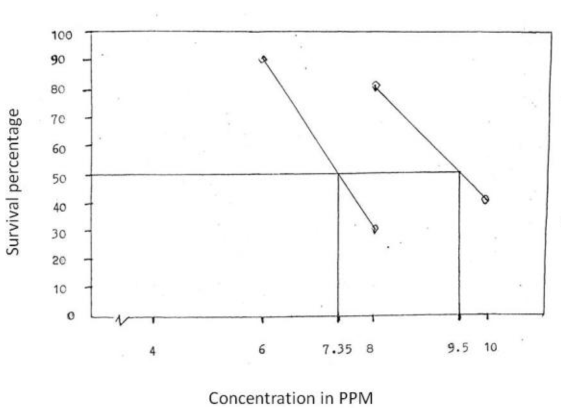


Figure 4
Median Tolerance Limit (TLM) for fingerlings of *O. niloticus* for Nogos on 24 and 48 hours.

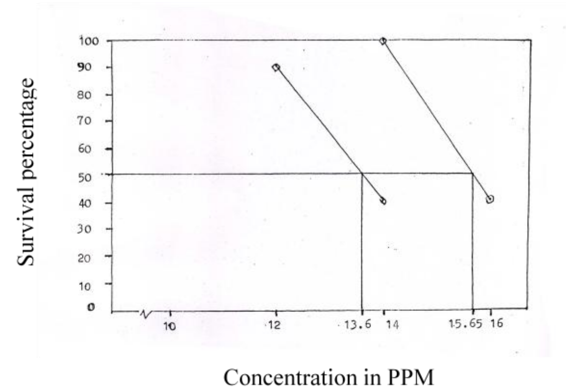


Figure 5
Median Tolerance Limit (TLM) for fingerlings of *P. gonionotus* for Nogos on 24 and 48 hours.

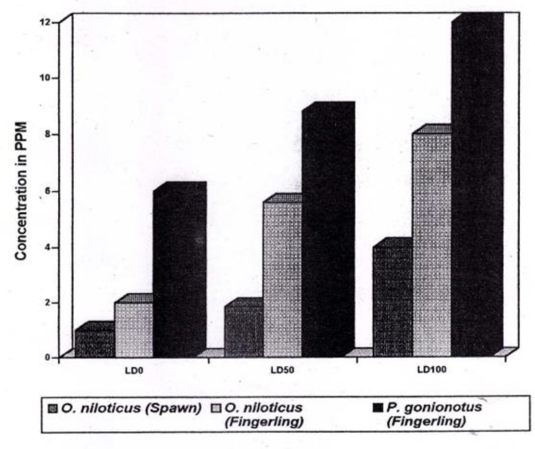


Figure 6
Concentrations of Sumithion required for 48 hours LD_0, LD_{50} and LD_{100}

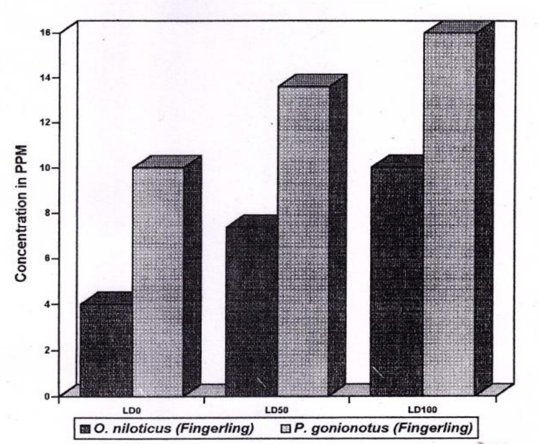


Figure 7
Showing the concentrations of Nogos required for 48 hours LD_0, LD_{50} and LD_{100}.

The LD_{50} values recorded for Sumithion in 48 hours exposure were found to vary from 1.85 ppm to 8.8 ppm with lowest value in spawn of *O. niloticus* and highest value in *P. gonionotus* (Figure 3). Similar to Sumithion LD_{50} values recorded for Nogos were also found to vary widely. The lower value (7.35 ppm) was recorded in *O. niloticus* and higher value (13.6 ppm) was recorded in *P. gonionotus* (Figure 4). The LD_{100} values recorded for tested fishes in Sumithion and Nogos were also found to vary widely similar to LD_{50} values (Tables 6, 7).

In Sumithion the lowest value (4 ppm) of the same was recorded in spawn of *O. niloticus* and the highest value (12 ppm) was recorded in *P. gonionotus* (Figure 6). In Nogos the LD_{100} values recorded were 10 ppm in *O. niloticus* and 16 ppm in *P. gonionotus* (Figure 7).

The LD_{50} values of Sumithion recorded by Samina (1993) were 7.25 ppm for *O. niloticus* and 7.6 ppm for *C. punctatus* and LD_{100} values recorded were 9 ppm and 12 ppm for *O. niloticus* and *C. punctatus* respectively. The LD_{50} and LD_{100} values recorded in the present study for *O. niloticus* were slightly lower than the values recorded by Samina (1993).

Table 6
Concentration of Sumithion required for 48 hours LD_0, LD_{50} and LD_{100} for fishes determined by laboratory test.

Name of species	Number of fishes	Concentrations in ppm		
		LD_0	LD_{50}	LD_{100}
Spawn of *O. niloticus*	10	1	1.85	4
Fingerling of *O. niloticus*	10	2	5.6	8
Fingerling of *P gonionotus*	10	6	8.8	12

Table 7
Concentration of Nogos required for 48 hours LD_0, LD_{50} and LD_{100} for fishes determined by laboratory test.

Name of species	Number of fishes	Concentrations in ppm		
		LD0	LD50	LD100
Fingerling of *O. niloticus*	10	4	7.35	10
Fingerlings of *P. gonionotus*	10	10	13.6	16

The LD_{50} and LD_{100} values recorded in the present study for *O. niloticus* and *P. gonionotus* were almost close to the values recorded by Samina (1993). But the LD_0, LD_{50} and LD_{100} values of Nogos recorded by Konar (1969) were 4 ppm, 6.16 ppm and 10 ppm in *P. sophore* and 13 ppm, 17.78 ppm and 25 ppm respectively for *Heteropneustes fossilis.*

In the present study the concentrations required for LD_0, LD_{50} and LD_{100} varied with the species and the types of the toxicant. These findings are in conformity with the findings of Shrivastava, and Konar (1965) and Samina (1993).

Between the tested fishes *P. gonionotus* was found more resistant to toxicity of insecticides than that of *O. niloticus*. Between the two tested insecticides Sumithion was found to be more toxic than Nogos. Similar findings were also reported by Samina (1993) in her study.

Safe Application Rate (SAR)

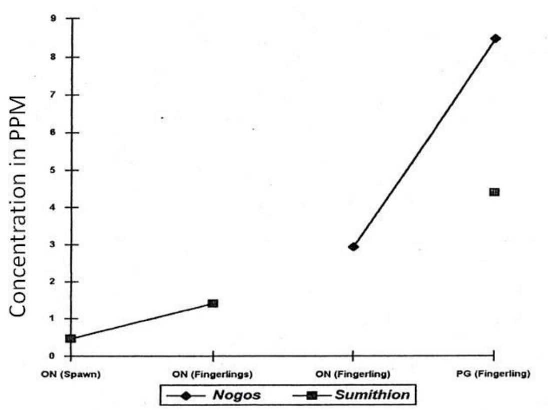
The safe application rate was found to vary with the species and with the insecticides similar to LD_{50} and LD_{100} (Tables 8, 9 and Figure 8).

Table 8
Estimation of safe application rate (SAR) of Sumithion using safe application factor equation (SAFE).

Test fishes	SAFE = LD_{50}/LD_{100}	SAR = SAFE×LD_{50} (ppm)
Spawn of *O. niloticus*	0.25	0.46
Fingerling of *O. niloticus*	0.25	1.40
Fingerling of *P. gonionotus*	0.5	4.4

Table 9
Estimation of safe application rate (SAR) of Nogos using safe' application factor equation (SAFE).

Test fishes	SAFE = LD50/LD100	SAR = SAFE×LD50 (ppm)
Fingerling of *O. niloticus*	0.4	2.94
Fingerling of *P. gonionotus*	0.625	8.50



ON (Spawn) = *O. niloticus* (Spawn)
ON (Fingerlings) = *O. niloticus* (Fingerlings)
ON = *O.niloticus* PG =*P.gonionotus*
(Fingerling) (Fingerling)

Figure 8
Showing the safe application rate (SAR) of Nogos and Sumithion.

The safe application rates of Sumithion recorded for spawn of *O. niloticus*, fingerling of *O. niloticus* and *P. gonionotus* were 0.46 ppm, 1.40 ppm and 4.4 ppm, whereas, for Nogos the values recorded were 2.94 ppm and 8.50 ppm for *O. niloticus* and *P. gonionotus respectively.*

Similar to LD_{50} and LD_{100} values, the safe application rate required for *P. gonionotus* was recorded higher than that of *O. niloticus*. Konar (1971) also recorded highest safe application rate for *P. sophore* which is similar to *P. gonionotus* and thus conforms the finding of the present study.

The safe application rates of Nogos recorded in the present study for *O. niloticus* were more or less close to the values recorded by Samina (1993). But the values of the same recorded for Sumithion in *O. niloticus* differred remarkably.

Between the two size groups of *O. niloticus* spawn was found to be more susceptible to toxicity than that of fingerling, and the concentration required for cent percent mortality was found to be about half of concentration required for fingerling. This finding indicated that the toxicity effects of insecticides also vary with the size of the fish. Singh and Sahai (1984) reported safe application rate for 15 days old *P. ticto* was 4 ppm in Malathion.

CONCLUSION

The water of paddy-fields, flood-plains and large-small-scale industries contain high- dose various toxic insecticides and heavy metals. As *P. gonionotus* are tolerant of that high dose toxicity, they can be cultured in that water resulting in boosting fish production as well as meeting protein dificit. Considering the resistant power of toxicity of the two- tested species of fish, *P. gonionotus* may be recommended for rice-cum- fish and other integrated aquaculture in this country as well as throughout the globe. Sumithion was found to be more toxic to fish than Nogos and was economically more viable compared to the application of the latter. So, Sumithion can be recommended as a cost- effective insecticide in this technology. The study revealed that the concentration required for cent percent mortality (LD_{100}) of spawn of *O. niloticus* was found to be nearly half of the concentration required for fingerlings which was vital to know that, how much lesser content, the overcrowding of *O.*

niloticus can be checked in both mono and polyculture due to its prolific breeding habits. This ultimately helped a great deal in obtaining sustainable yield of *O. niloticus* in pond fish culture as well as achieving food security, a great challenge of the current globe. So, the results of this technology i.e study may be applied in case of the aforesaid water-bodies and highly insecticide-resistant fish species can be cultured there from which massive fish production can be obtained meeting the protein requirement and strengthening the overall economy of the globe.

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