Delta. J. Sci. 16 (3) 1992

TOLERANCE OF TILAPIA NILOTICA AND T. ZILLIi TO ZINC AND MERCURY UNDER LABORATORY CONDITIONS

BY

*Tharwat S. Shenouda **Abdel-Naeim M.Al-Assiuty
** Fouad A. Abou-Zaid * Ahmed A. Abada
* Faculty of Education, Tanta Univ., Kafr El-Sheikh.
** Faculty of Science, Tanta Univ., Tanta.

Received: 17 - 9 - 1992.

ABSTRACT

Both Tilapia species were subjected to different concentrations of zinc and mercury under ambient laboratory conditions. The changes in the values of the median lethal time (LT 50), regression coefficient of mortality, mortality deviation, beside the mean length of life, were discussed. Also, the median lethal metal concentration (LC 50) that kills 50% of individuals after 24, 48, 72 and 96 hours was deduced from the obtained data. It was found that zinc is more toxic on T. nilotica than on T. zillii at any certain concentration. Comparable values of LC 50 were obtained for both species at the different Hg concentrations, which indicates that mercury is highly toxic on each of them, with the same rate.

INTRODUCTION

As a result of the modern industrial progress in Egypt, hundreds of factories and manufactures were constructed on the banks of the River Nile and its branches. Unfortunately, many of them pour their wastes into the freshwater streams without treatment, regardless the influence of these wastes on both aquatic inhabitants and man.

The industrial wastes contain a great number of organic and inorganic materials, some of which are highly toxic to fishes and consequently to man as their main consumer. This will certainly lead to a poor fish population and unhealthy man.

Tilapia nilotica L. and T. zillii Gervais are exclusively the most dominating fishes in the River Nile and the most popular edible fishes.

It was found that many industrial wastes contain high concentrations of zinc (Shenouda *et al* , 1992) and mercury (Kimbal , 1975).

For these reasons, it was found interesting to study the tolerance of the two previously stated Tilapia species to different concentrations of zinc & mercury under ambient conditions and deduce the metal concentrations that kills 50 % of the tested individuals after 24, 48, 72 and 96 hours.

MATERIAL AND METHODS

All experiments were carried out under normal ambient laboratory conditions : temperature 17.0 ± 4.0 ^{0}C, dechlorinated tap water with hardness of about 23 ppm. (as Ca and Mg carbonate) and pH 6.2 ± 0.2 .

Series of 30 litre glass aquaria (60 x 30 x 40 cm.) were thoroughly cleaned, provided with continuous air supplying resources. Stock solutions of zinc acetate and mercuric chloride were weekly prepared. One or two droplets of Hcl were added to each stock solution for reducing precipitation of basic metal salts.

Samples of Tilapia species were collected from Desouk fishing farm at Kafr El-Sheikh Governorate. After quick transportation of fishes, which were put into nylon bags with oxygen, to the laboratory, they were kept into temporary glass aquaria for 2-3 days, for adaptation. Ten healthy individuals, almost of the same size, were transferred to one of the glass aquaria, which contained different zinc and mercuric concentrations. The zinc concentrations used were : 20, 30, and 40 ppm. for Tilapia nilotica and 20, 30, 40, and 50 ppm. for T. zillii individuals. Fishes of both species were subjected to mercuric concentrations of 0.8, 1.2 and 1.4 ppm. . Each concentration of both metals was tested in five replicates. The experiments were accompanied by controls. For all experiments 400 individuals of Tilapia nilotica and 450 individuals of T. zillii were employed.

Deaths of the tested fishes were recorded at intervals according to the metal concentration.

The available data were statistically treated by applying the least square method to the variables. The median lethal time (LT 50), regression coefficient of mortality (b), mortality deviation corresponding to the LT-50 time ($\hat{Y}$) as well as the mean length of life (M), were estimated.

RESULTS

A- Tolerance to zinc

Tilapia nilotica fishes were subjected to three zinc concentrations: 20, 30 and 40 ppm., whereas those of T. zillii were tested against the same concentrations beside a fourth one of 50 ppm. The resulted data are shown in table (1) and illustrated in figures (1-3) for T. nilotica and (5-8) for T. zillii.

1- Tilapia nilotica :

From the obtained data it can be observed that the values of the sample regression coefficient of mortality (b) for T. nilotica were considerably different from each other. Thus, as zinc concentration increases a marked increase in mortality coefficient can be seen. At the lowest concentration (20 ppm) the tested individuals were more tolerable against zinc pollution. However, with zinc concentration of 30 ppm. the tolerance of the tested fishes markedly decreased by a factor of about two folds. Moreover, at 40 ppm. of zinc concentration a minimum relative tolerance was achieved with a mortality coefficient of about 1.06 individual / time unit.

On the other hand, a negative correlation was observed between the obtained mortality deviations ($\hat{Y}$) corresponding to LT 50 times and the metal concentrations. Thus, at concentrations of 20, 30, and 40 ppm. of zinc, the mortality deviations were: 14.14, - 4.4 and - 13.7, respectively. This probably reflects that the population intrinsic resistance of the tested fish decreases as metal concentration increases. The negative values of ($\hat{Y}$) indicate that the time at which 50% of individuals were killed is less than the mean time (Mx) of the experimental intervals. This may be due to the strong effect of the high zinc concentrations (30 and 40 ppm.). However, in case of 20 ppm. the positive value of ($\hat{Y}$) may reflect a clear figure about the high population intrinsic resistance of the tested individuals against such metal concentration.

2- Tilapia zillii

The data for this species showed the presence of a proportional relationship between the regression coefficient of mortality (0.15, 0.17 and 0.19) and metal concentrations (20, 30 and 40 ppm. of zinc). However, at 50 ppm. of zinc concentration, this species had a low survival ability, since the regression coefficient of mortality was relatively high (3.35). This could be explained on the basis of the high population intrinsic resistance in the first three concentrations. Moreover, no significant differences were observed between the toxicity of the first three tested concentrations, based on the standard error among the different replicates. On the contrary, with 50 ppm. zinc concentration, the mean length of life of the tested individuals was sharply decreased by a factor of 10 to 12 folds. This idea was confirmed by the positive values of ($\hat{Y}$) at the first three Zn concentrations as a high population intrinsic resistance was existing. The negative value of ($\hat{Y}$) in case of 50 ppm. of Zn showed that a great reduction in this resistance had occurred. Also, these results clearly show that the increase in metal concentration from 20 to 50 ppm. caused a marked increase in mortality function and shortened the LT50 values. Thus, at the lowest metal concentration (20 ppm.) the LT50 value was 248.1 h., while at 50 ppm. a marked decrease in the resistance could be observed since the LT50, at this concentration, significantly decreased to 22.4 h. instead of 244.2 h. at 40 ppm.

The indirect proportional relationship between LT50 times and zinc concentrations could be explained according to Bryan view (1976), who indicated that the relationship between the rate of absorption and external concentration of zinc is not directly proportional to each other because the zinc uptake is more closely related to its adsorption on the surface of the body during the uptake process and binded by the surface mucous layer.

Table (1) and figures 4 and 9 indicate the median lethal Zn concentrations that kill 50% of individuals (LC 50) of T nilotica and T. zillii, respectively after 24, 48, 72 and 96 hours. They were found to be 39.4, 34.8, 30.2 and 25.6 ppm. for the first species and 49.7, 46.6, 43.4 and 40.2 for the second one. This shows that Zn is more toxic, at the concentration of 39.4 ppm. (24 h.LC50), on T. nilotica than on T. zillii.

B - Tolerance to mercury

Each of the experimental fish species was subjected to three different mercuric concentrations i.e.0.8, 1.2 and 1.4 ppm. The obtained results are shown in table (2) and illustrated in figures (10 - 12) for T. nilotica and (14 -16) for T. zillii.

1- **Tilapia nilotica** :

The results for this species revealed the presence of a proportional relationship between the metal concentration and the regression coefficient of mortality. Thus, the different values of (b) in the cited table were: 0.22, 0.49 and 2.74 at the mercuric concentrations of 0.8, 1.2 and 1.4 ppm., respectively. However, a negative relationship was noticed between the Hg concentration and LT50 values. Thus, the values of LT50 were: 89.7, 58.7 and 7.6 h. corresponding to the previous mercuric concentrations, respectively.

On the other hand, the mortality deviation ($\hat{Y}$) showed a positive value (11.43) at the concentration of 0.8 ppm., whereas it indicated negative values (-5.0 and -8.7) at the other concentrations of 1.2 and 1.4 ppm., respectively. This may probably assume that the tested fishes had a relatively good population intrinsic resistance at the lowest concentration. However, at the following concentrations the tested individuals showed faint resistances.

2- Tilapia zillii :

The results presented in table (2) for this species, also revealed the existance of a proportional relationship between the regression coefficient of mortality (b) and the mercuric concentration. Thus, the values of (b) were : 0.14, 1.86 and 3.99 at the metal concentrations cited before, respectively. The same negative relationship - as in the former species - between the values of LT50 and the Hg concentrations was found. Thus, the values of LT50 were : 143.8, 18.11 and 10.72 h. corresponding to the mercuric concentrations of 0.8, 1.2 and 1.4 ppm., resectively.

On the other hand, the obtained values for the mortality deviation ($\hat{Y}$) were found to be correlated with the different metal concentrations. It had a positive value (11.43) at the lowest concentration (0.8 ppm.), which may indicate the relatively high intrinsic resistance of this species. The other values of ($\hat{Y}$) indicated negative figures, being - 5.0 and -8.8 at 1.2 and 1.4 ppm. concentrations, respectively. This means that the intrinsic resistance of T. zillii decreases with increasing metal concentration.

Table (2) and figures 13 and 17 indicate the values of LC50 when using different mercuric concentrations for T. nilotica and T. zillii after 24, 48, 72 and 96 hours, respectively. These values were found to be : 1.28, 1.1, 0.92 and 0.75 ppm. for the first species and 1.34, 1.23, 1.12 and 1.01 ppm. for the second one, respectively. This shows that mercury is a highly toxic metal and its effect is comparable on both Tilapia species.

DISCUSSION AND CONCLUSIONS

Pollutants entering water sources are much diversed. According to Kimbal (1975) the major sources of pollution come from industrial, domestic and agricultural wastes. The industrial wastes include metals such as zinc, mercury, lead, copper, ...etc., beside many organic and inorganic toxicants. Many freshwater and agricultural soil areas are greatly polluted by the disposal of waste-metal solutions resulting as by-products from industrial, mining processes, ...etc. into rivers and canals. All these forms are harmful to water fauna and their toxicity greatly depends on water characteristics (Chapman, 1978) and soil properties (Ma Wei-Chun, 1982). Wilbure (1969) mentioned that all chemicals of industrial wastes are toxic to animals and may cause death or sublethal pathological manifestations of many internal organs in both invertebrate and vertebrate aquatic animals. Moreover, Stum & Bilinski (1973) stated that metals are well-known pollutants causing disorder in population-function of some, if not all, living organisms.

Zinc wastes can have a direct toxicity to aquatic life and fisheries can be affected by either zinc alone or more often with other metals (Alabaster and Lloyd, 1982). Effects of zinc on fish have been critically reviewed by many authors of which Doudoroff & Katz (1953), Skidmore (1964), Abou-Zaid *et al.* (1988) and Shenouda *et al.* (1992) could be mentioned.

On the other hand, many lakes and rivers contain undesirable levels of mercury (Goldwater, 1971; Katz, 1972; Fishbein, 1974). It was found that almost all sediments contain this metal which results from human activities (Ackefors, 1968; Gavis & Ferguson, 1972 and Lexmond *et al*, 1976). Mercury in the water mass is predominant in inorganic form (Jensen and Jernelov, 1969; Fimreit *et al*, 1971; Keeney, 1972).

The present study is concerned with the tolerance of two of the most important fishes in the River Nile, i.e.

Tilapia nilotica and Tilapia zillii to different zinc and mercuric concentrations. From the discussed analyses of the obtained results it can be concluded that a positive correlation exists between the regression coefficient of mortality and the metal concentration either zinc or mercury for both Tilapia species. However, a negative correlation is present between the mortality deviation corresponding to LT50 times and concentration of both metals, for both fish species. The population intrinsic resistance of T. zillii appeared to be higher than that of T. nilotica at the same metal concentration.

The study of the relation between zinc concentration and the corresponding LT50 time revealed that Zn is more toxic, at the concentration of 39.4 ppm. (24 h. LC50), for T. nilotica than for T. zillii.

The comparison between the effect of mercury on T. nilotica and T. zillii showed that the values of the regression coefficient of mortality (b) sharply increase, while those for the median lethal time (LT50) and mortality deviation ($\hat{Y}$) sharply decrease, with nearly the same rate in both species as the metal concentration increases. This means that mercury has a high toxic effect on both tested fishes. This was ensured by the values of the median lethal concentration (LC50) which were comparable for both species under study.

Table (1) : The regression data at the different concentrations of zinc for *T.nilotica* (n) and *T.zillii* (z) , under laboratory ambient conditions .

Conc . (ppm.)	Fish sp.	Equation of regression	M	a	b	LT50	Ŷ	Mx	My	Error in fitting the line			
										syx	syx^2	sb	t
20	n	Y = 7.98 + 0.34 X	89.60	7.98	0.34	124.90	14.14	83.3	36.0	9.33	87.10	0.12	3.14
	z	Y = 13.60 + 0.15 X	212.80	13.60	0.15	248.10	10.00	179.8	40.0	7.50	56.20	0.02	6.69
30	n	Y = 1.13 + 0.71 X	67.19	1.13	0.71	69.15	-4.40	75.4	54.4	12.55	157.50	0.11	6.72
	z	Y = 8.02 + 0.17 X	233.80	8.02	0.17	247.20	5.00	219.5	45.0	7.93	62.80	0.02	7.80
40	n	Y = 27.90 + 1.06 X	25.20	27.90	1.06	20.88	-13.70	33.8	63.7	14.07	198.14	0.24	4.38
	z	Y = 26.22 + 0.19 X	158.90	26.22	0.19	244.20	1.00	126.8	38.5	13.69	187.50	0.04	2.68
50	z	Y = - 25.2 + 3.35 X	21.18	-25.20	3.35	22.40	-2.50	23.2	52.5	14.13	199.50	0.59	5.64

Table (2) : The regression data at the different concentrations of mercury for *T.nilotica* (n) and *T.zillii* (z) , under laboratory ambient conditions .

Conc . (ppm.)	Fish sp.	Equation of regression	M	a	b	LT50	Ŷ	Mx	My	Error in fitting the line			
										syx	syx^2	sb	t
0.8	n	Y = 30.40 + 0.22 X	50.16	30.40	0.22	89.70	11.43	37.2	38.5	15.93	253.90	0.11	2.00
	z	Y = 29.80 + 0.14 X	78.20	29.80	0.14	143.80	11.43	62.2	38.5	16.17	261.40	0.07	1.93
1.2	n	Y = 21.10 + 0.49 X	60.64	21.10	0.49	58.70	-5.00	68.9	55.0	9.39	88.15	0.05	9.25
	z	Y = 16.27 + 1.86 X	18.20	16.27	1.86	18.11	-5.00	20.8	55.0	14.22	202.10	0.03	5.73
1.4	n	Y = 29.10 + 2.74 X	8.20	29.10	2.74	7.60	-8.70	10.8	58.7	18.53	343.70	0.69	3.90
	z	Y = 7.16 + 3.99 X	11.15	7.16	3.99	10.72	-8.80	[illegible]	58.8	[illegible]	[illegible]	[illegible]	[illegible]

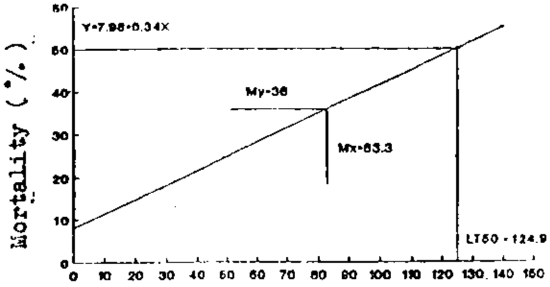

Fig. (1) Time (hrs.)
20 ppm.Zn

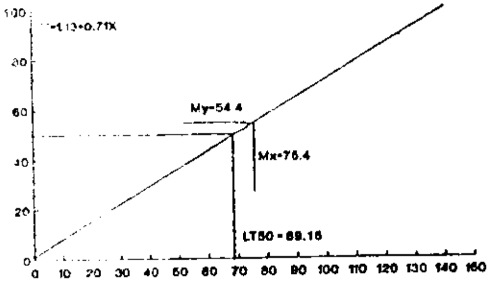

Fig. (2) Time (hrs.)
30 ppm.Zn

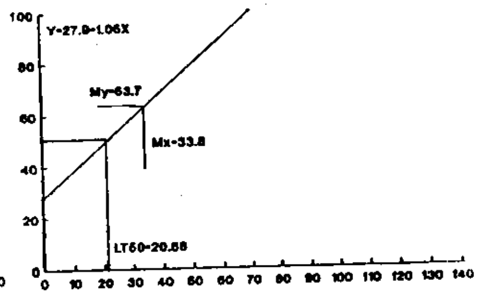

Fig. (3) Time (hrs.)
40 ppm.Zn

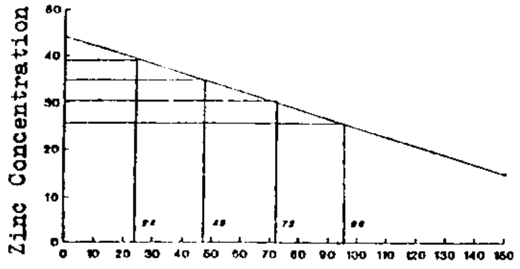

Fig. (4) LT 50 Time

Tolerance of T.nilotica to different zinc concentrations : 20 ppm. (Fig.1) , 30 ppm. (Fig.2) and 40 ppm. (Fig.3) .

Figure (4) illustrates the deduced median lethal concentrations , which kill 50 % of individuals of T.nilotica (LC 50) , after 24 , 48 , 72 and 96 hours .

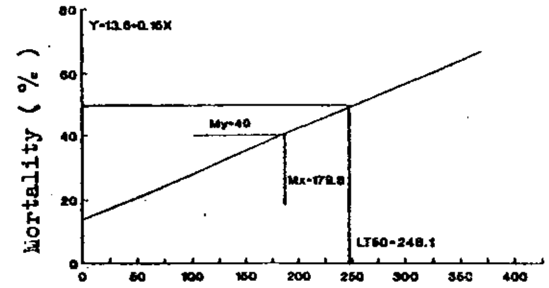

Fig. (5) Time (hrs.)
20 ppm.Zn

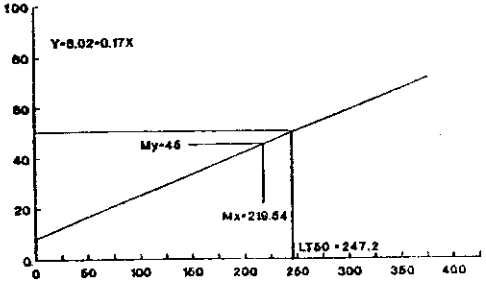

Fig. (6) Time (hrs.)
30 ppm.Zn

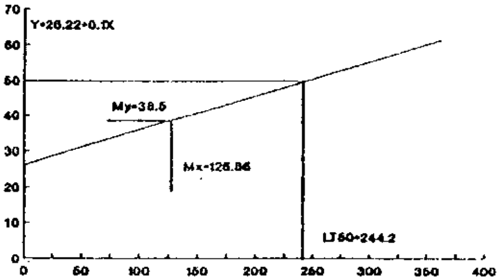

Fig. (7) Time (hrs.)
40 ppm.Zn

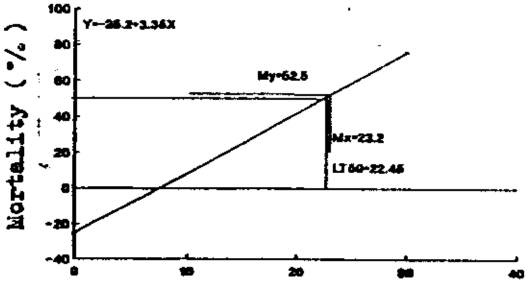

Fig. (8) Time (hrs.)
50 ppm.Zn

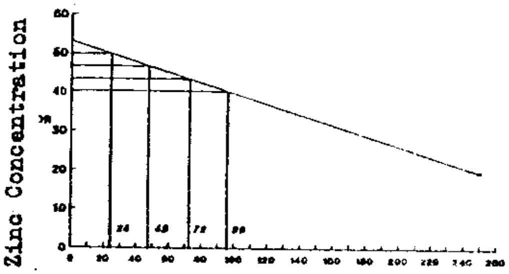

Fig. (9) LT 50 Time

Tolerance of T.zillii to differ zinc concentrations : 20 p (Fig.5) , 30 ppm. (Fig.6) , 40 (Fig.7) and 50 ppm. (Fig.8) .

Figure (9) illustrates the deduc median lethal concentrations which kill 50 % of indivi als of T.zillii (LC50) , after 48 , 72 and 96 hours .

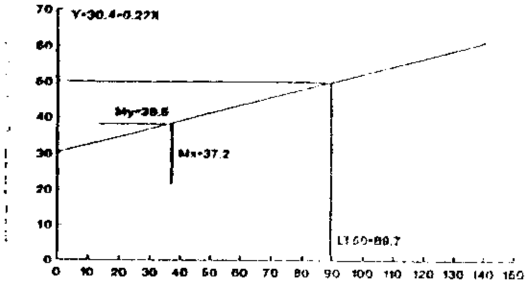

Fig. (10) T i m e (hrs.)
0.8 ppm.Hg

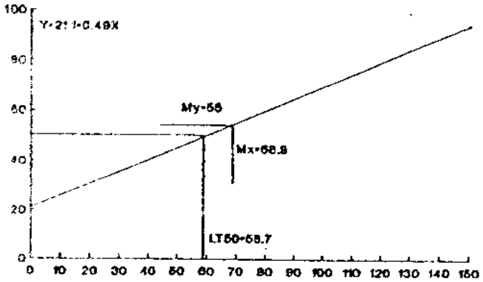

Fig. (11) T i m e (hrs.)
1.2 ppm.Hg

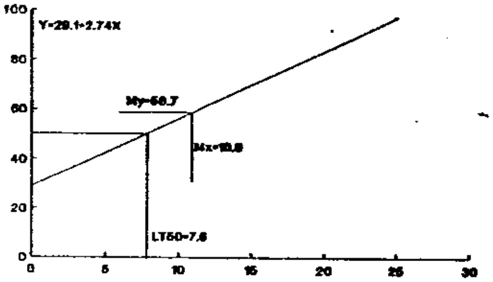

Fig. (12) T i m e (hrs.)
1.4 ppm.Hg

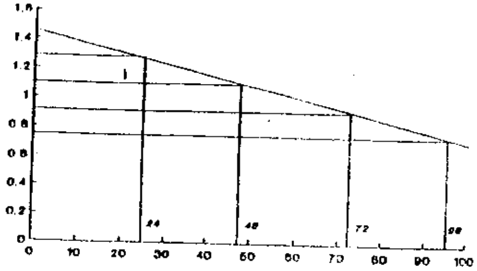

Fig. (13) LC 50 time

Tolerance of T.nilotica to different mercuric concentrations: 0.8 ppm. (Fig.10) , 1.2 ppm. (Fig.11) and 1.4 ppm. (Fig.12) .

Figure (13) illustrates the deduced median lethal concentrations , which kill 50 % of individuals of T.nilotica(LC50), after 24 , 48 , 72 and 96 hours .

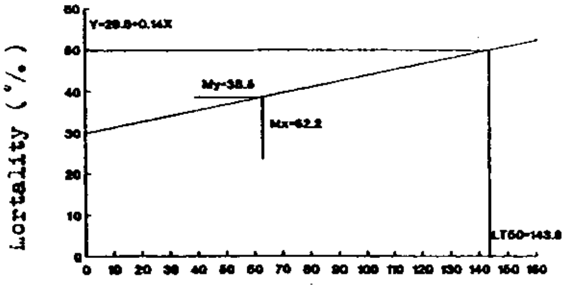

Fig. (14) Time (hrs.)
0.8 ppm.Hg

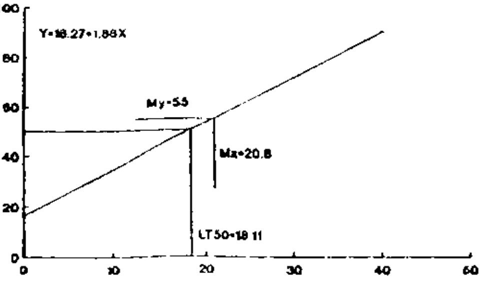

Fig. (15) Time (hrs.)
1.2 ppm.Hg

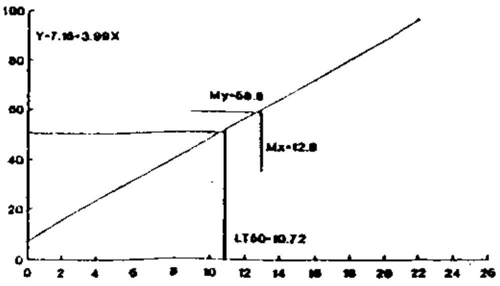

Fig. (16) Time (hrs.)
1.4 ppm.Hg

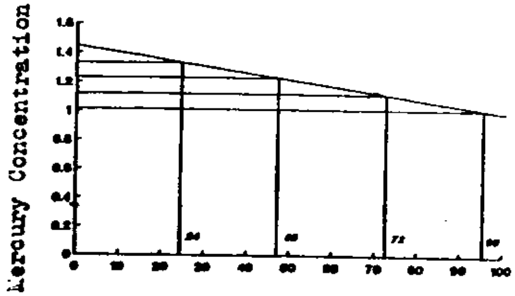

Fig. (17) ; LC 50 time

Tolerance of T.zillii to different mercuric concentrations : 0.8 ppm. (Fig.14) , 1.2 ppm. (Fig.15) and 1.4 ppm. (Fig.16).

Figure (17) illustrates the deduced median lethal concentrations , which kill 50 % of individuals of T.zillii(LC50), after 24 , 48 , 72 and 96 hours .

REFERENCES

1- **Abou-Zaid, F.A.; Elserafy, S. and El-Shourbagy, I.K.,(1988): The toxicity of copper and zinc of three fish of Genus Tilapia. Egypt. J. Appl. Sci., 3 (3): 8-16**

2- **Ackefors, H., (1968): A survey of the mercury problem in Sweden with special reference to fish. In formal meeting of a group of consultants on the problems of toxicant in sea-food. 18-22 November 1968 (W.p.11).**

3- Alabaster, J.S. and Lloyd, R., (1982): Water quality criteria for freshwater fish. Food and Agr. Organ. U.N. Butter-worth. Sci. Lond., pp. 361.

4- Bryan (1976): Quoted from Pratap *et al.*, (1989).

5- Chapman, G.A., (1978): Toxicities of cadmium, copper and zinc to four juvenile stages of chinnok salmon and steel head. Trans. Am. Fish. Soc., 107: 841-847.

6- Doudoroff, P. and Katz, M., (1953): Critical review of literature on the toxicity of industrial wastes and their components to fish -2- The metals as salts. Sewage Ind. Wastes, 25: 802-839.

7- **Fimreit, N.; Holsworth, W.N.; Keith, J.A.; Peace, D.A. and Gruchy, I.M., (1971): Mercury in fish and fish-eating birds near sites of industrial contamination in Canada. Can. Field Nat., 85: 211-220.**

8- **Fishbein, L., (1974): Mutagens and potential mutagens in** the biosphere. II-Metals: mercury, lead, cadmium, tin. Environ., 2: 341-371.

9- Gavis, J. and Ferguson, J.F., (1972): The cycling of mercury through the environment. Water Res., 6: 989-1008.

10- Goldwater, L.J., (1971): Mercury in the environment. Sci. Am., 22: 15-21.

11- Jensen, S. and Jernelov, A., (1969): Biological methylation of mercury in aquatic organisms. Nature, 233: 753-824.

12- Katz, A., (1972): Mercury pollution. The making of an environmental crisis. Crit. Rev. Environ. Control., 2: 517-534.

13- Keeney, A.R., (1972): Total mercury and methylmercury in fish organs. 40-45. In J.F.U. (ed). Mercury in aquatic environment: a summary or research carried out by the freshwater Inst. 1970-1971. Can. Fish. Mar. Serv. MS. Rep. 1167.

14- Kimbal (1975): Quoted from Verma *et al.*, (1985).

15- Lexmond, T.M.; Dehan, F.A. and Frissel, M.J., (1976): On the methylation of inorganic mercury and the decomposition of organo-mercury compounds - a review. Neth. J. Agr. Sci., 24: 79-97.

16- Ma Wei-Chun, (1982): The influence of soil properties and worm-related factors on the concentration of heavy metal in earthworms. Pedobiologia, 24: 109-119.

17- Pratap, H.B.; Lock, R.A. and Bonga, S.E., (1989): Effect of waterborne and dietary cadmium on plasma ions of the teleost Oreochromis mossambicus in relation to water calcium levels. Arch. Environ. Contam. Toxicol., 18 (4): 568-575.

18- Shenouda, Th. S.; Abou-Zaid, F.A.; Al-Assiuty, A.I. and Abada, A.E., (1992): Waterpollution and bioaccumulation of the highly pollutant agents in different organs of Oreochromis niloticus, near Kafr El-Zayat. Proc. Zool. Soc., A.R. E., (in press).

19- Skidmore, J.F., (1964): Toxicity of zinc compounds to aquatic animals with special reference to fish. Q. Rev. Biol., 39: 227-248.

20- Stumm, W. and Bilinski, H., (1973): Trace metals in natural waters, difficulties of interpretation arising from our ignorance of their speciation. In Jenkins, S.H. (ed). (Advances in water pollution Research, Proceeding 6th international Conference)., 946: 39-52.

21- Verma, P.S.; Agarwal, V.K. and Tyagi, B.S., (1985): Animal physiology and ecology. Reprinted and Published by S. Chand Comp. Ltd. Ram. Nagar, New Delhi, 110055.

22- Wilbur (1969): Quoted from Verma *et al.*, (1985).

Delta J. Sci. 16 (3) 1992

إحتمال أسماك البلطى النيلى والبلطى الأخضر لتأثيرات معدنى الزنك والزئبق

* عبد النعيم إبراهيم الأسيوطى ثروت شنودة
** فؤاد عفيفى أبو زيد أحمد السيد عبادة
* كلية التربيه - جامعة طنطا - كفر الشيخ
** كلية العلوم - جامعة طنطا - طنطا

عرضت أسماك هذين النوعين لتركيزات مختلفة من محاليل أملاح الزنك والزئبق فى الظروف الطبيعيه المعمليه • نوقشت أسباب الإختلافات فى قيم كل من متوسط وقت الوفاه ؛ معامل إنحدارها ؛ معامل إنحرافها بالإضافه إلى متوسط العمر • كما تم إستنتاج متوسط تركيز هذين المعدنين الذى يقتل نصف أعدادهما بعد ٢٤ ؛ ٤٨ ؛ ٧٢ ؛ ٩٦ ؛ ساعة • وقد وجد أن للزنك تأثير أكثر سمية على أسماك البلطى النيلى عن البلطى الأخضر ؛ بينما للزئبق بمختلف تركيزاته - تأثير متساوى تقريبا على كل من هذين النوعين من الأسماك مما يدل على إرتفاع درجة سميته بمعدل ثابت عليهما •