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EFFECT OF THE HEAT-TREATED NILE SILT AND POPULATION DENSITY ON ACUTE TOXICITY OF ZINC AND MERCURY FOR TWO TILAPIA SPP.

BY

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ABSTRACT

Two Tilapia species (T. nilotica and T. zillii) were subjected to acute zinc and mercuric concentrations (80 ppm. and 1.4 ppm., respectively) after the addition of 10 gms. of heat-treated Nile silt, in order to evaluate its role in protecting these fishes from their toxicosis. The resulted data revealed that nonsignificant role was played by this type of silt for both Tilapia species against Hg and T. nilotica and against Zn. However, silt addition showed a significant role against Zn toxicity to T. ZILLII Different numbers of each species constituted three populations of 4, 12 and 20 individuals were subjected to the same concentrations of Zn and Hg, for studying the influence of population density on their toxicity. It was found that there was a proportional relationship between the intrinsic resistance of population and the population density for both studied species. This resistance was higher for T. zillii than for T. nilotica, in all cases.

INTRODUCTION

The polluted environment, undoubtedly, is reflected by its inhabitants. Accordingly, the polluted water streams must be reflected by their aquatic fauna. Water pollutants come from many sources, of which metals, as by-products of industrial operations, are the most important.

Zinc and mercury are two toxic metals found in many of these industrial wastes. Their sublethal concentrations cause many pathological effects in the cell structure, consequently affect nearly all internal organs of aquatic animals, including fishes, which are considered as one of the main protein resources for man.

It was found that the heat-treated Nile silt shows remarkable reducing properties for both organic and inorganic cations. Its basic character means that it could be applied as a safe way of reducing the acidity of water resources, where the acidity is too high (Ebeid et al., 1987).

Also, it seemed possible that the number of individuals in the population may play a role in the degree of effectiveness of the toxic metals on fishes.

Therefore, it was found interesting to evaluate the role of the heat-treated Nile silt and the influence of population density on the acute toxicity of zinc and mercury for Tilapia nilotica and Tilapia zillii, which are the most dominating freshwater fish.

MATERIAL AND METHODS

A series of 30 litre glass aquaria (60 x 30 x 40 cm.) were thoroughly cleaned, equipped with continuous air supplying resources. Stock solutions of zinc-acetate and mercuric-chloride were weekly prepared as 1000 mg/L. One to two drops of Hcl were added to the stock solution for reducing precipitation of basic metal salts.

Silt was collected from the side of the River Nile at Kafr El-Zayat city (about 110 Km. Northward of Cairo). Following Ebeid et al (1987) the silt was manually crushed, sieved through a wire-sieve to give small sized particles (less than 0.5 mm.), and calcined in muffle furnace at 650 ^{0}C for 24 hs.

Fish samples were brought from Fowa fishing farm, at Kafr El-Sheikh Governorate, into nylon bags filled with oxygen. After quick and careful transportation of these samples to the laboratory they were kept in special temporary aquaria, for 3-4 days, for adaptation.

For carrying out the first type of experiments i.e. evaluation of the role of the heat-treated silt on the high toxicity of Zn and Hg, four aquaria were used for each species, of which two are considered as controls and filled with either 80 ppm. of zinc or 1.4 ppm. of mercury only. The other two aquaria were filled with the same metal concentrations, beside 10 gms. of the treated silt. Ten healthy individuals were put in each aquarium, thus 80 individuals of both species were employed for this experiment.

In the second type of experiments i.e. for studying the influence of population density of both Tilapia species on the high toxicity of Zn and Hg, four sets of aquaria were used, one for each metal for each species. Each set was composed of 3 aquaria, into which different numbers of populations were put, they were : 4, 12 and 20 individuals. Thus, 144 individuals of both Tilapia sp. were employed, of which 72 individuals belong to each of them. The same metal concentrations which were used in the first type of experiments were used here i.e. 30 ppm. of Zn and 1.4 ppm. of Hg.

The two types of experiments were repeated three times, accordingly 672 individuals of both species, equally, were employed in carrying out the present study.

All experiments were carried out under normal controlled laboratory conditions. The pH was maintained at 6.2 ± 0.2 using Hcl. The temperature and the dechlorinated water hardness (as Ca and Mg carbonate) were : 11.0 ± 4 °C and 18-19 ppm. for the first type of experiments, while they were 25.0 ± 1 °C and 15-16 ppm. for the second one. These differences in the temperature degrees and the values of water hardness were attributed to the experimental time, since the first type of experiments was fulfilled in winter while the second type, during spring. The pH values were measured by using digital pH meter and the total hardness, by direct titration.

The available data were statistically treated by applying the least square method to the variables. Also, Kruskal-Wallis test and the T-test were calculated according to steel and Torrie (1976). The percentage of mortality was corrrected by applying Abbot's formula for any response of the controls according to Al-Assiuty (1981). The median lethal time (LT 50), regression coefficient of mortality (b), mortality deviation corresponding to the LT 50 time ($\hat{Y}$), mean length of life (M) as well as the error in fitting the line, were computed.

RESULTS

1 - Role of Silt

a- Toxicity of zinc :

The obtained data are shown in table (i) and graphically represented by figures (1&2) for *T. nilotica* and (3&4) for *T. zillii*.

From these data it can be observed that the mean values of LT 50 of the treated and controlled aquaria for *T. nilotica* were not significantly changed. It was 20.8 hours in the treated and 19.7 hours in the controlled ones. The mortality deviations ($\hat{Y}$) corresponding to LT 50 were the same, having negative values in both cases.

On the other hand, the results obtained for *T. zillii* indicated that there was an increase in the mean value of LT

50 of the treated aquarium (with silt) than that of the controlled one, they were 41.1 h. and 29.6 h. for the treated and controlled aquaria, respectively.

b- Toxicity of mercury :

The resulted data are shown in table (1) and graphically illustrated by figures (5&6) for T. nilotica and (7&8) for T. zillii.

These data clearly reflected the high toxicity of mercury. Thus, by comparing the LT 50 values of the treated and controlled aquaria for T. nilotica, only a slight difference was found, they were 9.43 and 11.09, respectively.

The LT 50 values of the treated and controlled aquaria for T. zillii were nearly comparable, they were 15.29 and 16.33 h., respectively.

Also, it was found that the values of the mortality deviations ($\hat{Y}$) of both treated and controlled aquaria and for each of the two Tilapia species were nearly the same, having negative signs, indicating that the intrinsic resistance of these fishes ware low in the presence or absence of silt.

2- Population density

a- Toxicity of zinc :

The obtained data are shown in table (2) and graphically represented by figures (9,10 & 11) for T. nilotica and (12,13 & 14) for T. zillii.

The resulted data indicated that the mean values of LT 50 in the three different population densities for T. nilotica were comparable to each other, being 8.13, 9.87 and 8.76 h., respectively. This may be attributed to the low resistance of this fish and also to the very high concentration of Zn used (80 ppm.) to the level at which all individuals of the three populations died in comparable times, regardless the number of individuals in each population.

On the other hand, in case of T. zillii a marked variation in resistance could be observed, where the mean values of LT 50 were 10.4, 28.6 and 24.6 h., respectively. These values may be explained on the basis of the acute effect of Zn.

b- Toxicity of mercury :

The resulted data are shown in table (2) and illustrated by figures (15,16 & 17) for T. nilotica and (18,19 & 20) for T. zillii.

These data revealed that the mean values of LT 50 were decreasing as the number of individuals increases. However, the differences in these values were not significant in both species. Thus, in case of T. nilotica the values of LT 50 were 5.02, 4.89 and 4.08 h., whereas they were 6.79, 5.84 and 4.34 h. for T. zillii, at the population densities of 4, 12 and 20 individuals, respectively.

The values of LT 50 for T. nilotica were slightly lower than that for T. zillii, which may reflect the relatively higher resistance of the second species.

DISCUSSION AND CONCLUSIONS

Metal pollution is considered as one of the most important types in water streams. It comes as a by-product from many factories and has a toxic effect on the internal organs of aquatic inhabitants, which may lead to their death.

Fishes which are subjected to sublethal concentrations of toxic metals may cause some diseases to man, if he feeds on them.

Zinc and mercury are two toxic metals found in many industrial wastes. Zinc is an essential trace-element in all living organisms, being involved in nucleic acid synthesis and occur in many enzymes. However, the increase of its concentration in water streams will affect the biota or some, if not all, organs of fishes without killing them, since it makes many pathological alterations in the cell structure. Thus, according to Abou-Zaid et al. (1992) the subjection of Tilapia species to 3.0 ppm. of Zn caused many pathological alterations in the hepatocyte structure. Also, the chloride cells had increased in number after treating the dogfish with 10 ppm. of Zn for three weeks (Crespo et al., 1981). The gill epithelium of this species exhibited surface microvilli or microridges in the pavement cells (Crespo, 1982).

Effects of zinc on fishes have been critically reviewed by many authors, such as Doudoroff & Katz (1953), Skidmore (1964), Kumar & Pant (1984), Wunder et al. (1984), Hilmy et al. (1987), Abou-Zaid et al. (1988 a,b) and Shenouda et al. (1992 a,b).

Also, toxic effects on fishes were remarked after their subjection to sublethal concentrations of mercury. Thus, according to Panigrahi and Misra (1980) the clinical symptoms which appeared on Tilapia mossambica, after exposure to sublethal concentration of 0.5 mg/L of mercury were inappetence and ataxia after 2 days and blindness of about 60% of fishes after 10 days.

Different effects of Hg on fish have been studied by many authors, such as Bhattacharya et al. (1985), Fletcher & White (1986) and Victor et al. (1986).

Ebeid et al. (1987) found that the heat-treated Nile silt showed remarkable sorption properties for both organic and inorganic cations. They mentioned that it could be applied as a safe way of reducing the acidity of water resources, where the acidity is too high.

In the present work two types of experiments were carried out. The first type of experiments was aimed to evaluate the role of the heat-treated Nile silt in reducing the high toxicity of Zn and Hg on T. nilotica and T. zillii. Both Tilapia species were subjected to acute concentrations of either Zinc (80 ppm.) or mercury (1.4 ppm.), after addition of 10 gms. of silt, treated according to Ebeid et al. (1987), to each aquarium. The resulted values of LT 50 and mortality deviations indicated that silt did not provide protection to T. nilotica against the sited Zn concentration, whereas it reduced the zinc toxicity on T. zillii, since the LT 50 value was remarkably increased. The non protective role of silt is probably due to the high sensitivity of this species towards low Zinc concentrations. On the other hand, reducing the high toxicity of 80 ppm Zinc by silt addition against T. zillii may be explained on the basis of two factors : firstly the self rosistance of this species (Abu-Zaid et al, 1988) and secondly the silt addition has apparently reduced the acidity of media (Ebeid et al, 1987) which is followed by precipitation of basic metal salts; thus Zinc becomes less toxic.

The slight difference between the mean LT 50 values of the treated and controlled aquaria for T. nilotica after the subjection to acute Hg concentration may possibly reflect a very slight influence of silt on its toxicity for this species, whereas it had an insignificant influence on the toxicity of mercury for T. zillii fishes.

Generally speaking, the sited results conspicuously revealed that the heat-treated silt has a nonsignificant effect on mercury toxicosis for both Tilapia species. This may be mainly attributed to the highly toxic nature of mercury.

The comparison between the different mean values of the LT 50 times of zinc and mercury toxicosis, for T. nilotica and T. zillii revealed that the latter species was relatively more resistant in both cases.

The second type of experiments was done for studying the influence of the population density of both Tilapia species on the acute toxicity of zinc and mercury at the same metal concentrations used before. Three population densities of 4, 12 and 20 individuals were used for each species, for each metal.

In case of Zn toxicosis, the mean values of LT 50 of these populations for T. nilotica were nearly comparable, whereas for T. zillii a marked variation in resistance could be observed. This may be explained on the basis of the acute effect of Zn. Thus, in the first population the density was the smallest (4 individuals), therefore each individual obtained the largest amount of the toxic metal, hence all individuals died quickly. In the second population (12 individuals) the amount of oxygen in the aquarium was possibly sufficient to provide some resistance against the toxicity of this metal. There was an equilibrium between the toxic effect of Zn and oxygen content in the aquarium, which resulted in an increase in the LT 50 time. The value of LT 50 in the third population (20 individuals) occupied an intermediate position between the other two populations. This may possibly be due to the relatively increased mortality rate resulted from some interfered factors, such as : the indirect effect of the small amount of the toxic metal taken by each individual, the increase of oxygen consumption from water in the aquarium and also as a result of the high fish excrements & microorganisms activity.

Mercury toxicosis showed, also, that the intrinsic resistance of T. zillii is relatively higher than that of T. nilotica.

From the previous discussion it can be concluded that there is a proportional relationship between the population intrinsic resistance and population density. This may be attributed to the large number of individuals which may be considered as a chance for providing the tested group with some individuals having more resistance than others against pollution. This resistance is higher for T. zillii than for T. nilotica, in all cases. Accordingly, it is advised to increase the culture-rate of Tilapia zillii fishes in all water areas, specially in fishing farms and rice-fields.

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Table (1) : Effect of heated-silt on the acute toxicity of zinc (80 ppm.) and mercury (1.4 ppm.) for <u>Tilapia nilotica</u> and <u>T.zillii</u> .

Metal	Fish sp.	Type of aquarium	Equation of regression	K	a	b	LT 50	♀	Mx	My	Error in fitting the line: syx	syx²	sb	t	Fig. No.
Zinc	T.zil.	Controlled (Zn only)	Y = - 0.14 + 2.54 X	19.69	- 0.14	2.54	19.70	- 5.00	21.70	55.00	11.17	124.70	0.33	7.63	1
		Treated (Zn + 10 gm silt)	Y = - 14.98 + 3.23 X	19.59	- 14.90	3.23	20.80	- 5.00	21.64	55.00	16.20	262.80	0.67	4.80	2
	T.zil.	Controlled (Zn only)	Y = - 85.30 + 4.56 X	28.40	-.85.30	4.56	29.60	- 7.14	31.22	57.10	6.64	44.14	0.41	11.20	3
		Treated (Zn + 10 gm silt)	Y = 5.83 + 1.07 X	40.80	5.83	1.07	41.10	- 7.14	47.74	57.14	20.40	416.92	0.36	2.55	4
Mercury	T.zil.	Controlled (Hg only)	Y = 4.38 + 4.11 X	11.01	4.38	4.11	11.09	- 5.00	12.30	55.00	7.30	53.30	0.34	12.40	5
		Treated (Hg + 10 gm silt)	Y = - 3.80 + 5.71 X	9.36	- 3.80	5.71	9.43	- 5.00	10.30	55.00	3.95	15.60	0.25	22.80	6
	T.zil.	Controlled (Hg only)	Y = 19.40 + 1.87 X	16.50	19.40	1.87	16.33	- 6.29	19.68	56.25	16.20	26.30	0.43	4.35	7
		Treated (Hg + 10 gm silt)	Y = - 21.50 + 4.68 X	14.81	- 21.50	4.68	15.29	- 6.25	16.60	56.25	12.30	153.30	0.77	6.07	8

Table (2) : Effect of population density on the acute toxicity of zinc (80 ppm.) and mercury (1.4 ppm.) for *T. nilotica* and *T. zillii* .

Metal	Fish sp.	Pop. den.	Equation of regression	M	a	b	LT 50	Ϙ	Mx	My	Error in fitting the line				Fig. No.
											syx	syx^2	sb	t	
Zinc	nilotica	4	Y = − 32.5 + 10.15 X	7.67	−32.5	10.15	8.13	−12.50	5.36	62.5	10.00	100.5	1.80	5.30	9
		12	Y = − 31.6 + 8.27 X	9.79	−31.6	8.27	9.87	− 4.17	10.30	54.1	10.40	109.1	0.92	9.00	10
		20	Y = − 21.3 + 8.15 X	8.65	−21.3	8.15	8.76	− 2.50	9.07	52.5	9.33	86.9	0.62	13.16	11
	zillii	4	Y = 23.3 + 2.56 X	11.38	23.3	2.56	10.40	−12.50	15.29	62.5	7.60	57.6	0.35	7.22	12
		12	Y = − 84.5 + 4.70 X	27.90	− 4.5	4.70	28.60	− 4.16	29.50	54.1	6.26	39.2	0.30	15.60	13
		20	Y = − 54.4 + 4.24 X	24.16	−54.4	4.24	24.60	0.00	24.60	50.0	13.15	172.9	0.52	8.09	14
Mercury	nilotica	4	Y = − 29.5 + 15.83 X	4.77	−29.5	15.83	5.02	−12.50	5.61	62.5	14.80	221.5	4.55	3.48	15
		12	Y = − 6.4 + 11.53 X	4.88	− 6.4	11.53	4.89	− 4.16	5.25	54.1	8.91	79.3	1.07	10.73	16
		20	Y = − 21.3 + 17.40 X	3.93	−21.3	17.40	4.08	− 4.00	4.31	54.0	14.12	194.3	3.01	5.82	17
	zillii	4	Y = − 56.94+ 15.74 X	6.34	−56.9	15.74	6.79	−12.50	7.59	62.5	4.77	22.7	1.35	11.64	18
		12	Y = − 4.70+ 9.38 X	5.71	− 4.7	9.38	5.84	− 4.19	6.29	54.2	11.57	133.9	1.17	.02	19
		20	Y = − 9.5 + 13.70 X	4.21	− 9.5	13.70	4.34	− 2.50	4.52	52.5	14.03	196.8	1.68	[illegible]	20

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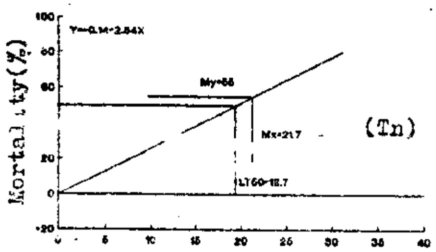

Fig.(1) Time (hrs)
80 ppm.Zn

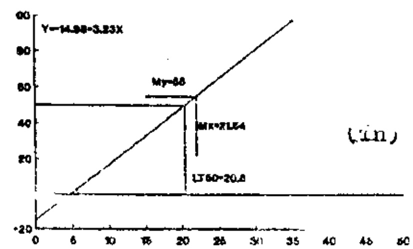

Fig.(2) Time (hrs)
80 ppm.Zn+10gm Silt

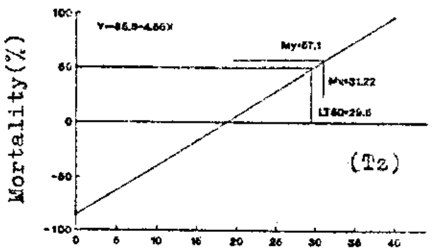

Fig.(3) Time (hrs)
80 ppm.Zn

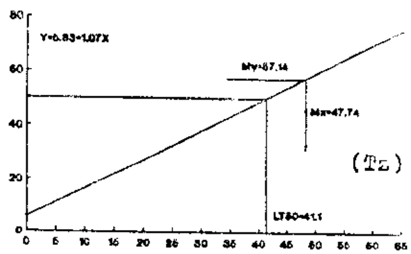

Fig.(4) Time (hrs)
80 ppm.Zn+10gm Silt

Figures (1) and (3) show the effect of 80 ppm. of zinc , only , on Tilapia nilotica (T n) and T.zillii (T z) , while figures (2) and (4) show the effect of this concentration after the addition of 10 gm. of treated silt ,on each species respectively .

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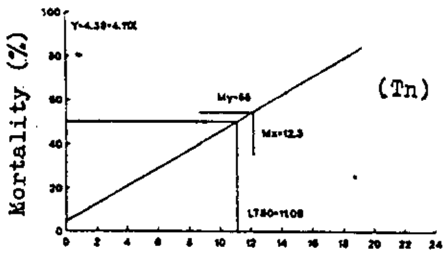


Fig.(5) Time (hrs.)
1.4 ppm.Hg

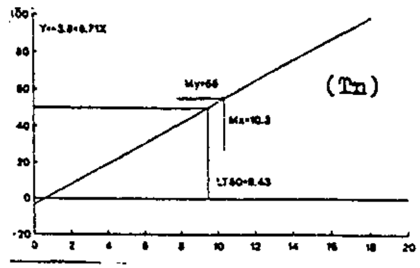


Fig.(6) Time (hrs.)
1.4 ppm.Hg+10gm Silt

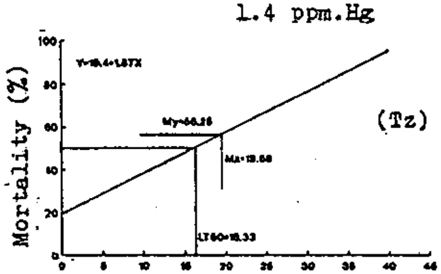


Fig.(7) Time (hrs.)
1.4 ppm.Hg

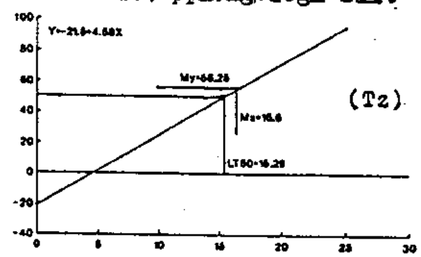
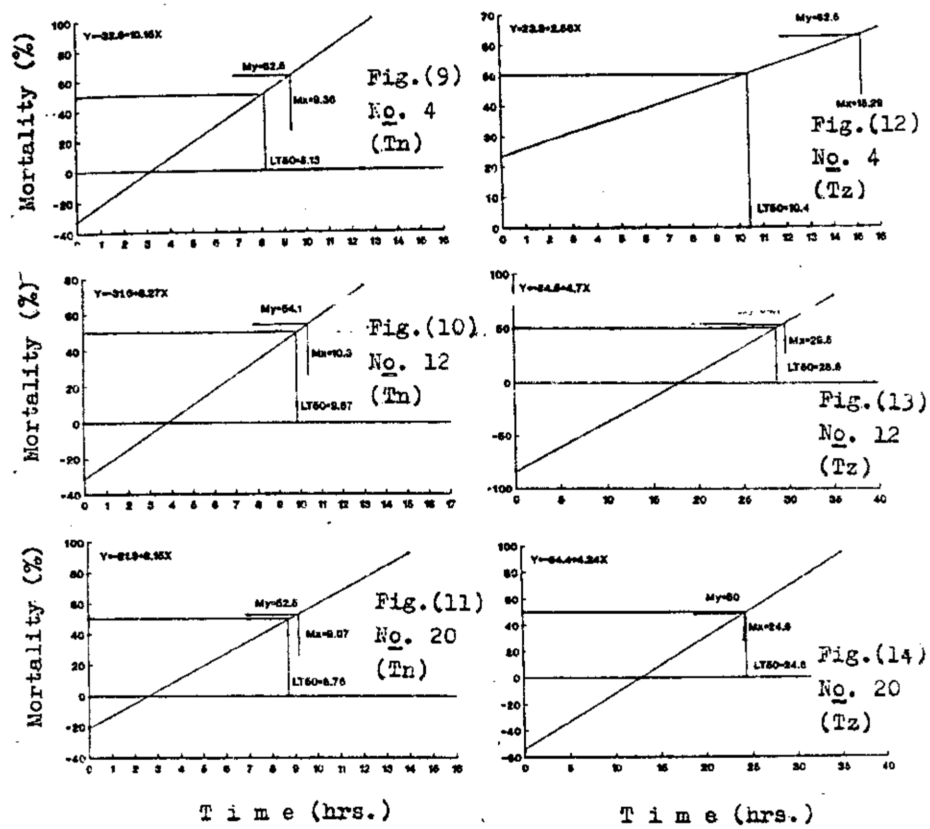
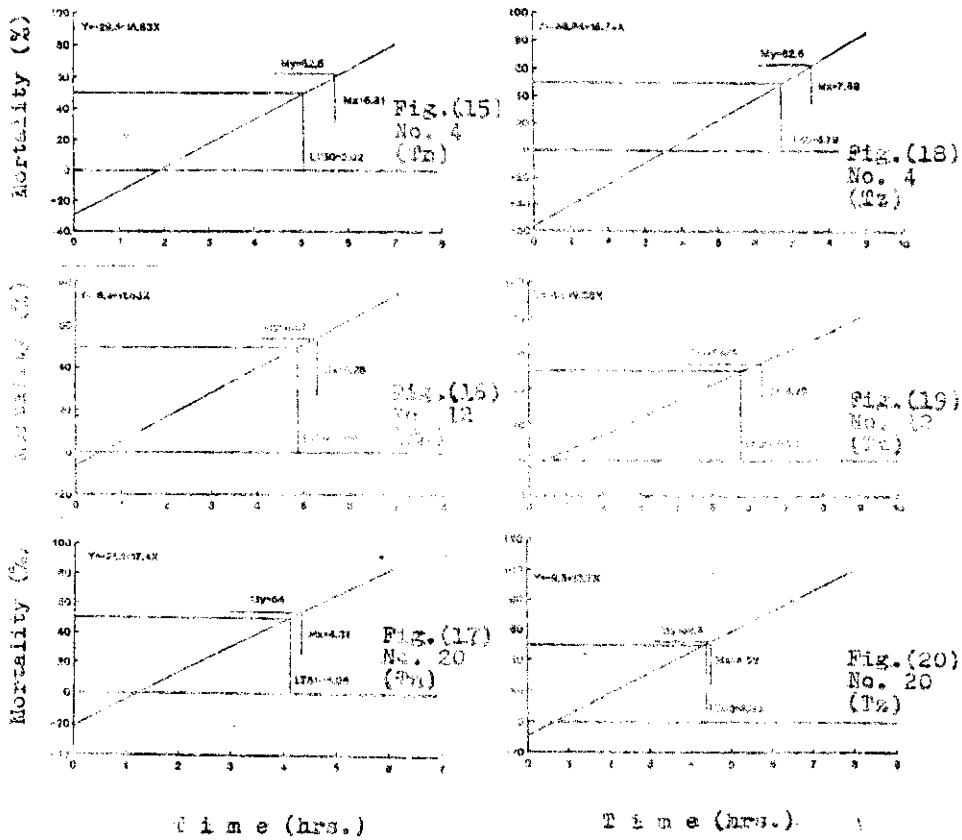


Fig.(8) Time (hrs.)
1.4 ppm.Hg+10gm Silt

Figures (5) and (7) show the effect of 1.4 ppm. of Hg, only, on Tilapia nilotica (Tn) and T.zillii (Tz), while figures (6) and (8) show the effect of this concentration after the addition of 10 gm. of treated silt, on each species respectively.



Figures (9,10 & 11) for T.nilotica (Tn) and figures (12,13 & 14) for T.zillii (Tz) illustrate the effect of different numbers of individuals in the population (No. 4 , 12 & 20) respectively , on the high toxicity of zinc, at a concentration of 80 ppm.



Figures (15,16 & 17) for T.nilotica (Tn) and figures (18,19 & 20) for T.zillii (Tz) illustrate the effect of different numbers of individuals in the population (No. 4 , 12 & 20) respectively , on the high toxicity of mercury , at a concentration of 1.4 ppm.

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تأثير طمى النيل المعامل حراريا ؛ والكثافة العددية على سمية معدنى الزنك والزئبق على نوعين من أسماك البلطى

عبد النعيم إبراهيم الأسيوطى ثروت صادق شنودة
فؤاد عفيفى أبو زيد أحمد السيد عباده

إشتمل هذا البحث على سلسلتين من التجارب المعملية ؛ أستهدفت الأولى منهما تقدير دور طمى النيل المعامل حراريا فى تقليل سمية معدنى الزنك والزئبق على نوعين من أسماك البلطى (النيلى والأخضر) ؛ بينما إستهدفت الثانية دراسة تأثير الكثافة العددية لثلاث مجتمعات من كل نوع من هذه الأسماك على نفس تركيزات المعدنين المذكورين ٠

ولذلك فقد تم فى السلسة الأولى تعريض أسماك البلطى (بنوعية) للزنك بتركيز ٨٠٪ جزء / مليون وللزئبق بتركيز ١,٤ جزء / مليون ؛ بعد إضافة ١٠ جرامات من الطمى المعامل حراريا ؛ بينما أجريت السلسلة الثانية على كل من هذين النوعين من الأسماك وبالنسبة لكل معدن على حده بكثافات عددية مختلفة : ٤ ؛ ١٢ ؛ ٢٠ فردا ٠

أوضحت نتائج السلسلة الأولى عدم وجود دورا فعالا لهذا الطمى فى تقليل سمية هذين المعدنين - بالتركيزات المشار إليها - على كلا النوعين من الأسماك ٠ بينما أظهرت نتائج السلسلة الثانية وجود علاقة طردية موجبه بين الكثافة العددية والمقاومة الداخلية للمجتمع لكل من أسماك البلطى النيلى والأخضر ٠

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بينت هذه التجارب أن المقاومة الداخلية لأسماك البلطي الأخضر أكبر منها لأسماك البلطي النيلي في جميع الحالات السابقة بصفه عامه ؛ سواء بإستخدام طمي النيل مع الزنك أو الزئبق ؛ أو بإستخدام الكثافة العددية المختلفة مع هذين المعدنين •

ولذلك يوصى بزيادة معدل تربية أسماك البلطي الأخضر في جميع المسطحات المائية بصفه عامة وفي المزارع السمكية وحقول الأرز بصفه خاصه •