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Acute Toxicity of Chromium, Aluminium and Their Combinations to the Larvae of *Chironomus Tentans*

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Abstract

Heavy metals pose serious environmental problems not only to human beings but also to other animals and plants. They are the major constituents of industrial effluents and they cannot be degraded by microbes like other organic compounds. Hence they accumulate in organisms and move up the food chain resulting in biomagnification. The larvae of *Chrionomus* spp. are considered as bioindicators and they are commonly found in sewage contaminated sites. In the present study, acute toxicity of chromium, aluminium and their combinations to the larvae of *Chironomus tentans* was determined using static bioassays. The LC50 values for 24, 48, 72 and 96 hours were worked out using probit analysis, regression analysis and chi-square tests. The 96hr LC50 values of Cr, Al, (Cr)+Al and (Al)+Cr combinations are 1.23, 25.55, 46.34 and 26.06ppm respectively. The significance of the results is discussed.

Keywords: *Chironomus tentans*, Chromium, Aluminium, Mixture toxicity.

Contents

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1. Introduction

The larvae of *Chironomus*, commonly known as 'blood worms,' are red in colour due to the presence of hemoglobin [1]. Though they are found in all geographical regions, they are abundant in tropical regions. The larvae of *Chironomus* are chiefly herbivorous, feeding on algae, aquatic plants and detritus. They do form an important food source for fresh water fish and other aquatic animals [2]. Chironomids were considered as one of the most useful groups in assessing the quality of aquatic systems because of their abundance, diversity and colonizing ability [3]. Their larvae are highly responsive to environmental stress and represent the most metabolically active stage in the life cycle of the species [4].

When aquatic systems receive heavy metals from the surface run off, these metals settle at the bottom along with the sediments and cause deleterious effects on fish and other benthic organisms [5]. As the midges spend most of their life cycle in aquatic environment, they are continuously exposed to contaminants. Toxicity of heavy metals to the larvae of chironomids has been reported already [6-11].

Organisms are exposed to multi-component chemical mixtures, present in the surrounding media like air, water and soil, in food and in consumer products. Only fewer studies have been carriedout with mixtures composed of heavy metals. Hence in the present work an attempt has been made to study to mixture toxicity of chromium and aluminium to the larvae of *Chironomous tentans*.

2. Materials and Methods

The larvae of *Chironomus tentans* were collected from local aquatic systems and acclimatized to laboratory conditions. The stock solutions of aluminium and hexavalent chromium were prepared from their salts and the desired degrees of concentrations were prepared by adapting the dilution techniques. For Cr + Al combination, 0.123 ppm of chromium (1/10 of 96 hr LC_{50} value) was taken along with all the test concentrations of aluminium. For Al + Cr combination, 2.55 ppm of aluminium (1/10 of 96 hr LC_{50} value) was added along with all the test concentrations of chromium.

Feeding was stopped one day before the larvae were subjected to experiment to avoid change in the toxicity of metals due to excretory products. After the addition of the metal concentration in the test container having ten larvae, mortality was recorded after 24, 48, 72 and 96 hours. The larvae were considered dead when they gave no response to probing with glass rod. As dead larvae in the static bioassay may deplete the dissolved oxygen, they were removed immediately at first glance. The mortality data was subjected to weighted probit analysis and the LC_{50} values for 24, 48, 72 and 96 hours were calculated with 95% fiducial limits [12]. Goodness of fit was evaluated with Chi-square tests [13].

3. Results and Discussion

Table 1 divulges the acute toxicity test results of chromium to the larvae of *Chironomus tentans*. The 24, 48, 72 and 96 hr LC_{50} values were 112.80, 71.21, 13.29 and 3.83 ppm respectively. The slope function exhibited an increase with the increase in exposure period. The Chi-square values were significant for 72 and 96 hours while they were not significant for 24 and 48 hours.

Acute toxicity test results of aluminium to the larvae of *C. tentans* are exhibited in Table 2. The 24, 48, 72 and 96 hr LC_{50} values were 160.67, 79.07, 52.06 and 25.55 ppm respectively. The Chi-square values were not significant for all the four exposure periods. Table 3 shows the acute toxicity test results of Cr+Al combination to the larvae of *C. tentans*. The 24, 48, 72 and 96 hr LC_{50} values were 139, 101.84, 66.54 and 46.34 pm respectively. All the Chi-square values except for 24 hours were significant.

Acute toxicity test results of Al + Cr combination are shown in Table 4. The 24, 48, 72 and 96 hr LC50 values were 167.26, 88.16, 48.50 and 26.06 ppm respectively. All the Chi-square values were statistically significant. With reference to mixture toxicity, toxicity of chromium was reduced in the presence of aluminium and the toxicity of aluminium was also reduced in the presence of chromium. Chromium was more toxic to the larvae of *C. tentans* than that of aluminium.

Mixture toxicity studies are often referred to as interaction studies. The interactions are generally between the chemicals and physiological systems within the body rather than between the chemicals. Many interactions are so complex, obscure or trivial that they remain undetected [14]. In the present study chromium was more toxic than aluminium to the larvae of *C. tentans* and both the metals were antagonistic in their effect.

Assessment of mixture toxicity began as an art, but it has developed into a science used in many disciplines; pharmacology, toxicology, physiology, human and veterinary medicine, agriculture and especially pest control. However, some chemical mixtures pose a greater hazard to non-target organisms and to the environment [14]. Most of the industrial effluents that are discharged into the aquatic systems are mostly the blend of heavy metals and other chemicals.

According to Vedamanikam [9], the toxicity of zinc to the larvae of *Chirnomus plumosus* was reduced in the presence of chromium, silver, nickel, mercury, lead, copper, manganese and cadmium. There is no experimental evidence for metal to metal binding to be responsible for the antagonistic or synergistic effects of the metals in combination [15]. According to them, synergistic effects of metals in combination may be due to intrinsic affinity of the individual metal for the critical sites, or the relative concentration and distribution of the metals within the target organ sites and antagonism due to the partial occupation of receptor sties with lesser toxic metal which leads to the blocking of higher toxic metal. The critical sites in most cases are –SH groups [16].

4. Conclusion

The larvae of *Chironomus tentans* were more sensitive to chromium than aluminium and these two metals were antagnonistic in their effect.

5. Acknowledgement

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Table-1. Acute toxicity test results of Chromium to the larvae of *Chironomus tentans*

Hours	Lethal concentration values (ppm)							95% Fiducial Limits of LC_{50} (ppm)		Probit regression Equation	Slope Function "S"	Chi-Square values		
	LC_5	LC_{10}	LC_{16}	LC_{50}	LC_{84}	LC_{90}	LC_{94}	Lower	Upper	Y=a+bx		Observed	Table	Signi-ficance
24	48.9	58.85	68.08	112.80	186.88	216.20	367.47	106.46	119.5	Y= -4.31+4.53x	1.65	9.01	11.07	NS
48	45.5	50.25	54.33	71.21	93.34	100.91	134.9	68.7	73.82	Y= -10.68+8.46x	1.31	3.49	7.81	NS
72	0.5	1.16	2.01	13.29	87.77	151.31	199.12	3.75	47.11	Y= 3.63+1.21x	6.60	48.63	9.49	S
96	7.1	6.14	3.37	3.83	452.01	482.47	226.8	3.62	4.20	Y= 4.96+0.38x	365.93	63.84	5.99	S

S = Significant
NS = Not Significant

Table-2. Acute toxicity test results of Aluminium to the larvae of *Chironomus tentans*

Hours	Lethal concentration values (ppm)							95% Fiducial Limits of LC_{50} (ppm)		Probit regression Equation	Slope Function "S"	Chi-Square values		
	LC_5	LC_{10}	LC_{16}	LC_{50}	LC_{84}	LC_{90}	LC_{94}	Lower	Upper	Y=a+bx		Observed	Table	Signi-ficance
24	21.9	34.04	48.18	160.67	535.76	758.41	887.80	115.54	223.4	Y = 0.8 + 2.73x	3.33	2.76	7.81	NS
48	19.7	26.82	34.17	79.07	182.95	233.06	562.62	70.44	88.77	Y = -0.18+2.73x	2.31	3.56	9.49	NS
72	2.78	5.31	8.85	52.06	305.95	510.04	628.33	43.01	63.03	Y = 2.77 + 1.29x	5.87	5.98	9.49	NS
96	2.15	3.72	5.73	25.55	111.53	175.34	342.88	21.83	29.92	Y = 2.84 + 1.53x	4.45	9.92	15.51	NS

NS = Not Significant

Table-3. Acute toxicity test results of Chromium and Aluminium mixture to the larvae of *Chironomus tentans*

Hours	Lethal concentration values (ppm)							95% Fiducial Limits of LC_{50} (ppm)		Probit regression Equation	Slope Function "S"	Chi-Square values		
	LC_5	LC_{10}	LC_{16}	LC_{50}	LC_{84}	LC_{90}	LC_{94}	Lower	Upper	Y=a+bx		Observed	Table	Signi-ficance
24	37.42	50.01	62.87	139.0	307.34	386.42	889.37	127.60	151.36	Y = -1.18 + 2.88x	2.21	9.18	11.07	NS
48	29.45	38.74	48.10	101.84	215.61	267.71	588.72	81.99	126.49	Y = -1.13 + 3.05x	2.11	34.63	12.59	S
72	8.67	13.60	19.41	66.54	228.12	325.52	1187.58	38.03	116.40	Y = 1.60 + 1.85x	3.42	105.28	14.07	S
96	2.31	4.48	7.56	46.34	284.06	479.32	3220.36	26.82	80.05	Y = 2.89 + 1.26x	6.12	36.87	12.59	S

S = Significant
NS = Not Significant

Table-4. Acute toxicity test results of Aluminium and Chromium mixture to the larvae of *Chironomus tentans*

Hours	Lethal concentration values (ppm)							95% Fiducial Limits of LC_{50} (ppm)		Probit regression Equation	Slope Function "S"	Chi-Square values		
	LC_5	LC_{10}	LC_{16}	LC_{50}	LC_{84}	LC_{90}	LC_{94}	Lower	Upper	Y=a+bx		Observed	Table	Signi-ficance
24	50.12	65.41	80.72	167.26	346.59	427.68	919.48	126.90	220.30	Y = -1.99 + 3.14x	2.07	18.73	9.49	S
48	13.28	20.18	28.08	88.16	276.78	385.05	780.94	64.73	120.12	Y = 1.10 + 2.0x	3.13	42.65	14.07	S
72	1.82	3.76	6.68	48.50	352.20	424.10	500.94	27.41	85.83	Y = 3.05 + 1.15x	7.26	33.27	12.59	S
96	0.99	2.05	3.62	26.06	187.06	187.45	331.25	10.56	26.32	Y = 3.35 + 1.16x	7.19	56.07	12.59	S

S = Significant