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A Study on the Effects of Copper and ®Hostathion on Selected Metabolic and Haematological Parameters of a Teleost Fish, *Oreochromis mossambicus*

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Abstract: ***Toxicology, the study of poisons, is typically a multidisciplinary field of science which deals with the detrimental consequences of toxic substances on individual organisms and involves the analyses of internal distribution of toxicants in the body of organisms and their mode of action. It also deals with the transformation of toxicants within the organisms and the formation of their metabolites. Today, environmental pollution, which causes hazards to fauna and flora as well as human health, has become a major global issue. Water pollution is recognized globally as a potential threat to both human and other animal populations which interact with the aquatic environments. The aquatic environment is subjected to different types of pollutants which enter water bodies with industrial, domestic and agricultural waste waters and severely affect the aquatic organisms by tampering with the natural quality of water. Day by day our water bodies are getting more and more contaminated with diverse toxic substances. This can be a serious problem as far as Kerala is concerned. Kerala is a South Indian state which has innumerable water bodies as well as cultivation areas. Pesticides that are applied in the paddy fields can run off in to the water bodies and there by contaminate them. Both the flora and fauna of these contaminated water bodies too get affected which will definitely affect the biodiversity of these water bodies. The present study was an attempt to compare the toxicity between a heavy metal (copper) and a pesticide (®Hostathion) on the behavioural as well as metabolic and haematological parameters of the fish Oreochromis mossambicus. Results clearly show that pesticides have an adverse effect on the living biota in aquatic environments. Hence it is highly imperative that we should resort to biopesticides.***

Keywords: Oreochromis mossambicus, ®Hostathion, copper, haematological parameters.

1. Introduction

A toxic substance is one which can create adverse or detrimental consequences in biological systems by interfering with their structure and function, thus leading to mortality. When such substances are indiscriminately introduced into various ecosystems, the quality of the environment is impaired. These environmental toxicants are also known as xenobiotics. From the point of view of toxicology, no chemical can be regarded as either absolutely safe or dangerous. The harmless or dangerous nature of toxic substances depends on the dosage of the substance and the duration for which the organisms are exposed to it [1].

Water pollutants are shown to affect feeding, food utilization, oxygen consumption, metabolic turnover, muscular action, endocrine coordination and enzyme action, as well as reproduction of aquatic organisms. Even at sub lethal concentrations, the pollutants affect the life of aquatic fauna which are manifested as changes in physiology, biochemistry, and activity levels of many enzymes [1]. Pesticides and heavy metals are the most commonly found water pollutants and they originate from human activity or agricultural farming that are discharged directly or indirectly into the receiving waters. The presence of these chemicals in the environment has become a global issue. They destroy the delicate balance between species that characterizes a functioning ecosystem [2]. They produce many physiological and biochemical changes in freshwater organisms by influencing the activities of several enzymes. Alterations in the chemical composition of the natural aquatic environment generally affect behavioural and physiological systems of the inhabitants, particularly those of fishes.

Of all the aquatic organisms, fishes are the most severely affected by water pollutants like pesticides and heavy metals. Water pollutants are also found to interfere with the respiratory metabolism of crustaceans, insects and bivalves, causing a diminution in the rate of oxygen uptake.

The present study was conducted to compare the effects of the heavy metal copper and the pesticide ®Hostathion on the behavioural and physiological activities of the Teleost fish, *Oreochromis mossambicus* and thereby to study the impact of the same on this fish population.

2. Materials and Methods

Test Organism

The fish *Oreochromis mossambicus* (Tilapia) was selected for the present study. Tilapia is the common name for nearly a hundred species of cichlid fish from the tilapiine cichlid tribe. They inhabit a variety of fresh and, less commonly, brackish water habitats from shallow streams and ponds through to rivers, lakes, and estuaries. They have pale olive to silver-grey bodies with two to five indistinct dark blotches on the side. *O. mossambicus* are hardy fish and can survive temperatures between 8 and 42 ^{o}C. They can also withstand high salinities and low dissolved oxygen. They feed mainly on plankton, insects and weed, showing that they are

omnivorous in diet. They are mouth brooders, protecting the eggs and larvae from predators.

The fishes for the experiments were collected from a hatchery near Pallathuruthi in Alappuzha district. They were brought to the laboratory in polythene jars and were carefully transferred to a large 20 L capacity aquarium tank containing well aerated tap water. Care was taken not to disturb the fishes while transferring them from the jars to the tank. They were allowed to acclimatize to the laboratory conditions for 48 – 96 hrs (temperature 28°C, pH 7) and were fed with fish food. All fishes selected for any set experiment belonged to the same population.

Test Medium

Dechlorinated tap water, aerated to full saturation, was taken as the test medium. The pH of the test medium was 7.0 – 7.5. The addition of toxicants did not bring about any appreciable variation in the pH. All the experiments were carried out at laboratory temperature, 28 ± 1º C.

Toxicants

Two toxicants, a heavy metal and a pesticide, were used for the study. Copper as Copper Sulphate was the heavy metal selected and purchased as laboratory grade reagent from HiMedia. ®Hostathion, a commercial product of Bayer CropScience Ltd, was a broad spectrum insecticide with Triazophos as active ingredient. Its chemical name is O, O-diethylO-1-phenyl-1H-1,2,4-triazol-3-ylphosphorothioate. Physically it is a light yellow to dark brown liquid with a characteristic odour of phosphoric ester. ®Hostathion is readily soluble in most organic solvents like aromatic hydrocarbons, alcohols, esters and ketones.

Toxicity Studies

Acute toxicity tests were conducted to measure the impact of toxicants on aquatic life within a period of 96 hrs. LC_{50} is a statistical estimate of the concentration of the toxic materials in water that kills 50% of the test animals under experimental conditions at specific time intervals **[**3]. This value is ideally suited for toxicity studies as it gives a more acceptable and reproducible concentration required to affect 50% of the organism than any other value.

Lethal toxicity studies

Before conducting acute toxicity tests, exploratory tests were performed to narrow down the lethal toxicity test doses of both the toxicants. During lethal toxicity tests, laboratory conditioned fishes of uniform weight, 15–25 g were exposed to 50 litres of test solution separately that contained graded "logarithmic series" of concentrations of the toxicants i.e. copper and ®Hostathion. Ten fishes were used for each test concentrations of both the toxicants. The experimental tanks were kept covered to minimize external disturbances. The tests were carried out at room temperature (28 ± 1º C) and the fishes were fed with fish food during the test period. The fishes were examined every 12 hrs and were considered dead if they did not respond to mechanical stimulation. The 96 hr LC_{50} value was calculated using probit analysis [4].

Effects of Copper and ®Hostathion on behavior

Behaviour of the fishes were recorded during the course of the experiment with sub lethal concentrations of Copper and ®Hostathion up to 24 hrs post exposure. In order to study the effect of Copper and ®Hostathion, fishes were exposed to three different concentrations of Copper (0.01, 0.02 and 0.03 ppm) and ®Hostathion (0.0001, 0.0002 and 0.0003 ppm) respectively along with the control and the following parameters were recorded at 2 hr, 6 hr, 12 hr and 24 hr post exposure - nature of opercular beat, nature of body movement and deposition of mucus over the body.

Effects of Copper and ®Hostathion on opercular beat

To study the effect of copper and ®Hostathion on the opercular beat of *Oreochromis mossambicus*, healthy and disease free fishes with body weights ranging from 15 – 25 g were selected. Three groups each with five fishes were exposed to different concentrations of copper and ®Hostathion along with a control. The different concentrations of copper were 0.01, 0.02 and 0.03 ppm, and that of ®Hostathion were 0.0001, 0.0002 and 0.0003 ppm. Opercular beats per minute were recorded from the beginning of the experiment followed by 2, 6, 12 and 24 hrs post exposure.

Effects of Copper and ®Hostathion on oxygen consumption

In order to study the oxygen consumption of fishes per hour, fishes were introduced into different concentrations of copper (0.01, 0.02 and 0.03 ppm) and ®Hostathion (0.0001, 0.0002 and 0.0003 ppm), along with control. Initial amount of dissolved oxygen prior to the exposure and the amount of dissolved oxygen after 1 hr post exposure were measured using Winkler's method and the rate of oxygen consumption per hour was recorded.

Effects of Copper and ®Hostathion on blood parameters. In order to study the haematological parameters, 35 fishes were selected and divided into 7 groups each having 5 fishes. The first group comprised the control. The second, third and fourth groups were exposed to 0.01, 0.02 and 0.03 ppm of copper respectively. The fifth, sixth and the seventh groups were exposed to 0.0001, 0.0002 and 0.0003 ppm of ®Hostathion respectively.

Blood samples were collected from copper and ®Hostathion exposed fishes along with control at 2 hrs, 6 hrs, 12 hrs and 24 hrs post exposure and the blood samples were used to estimate blood protein, haemoglobin content and RBC count. Blood samples were collected in heparinised capillary tubes by cutting caudal peduncle.

Enumeration of RBC was done using haemocytometer. Blood samples from control, copper and ®Hostathion exposed fishes were pipetted out up to 0.5 mark of a RBC pipette. Blood was diluted by using RBC diluting fluid and filled up to 101 mark. The blood was diluted 200 times by mixing with the diluting fluid. After placing a cover slip over the diluting chamber, a drop of diluted blood was placed in between the cover slip and central platform, after discarding the first few drops. The chamber was kept undisturbed for a few minutes. Then it was placed under a microscope and the RBCs in the five small squares were counted.

Haemoglobin was estimated by using Sahli's haemoglobinometer.

For the estimation of blood proteins, 0.01 ml sample was pipetted into a test tube containing 1.0 ml of 10% TCA. The sample was mixed well and centrifuged for 15 minutes at 2500 rpm. The supernatant was decanted carefully and discarded. The precipitate was dissolved in 1.0 ml of 0.1 N NaOH. 0.2 ml of the sample was pipetted to another test tube and made up to 1.0 ml with distilled water. After mixing thoroughly, 5.0 ml of alkaline copper reagent was added, mixed well and after 10 min, 0.5 ml of Folin's phenol reagent was added and shaken well. After 45 min, the optical density of the sample was read at 500 nm. From the optical density, the corresponding concentrations of proteins were found out from the standard curve prepared with bovine serum albumin, and expressed as mg protein per 100 ml of blood [5].

Computation of data

The results were statistically analyzed using Student's 't' test. Level of significance was represented at 0.05 level [6].

3. Results

3.1 Toxicity studies

Lethal toxicity of copper and ®Hostathion for *Oreochromis mossambicus* was studied and the results are as follows. The 96 hr LC_{50} values for copper and ®Hostathion were found to be 1.6 ppm and 0.01 ppm respectively. The concentrations selected for sub lethal toxicity studies were 0.01, 0.02 and 0.03 ppm for copper which roughly corresponds to 1/160, 1/80 and 1/53 of the 96 hr LC_{50} value for copper and 0.0001, 0.0002 and 0.0003 for ®Hostathion which corresponds to 1/100, 1/50 and 1/33 of the 96 hr LC_{50} value for ®Hostathion respectively.

3.2 Effects of Copper and ®Hostathion on behavior

Behavioural responses involved unrhythmic, irregular body movements and aggressive nature at higher concentrations of copper and ®Hostathion. The effects of copper and ®Hostathion on the pattern of opercular beat of *Oreochromis mossambicus* are shown in Tables 1 and 2 respectively.

Table 1: Pattern of opercular beat shown by *Oreochromis mossambicus* exposed to different concentrations of copper

Conc.	*Time Period*			
	2 Hour	*6 Hour*	*12 Hour*	*24 Hour*
Control	Normal	Normal	Normal	Normal
0.01 ppm	Slightly fast	Fast	Slowed down	Slowed down
0.02 ppm	Fast	Fast	Slowed down	Slowed down
0.03 ppm	Fast	Slowed down	Slowed down	Slowed down

Table 2: Pattern of opercular beat shown by *Oreochromis mossambicus* exposed to different concentrations of ®Hostathion

Conc.	Time Period			
	2 Hour	6 Hour	12 Hour	24 Hour
Control	Normal	Normal	Normal	Normal
0.0001 ppm	Slightly fast	Fast	Fast	Normal
0.0002 ppm	Slightly fast	Very fast	Slowed down	Slowed down
0.0003 ppm	Slightly fast	Very fast	Slowed down	Occasional

3.3 Effects of Copper and ®Hostathion on opercular beat

The opercular beats/min in control fishes were in the range of 58 – 65 throughout the period of exposure. In 0.01 ppm copper exposed fishes, there was a slight increase in the number of beats towards 6 hrs post exposure. Then the values declined. In 0.02 ppm copper exposed fishes also the net result was the same with an initial increase followed by a decrease in value. In 0.03 ppm copper exposed fishes a sudden decline in the opercular beat was noticed just after an initial increase. The decline in the value started just after 6 hrs post exposure.

The effect of ®Hostathion on the opercular beat was more severe than that of copper. In 0.0001 ppm ®Hostathion exposed fishes, there was an initial increase in the number of beats followed by a decrease in value only after 12 hrs post exposure. But in 0.0002 and 0.0003 ppm ®Hostathion exposed fishes, after an initial increase a drastic decrease in the number of beats was observed after 12 hrs of exposure.

3.4 Effects of Copper and ®Hostathion on oxygen consumption

The results on oxygen consumption per hour showed an increase in the rate of consumption as the toxicant concentrations increased. In control fishes the rate of oxygen consumption was 0.080 mg/l/hr/body weight, while in 0.01 ppm, 0.02 ppm and 0.03 ppm copper exposed fishes the rate of oxygen consumption increased to 0.095, 0.135 and 0.165 mg/l/hr/body weight respectively. Similarly in fishes exposed to 0.0001 ppm, 0.0002 ppm and 0.0003 ppm ®Hostathion, the rate of oxygen consumption was 0.136, 0.141 and 0.144 mg/l/hr/body weight respectively. But the control value was 0.074 mg/l/hr/body weight.

3.5 Effects of Copper and ®Hostathion on Total Erythrocyte Count

In the control fishes the TEC ranged between 4.68 – 4.82 million/mm^3. In fishes exposed to 0.01 ppm and 0.02 ppm copper, a significant decrease in the count was observed only for 24 hr post exposure. But a significant decrease of about 3.60 million/mm^3 and 2.86 million/mm^3 were observed in 0.03 ppm copper exposed fishes at 12 hrs and 24 hrs post exposure respectively ($P < 0.05$). Figures 1 and 2 depict the effect of varying concentrations of copper on the Total Erythrocyte count of *Oreochromis mossambicus*.

In the case of 0.0001 ppm ®Hostathion exposed fishes, there was only a slight decrease in the count till 24 hrs post exposure but without any significance. But in 0.0002 ppm exposed fishes a significant decrease in the number of erythrocytes was noticed from 12 hrs post exposure.

®Hostathion proved to be more toxic to the fish when they were exposed to 0.0003 ppm showing a significant decrease in the erythrocyte count even from 6 hrs post exposure ($P < 0.05$).

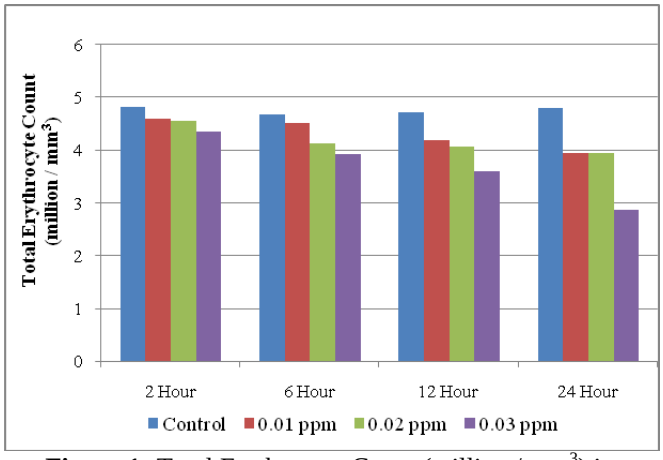

Figure 1: Total Erythrocyte Count (million / mm^3) in *Oreochromis mossambicus* exposed to sub lethal concentrations of Copper

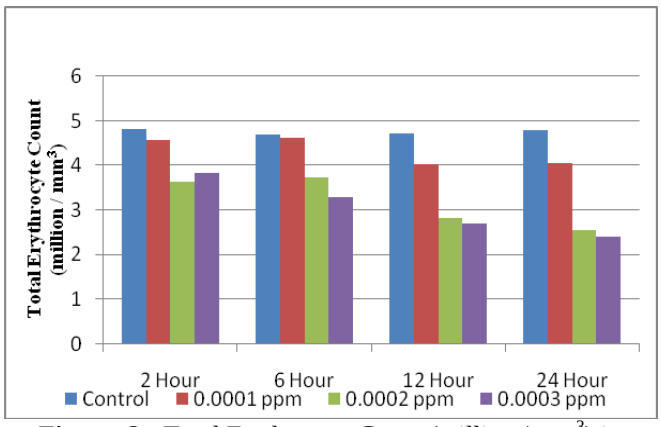

Figure 2 - Total Erythrocyte Count (million / mm^3) in *Oreochromis mossambicus* exposed to sub lethal concentrations of ®Hostathion

3.6 Effects of Copper and ®Hostathion on haemoglobin count

Haemoglobin content in copper exposed fishes was found to be lower at higher concentrations than the control fishes. In 0.01 ppm copper exposed fishes 5-10% decrease was observed at 12 and 24 hrs while in 0.02 ppm exposed fishes the decrease in Hb content ranged between 10-15 %. A significant decrease in Hb count was observed in 0.03 ppm copper exposed fishes where the Hb content was 7.2g/100ml after 24 hrs which was far from the normal count of 11.6g/100ml at the same period.

In ®Hostathion exposed fishes, the reduction in Hb content was more obvious than that of copper exposed ones. When the Hb content of 0.0001 ppm ®Hostathion exposed fishes ranged from 10.8–10.4g/100ml from 2 hrs-24 hrs, the same for 0.0002 ppm ®Hostathion exposed fishes ranged from 10.2-8.0 g/100ml for the same period with a slight significant decrease only at 12 hrs and 24 hrs post exposure. Whereas 0.0003 ppm ®Hostathion exposed fishes showed a significant decrease in the value even from 6 hrs after exposure with a drastic decrease of 4.8g/100ml from that of normal for the same period of exposure ($P < 0.05$).

3.7 Effects of Copper and ®Hostathion on Blood Protein

The blood protein level in control fishes ranged between 13.86 and 14.28. In 0.01 ppm copper exposed fishes there was no significant changes in the protein content. In 0.02 ppm and 0.03 ppm copper exposed fishes there was a significant decrease at later time periods. In 0.03 ppm exposed ones, the blood protein level was lowered to 12.86 - 11.64 mg / 100 ml at 12 and 24 hrs post exposure.

In ®Hostathion exposed fishes, the decrease in the value was more drastic. In 0.0001 ppm ®Hostathion exposed fishes, the protein level was 12.08 mg/100ml at 24 hrs post exposure. In 0.0002 ppm exposed fishes, it declined to 10.64 mg/100ml. Where as in 0.0003 ppm ®Hostathion exposed fishes, there was a significant decrease. At 12 hrs post exposure the protein content was 11.02 mg /100ml and 9.94 mg /100ml at 24 hr post exposure, i.e. the decrease was about 25 – 35% at later time periods in higher concentrations.

4. Discussions

Heavy metals and pesticides contribute a major role in water pollution and these pollutants produce toxic effects and endanger the life of aquatic fauna, of which fishes are the most sensitive group. Heavy metals are continuously introduced into the aquatic system by means of weathering of soils and rocks and from a variety of anthropogenic activities like mining, melting, processing, and manufacturing of metal articles and using the substances containing metal contaminants [7]. The contamination of aquatic system with pesticides is mainly due to indiscriminate use of insecticides and pesticides in modern agricultural practices. The accumulation of heavy metals causes physiological stress in the organism and thereby reduces growth. Heavy metal pollution decreases the growth rate and exhausts the biochemical reserves [8].

The present study was an attempt to compare the effects of two pollutants, an organophosphorus pesticide ®Hostathion and a heavy metal copper on selected physiological activities of the fresh water fish, *Oreochromis mossambicus*.

Among the pollutants used, ®Hostathion was found to be more toxic than copper to *O. mossambicus*. 96 hr LC_{50} value of copper for *O. mossambicus* was found to be 1.6 ppm and that of ®Hostathion was 0.01 ppm. From 96 hr LC_{50} value, three sub lethal concentrations were selected for the present study. The sub lethal concentrations of copper selected were 0.01, 0.02, 0.03 ppm and that of ®Hostathion were 0.0001, 0.0002, 0.0003 ppm.

The opercular beats/min showed an initial increase at 2 and 6 hrs post exposure followed by a decline towards 12 hrs and 24 hrs post exposure in all the three sub lethal concentrations of both the pollutants. Similarly an initial aggressiveness

was observed in body movements followed by occasional movements at later time periods in higher concentrations. In ®Hostathion exposed fishes, mucus production started at 6 hrs post exposure in 0.0002 ppm and 0.0003 ppm and prolonged to 24 hrs post exposure. In 0.0001 ppm exposed fishes, the mucus production occurred only at 6 hrs post exposure and there was no further change till 24 hrs post exposure. Mucus production started at 24 hrs post exposure in 0.02 and 0.03 ppm exposed fishes. These behavioural responses may be due to the stress caused by the pollutants and in order to overcome the stress, respiratory centre may be activated resulting in an increase in opercular beat at early periods of exposure. It was reported that during the intoxication period, there is an initial increase in opercular beat rate but as the duration is increased, the opercular beat rate gradually decreased. The opercular beat per minute showed progressive decrease with increase in the concentrations of the pollutants. A similar result was observed by Mohammad Noor Alam [9] while studying the toxic effects of Matacid 50 on *Channa punctatus.* Fishes showed gradual loss of their balance and strength in the body and finally sank to the bottom. Such reports have also been made by Santhakumar *et al*. [10], Khilare [11] and Sancho *et al*. [12].

The drastic decrease of opercular beat at 12 hrs and 24 hrs in 0.0002 ppm and 0.0003 ppm ®Hostathion exposed fishes may be due to the decreased metabolic activities. The drastic decrease acts as a measure of physiological activities of the fishes resulting in the decreased rate of metabolism. Decrease in metabolism leads to decreased oxygen consumption which in turn depresses the activity of the respiratory centre which in turn leads to toxic conditions.

Increase in opercular beat/min correlates with the increase in oxygen consumption and there by an increase in the metabolic rate of fish. In the present study, ®Hostathion brought about an increase in opercular beats/ min at 2 hrs post exposure. The oxygen consumption recorded after 1 hr post exposure was also high. Rate of oxygen consumption in copper exposed fishes showed a higher value at 0.02 ppm and 0.03 ppm than that of the control. Similarly the rate of oxygen consumption was found to be higher in ®Hostathion exposed fishes in all the three concentrations. This increase in oxygen consumption correlates with an increase in opercular beats/ min in the initial stages of exposure.

During the exploratory tests for finding out the LC_{50} value, fishes were found to be dead at higher concentrations of the toxicants. The lethality is found to be increased as the concentration of the toxicants increased. It may be due to the interruption of biochemical activities due to the accumulation of the toxicants there by leading to necrosis or tissue death. During the time of exposure, the fishes showed an initial increase in opercular beats followed by a sudden decline within a few hours, leading to their death. This decrease in opercular beats/ min shows the decrease in oxygen consumption and decrease in metabolic rate of fish. The death is due to the depression of the respiratory centre followed by anoxia. At minimum levels of metabolism and at low temperature, oxygen consumption of fish is at its lowest point. This is called the incipient lethal level. Below this incipient level fish is living in a zone of resistance. In the sub lethal concentrations of the pesticides used in the present study, the fishes were living below the lethal incipient level and thereby in a zone of resistance.

Haematological parameters are important diagnostic tests and equally valuable as indicators of disease or stress in fishes. In the present study, total blood protein concentration, Hb content and total erythrocyte count were recorded up to 24 hrs in three sub lethal concentrations of copper and ®Hostathion. Blood proteins play an important role in maintaining the osmolarity, transport of ions, immune mechanisms and homeostasis. The effect of heavy metals on fish metabolism has been extensively investigated. As a result of toxicity, tissue proteins are continuously converted into soluble fractions and through blood these soluble fractions are utilized. It is suggested that during initial periods of exposure, the proteins are less used and as time proceeds, much energy must have been used to compensate the stress, hence the depletion of protein [13]. The results of the present study agree with this observation. Here also blood protein content decreased about 20% as the time of exposure was prolonged to 24 hrs at higher concentrations of copper. At 24 hrs, a significant decline was observed.

In ®Hostathion exposed fishes, about 10% decrease was observed at 6 hrs post exposure in all the three concentrations. The decrease was about 25-35% at later time periods in higher concentrations. The decreased protein content may be due to renal excretion such as albuminuria or impaired protein synthesis due to liver disorder. It should also be noted that serum protein may be appreciably reduced in conditions of severe haemorrhage [14]. The decrease in serum proteins may be also due to the inhibition of many metabolic functions, including protein synthesis and enzyme inhibition by toxicants [15].

The effects of heavy metals on blood characteristics and histological changes in erythrocytes are reported by Panigrahi [16] and Panigrahi and Misra [17]. In the present study a significant decrease in TEC was observed in 0.03 ppm exposed fishes. At 2 hrs post exposure 10% reduction in TEC was observed followed by 16 % at 6 hrs, 24% at 12 hrs and 40% at 24 hrs post exposure. In 0.02 ppm exposed fishes, TEC decreased about 5% at 2 hrs, 12% at 6 hrs, 14% at 12 hrs and 20% at 24 hrs post exposure. In 0.01 ppm exposed fishes, 13-20 % reduction in TEC was observed at 12 and 24 hrs post exposure. The magnitude of decrease of erythrocyte count increases with increase in the concentration of copper for different time periods registering a range of 5- 40 % decrease. The decrease in TEC may be probably due to metal poisoning [16] or due to the destructive or suppressive effect of erythropoietic tissue [17] or due to haemolysis causing haemolytic anaemia [18]. In ®Hostathion exposed fishes the decrease in TEC was more prominent than that of copper.

In 0.0001 ppm exposed fishes, TEC showed a significant reduction ranging from 10- 20% and in 0.0002 ppm and 0.0003 ppm it ranged between 30- 50%. Shanta Satyanarayanan [19] reported the effects of pesticides on blood parameters of fishes.

The normal haemoglobin content in control fishes was 11.2 - 12g/100 ml. In 0.01 ppm copper exposed fishes, 5-10% decrease was observed at 12 and 24 hrs, while in 0.02 ppm exposed fishes, the decrease in Hb content ranged between 10-15%. In 0.03 ppm exposed fishes, reduction in Hb content ranged between 20- 35 % at later time periods. In ®Hostathion exposed fishes, the reduction in Hb content was more obvious than that of copper exposed ones. About 5-10 % reduction was observed in 0.0001 ppm exposed ones and about 20- 30 % reduction was observed at 12 hrs and 24 hrs in 0.0002 ppm. In 0.0003 ppm exposed fishes, 30-40 % reduction was observed at 12 and 24 hrs post exposure. Similar decrease was also observed in total erythrocyte count. Raja Rishi [20] reported a significant reduction in TEC and haemoglobin content in Thiodon exposed fishes. They reported hyperchronic microcytic anaemia with reduced iron content and lowered oxygen carrying capacity of blood which in turn resulted in the reduction of erythrocyte count and haemoglobin concentration.

5. Conclusion

In conclusion, it could be stated that exposure of Oreochromis mossambicus to different concentrations of copper and ®Hostathion resulted in a reduction of erythrocyte count, haemoglobin content and total protein content of the blood there by resulting in haemolytic anaemia with reduced iron content and lowered oxygen carrying capacity of blood. The changes in these haematological parameters were more obvious in fishes exposed to ®Hostathion than that of copper and it could be concluded that the pesticide ®Hostathion is more toxic than heavy metal to this species. By analyzing the above results it can be concluded that pesticides such as ®Hostathion are more toxic to aquatic biota than heavy metal toxicants like copper.

Pesticides occupy a rather unique position among the many chemicals that man encounters daily, in that they are deliberately added to the environment for the purpose of killing or injuring some form of life [21]. Ideally their injurious action would be highly specific for undesirable target organisms and noninjurious to desirable, nontarget organisms [22]. In fact, however, most of the chemicals that are used as pesticides are not highly selective but are generally toxic to many nontarget species, including man, and other desirable forms of life that co inhabit the environment. Therefore, lacking highly selective pesticidal action, the application of pesticides must often be predicated on selecting quantities and manners of usage that will minimize the possibility of exposure of nontarget organisms to injurious quantities of these useful chemicals [21].

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