

Fate of Nucleic Acids in the Tissues of *Cyprinis carpio* under the Toxicity of Heavy Metals

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ABSTRACT

By using freshwater fishes, the LC_{50} 96 hr values of zinc, cadmium and lead were determined through static bioassays. On exposure to the sub lethal concentrations of the metals, tissues like liver, kidney and muscle were used to estimate the DNA and RNA content. Both DNA and RNA levels decrease in the tissues of the fishes suggesting the impairment of protein synthesis machinery. The study was also indicative of manifestation of malfunction and degenerative changes in organ system.

Key words: Tissues, DNA and RNA content, Heavy metals, *Cyprinus carpio*.

INTRODUCTION

Fresh water is of vital requirement for the manifestation of life but quality of water has become altered due to the introduction of a number of pollutants in to the waterbodies. While the quality of life has been improved by technological development, it has resulted the discharge of toxic chemicals into the environment affecting the biological system³. The rapid growth of human population and his increased need of several amenities have increased the environmental degradation in recent times. Vutukuru¹⁴ has also pointed out that the freshwater contamination by the pollutants is a marker of great concern over the last few decades effecting the marine life. One of the most significant changes caused by men is dumping of various pollutants containing a number of heavy metals in to the water courses.

Bio monitoring of hazardous substances in the tissues of aquatic organisms has been

successfully applied during recent years for heavy metal contamination⁵. The accumulation of heavy metals is shown to adversely affect the metabolism, development and growth of fishes¹.

Shukla *et al.*,¹² have reported that the fishes account for symbol and reliable biomarkers of heavy metals as the metabolic ores present in the water enters in to body of fishes and get accumulated in various organs like liver and kidney. In other words, the fishes are good accumulators of organic and inorganic pollutants in the body.

Investigators like Raksheskar¹⁰, Ravikiran and Kulkarni¹¹ and Pradap and Singh⁸ have studied the toxicity of a number of pollutants with reference to nucleic acids in the tissues of fishes. The nucleic acids are high molecular weight biopolymers responsible for the biosynthesis of cellular proteins.

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The survival of organisms depends on the status of nucleic acids content and protein synthesis so that the nucleic acids assays serve as important tools for assessing pollutant impact. Therefore, the alterations caused by the heavy metals in the nucleic acids of tissues in the freshwater fish *Cyprinus carpio* has been carried out in the present investigation.

MATERIALS AND METHODS

The common freshwater fish and heavy metals such as zinc, cadmium and lead were used in the present work to estimate LC₅₀ 96 hr values of metals to the fishes through static bioassays. Then a group of laboratory acclimatized fishes were treated in various sub lethal concentrations of individual metals (0.05, 0.10, 0.15, 0.20 and 0.25%) for 30 days along with suitable controls. Then liver, kidney and muscle were collected from the treated fishes and processed to estimate the nucleic acids.

The DNA content in the tissues of fishes was estimated by the method given by Raghuramalu *et al.*,⁹. The RNA content was analysed in the tissues by using the technique given by Chomczynski and Mackey².

The results of DNA and RNA content were expressed in mg/g tissue.

RESULTS AND DISCUSSION

Percent changes in the concentrations of various nucleic acids in the tissues of *C. Carpio* on exposure to five concentrations of zinc from 0.05% to 0.25% is given in Table 1. The exposure of zinc has systematically quantitatively reduced the DNA and RNA contents in all the organs with the increase of concentration. The reduction in DNA (-1.5 to -5.93%) and RNA (-0.76 to -4.85%) was lowest in liver as compared to the reduction in nucleic acid content of muscle and kidney. The reduction in DNA (-4.5 to -18.38 %) and RNA (-3.88 to -19.10 %) with the increased concentration of zinc was highest in kidney.

Percent changes in the concentrations of various nucleic acids in the tissues of *C. carpio*. on exposure to five concentrations of cadmium from 0.05% to 0.25% is given in Table 2. The adverse effect of cadmium was also similar to

zinc where nucleic acids contents in various tissues were reduced with the concentration of metal. While the reduction in both DNA (-1.34 to -8.27 %) and RNA (-1.72 to -7.70 %) contents with the increase in doses in liver was observed to be lowest, the reduction in nucleic acid contents in muscles was intermediate and highest in kidney. Table 3 shows the percent changes in the concentrations of various nucleic acids in the tissues of *C. carpio* on exposure to lead concentrations from 0.05% to 0.25%. The pattern of adverse effect of lead on nucleic content was similar to that of other metals. The reduction in DNA (-3.10 to -26.62 %) and RNA (-6.31 to -23.32 %) contents of kidney were highest compared to that in liver and muscle. However, the adverse effect on nucleic acid in muscle was moderately high in reducing DNA (-2.39 to -18.08 %) and RNA (-1.52 to -11.16 %) contents.

It is clearly evident from the present study that the heavy metals cause a significant decrease of nucleic acids in various tissues of *C. carpio*. The nucleic acids play decisive role in regulating cellular activities so that they serve as important biomarkers of metabolic potential of cells in organism. The fall in nucleic acids content in the tissues of present experimental fishes is suggestive of impairment of protein synthesis. Similar reports have also been recorded and the quantity of DNA and RNA in fishes on metal exposure^{4,6,8,13}.

A fall in DNA and RNA content in the tissues of *C. carpio* would reflect the inhibited synthesis of nucleic acids. This clearly evidences that the protein synthesis machinery of the fishes has been adversely affected. It is also shown that the inhibition of DNA synthesis would affect both protein and amino acids level by reducing the RNA content⁸. In corroboration with the reports of Kumar and Banerjee⁴, the decrement of DNA and RNA content in the present species specifies the manifestation of malfunction and degenerative changes in organ systems. As per the version of Nagaraju and Rathnamma⁷, the quantitative changes in DNA and RNA levels in *C. carpio* would be due to increased activity of DNA and the inhibition of RNA polymerase function.

Table 1. Percent changes in the concentrations of various nucleic acids in the tissues of *C. carpio* on exposure to zinc

Concentration (%)	Muscle		Liver		Kidney	
	DNA	RNA	DNA	RNA	DNA	RNA
0.05	-2.02	-1.15	-1.59	-0.76	-4.50	-3.88
0.10	-6.59	-2.88	-3.18	-1.36	-7.81	-8.23
0.15	-9.18	-6.39	-4.18	-2.13	-12.53	-11.94
0.20	-12.48	-7.63	-5.04	-3.84	-15.84	-13.49
0.25	-16.42	-9.21	-5.93	-4.85	-18.38	-19.10

(-) Represents percent decrease from control

Table 2. Percent changes in the concentrations of various nucleic acids in the tissues of *C. carpio* on exposure to cadmium

Concentration (%)	Muscle		Liver		Kidney	
	DNA	RNA	DNA	RNA	DNA	RNA
0.05	-3.41	-1.93	-1.34	-1.72	-2.93	-7.97
0.10	-6.64	-5.24	-2.26	-3.83	-7.47	-13.80
0.15	-12.17	-8.84	-4.27	-4.62	-15.08	-17.28
0.20	-15.61	-9.70	-6.65	-6.06	-18.77	-24.70
0.25	-21.83	-12.89	-8.27	-7.70	-23.28	-28.57

(-) Represents percent decrease from control

Table 3. Percent changes in the concentrations of various nucleic acids in the tissues of *C. carpio* on exposure to lead

Concentration (%)	Muscle		Liver		Kidney	
	DNA	RNA	DNA	RNA	DNA	RNA
0.05	-2.39	-1.52	-1.27	-0.88	-3.10	-6.31
0.10	-8.01	-3.48	-2.32	-1.50	-7.67	-10.44
0.15	-11.45	-7.52	-3.72	-3.07	-13.33	-15.82
0.20	-14.16	-9.50	-5.50	-4.54	-18.17	-19.83
0.25	-18.08	-11.16	-6.68	-5.89	-26.62	-23.32

(-) Represents percent decrease from control

CONCLUSION

In the present investigation the alterations caused by the heavy metals in the nucleic acids of tissues in the freshwater fish *Cyprinus carpio* has been proved that, the accumulation of heavy metals adversely affects the growth of fishes. Biomonitoring these hazardous substances to be watched carefully in future to avoid the pollutants to the water bodies in affecting the marine population.

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