

## Biochemical changes in carbohydrate metabolism of the fish – *Cyprinus carpio* during sub-lethal exposure to biopesticide – Derisom

Tasneem S.<sup>1\*</sup>; Yasmeen R.<sup>1</sup>

Received: March 2017

Accepted: December 2017

### Abstract

The effect of biopesticide - Derisom on certain metabolites and enzymes of carbohydrate metabolism were evaluated in gill, liver, kidney and muscle of *Cyprinus carpio* during sub-lethal toxicity exposure of 21 days. A dose of 0.28 ppm was taken as the sub-lethal dose. The organs were taken from exposed and control fish at the end of 24 hrs, 7, 14 and 21 days and used for the estimation of total carbohydrates, total glycogen, succino dehydrogenase (SDH) and lactate dehydrogenase (LDH) activities. All the organs showed the significant difference between control and exposed groups in all the estimated parameters on all days of exposure. In the present study, all the parameters i.e., total carbohydrates, total glycogen, SDH and LDH significantly decreased as the days of sub-lethal exposure increased, up to the completion of 21 days of exposure. The present study considers biochemical parameters as important biomarkers in determining the level of toxicity caused by the biopesticide – Derisom.

**Keywords:** *Cyprinus carpio*, Derisom, Metabolism, Carbohydrates, Organs

---

1-Department of Zoology, University College of Science, Osmania University, Hyderabad, Telangana State, 500007, India.

\*Corresponding author's Email: shoeiba.tas@gmail.com

## Introduction

Contamination of the water bodies has become a major problem at local, regional, national, and global levels (Spalding *et al.*, 2003). The water bodies contain a large number of pollutants such as chemical compounds, industrial and agricultural wastes. Insecticides constitute the major pollutants of many aquatic habitats. The major routes of insecticides polluting the aquatic ecosystems include rainfall, runoff, and atmospheric deposition. The insecticides finally make their way into ponds, lakes, and rivers (Arjmandi *et al.*, 2010) and exhibit some kind of toxic effects on non-target organisms. Presence of toxic substances such as pesticides, in the aquatic environment causes a reduction in the quality of water which leads to health hazards in the aquatic organisms especially fish (Roberts, 2001).

The contamination of aquatic ecosystems by pesticides causes harmful effects on health, growth, survival and reproduction of aquatic animals especially fishes, which constitute an important source of food for human and animal consumption (Banaee *et al.*, 2008). Fishes are extremely sensitive to any kind of pollutants present in the water. Hence, pesticides may cause significant alterations in certain biochemical processes in the tissues of fish (John, 2007). It has also been found that the pesticides can cause serious alterations in the physiological well-being and health condition of fishes (Begum, 2004). Since fishes are the important

food source for humans therefore the health of fish is important.

The biochemical alterations in organisms are considered as most sensitive and earliest events of any pollutant damage. Effects of pesticides on biochemical processes in aquatic animals have been done earlier in India by Tripathi and Singh (2002). The metabolites of carbohydrate metabolism and enzymes examined are one of the most important parts of biological function. Similar kind of work i.e., the effect of pesticides on fishes has also been done by Begum (2004). Exposure to pesticides causes severe alterations in tissue biochemistry of fishes (Shrivastava and Singh, 2004). Hence, biochemical parameters are the best physiological indicators of the fish health. Therefore they are important to be focused while studying the toxic effects of various pesticides and pollutants on fish.

The pesticide used in the present work is a plant-based biopesticide Derisom. The fish species used for the study is the common carp *Cyprinus carpio*. Common carp is a very popular edible fish and is grown in rice fields in some states of India as a practice of integrated farming. It is grown in many natural and artificial ponds. The aim of the present study is to estimate the biochemical changes of carbohydrate metabolism and related enzymes in various tissues of *C. carpio* during sub-lethal exposure to Derisom.

## Materials and methods:

*C. carpio* ranging in length  $14 \pm 0.83$  cm and weighing  $28.53 \pm 1.79$  g were

collected from Kaikaluru village of Andhra Pradesh State and transported to the laboratory in well-aerated condition. The fish were acclimatized in well-aerated tanks for a period of one month. They were fed twice daily with commercially available fish feed pellets and the water was renewed daily. The 96 hrs LC<sub>50</sub> value of Derisom was already estimated as 2.8 ppm. 1/10<sup>th</sup> of the 96 hrs LC<sub>50</sub> value i.e., 0.28 ppm is taken as the sub-lethal dose. The fish were exposed to the sub-lethal dose for a period of 21 days. After the completion of 24 hrs, 7 days, 14 days and 21 days the fish of both control and exposed groups were dissected and the organs (gill, liver, kidney and muscle) from six individuals were collected and estimated for biochemical parameters (total carbohydrates, total glycogen, succinate dehydrogenase and lactate dehydrogenase).

The toxic compound used for the study is a biopesticide–Derisom, manufactured by Agri Life India private limited, IDA bollaram, Hyderabad. The biopesticide was procured from the manufacturer. The biopesticide is a product extracted from the seeds of *Pongamia pinnata*. Its active ingredient is Karanjin. It is a liquid formulation containing Karanjin in 20,000 ppm concentration.

Total carbohydrates and total glycogen were estimated by the method of Nicholas *et al.* (1956) using Anthrone reagent with some modifications. The SDH and LDH assays were estimated by modified method of Nachlas *et al.* (1960) with some modifications.

For the estimation of total carbohydrates, 10 mg mL<sup>-1</sup> (W V<sup>-1</sup>) liver and 20 mg mL<sup>-1</sup> (W V<sup>-1</sup>) gill, kidney and muscle tissues were homogenized in 10% TCA. The homogenate was centrifuged at 3000 rpm for 15 min. One mL of clear supernatant was directly used for the estimation of total carbohydrates. Five ml of Anthrone reagent was added to each tube having 1 mL of clear supernatant, in an inclined position. All the tubes were capped and cooled down to room temperature. The colour developed was read against blank at 620 nm in a UV – visible spectrophotometer. The values obtained were expressed as mg of glucose/g wet wt of tissue.

For the estimation of total glycogen, 10 mg mL<sup>-1</sup> (W V<sup>-1</sup>) liver and 20 mg mL<sup>-1</sup> (W V<sup>-1</sup>) gill, kidney and muscle tissues were homogenized in 10% TCA. The homogenate was centrifuged at 3000 rpm for 15 min. To 1 mL of supernatant, 5 mL of absolute ethanol was added. The tubes were capped and kept overnight in the refrigerator for complete precipitation. The tubes were then centrifuged at 3000 rpm for 15 min. The clear liquid was gently decanted from packed glycogen. The tubes were drained in an inverted position for 10 min. The glycogen obtained was dissolved in 1 mL of distilled water. Five mL of Anthrone reagent was added to each tube in an inclined position. All the tubes were capped and cooled down to room temperature. The colour developed was read against blank at 620 nm in a UV – visible spectrophotometer. The values

obtained were expressed as mg of glycogen g<sup>-1</sup> wet wt of tissue.

For the estimation of SDH assay 200 mg mL<sup>-1</sup> (W V<sup>-1</sup>) gill and 100 mg mL<sup>-1</sup> (W V<sup>-1</sup>) liver, kidney and muscle tissues were taken and homogenized in 0.25 M ice-cold sucrose solution. The homogenate was centrifuged at 2000 rpm for 10 minutes. The clear supernatant was used for the enzyme assay. Two mL of incubation mixture consisted of 100 μ moles of phosphate buffer (pH 7.4), 2 μ moles of INT, 100 μ moles of sodium succinate (pH 7), 0.1 mL of distilled water and 0.5 mL of clear supernatant. The reaction mixture was incubated at 37° C for 30 min. The reaction was stopped by adding 4 mL of glacial acetic acid. The colour was extracted by adding 4 mL of toluene. All the tubes were shaken well, capped and kept in the refrigerator overnight. Formazon formed was measured at 490 nm against blank in a UV – visible spectrophotometer. The values obtained were expressed as μ moles of formazon formed mg<sup>-1</sup> tissue hr<sup>-1</sup>.

For the estimation of LDH assay, 50 mg mL<sup>-1</sup> (W V<sup>-1</sup>) gill, liver, kidney and muscle tissues were taken and homogenized in 0.25M ice-cold sucrose solution. The homogenate was centrifuged at 2000 rpm for 10 minutes. The clear supernatant was used for the enzyme assay. Two mL of incubation mixture consisted of 100 μ moles of phosphate buffer (pH 7.4), 2 μ moles of INT, 50 μ moles of sodium lactate (pH 7.4), 0.1 μ mole of NAD and 0.5 mL of clear supernatant. The reaction mixture was incubated at 37° C for 30 min. The reaction was stopped by adding 4 mL of

glacial acetic acid. The colour was extracted by adding 4 mL of toluene. All the tubes were shaken well, capped and kept in the refrigerator overnight. Formazon formed was measured at 490 nm against blank in a UV –visible spectrophotometer. The values obtained were expressed as μ moles of formazon formed mg<sup>-1</sup> tissue hr<sup>-1</sup>.

All the results obtained were subjected to statistical analysis using IBM SPSS software version 21. The test used was one-way ANOVA. All the results are presented as mean±standard deviation at *p*<0.05 level of significance. The graphs were made using Graph Pad Prism software version 5.

## Results

The fish during sub-lethal dose exposure (0.28 ppm) within 21 days to the biopesticide- Derisom showed the following results in gill, liver, kidney, and muscle when compared to the control group.

The results of the present study show that the carbohydrate metabolism in gill, liver, kidney, and muscle is disrupted on exposure to biopesticide – Derisom to some extent. The alterations were tissue specific and hence can be used as an important indicator of pesticide pollution. This type of study with fish provides useful information about the nature of the adverse effects of pesticides and biopesticides on aquatic biota especially fish, which constitute an important food source for human consumption. Hence, it is important to monitor the usage of every pesticide whether synthetic or bio. As

both of them cause adverse effect on fauna – fish.  
the health and well-being of the aquatic

**Table 1: Total carbohydrate (mg g<sup>-1</sup>) in gill, liver, kidney and muscle of *Cyprinus carpio* on exposure to sub-lethal dose of biopesticide – Derisom.**

Tissue	Control	24 hrs	7 days	14 days	21 days
Gill	21.97±0.6	17.36±0.55*	14.12±0.49*	11.42±0.57*	10.19±0.62*
Liver	131.39±0.92	117.45±0.67*	103.26±1.29*	88.44±1.69*	72.76±0.17*
Kidney	21.38±0.56	19.4±0.71*	15.68±1.08*	12.80±0.57*	10.87±0.58*
Muscle	73.37±0.57	66.84±0.55*	58.84±0.58*	53.58±0.62*	46.89±0.62*

Values are expressed as mean ± standard deviation. \**p*<0.05.

**Table 2: Total glycogen (mg g<sup>-1</sup>) in gill, liver, kidney and muscle of *Cyprinus carpio* on exposure to sub-lethal dose of biopesticide – Derisom.**

Tissue	Control	24 hrs	7 days	14 days	21 days
Gill	5.7±0.61	4.3±0.68*	3.02±0.58*	2.01±0.29*	1.48±0.77*
Liver	46.27±0.7	39.81±0.7*	35.05±1.17*	28.28±1.29*	23.57±1.21*
Kidney	7.63±0.63	6.94±0.58*	5.6±0.51*	4.81±0.64*	3.57±0.57*
Muscle	14.15±0.58	12.77±0.57*	10.29±0.59*	7±0.58*	6.14±0.32*

Values are expressed as mean ± standard deviation. \**p*<0.05.

**Table 3: Succinate dehydrogenase (μmoles of formazon formed mg<sup>-1</sup> tissue hr<sup>-1</sup>) in gill, liver, kidney and muscle of *Cyprinus carpio* on exposure to sub-lethal dose of biopesticide – Derisom.**

Tissue	Control	24 hrs	7 days	14 days	21 days
Gill	2.57±0.07	2.31±0.07*	1.91±0.06*	1.5±0.06*	1.18±0.07*
Liver	12.29±0.16	11.64±0.17*	10.92±0.22*	10±0.14*	9.03±0.15*
Kidney	27.1±0.13	25.8±0.13*	22.22±0.12*	18.32±0.13*	15.85±0.15*
Muscle	7.76±0.15	6.72±0.16*	5.62±0.13*	3.5±0.16*	2.85±0.16*

Values are expressed as mean ± standard deviation. \**p*<0.05.

**Table 4: Lactate dehydrogenase (μmoles of formazon formed mg<sup>-1</sup> tissue hr<sup>-1</sup>) in gill, liver, kidney and muscle of *Cyprinus carpio* on exposure to sub-lethal dose of biopesticide – Derisom.**

Tissue	Control	24 hrs	7 days	14 days	21 days
Gill	27.83±0.31	25.54±0.26*	22.62±0.31*	19.32±0.28*	16.12±0.29*
Liver	58.79±0.33	54.88±0.27*	47.05±0.29*	38.93±0.29*	35.81±0.31*
Kidney	45.79±0.28	40.52±0.27*	36.31±0.26*	32.85±0.12*	26.52±0.31*
Muscle	30.82±0.29	25.88±0.27*	19.32±0.27*	13.47±0.29*	11.2±0.28*

Values are expressed as mean ± standard deviation. \**p*<0.05.

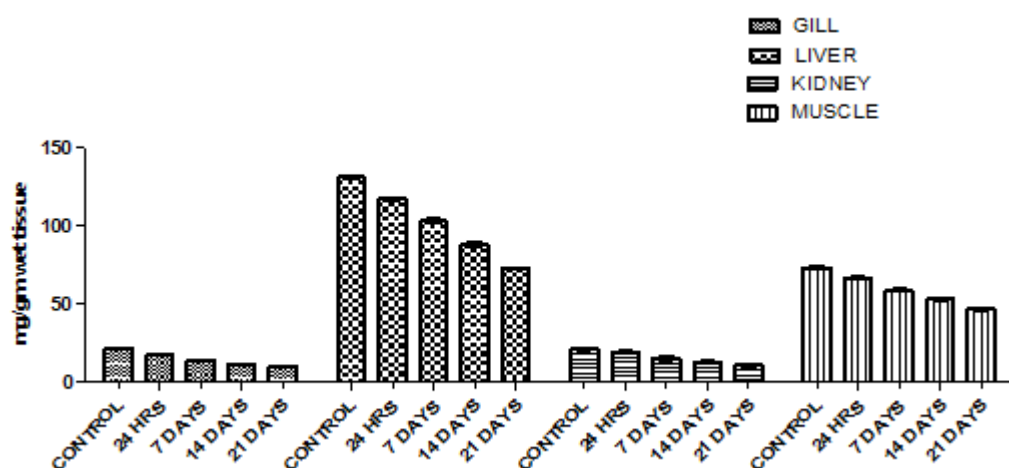
The total carbohydrate content was found to be highest in the liver, followed by muscle, kidney and gills, respectively. The concentration of total carbohydrates showed the significant decrease in all the four organs – gill, liver, kidney and muscle as the days of exposure increased. The total glycogen

content was found to be highest in the liver followed by muscle, kidney and gill. The concentration of glycogen showed significant decrease in all four organs as the days of exposure increased. The total carbohydrate and glycogen value in all the four organs gill, liver, kidney and muscle was found

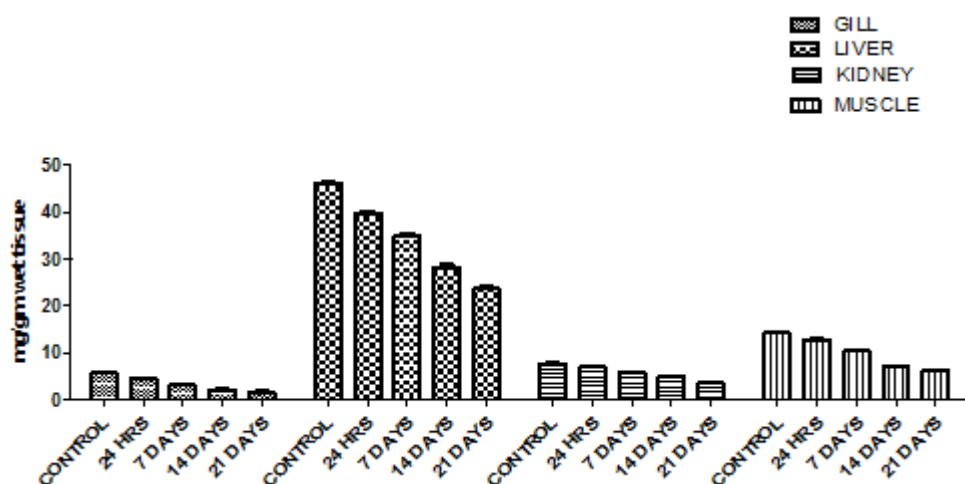
to be highest in the control fish and least in fish of 21 days exposure.

The SDH content was found to be highest in kidney, followed by liver, muscle and least in the gills. The concentration of SDH showed a significant decrease in all the four organs as the days of exposure

increased. The LDH content was found to be highest in liver, followed by kidney, muscle and gill. The LDH concentration decreased significantly in all of the four organs as the days of exposure increased.



**Figure1:** Total Carbohydrate conc. in Gill, Liver, Kidney and Muscle of fish- *C. carpio*. during exposure to sub-lethal conc. of Derisom.



**Figure 2:** Total Glycogen conc. in Gill, Liver, Kidney and Muscle of fish-*C. carpio* during exposure to sub-lethal conc. of Derisom..

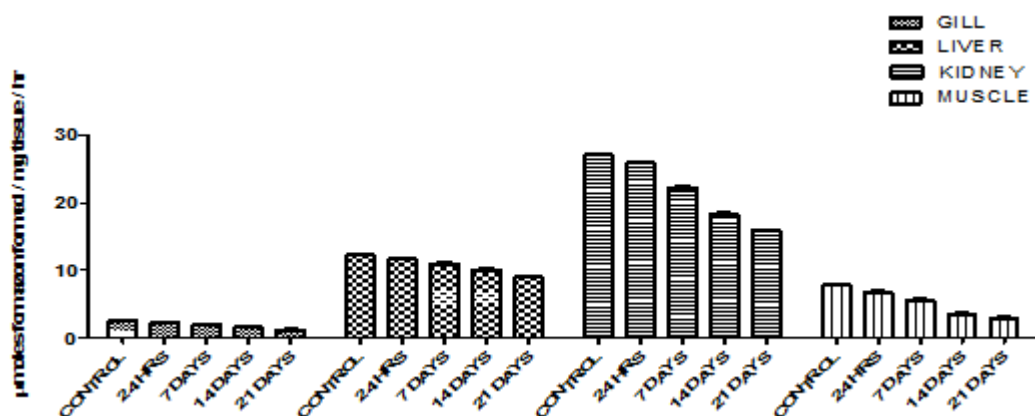


Figure 3: S.D.H. conc. in Gill, Liver, Kidney and Muscle of fish-*C. carpio* during exposure to sub-lethal conc of Derisom.

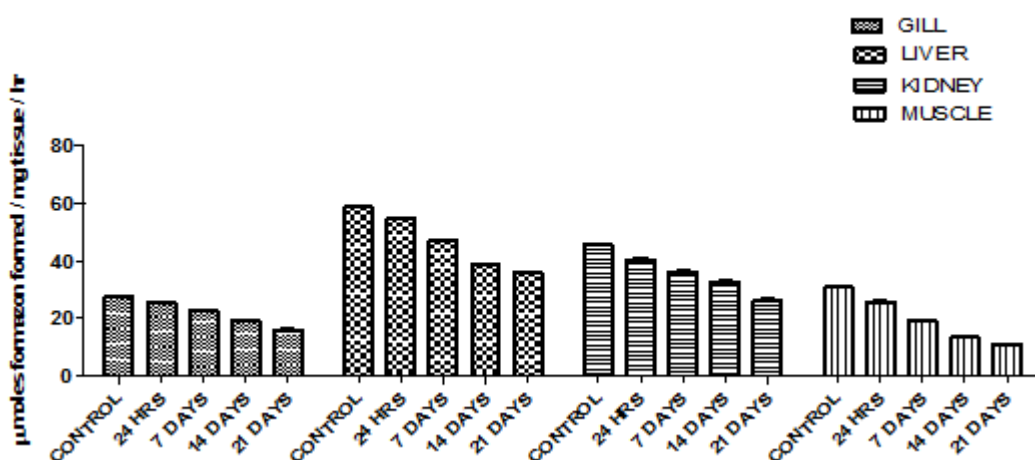


Figure 4: L.D.H. conc. in Gill, Liver, Kidney and Muscle of fish- *C. carpio* during exposure to sub-lethal conc. of Derisom.

## Discussion

The results obtained from the present study show that the values of total carbohydrates, total glycogen, succinate dehydrogenase and lactate dehydrogenase in all the four organs – gill, liver, kidney and muscle decreased significantly after the completion of 24 hrs, 7 days, 14 days and 21 days, on exposure to sub-lethal concentration of Derisom. The results obtained in the present study are in correlation with the results obtained by many other researchers.

Gills are thin, fine respiratory structures which are in continuous contact with water and they carry out

some important functions like - gases exchange, ion regulation and excretion of metabolic wastes. As gills are in constant contact with the external environment, they are the first targets of waterborne pollutants (Perry and Lauvent, 1993). Liver is the first organ to encounter ingested nutrients, drugs and environmental toxicants, it is involved in the synthesis of various proteins and is also a regulatory center of metabolism. Liver functions can be altered by changes caused during acute or chronic exposure to toxicants (Al-Attar, 2011). Kidney the important organ of excretion and osmoregulation is indirectly affected by pollutants

through blood circulation (Newman and McLean, 1974). Devi (1981) reported that the kidney is the site of degradation and detoxification of toxic substances. Muscle - rich in protein forms mechanical tissue intended for mobility and it does not participate in any metabolic activities. The impact of contaminants on the aquatic ecosystem can be assessed by measuring the biochemical parameters in fish that respond specifically to specific toxicant (Petrivalsky *et al.*, 1997).

The study conducted in the present paper provides the evidence that like other kinds of synthetic pesticides, the biopesticides or botanical pesticides also affect carbohydrate metabolism in different tissues by altering the levels of metabolites and their associated enzymes. Carbohydrates are the first and immediate energy source to be utilized to a greater extent particularly in case of stress. Exposure to any kind of pollutant or toxicants results in stress which ultimately results in a reduction of total carbohydrates content in various tissues. Under stressful conditions, carbohydrate reserves are depleted in order to meet energy requirement by all tissues (Arasta *et al.*, 1996).

Under stress conditions, the energy demands are met by increased glycogenolysis which leads to decrease in tissue glycogen content (Wasserman *et al.*, 1970). The reduction in liver glycogen stores and carbohydrates could be due to reason that the liver synthesis of detoxifying enzymes requires high energy levels (Begum and Vijayaraghavan, 1995; Hori *et al.*,

2006). In pesticide-exposed fish the decrease in glycogen content clearly indicates its rapid utilization to meet the enhanced energy demands through glycolysis or hexose monophosphate pathway. Other reason for the decrease in glycogen content may be the inhibition of the enzyme glycogen synthetase. A decrease in tissue glycogen was observed in *Labeo rohita* on exposure to malathion and nuvan (Anuradha, 1993). Similar reduction in tissue glycogen was observed when *S. mossambicus* was exposed to DDT, malathion and mercury (Ramalingam, 1988). The findings of the present study are also in agreement with those of Bakhshwan *et al.* (2009).

SDH is one of the active regulatory enzymes of the TCA cycle. Decreased SDH activity clearly indicates the depression of TCA cycle i.e., depletion in the oxidative metabolism at the level of mitochondria. A similar decrease in the SDH activity was observed by Jacob *et al.* (2007) in freshwater fish exposed to cypermethrin. A similar trend of decrease in SDH activity was also reported in different organisms exposed to different chemicals (Sudharsan *et al.*, 2000; Al-Ghanim and Mahboob, 2012).

LDH is a potential marker enzyme for assessing the toxicity of pollutants and toxicants. Alterations in the LDH activity has been proven to be a very good marker and also serves as a diagnostic tool in toxicology studies for tissue damage in fish (Ramesh *et al.*, 1993), muscular damage (Balint *et al.*, 1997) and hypoxic conditions (Das *et al.*, 2004). LDH plays a very



important role in carbohydrate metabolism by interconverting lactate and pyruvate (Lehninger *et al.*, 1993). LDH acts as a connecting enzyme between the glycolytic pathway and TCA cycle. Studies conducted by various researchers revealed that under toxicant exposure the LDH activity of various tissues gets altered (Tripathi *et al.*, 1990; Diamantino *et al.*, 2001; Mishra and Shukla, 2003; Rao, 2006; Agrahari and Gopal, 2009).

Alphamethrin exhibited alterations in biochemical parameters of *Channa punctatus* was observed by Tripathi and Singh (2013). According to Bhaskara and Vijaya (2016) Butachlor and Machete induced biochemical alterations in *C. punctatus*. In another study performed by Muddassir (2015), it was reported that Carbofuran and Malathion induced biochemical alterations in *C. punctatus*. Effect of Triclosan on total protein content in *C. punctatus* was studied by Ravi *et al.* (2015). Studies of Illiyas *et al.* (2016) concluded that Dimethoate affected physiology of *Catla catla* and *Labeo rohita*. Indoxacarb exhibiting alterations in biochemical parameters of *L. rohita* were recorded by Veeraiah *et al.* (2013). Effect of two pesticides on the biochemistry of *L. rohita* was investigated by Nagaraju and Venkata (2013).

Cypermethrin induced biochemical changes in *Clarias batrachus* was reported by Prakash *et al.* (2014). Rather *et al.* (2015) thoroughly investigated the biochemical changes induced by carbaryl, carbosulfan and parathion in *C. batrachus*. Effect of

fenthion on enzymes of *C. carpio* was studied by Leena (2014). Khalid (2014) studied the effect of cypermethrin on enzyme activities of *C. carpio*. Effect of phorate on the level of total proteins in *C. carpio* was investigated by Lakshmaiah (2014). Due to Cypermethrin, the enzymatic alterations in *C. carpio* were recorded by Neelima *et al.*, (2015). Tulasi and Jayantha Rao (2013) conducted a study to find the effect of chromium on protein metabolism of *C. carpio*. Similar work using trivalent chromium was done by Zeynab *et al.* (2013) in *C. carpio* and the biochemical profile was observed.

### Acknowledgement

The authors are very thankful to the Department of Zoology, Osmania University for providing the research facilities. The work done in this paper is a part of Ph.D. work of ST. The authors give their sincere thanks to Prof. K. Venkaiah, HOD, Dept. of Statistics, NIN – Hyderabad, for helping us with the statistical analysis of the data. ST is immensely thankful to the UGC – Maulana Azad National Fellowship Scheme for financial assistance throughout the research period.

### References

**Agrahari, S. and Gopal, K., 2009.**

Fluctuations of certain biochemical constituents and marker enzymes as a consequence of monochrotophos toxicity in the edible freshwater fish, *Channa punctatus*. *Pesticide Biochemistry and Physiology*, 94, 5–9.

- Al-Attar, A.M., 2011.** Vitamin E attenuates liver injury induced by exposure to lead, mercury, cadmium and copper in albino mice. *Saudi Journal of Biological Sciences*, 18, 395-401.
- Al-Ghanim, K. and Mahboob, S., 2012.** Effect of sodium cyanide on the activities of some oxidative enzymes and metabolites in *Clarias gariepinus*. *African Journal of Biotechnology*, 11(41), 9849-9854.
- Anuradha, G., 1993.** Impact of organophosphate pesticides on *Labeo rohita*, Ph. D Thesis, Osmania University, Hyderabad, India.
- Arasta, T., Bais V.B. and Thakur, P., 1996.** Effect of Nuvan on some biochemical parameters of Indian catfish *Mystus vittatus*. *Journal of Environmental Research*, 80, 80-83.
- Arjmandi, R, Tavakol, M. and Shayeghi, M., 2010.** Determination of organophosphate insecticide residues in the rice paddies. *International Journal of Environmental Science and Technology*, 7(1), 175- 182.
- Bakhshwan, S.A., Marzouk, M.S., Hanna, M.I. and Hamed, H.S., 2009.** Some investigations on the clinical and biochemical alterations associated with diazinon toxicity in *Clarias gariepinus*. *Egyptian Journal of Aquatic Biology and Fisheries*, 13(2), 173-197.
- Balint, T., Ferenczy, J., Katai, F., Kiss, I., Kraczer, L. and Kufcsak, O., 1997.** Similarities and differences between the massive eel (*Anguilla anguilla* L.) devastations that occurred in lake Ablation in 1991 and 1995. *Ecotoxicology and Environmental Safety*, 37, 17-23.
- Banaee, M., Mirvagefi, R., Rafei, G.R. and Majazi, Amiri, B., 2008.** Effect of sub- lethal Diazinon concentrations on blood plasma biochemistry. *International Journal of Environmental Research*, 2(2), 189-198.
- Begum, G. and Vijayaraghavan, S., 1995.** Carbohydrate metabolism in hepatic tissue of fresh water *Clarius batracus* L. during dimethoate exposure. *Food and Chemical Toxicology*, 33, 423-426.
- Begum, G., 2004.** Carbofuran insecticide induced biochemical alterations in liver and muscle tissues of the fish *Clarias batrachus* (Linn) and recovery response. *Aquatic Toxicology*, 66, 83- 92.
- Bhaskara Tataji, P. and Vijaya Kumar, M., 2016.** Biochemical changes induced by Butachlor and Machete 50% EC to the freshwater fish *Channa punctata* (Bloch). *International Journal of Science and Research*, 5(3), 2048-2052.
- Das, P.C., Ayyappan, S., Jena, J.K. and Das, B.K., 2004.** Acute toxicity of ammonia and its sub-lethal effects on selected haematological and enzymatic parameters of *Cirrhinus mrigala* (Hamilton). *Aquaculture Research*, 35, 134-143.
- Devi, AP., 1981.** Studies on the toxicity of endosulfan to some fresh water fish with special reference to certain physiological changes induced in *Channa punctatus* (Bloch.). Ph.D. Thesis, Nagarjuna University.

- Diamantino, T.C., Amadeu, E., Soares, M.V.M. and Guilherminoc, L., 2001.** Lactate dehydrogenase activity as an effect criterion in toxicity tests with *Daphnia magna straus*. *Chemosphere*, 45(4-5), 553-560.
- Hori, T.S.F., Avilez, I.M., Inoue, L.K. and Moraes, G., 2006.** Metabolical changes induced by chronic phenol exposure in matrinxã *Brycon cephalus* (teleostei: characidae) juveniles. *Comparative Biochemistry and Physiology*, 143(1), 67-72.
- Jacob, Doss, P., Ramanaiah, S., Nagarjuna, A., Suhasini, N., Savithri, Y. and Rajendra, Prasad, S., 2007.** Toxicity of cypermethrin on brain and liver tissues of freshwater edible fish *Labeo rohita* with special reference to selected biochemical parameters. *Indian Journal of Environmental Science*, 11, 23-27.
- John, P.J., 2007.** Alteration of certain blood parameters of fresh water teleost *Mistus vittatus* after chronic exposure to metasystox and sevin. *Fish Physiology and Biochemistry*, 33, 15-20.
- Khalid, A.A., 2014.** Effect of cypermethrin toxicity on enzyme activities in the freshwater fish *Cyprinus carpio*. *African Journal of Biotechnology*, 13(10), 1169-1173.
- Lakshmaiah, G., 2014.** Toxic impact of lethal and sub-lethal concentrations of phorate on the total protein levels in different tissues of common carp *Cyprinus carpio*. *International Journal of Pharma and Bio Sciences*, 5(4), 422 – 428.
- Muralidharan, L., 2014.** Chronic toxic impacts of fenthion on the profiles of enzymes in the fresh water fish *Cyprinus carpio* (linn.). *International Journal of Fisheries and Aquatic Studies*, 1(4), 51-56.
- Lehninger, A.B., Nelson, D.L. and Cox, M.M., 1993.** Principles of biochemistry, New York, NY: Worth Publishers.
- Mishra, R. and Shukla, S.P., 2003.** Endosulfan effects on muscle malate dehydrogenase of the freshwater catfish *Clarias batrachus*. *Ecotoxicology and Environmental Safety*, 56(3), 425-433.
- Muddassir, A. T., 2015.** Comparative study of biochemical alterations induced by carbofuran and malathion on *Channa punctatus* (Bloch.). *International Research Journal of Biological*, 4(9), 61-65.
- Nachlas, M.M., Margulius, S.P. and Seligman, A.M., 1960.** Sites of electron transfer to tetrazolium salts in the succino oxidase system. *Journal of Biological Chemistry*, 235(9), 2739-2743.
- Nagaraju, B. and Venkata, Rathnamma, V., 2013.** Effect of two pesticides on some biochemical characteristics of the freshwater fish *Labeo rohita* (Hamilton). *Journal of Biology and Today's World*, 2(9), 425 - 441.
- Neelima, P., Govinda, Rao, K., Gopala, Rao, N. and Chandra, Sekhara, Rao, Jammu., 2015.** Enzymatic alterations as biomarkers of Cypermethrin (25%EC) toxicity

- in a freshwater fish, *Cyprinus carpio* (Linn.). *International Journal of Fisheries and Aquatic Studies*, 3(1), 149-158.
- Newman, M.W. and MacLean., 1974.** Physiological response of the cunner *Tautoglabrus adspersus* to cadmium VI: Histopathology No. A Tech. Report, NMFS, SSRF, 681 P.
- Nicholas, V.C., Longley, R.W. and Roe, J.H., 1956.** Determination of Glycogen in liver and muscle by use of anthrone reagent. *Journal of Biological Chemistry*, 220, 583-593.
- Perry, S.F. and Lauvent, P., 1993.** Environmental effects on fish gill structure and function. In: Rankin, J.C. and F.B. Jensen (eds.), *Fish Ecophysiology*, Chapman and Hall, London, pp. 231-264.
- Petrivsky, M., Machala, M., Nezveda, K., Piacka, V., Svobodova, Z. and Drabek, P., 1997.** Glutathione dependent detoxifying enzymes in rainbow trout liver: search for specific biochemical markers of chemical stress. *Environmental Toxicology and Chemistry*, 16, 1417-1421.
- Prakash, M.M., Gaherwal, S., Soni, R. and Nageshwar, W., 2014.** Cypermethrin induced biochemical changes in kidney of *Clarias batrachus*. *World Applied Sciences Journal*, 32(1), 18-21.
- Ramalingam, K., 1988.** Toxic effects of DDT, Malathion and Mercury on the tissue of *Sarotherodon mossambicus*. *Indian Academy of Sciences*, 97, 443-445.
- Ramesh, M., Sivakumari, K., Kanagaraj, M.K. and Manavalaramanujam, K., 1993.** Toxicity of dye effluent in lactate dehydrogenase activity in *Labeo rohita*. *Journal of Environmental Protection*, 13, 124127.
- Rao, J.V., 2006.** Biochemical alterations in euryhaline fish, *Oreochromis mossambicus* exposed to sub-lethal concentrations of an organophosphorus insecticide, monocrotophos. *Chemosphere*, 65(10), 1814-1820.
- Rather, A., A., Khan, A. A., Sharma, G.D. and Muddassir, T., 2015.** Biochemical changes induced by carbaryl, carbosulfan and parathion on fresh water catfish *Clarias batrachus* (Linn.). *International Research Journal of Biological Sciences*, 4(8), 4-9.
- Ravi, Kumar, Kola., Abdul, Rasheed., Mohdand, Prameela. and Devi, Yalavarthy., 2015.** Effect of triclosan on total protein content in freshwater fish, *Channa punctatus*. *International Journal of Recent Scientific Research*, 6(6), 4641-4643.
- Roberts, R.J., 2001.** *Fish Pathology*, 3<sup>rd</sup> Ed. W.B. Saunders, Philadelphia, Pennsylvania, 472 P.
- Shrivastava, S. and Singh, S., 2004.** Changes in protein content in the muscle of *Heteropneustes fossilis* exposed to carbaryl. *Journal of Ecotoxicology and Environmental Monitoring*, 14, 119-122.
- Spalding, R.F., Exner, M.E., Snow, D.D., Cassada, D.A., Burbach, M.E. and Monson, S.J., 2003.** Herbicides in ground water beneath Nebraska's management systems

- evaluation area. *Journal of Environmental Quality*, 32(1), 92-98.
- Sudharsan, R., Shobha, R.A., Reddy, T.N., Reddy, P.U.M. and Raju, T.N., 2000.** Effect of nitrite toxicity on the dehydrogenases in the fish *Tilapia mossambica*. *Journal of Environmental Pollution*, 7, 127-130.
- Tripathi, S.N., Chandola, H.M., Singh, B.C. and Chadha, A.N., 1990.** Study on hypoglycemic fraction of *C. tamala* and *T. belerica*. *Ayurveda*, 11, 1-12.
- Tripathi, P.K. and Singh, A., 2002.** Toxic effect of dimethoate and carbaryl pesticides on carbohydrate metabolism of fresh water snail *Lymnaea acuminata*. *Bulletin of Environmental Contamination and Toxicology*, 68, 606-611.
- Tripathi, G. and Singh, H., 2013.** Impact of alphamethrin on biochemical parameters of *Channa punctatus*. *Journal of Environmental Biology*, 34, 227-230.
- Tulasi, G. and Jayantha, Rao, K., 2013.** Effect of chromium on protein metabolism in different tissues of fish, *Cyprinus carpio*. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 4(1), 143-148.
- Veeraiah, K., Srinivas, Rao, P., Symyuktha, Rani, A. and Dhilleswarao, H., 2013.** Changes in biochemical parameters of freshwater fish *Labeo rohita* exposed to lethal and sub-lethal concentrations of Indoxacarb. *International Journal of Bioassays*, 2(10), 1382-1387.
- Wasserman, M., Wasserman, D. and Aronovaski, J., 1970.** Effect of organochlorine pesticides on serum cholesterol levels in people occupationally exposed. *Bulletin of Environmental Contamination and Toxicology*, 5, 368-372.
- Abedi, Z., Khalesi, M.K. and Kohestan Eskandari, S., 2013.** Biochemical and hematological profiles of common carp (*Cyprinus carpio*) under sub-lethal effects of trivalent chromium. *Iranian Journal of Toxicology*, 7(20), 782-792.