Summary & Conclusion
The present study was undertaken to assess the effect of pyrethroid insecticide, deltamethrin on a non-target organism fish, Cirrhinus mrigala is widely cultivated and consumed fish in and around Dharwad, Karnataka and India. Hence it is taken for experimentation. Damages caused to the fish due to the deltamethrin could pose a health problem to human beings as a result of biomagnifications. Hence selection of the problem is highly relevant.

The following are the important conclusions that have been arrived at after a systematic, meticulous and exhaustive experimentation.

- The dose response studies conducted for 96 h revealed the LC$_{50}$ value to be 8 $\mu$l/l. Thereafter the animals were exposed for lethal studies 1, 2, 3 and 4 days and for sublethal (0.8 $\mu$l/l) studies 1, 5, 10 and 15 days.

- The behavioural aspects of fish changed on being exposed to lethal concentration of deltamethrin. These changes include, repeated opening and closing of opercular coverings, hyper-extension of all fins, increase in surfacing activity, abnormal swimming behaviour, followed by S-jerks, partial jerks, rotating along horizontal axis, non-directed spurt of forward movement, burst swimming etc., were observed in lethal concentration. Where as in sublethal concentration these are found to be in lesser degree.

- Whole animal oxygen consumption of the fish was found to decrease at both lethal and sublethal concentrations. However at sublethal concentration the decrease was less compare to lethal concentration. This is
presumed to be interference of deltamethrin in oxidative metabolism and damage the integrity of gill structure leading to hypoxic conditions.

> Activity of AChE decreased under all the exposure periods both under lethal and sublethal concentration of deltamethrin. Whereas ACh content in the target tissues showed an elevation throughout the test period. It can be inferred that exposure of deltamethrin causes inhibition of AChE Activity and hence increase accumulation of ACh at synaptic junctions.

> Blood glucose was found increased and glycogen was reduced in gill, muscle and liver. Glycogenphosphorylase and glucose-6-phosphatase were found decreased in liver. This is considered to be a neuroendocrinal imbalance and is concentration and time dependent.

> Lactate dehydrogenases (LDH) and Succinate dehydrogenases (SDH) activity were found altered over the time of exposure both during median lethal and sublethal exposure periods. Impairment of oxidative phosphorylation is presumed to be the reason.

> Significant decrease in Na⁺, K⁺ and Ca²⁺ ions in gill, muscle and liver was noticed in lethal concentration to a significant level. Whereas the changes were not highly pronounced at sublethal concentration indicating low concentration of deltamethrin and its non-toxic effects. ATPases the membrane bound enzyme play a prominent role in maintaining intercellular ionic gradient, osmoregulatory and other physiological processes.
Na\textsuperscript+-K\textsuperscript+ ATPases were found inhibited throughout the exposure in all the tissues with varying percent inhibition. Mg\textsuperscript{2+} ATPases were also inhibited on all exposure periods. Inhibition in the ions specific ATPases could be attributed to membrane damage and cellular leakage.

Haematological parameters have been used to describe the health of fish, monitor stress response and physiological adaptations of animal to the pesticide medium. Haematological parameters are known to respond quickly to changes in environmental conditions. RBC, Hb and haematocrit values decreased consecutively under lethal concentration, whereas WBC increased on day 1 and further decreased on later exposure periods. Blood indices like MCH, MCHC and MCV altered, which were dependent on the variation exhibited by RBC, Hb and PCV values. Under sublethal concentration the values of blood parameters were found to alter till day 5 and 10 but on day 15 values observed revealed to be normal which could be overviewed as the possible adaptation of fish to ambient pesticide medium. Reduction in PCV could be attributed to low RBC count or haemodilution. Increase in MCV may be because of endosmosis. MCH and MCHC are derived from HB and RBC and any sort of alterations in the level of Hb and RBC would result in the alteration of MCH and MCHC.

From the above assessment pertinent to physiological, behavioural and biochemical response of freshwater fish, *Cirrhinus mrigala* to deltamethrin, the...
conclusion could be drawn that the changes arrived at are dependent on concentration of pesticide and the duration of exposure. Irreparable damage was caused to the physiological, biochemical and behavioural activities of the fish at higher concentration. The damage increased and prevailed over time of exposure. Under sublethal concentration fish were observed under stress only for short period (1 to 10 days) and on later days of exposure the stress appeared to lessen and the fish seemed to adapt the toxic environment. The recovery tendency shown by the fish, perhaps could be due to physiological resistance developed by the animal, which also be reasoned as possible enhancement of detoxification mechanism and deltamethrin elimination processes. Therefore the above statement suggests that the fish can adapt to low concentration of deltamethrin toxicity during long-term exposure periods.

In the vision of food and economic worth of this fish and numerous other aquatic animals, proper manage of pesticide use is of supreme importance not only in protecting aquatic fauna of economic importance, but also preservation of proper ecological balance.

It is hoped that this study will provide valuable scientific data, useful for formulating safe concentrations of pesticide to ensure proper protection of fishery resources and provide baseline information for future monitoring of pesticides in the aquatic environment.