6. SUMMARY

Fish proteins occupy an important place in human nutrition. They are well balanced with essential amino acids and are comparable to other proteins of animal origin. Moreover, carbohydrate content of the fish flesh is very low. Considering their nutritional value, it is essential for any nation, which is desirous of developing this rich protein source to develop a healthy freshwater fishery or an efficient agriculture system, for which maintenance of the environmental water quality is a prerequisite.

Herbicides are synthetic chemicals used for weed control. A major source of herbicides in water bodies is the runoff from agricultural fields. Some herbicides also enter inland waters, from industries, which up in their manufacturing processes or from the manufacturing of herbicides themselves. Herbicides adversely affect a wide range of organisms including beneficial insects and fish. Herbicides accumulate in the tissue of aquatic organisms through bioconcentration and biological magnification and adversely affect their metabolic processes including reproduction.

The aquatic organisms are sensitive to environmental changes. Herbicidal pollution causes the most dangerous health hazards apart from creating adverse effects on fish production. Review of literature revealed that most of the studies are related to individual effect organophosphorus or chlorotriazine herbicidal compounds on fishes. However, the relative effects of herbicides on Indian major carp, *Labeo rohita* have not been yet known. Hence, the present investigation has been carried out to study the effect of herbicides atrazine and glyphosate on
physiological, biochemical and ultrastructural aspects of the fingerling Indian major carp, *Labeo rohita* (Hamilton).

### 6.1. Effect of Toxicity of Atrazine and Glyphosate on *Labeo rohita*

The acute toxicity bioassays (96 h LC$_{50}$) were conducted for atrazine and glyphosate. The degree of toxicity was greater in glyphosate. Sub lethal concentrations namely 1/10 and 1/30 of the 96h LC$_{50}$ values were selected for each herbicides for studying their effects on various physiological, biochemical and histological aspects.

### 6.2. Effect of the Atrazine and Glyphosate on behavioural changes of *L. rohita*

The behavioural changes were observed in control and exposed fish. The fish maintained in normal freshwater behaved in usual manner i.e. they were very active with well coordinated movements. They were alert at slightest disturbance. But when exposed to herbicides, erratic swimming, imbalance in posture, increase in surfacing activity, opercular movement, gradual loss of equilibrium and spreading of excess of mucus all over the surface of the body were observed.

### 6.3. Effect of the Atrazine and Glyphosate on the rate of oxygen consumption in *L. rohita*

The rate of oxygen consumption of the test fishes exposed to 10% and 30% sub lethal concentrations of atrazine and glyphosate was estimated after 10, 20 and 30 days of exposure. A strong decrease in the rate of oxygen consumption was recorded at every time as compared to control fishes. Among the two herbicides, glyphosate affected more adversely the rate of respiration.
6.4. Effect of the Atrazine and Glyphosate on haematological parameters of *L. rohita*

The RBC and Hb content of blood significantly decreased in the fish, after chronic exposures to the herbicides compared to the corresponding control. On the contrary, there was a significant increase in WBC values in the fish following the exposures to herbicides.

6.5. Effect of the Atrazine and Glyphosate on the biochemical constituents of *L. rohita*

The effect of sub lethal concentrations of atrazine and glyphosate on biochemical components such as carbohydrates, proteins and lipids were studied in the fresh water fish *L. rohita* up to 30 days at an interval of 10 days. The exposed fishes exhibited various changes in biochemical constituents. The changes were dependent on period of exposure and concentrations of herbicides. The effect of glyphosate was found to be more pronounced than that of atrazine.

6.6. Effect of the Atrazine and Glyphosate on the acid and alkaline phosphatases activity of *L. rohita*

The fishes exposed to chronic exposure to herbicides showed an increase in acid phosphatase activity with increase in the exposure periods. The alkaline phosphatases activity of various organs was found to be decreased with increasing concentrations of atrazine and glyphosate and increase in exposure.
6.7. Effect of the Atrazine and Glyphosate on the histology of the different organs of *L. rohita*

Histopathological lesions in the gill, liver, intestine and kidney of fresh water *L. rohita* was assessed following 10, 20 and 30 days exposure to the herbicides. Tissues of experimental animal were collected, processed and stained with hematoxylin and eosin according to routine histology methods. Fish exposed in the herbicides the most common lesions were fusion of gill lamellae, detachment of gill epithelium, hyperplasia, hypertrophy of respiratory epithelium in the gills; dilation of blood sinusoids, vacuolization, hypertrophy and disintegration of cell boundaries in the liver; necrotic lesions in the epithelial layer, disintegrated columnar epithelial cells, ruptured villi and vacuolization in the intestine; enlargement of renal tubules, hyperplasia, vacuolation, necrosis and shrinkage of glomeruli in the kidneys. The lesions were comparatively most severe at 30 days of exposure. The above mentioned severe alterations indicate that the fish, *L. rohita* is an appropriate species to act as a biological marker of water pollution.

6.8. Effect of the Atrazine and Glyphosate on the ultrastructural (SEM and TEM) studies of the gill in *L. rohita*

Scanning electron microscopic studies revealed that the folding of epithelium, fusion of secondary lamellae, erosion of epithelium and degenerating microridges with mucous opening in the architecture of gill were observed in the herbicides exposed fish. Transmission electron microscopic study exhibited abundant distribution of cytoplasmic vacuoles as well as alterations of cytoplasmic organelles including mitochondria, endoplasmic reticulum, lysosomes and epithelial cells.