Sub-Lethal Effect of Cypermethrin on Ca⁺, Mg²⁺ and Na⁺/K⁺-ATPase Activity in Fresh Water Teleost, *Cyprinus carpio*

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**Abstract:** Pesticides usage is one of the major-concern for aquatic pollution. Pesticides enter the aquatic ecosystem through various routes and exert its effects to aquatic biota. Cypermethrin is a synthetic pyrethroid widely used to control many insect pests. The objective of the present study was to evaluate the sub-lethal effect of cypermethrin on the biochemical changes in the tissues such as gills, muscle, brain, liver and kidney of freshwater fish *Cyprinus carpio*. Fishes were exposed to sub-lethal concentration (1/10⁰ of LC₅₀) of cypermethrin for four different durations, 1, 10, 20 and 30 days. The activities of Adenosine Triphosphatases (ATPases) were evaluated. A significant decrease was observed in Ca⁺, Mg²⁺ and Na⁺/K⁺-ATPases activities in all the organs of experimental groups when compared with the control group. However, the observed changes were found to be in a duration dependent manner. The obtained results from the present study indicate a marked toxic effect of cypermethrin and suggest its impact on ionic balance of the fish and further membrane stability.

**Key words:** Cypermethrin • *Cyprinus carpio* • ATPases • Total protein

**INTRODUCTION**

Many freshwater ecosystems face high alarming levels of the pollutants. The pervasive use of pesticides leading to the contamination of the aquatic organisms poses great threat to the well-being of the environment. Biomonitoring of aquatic ecosystem is essential due to the increased exposure of chemicals such as pesticides. In the field of toxicology, the serious effect of the persistent nature of these pesticides forms the thrust area due to the elucidated action of the pesticides usage throughout the world.

Due to the increasing regulatory restrictions in the use of organophosphate pesticides, the synthetic pyrethroid pesticides have replaced the organophosphates for many purposes and mainly in agricultural practices [1]. Pesticides usage increased considerably to reduce the pest interference on crops. Among the pesticides, synthetic pyrethroids are most commonly used because of its non-persistent nature [2]. Synthetic pyrethroids are the modified derivatives of pyrethrins. They are natural substances obtained from flowers of pyrethrum species [3]. Cypermethrin is a synthetic pyrethroid insecticide used to control different types of pests such as the moth pests which attack cotton, vegetable crops and fruits and it replaced the organophosphates and often used in the field of agricultural practices and many other purposes [4]. Cypermethrin is extremely toxic to fishes and other aquatic invertebrates even at very low concentration and fish species are used as biomarkers to assess the toxicity effects [2, 5, 6]. Cypermethrin is one of the highly used recent pyrethroid compound which cause significant alterations in the levels of glutamine, ammonia and urea in the freshwater teleosts [7].

Fish products are an important source of protein for human consumption [8] and have very intimate contact with the aquatic environment and hence they are easily susceptible to the physicochemical changes which may reflect in their cell membrane components. The sensitivity of the fishes to pyrethroids may be explained by their relative slow metabolism in the elimination of these compounds from the body of *Tilapia mossambica* [9]. *Cyprinus carpio* is one of the most important edible fresh
water teleost and also an important finfish species in capture fisheries. It is also recognized as good biological model due to its easy for handling, maintenance in laboratory, culture and for studying the possible changes and adaptations to the xenobiotics in toxicological studies.

Osmoregulation is the fundamental physiological process required for the adaptation of aquatic animals maintaining osmotic balancing in extracellular fluids. ATPases in salt transporting tissues maintains the electrical gradients and ionic balance which are essential for transepithelial salt movements. The physiological regulations of major membrane enzymes particularly ATPases in fresh water fishes are very sensitive to environmental stress producing substances and commonly get changed in response to the xenobiotics which includes pesticides. ATPases are the integral membrane protein and they damage the cell membrane lipids and proteins.

In the present study, an attempt has been made to evaluate the sub-lethal toxicity of cypermethrin on the biochemical aspects which includes total protein and Ca\(^+\), Mg\(^+\) and Na\(^+/\)K\(^-\) adenosine triphosphatases were assessed in the gills, muscle, brain, liver and kidney of fresh water fish *Cyprinus carpio*.

**MATERIALS AND METHODS**

**Maintenance of Fishes:** Healthy *Cyprinus carpio* fishes of both sexes, with uniform weight of 100-110 g were procured from Governmental fish Farm, Puducherry. While collection, care was taken to avoid stress and injury to fishes, then they were carefully transported to the laboratory in oxygen pack. The active and healthy *Cyprinus carpio* were selected for acclimatization during which they were kept in glass aquaria for 10 days. During acclimatization, the fish were fed with commercial food pellets. The water was changed daily, the remaining food and fecal matters were removed and water quality is also monitored periodically.

Physicochemical characteristics of water such as temperature, pH, salinity, dissolved oxygen and total hardness were analyzed following standard procedure [10]. The healthy fishes were subsequently used for the present study. The fishes were examined carefully for any pathological symptoms and placed in water containing 0.1 mg/L of potassium permanganate solution to avoid the possibility of any dermal infection.

**Experimental Design:** *Cyprinus carpio* of same size with 100-110 g were chosen and sorted into 5 groups of 15 fishes each.

- **Group I:** Control fishes
- **Group II:** Fishes exposed to 1/10 of Lc\(_{50}\) value of cypermethrin (0.6µg/L), for 1 day (E1).
- **Group III:** Fishes exposed to 1/10 of Lc\(_{50}\) value of cypermethrin (0.6µg/L), for 10 days (E2).
- **Group IV:** Fishes exposed to 1/10 of Lc\(_{50}\) value of cypermethrin (0.6µg/L), for 20 days (E3).
- **Group V:** Fishes exposed to 1/10 of Lc\(_{50}\) value of cypermethrin (0.6µg/L), for 30 days) (E4).

The dose was selected based on our 96 hours LC\(_{10}\) value. The acute toxicity (96 h LC\(_{50}\)) of cypermethrin for the freshwater fish, *Cyprinus carpio* was determined in our laboratory using the semi-static method in OECD, (1996). The carp (12 in 20 L of test medium in each replicate) were exposed to varying concentrations of cypermethrin with six replicates for each concentration along with the control sets. Concentrations of the test compound used in short term definitive tests were between the lowest concentration at which there was 0% mortality (2 µg/L) and the highest concentration at which there was 100% mortality (8 µg/L). Test medium was renewed for every 24 hours with their respective test concentrations of the toxicant without aeration. Mortality was recorded every 24 hours and the dead fish were removed when observed, every time noting the number of fish death at each concentration up to 96 h for estimation of acute toxicity (LC\(_{10}\)). LC\(_{50}\) value was found to be 6.0 µg/L. for 96 hours. The 1/10 of the 96 hours LC\(_{10}\) (0.60 µg/L) was taken as the sub lethal concentration of cypermethrin used in the present study.

Test solution was renewed daily, which facilitated the removal of nitrogenous waste excreted by the test fishes and for the removal of unconsumed food. The fishes were fed during the experiment at least twice (morning and evening) a day. Feeding was stopped 24 hours prior to sacrifice. The stock and test solution was prepared by dissolving the pesticide in acetone. Fishes kept in a pesticide free medium served as control. The same volume of acetone used in the dissolution of pesticide was maintained in the control. 24 hours after the respective experimental period the fishes were sacrificed and the organs such as gills, brain, liver, muscle and kidney were surgically removed. Tissues were thoroughly washed in
normal cold saline (4-6°C), blotted dry, weighed and processed immediately for total protein and ATPases. Total protein content was estimated by following the method of Lowry et al. [11]. ATPases activity was assayed by the method of Takeo and Sakanashi [12].

**Statistical Analysis:** All the data were analyzed using Student’s t- test and the data were expressed as mean±SEM. The p value of <0.05 was considered as significant against control.

**RESULTS**

**Total Protein:** Effect of cypermethrin on total protein content in different organs of fresh water fish *Cyprinus carpio* is shown in Table 1.

From the result it is evident that in control fishes, total protein content is comparatively more in liver, followed by brain, muscle and gills. The kidney contains the lowest amount of protein content. In fishes exposed to one day (E1), the total protein content was not altered significantly in all the organs studied. The fishes exposed for 10 days (E2), the protein content significantly decreased in gills (p<0.05) and muscle (p<0.001). However no appreciable changes were observed in liver, brain and kidney. In 20 days (E3) and 30 days (E4) exposed group, total protein content significantly decreased in all the organs studied. The decrease in the protein content due to cypermethrin exposure is more evident in gills, muscle and kidney when compared to liver and brain.

**Ca**⁺⁺ - **ATPase:** Effect of cypermethrin on Ca⁺⁺ - ATPase activity in different organs of fresh water fish *Cyprinus carpio* is shown in Table 2.

In control fishes the activity of calcium dependent ATPase was more in gills and brain compared to kidney, muscle and liver. In all the organs studied the activity of calcium dependent ATPase was not altered in one day (E1) pesticide exposed group. In 10 days (E2) exposed fishes, this enzyme activity was significantly decreased (p<0.05) only in brain and unaltered in all the other four organs. However in 20 days exposed group (E3), the activity of calcium dependent ATPase significantly decreased (p<0.001) in gills and liver and also in muscle and brain (p<0.05). The activity was unaltered in kidney. In all the five organs the activity is decreased in 30 days (E4) exposed group. However, the decrease was not uniform in all the organs. The decrease was more evident in gills and liver (p<0.001) followed by brain, kidney (p<0.01) and muscle (p<0.05).

### Table 1: Effect of cypermethrin on total protein content in different organs of *Cyprinus carpio*

<table>
<thead>
<tr>
<th>Organs/Groups</th>
<th>Control</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gills</td>
<td>6.45 ± 0.267</td>
<td>6.12 ± 0.316 (5.1%)</td>
<td>5.41 ± 0.111** (-16%)</td>
<td>4.26 ± 0.174 *** (-33%)</td>
<td>4.11 ± 0.114 *** (-36%)</td>
</tr>
<tr>
<td>Muscle</td>
<td>6.54 ± 0.208</td>
<td>6.63 ± 0.244 (1.3%)</td>
<td>5.26 ± 0.122 *** (-23%)</td>
<td>4.81 ± 0.111 *** (-26%)</td>
<td>4.42 ± 0.172 *** (-32%)</td>
</tr>
<tr>
<td>Liver</td>
<td>6.91 ± 0.355</td>
<td>6.41 ± 0.329 (-7.2%)</td>
<td>6.05 ± 0.134 (-12%)</td>
<td>5.25 ± 0.329 (-24%)</td>
<td>4.83 ± 0.350 (-30%)</td>
</tr>
<tr>
<td>Brain</td>
<td>6.55 ± 0.369</td>
<td>6.56 ± 0.238 (0.1%)</td>
<td>5.69 ± 0.130 (-13%)</td>
<td>5.26 ± 0.110 (-19.6%)</td>
<td>5.08 ± 0.268 (-22%)</td>
</tr>
<tr>
<td>Kidney</td>
<td>6.18 ± 0.236</td>
<td>6.26 ± 0.313 (1.2%)</td>
<td>5.80 ± 0.269 (-6.1%)</td>
<td>4.83 ± 0.117 *** (-21%)</td>
<td>4.71 ± 0.118 *** (-23%)</td>
</tr>
</tbody>
</table>

The results are expressed as Mean ±SEM (n = 10) per treatment and respective control groups. Levels of significance values are *p<0.05, **p<0.01, ***p<0.001 compared with control group. P<0.05 considered to be statistically significant. Values in the same row with different * vary significantly (*p<0.05, **p<0.01, ***p<0.001) between exposed groups. Figures in the parenthesis indicate the percentage changes in each category.

### Table 2: Effect of cypermethrin on Ca⁺⁺ - ATPase activity in different organs of *Cyprinus carpio*

<table>
<thead>
<tr>
<th>Organs/Groups</th>
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<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gills</td>
<td>36.20 ± 0.663</td>
<td>35.00 ± 0.707 (-3.3%)</td>
<td>33.40 ± 1.029 (-7.7%)</td>
<td>25.20 ± 1.244*** (-30.3%)</td>
<td>20.80 ± 0.374*** (-42.5%)</td>
</tr>
<tr>
<td>Muscle</td>
<td>27.00 ± 1.000</td>
<td>25.40 ± 0.927 (-5.9%)</td>
<td>27.00 ± 1.067 (0.7%)</td>
<td>24.20 ± 0.663*(-10%)</td>
<td>21.80 ± 1.428*(-19.2%)</td>
</tr>
<tr>
<td>Liver</td>
<td>20.40 ± 0.509</td>
<td>21.00 ± 1.000 (2.9%)</td>
<td>19.20 ± 0.374 (-5.8%)</td>
<td>15.60 ± 0.678 ***(-23%)</td>
<td>14.20 ± 0.663***(-30%)</td>
</tr>
<tr>
<td>Brain</td>
<td>33.20 ± 1.241</td>
<td>33.60 ± 0.927 (1.2%)</td>
<td>28.00 ± 1.581 (-15%)</td>
<td>29.00 ± 1.140*(-12.6%)</td>
<td>27.40 ± 1.029** (-17.4%)</td>
</tr>
<tr>
<td>Kidney</td>
<td>28.20 ± 0.663</td>
<td>27.00 ± 1.140 (-4.2%)</td>
<td>25.40 ± 1.077 (-9.9%)</td>
<td>25.80 ± 0.916 (-8.5%)</td>
<td>23.80 ± 1.067**(-15.6%)</td>
</tr>
</tbody>
</table>

The results are expressed as Mean ±SEM (n = 10) per treatment and respective control groups. Levels of significance values are *p<0.05, **p<0.01, ***p<0.001 compared with control group. P<0.05 considered to be statistically significant. Values in the same row with different * vary significantly (*p<0.05, **p<0.01, ***p<0.001) between exposed groups. Figures in the parenthesis indicate the percentage changes in each category.
Table 3: Effect of cypermethrin on Mg\(^{2+}\) - ATPase activity in different organs of *Cyprinus carpio*

<table>
<thead>
<tr>
<th>Organs/Groups</th>
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<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gills</td>
<td>59.80±1.113</td>
<td>55.60±1.288(-7%)</td>
<td>54.80±1.157*(-8.3%)</td>
<td>53.60±1.435**(-10.3%)</td>
<td>50.40±1.568**(-15.7%)</td>
</tr>
<tr>
<td>Muscle</td>
<td>52.00±1.224</td>
<td>50.60±1.288(-2.6%)</td>
<td>51.60±1.326(-0.7%)</td>
<td>49.00±1.000(-5.7%)</td>
<td>46.60±0.812**(-10.3%)</td>
</tr>
<tr>
<td>Liver</td>
<td>45.40±0.748</td>
<td>45.20±0.860(-0.4%)</td>
<td>44.60±1.166(-1.7%)</td>
<td>41.20±1.157(-9.2%)</td>
<td>38.20±1.428**(-15.8%)</td>
</tr>
<tr>
<td>Brain</td>
<td>72.00±1.140</td>
<td>67.00±1.140(-6.9%)</td>
<td>66.40±1.208**(-7.7%)</td>
<td>61.20±0.860**(-15%)</td>
<td>59.20±1.529***(-17.7%)</td>
</tr>
<tr>
<td>Kidney</td>
<td>44.00±1.516</td>
<td>43.20±2.154(-1.8%)</td>
<td>42.00±1.141(-4.5%)</td>
<td>38.00±1.303*(-13.6%)</td>
<td>36.60±0.927**(-16.8%)</td>
</tr>
</tbody>
</table>

The results are expressed as Mean ± SEM (n = 10) per treatment and respective control groups. Levels of significance values are *p<0.05, **p<0.01, ***p<0.001 compared with control group. P<0.05 considered to be statistically significant.

Values in the same row with different * vary significantly (*p<0.05, **p<0.01, ***p<0.001) between exposed groups.

Figures in the parenthesis indicate the percentage changes in each category.

Table 4: Effect of cypermethrin on Na\(^+/K^+\) - ATPases activity in different organs of *Cyprinus carpio*

<table>
<thead>
<tr>
<th>Organs/Groups</th>
<th>Control</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gills</td>
<td>74.46±1.327</td>
<td>75.12±0.7090.8%</td>
<td>72.12±1.232-3.14%</td>
<td>62.64±1.303***-15.8%</td>
<td>61.94±0.972***-16.8%</td>
</tr>
<tr>
<td>Muscle</td>
<td>71.56±0.912</td>
<td>70.48±0.839-1.5%</td>
<td>70.80±0.994-1%</td>
<td>62.66±1.141***-12.4%</td>
<td>58.82±1.450***-17.8%</td>
</tr>
<tr>
<td>Liver</td>
<td>75.12±1.671</td>
<td>74.25±1.6671.1%</td>
<td>73.73±1.504-1.8%</td>
<td>71.57±3.5004.7%</td>
<td>69.61±1.620*-7.3%</td>
</tr>
<tr>
<td>Brain</td>
<td>83.47±1.620</td>
<td>80.25±0.787-3.8%</td>
<td>76.79±1.432*-8%</td>
<td>73.29±1.375**-12%</td>
<td>68.65±1.191***-17%</td>
</tr>
<tr>
<td>Kidney</td>
<td>61.26±1.545</td>
<td>61.35±0.4220.1%</td>
<td>61.89±2.4031%</td>
<td>59.53±2.272-2.8%</td>
<td>51.67±0.762***-15%</td>
</tr>
</tbody>
</table>

**Mg\(^{2+}\) - ATPase:** Effect of cypermethrin on Mg\(^{2+}\) - ATPase activity in different organs of fresh water fish *Cyprinus carpio* is shown in Table 3.

In control fishes the activity of Mg\(^{2+}\) - ATPase was more in brain and followed by gills, muscle, liver and kidney. In one day (E1) pesticide exposed group, this enzyme activity was significantly decreased (p<0.05) only in brain and unaltered in all the other four organs. The fishes exposed to cypermethrin for 10 days (E2) showed significant decrease in the activity of Mg\(^{2+}\) - ATPase (p<0.05) in gills and brain (p<0.01). No change was observed in other organs of the fishes in this group. In 20 days (E3) exposed group, the magnesium dependent ATPase activity decreased significantly in gills (p<0.01), liver (p<0.05), brain (p<0.001) and kidney (p<0.05); and unaltered in muscle. In fishes exposed to 30 days (E4) in all the organs, the enzyme activity further decreased (p<0.01). However, the decrease was more in brain (p<0.001).

**Na\(^+/K^+\) - ATPase:** Effect of cypermethrin on Na\(^+/K^+\) - ATPase activity in different organs of fresh water fish *Cyprinus carpio* is shown in Table 4.

In control fishes the activity of sodium-potassium dependent ATPase was more in brain followed by liver, gills, muscle and kidney. In all the organs studied the activity of sodium-potassium dependent ATPase was not altered in one day (E1) pesticide exposed group. In 10 days (E2) exposed fishes, this enzyme activity was significantly decreased (p<0.05) only in brain and unaltered in all the other four organs. However in 20 days exposed group (E3), the activity of sodium-potassium dependent ATPase significantly decreased (p<0.001) in gills and muscle and also in brain (p<0.01). The activity was unaltered in liver and kidney. In all the five organs the activity is decreased in 30 days (E4) exposed group. However, the decrease was comparatively less in liver (p<0.05). The decrease was more significant in all the other four organs (p<0.001).

**DISCUSSION**

Pesticides are an important kind of the water contaminant because they are potentially toxic to fish which elicits the biochemical changes which may have an effect on the survival, growth and reproduction. The organisms present in the aquatic environment may accumulate the toxic materials which may ultimately affect not only the productivity and reproductive capabilities of the organisms, but also the health of the human beings that depend on those organisms as a major source of nutrition.

Proteins are mainly involved in the architecture of the cell. They are the chief source of nitrogenous metabolism and also during chronic period of stress conditions as it has been indicated [13]. The loss of protein (hypoprotenemia) in various organs as observed in the present study may due to cypermethrin stress or it may be either due to the reduced liver protein synthesis or impaired kidney function which was also suggested earlier in metal toxicity of *Heteropneustes fossilis* [14]. The decrease in total protein content in all the organs studied may be due to the disturbance in RNA synthesis leading to reduced RNA as well as reduced protein
content. It is evident from our earlier study in which reduced RNA and DNA was observed in cypermethrin exposed fishes [15]. The observed reduction in protein content in the present study may also be due to increased proteolysis particularly during stress conditions, as also been suggested already [16]. Proteins could have been channeled towards tissue repair and enhanced mobilization of protein into the gluconeogenetic pathway to meet the energy requirements of the fishes during the toxicant exposure period.

Cypermethrin present in the ambient medium being lypophilic [17] in nature comes in direct contact with gills and ruptures the chloride cells membrane through which insecticide enters blood and reaches the target tissues. Cypermethrin is inherently more toxic to aquatic organisms due to their strong lipophilicity and it is also evident from the previous study [18]. The inhibition of ATPases leads to the disruption of active transport and possibly affecting ionic movement and balance. Hence, the study of Na⁺/K⁺ - ATPase, Ca²⁺ - ATPase and Mg²⁺ - ATPases in the gills, muscle, brain, liver and kidney of cypermethrin exposed fishes may be more helpful in the assessment of membrane stability.

ATPases exist in all cell membranes and regulate the ionic concentrations inside the cells. Calcium ions are essential for the transmitter release from neurons [19]. Ca²⁺-ATPase activity is associated with neuronal excitability, cellular depolarization and regulating Ca²⁺ channel [20]. The level of calcium is regulated by Ca²⁺ - ATPase. Decreased Ca²⁺ - ATPase activity due to cypermethrin exposure may lead to high internal Ca²⁺ level in cells, as it has been already suggested [21]. Significant depletion in Ca²⁺ - ATPase activity was observed in all the organs studied. Due to the declination of Ca²⁺ - ATPase, the availability of calcium may be reduced in these organs of cypermethrin intoxicated fishes and this may disturb the homeostatic adaptation. Similar observation was reported in the previous study [22] in which the inhibition of ATPase activities in brain, kidney and liver of the Indian major carp, Labeo rohita by cypermethrin exposure.

Mg²⁺-ATPase have an important role in energy synthesis through oxidative phosphorylation in mitochondria [23]. Mg²⁺-ATPase activity associated with mitochondrial membrane bound enzyme is involved in the turnover of ATP synthesis. It is present in all types of cells and responsible for the transepithelial regulation of Mg²⁺ ions essential for the integrity of the cellular membrane and stabilizing of branchial permeability. Ca²⁺ and Mg²⁺ ATPases are involved in the regulation of Ca²⁺ and Mg²⁺ ions playing a vital role in many metabolic pathways. Mg²⁺ - ATPase is involved in the control of passive permeability [21] and it is also involved in oxidative phosphorylation [24]. Decreased activity of Mg²⁺ - ATPase observed in the present study may disturb the passive permeability of ions and also oxidative phosphorylation which may paralyze the membrane integrity and may also lead to hypomagnesia as already suggested in endosulfan exposed Tilapia mossambica [25].

Na⁺/K⁺- ATPase is responsible for the generation of the membrane potential through the active transport of sodium and potassium ions in the central nervous system necessary to maintain neuronal excitability [19]. Toxicants can alter Na⁺/K⁺- ATPase activity by disrupting the energy producing metabolic pathway or interacts directly with enzymes. Inhibition of Na⁺/K⁺-ATPase as observed in the present study in different organs may influence the Na⁺, K⁺ pumps which may result in erratic entry of ions into cells. The Na⁺/K⁺ - ATPase in turn, depend on an adequate supply of ATP, more than 90% of which is derived from mitochondrial oxidative metabolism [26]. It provides energy for K⁺ and Na⁺ active transport across the cell membrane which also affects the transepithelial movements of cations in gills. Along with the concentration gradient and water molecules, the osmotic gradient may cause swelling of the cell and finally the membrane ruptures.

From the present investigation it is evident that among the organs studied the brain was most affected by cypermethrin followed by gills and liver. Among the three ATPases studied Ca²⁺ - ATPase was greatly influenced by cypermethrin. Thus in the present study it may be inferred that pesticide exposure may gradually lead to fish mortality as it has also been already suggested that environmental pollution causes diseases, poisoning and also mortality in fishes [27].

CONCLUSION

Thus, from the present study, it is evident that the sub-lethal exposure of cypermethrin in freshwater fish significantly inhibited total protein and ATPases. Thus toxic potential of cypermethrin was clearly illustrated by the increased inhibition or decreased activity levels of Na⁺/K⁺- ATPase, Mg²⁺ and Ca²⁺ - ATPase activity in different tissues of the freshwater fish Cyprinus carpio. Further it indicates severe disruption in the cellular ionic regulation and may have greater influence on the membrane permeability characteristics.
REFERENCES


