Chapter 5

Respiratory responses

INTRODUCTION

The physiology of the respiratory system traditionally has been one of the most dynamic areas in fish physiology and a crucial focal point of fish biology. Respiration in fish blood is clearly more diverse than that in mammals, in fact an actively regulated adaptation to changing states. The main catabolic pathway in fish blood is respiration (Boutilier and Ferguson, 1989; Nikinmaa, 1990). Respiration is an important physiological process occurring in all living cells. It is an oxidative, exothermic and catabolic reaction. Respiration may be defined as an oxidative process during which food materials undergo oxidation and get converted into carbon dioxide, water and energy. Most animals satisfy their energy requirements by oxidation of food materials where oxygen plays a significant role. The events involved in energy metabolism can be viewed through biological, biophysical and molecular perspectives to unravel several secrets of nature in the synthesis of biochemical energy specifically ATP (Lehninger, 1980). Determination of oxygen consumption of aquatic animals will undoubtedly provide information on the effects of interactions of toxicants on the physiology of aquatic life (Sarkar, 1999).

The rate of oxygen consumption is influenced by several factors such as activity, temperature, body size, stage in life cycle, season, time of the day and
genetic background (Prosser, 1973 and Asheera Banu and Kanabur, 2001). In aquatic animals, in addition, it is influenced by the oxygen concentration, salinity and pH of water medium. The total oxygen consumption of the animal reflects the basal metabolic status. This serves not only as a tool in evaluating the susceptibility or resistance or potentiality of the animal but also useful to correlate the behaviour of the animal. A change in oxygen consumption, as indices of energy expenditure, is a useful tool to assess the physiological stress on aquatic organisms.

Oxygen consumption is an important parameter to assess the toxicological stress, since it serves as index of energy expanded and speaks of physiological and metabolic state of an organism. Generally when toxicants gain entry through food chain or respiratory surfaces, the physiological function to be affected is oxygen consumption. The metabolic rate has been measured by determining the oxygen consumption, which provides information on the ability of the fish to extract oxygen from pesticide polluted water. An early symptom of acute pesticide toxicity is respiratory distress (David, et. al, 2002 and Mushigeri, et. al, 2003). Respiratory rate has been recognised as an important indicator of stress in organisms exposed to toxic substances. With this viewpoint an attempt has been made to study the effect of Cypermethrin on the rate of oxygen consumption at lethal and sub lethal exposure periods in the freshwater fish, Labeo rohita.

RESULTS
The rate of whole animal oxygen consumption of control and cypermethrin treated fishes are presented in Table 6 and Fig 3. Fish exposed to a lethal concentration depicted increased (Fig. 1) oxygen consumption on day 1 (8.597%) to day 2 (17.409%) and the increase was decreased (1.289%) on day 4 (Table 2). In the sublethal concentration oxygen consumption increased (Fig. 1) on day 1, 5, 10 and 15 as compared to the control (Table 2) in the order of 1 (2.7942%) <5 (17.141%) <10 (16.497%) <15 (22.515%).

DISCUSSION

Since most fish breathe water in which they live, changes in the chemical properties thereof may be reflected in the animal’s ventilator activity, particularly if the environment affects respiratory gas exchange (David and Philip, 2005). Toxicants from the environment mainly enter fish by means of their respiratory systems (David, et. al. 2004). A mechanism of toxicant uptake through gills probably occurs through pores by simple diffusion and is then absorbed through cell membranes (Roesijadi, et. al, 1994). Studies on the course of oxygen consumption in lethal and sub lethal concentration indicate the sequence of the type of compensatory mechanism, if any, which operates within the animal to overcome the load of toxic stress.

Variation in oxygen consumption is an indicator of stress, which is frequently used to evaluate the changes in metabolism under environmental deterioration. It is evident from the studies that the cypermethrin affected
oxygen consumption of *L. rohita* under lethal and sublethal concentrations. Fish exposed to lethal concentrations depicted increased oxygen consumption on day 1 to day 2 and the increase decreased on day 4. In sublethal exposure oxygen consumption increased on day 1, 5, 10 and 15 as compared to the control. Since most fish breathe in the water in which they live, changes in the chemical properties in it may be reflected in the animal’s ventilator activity, particularly if the environment factors affect respiratory gas exchange (Mushigeri, 2003). The fluctuated response in respiration may be attributed to respiratory distress because of the impairment of oxidative metabolism. Disturbance in oxidative metabolism has been reported earlier under cypermethrin toxicity in *Cyprinus carpio* (David, *et al.*, 2004). Gills are the major respiratory organs, all metabolic pathways depend upon the efficiency of the gills for their energy supply, and damage to these vital organs causes a chain of destructive events, which ultimately lead to respiratory distress (Magare and Patil, 2000). Pronounced secretion of a mucus layer over the gill lamellae has been observed during cypermethrin stress. Secretion of mucus over the gill curtails the diffusion of oxygen (David *et al.*, 2002), which may ultimately reduce the oxygen uptake by the animal.

If the gills are destroyed due to xenobiotic chemicals or the membrane functions are disturbed by changed permeability, oxygen uptake rate would rapidly decrease (Mushigeri and David, 2002). On the other hand, the metabolic rate (in relation to respiration) of fish could be increased under chemical stress.
Kalavathy, et. al., (2001) reported that the dimethoate is efficiently absorbed across the gill and diffuses into the blood stream resulting in toxicity to the fish.

Gulping air at the surface, swimming on the water surface, disrupted shoaling behaviour and easy predation was seen on the first day itself in lethal and sub lethal exposure periods and continued the same more intensely, which is in accordance with the observations made by Ural and Simsek (2006). Gulping of air may help to avoid contact with the toxic medium. Surfacing phenomenon i.e., significant preference of upper layers in the exposed group might be the result of the need for higher oxygen levels during the exposure period (Katja, et. al, 2005). Finally fish sank to the bottom with the least opercular movements and died with their mouths open. In sublethal exposure, the fish’s bodies became lean towards the abdomen position compared to the control fish and they were found to be under stress, but this was not fatal. Leanness in fish indicates a reduced amount of dietary protein consumed by the fish under pesticide stress which is immediately utilized and not stored as body mass (Kalavathy, et. al, 2001).

The analysis of data from cited literature as well as present investigation evidenced that pyrethroids in general and cypermethrin in particular, primarily influence modulations in the level of oxygen consumption. This has led to the imbalance in cellular homeostasis.
Table 6: Oxygen consumption (ml of oxygen consumed/g wet wt of fish/h) of the fish, *Labeo rohita* following exposure to lethal (4.0 µg/l) and sub lethal (0.4 µg/l) concentrations of cypermethrin.

<table>
<thead>
<tr>
<th>Estimation</th>
<th>Control</th>
<th>Exposure periods</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Lethal (h)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Oxygen consumption</td>
<td>0.1861</td>
<td>0.2021</td>
</tr>
<tr>
<td>SD ±</td>
<td>0.003</td>
<td>0.002</td>
</tr>
<tr>
<td>% Change</td>
<td>----</td>
<td>8.597</td>
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</tbody>
</table>

Values are means ±SD (n=6) for oxygen consumption in a row followed by the same letters and are not significantly different (P≤0.05) from each other according to Duncan’s multiple range test.
Fig. 3. Percent change in oxygen consumption (ml of oxygen consumed/g wet wt of fish/h) of the fish, Labeo rohita following exposure to lethal (4.0 µg/l) and sub lethal (0.4 µg/l) concentrations of cypermethrin.