Oxygen Consumption
INTRODUCTION

Respiration is an important physiological event concerning the transformation of energy in biological systems. Most animals satisfy their energy requirements by oxidation of food materials where in oxygen play a significant role. The events involved in energy metabolism can be viewed through biological, biophysical and molecular perspectives to unravel many of the secrets of nature specifically in the synthesis of biochemical energy namely 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. Changes in oxygen consumption, as indices of energy expenditure, is a useful tool to assess the physiological stress on aquatic organisms.

Heavy contamination of the pesticides in water leads to oxygen depletion and cases of poisoning resulting in a mass mortality of aquatic organism including the fish (Balachandra et al., 2001). 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 (Holden, 1973). Respiratory rate has been recognised as an important indicator of stress in organisms exposed to toxic substances (Bharathi et al., 2001). In view of the vital role ascribed to the enzymes involved in the energy pathways through respiratory processes by utilizing oxygen, study of respiration at whole animal level needs emphasis to ascertain the oxygen requirements of fish under toxic environmental conditions, since it serves as an index of energy expended and speaks of physiological and metabolic state of an organism (Andryash Chantaka, 1971). With this perspective 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, Cirrhinus mrigala.

RESULTS

The rate of whole animal oxygen consumption of control and cypermethrin treated fishes are presented in Table 7 and Fig 3. The data indicates that in fish exposed to lethal and sub lethal concentrations of cypermethrin, oxygen consumption was reduced. The whole animal O$_2$ consumption is reduced by about 45.83 per cent on day one and reached maximum reduction of 72.23 per cent by day 4. Even during day 2 and 3 there was high rate of decrement as seen in Table 7. The decrement was a sudden reduction from day one to day two, from then it was gradual reduction. However in sub lethal concentrations, the day 1 showed high rate of decrease of 55.81 per cent, which reached 53.86 by day 7. Subsequently, there was an improvement in O$_2$ consumption as by day 14 it was reduced to 37.61 per cent and day 21 showed minimal decrease which was recorded at 28.88 per cent. All the results are significant at 0.05, levels.
DISCUSSION

Since most fish breathe water in which they live, changes in the chemical properties there of, may be reflected in the animal’s ventilator activity, particularly if the environment affects respiratory gas exchange (Sellers et al., 1975). Toxicants from the environment mainly enter fish by means of their respiratory systems (Tovell et al., 1975). A mechanism of toxicant uptake through gills probably occurs through pores by simple diffusion and is then absorbed through cell membranes (Opperhuizen et al., 1985). 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.

From the results, presented in the table 7 and fig 3 it is clearly evident that cypermethrin affects the oxygen consumption of the fish, *Cirrhinus mrigala* under lethal and sub lethal concentrations. The observed decrease in oxygen consumption by the whole animal may be due to the respiratory distress as a consequence of the impairment of oxidative metabolism. Disturbance in oxidative metabolism was reported earlier under fenvalerate toxicity in *Labeo rohita* (David et al., 2002); cypermethrin toxicity in *Tilapia mossambica* (Reddy and Yellamma, 1991). Several authors reported similar decline in whole animal oxygen consumption in different species of fishes exposed to pesticides (Kabeer et al., 1981; Rangaswamy, 1984; Deva Prakasa Raju, 2000; David et al., 2002). Gills are the major respiratory organs and all metabolic pathways depend upon the efficiency of the gill for their energy supply and damage to these vital organs causes a chain of destructive events, which ultimately lead to respiratory distress (Radhaiah and Jayantha Rao, 1988; Esther, et al., 2001). In consonance with this, he also reported that the
depletion in O₂ consumption was due to the disorganization of the respiratory function caused by rupture in the respiratory epithelium of the gill. It is also due to the disturbance in mitochondrial integrity and decreased activities of some mitochondrial enzymes (Ravinder, 1988). Further, it would also be due to the fact that the pyrethroids is efficiently absorbed across the gill into the blood stream (Bradbury et al., 1987) resulting in toxicity to fish. Magare and Patil (2000) reported a decrease in the rate of O₂ consumption in Puntus ticto exposed to endosulfan. In addition to gill damage decrease in haemaglobin content and decrease in tissues respiration (Koundiny and Ramamurthi, 1978; Sarkar, 1999) may also interfere with respiratory process resulting in respiratory failure.

The decrement can also be attributed to the induction of hypoxic conditions within the animal due to the in-time contact of the respiratory surface with the polluted water resulting in the alteration of normal respiratory area of the animal. The secretion of mucus layer over the gill lamellae has been observed during cypermethrin stress. Excessive secretion of mucus over the gills may inhibit the diffusion of oxygen during the process of gaseous exchange (Muniyan and Veeragahavan, 1999; David et al., 2002). The coagulation of mucus on the gills caused demolition of various important processes such as gas exchange, nitrogen excretion, salt balance and circulation of blood (Skidmore, 1964). The alternative reason for the decrease in the oxygen consumption would be due to the internal action of cypermethrin. This toxic substance appears to alter the metabolic cycle at sub-cellular level (Bradbury et al., 1986).

Greater decrease in the rate of O₂ consumption of the fish, exposed to lethal concentration than the sub lethal concentration, may be due to the considerable damage to the gill structure and also due to the greater precipitation of mucus upon
gill filaments leading to the clogging of gills. Probably suffocation imposed by the coagulated mucus film and necrosis on the epithelial and inter lamellar cells of gills is one of the reasons for the death of animal in lethal concentration. Greater decrease in the rate of $O_2$ consumption of the fish in lethal concentration may also be due to the greater damage caused to R.B.C. as evident by the drastic decrease in the number of these cells (Venkataramana, 1987).

Lowering of $O_2$ consumption of fish in the sub lethal concentration of cypermethrin may be mostly due to the lowering down of energy requirements and if so, such lowering of maintenance energy requirement is to be considered adaptive and even strategic. This lowering of maintenance energy requirements may be achieved by reducing osmotic gradient through the lowering of electrolyte levels in the body fluids. Further, there is evidence for a considerable metabolic reorganization and increased utilization of anaerobic metabolism in fishes exposed to sub lethal concentration of cypermethrin. If so, the lowering of the oxidative metabolism in *Cirrhinus mrigala* might have been compensated at least by some degree of glycolysis.

The present investigation is in confirmation with the trend observed in earlier investigations. Bradbury et al., 1986 observed a decrease in oxygen uptake efficiency in rainbow trout exposed to fenvaleate. Malla Reddy (1987) also reported significant drop in the rate of oxygen consumption in *Cyprinus carpio* exposed to both fenvaleate and cypermethrin. Similar situation was also noticed in *Macrognathus aculeatum* and *Anabas scandens* treated with endosulfan (Rao et al., 1981). Devi Swetharanyam (1991), Muniyan and Veeraragahavan (1999), observed decreased level of $O_2$ consumption in *Oreochronis mossambicus* when experimented with the pyrethroid derivative, ethofenprox.
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. The inhibition of oxygen consumption is explained by this manner in which cypermethrin is incorporated into this fish system for energy.
Fig: 3
Percent decrease over control in whole animal oxygen consumption of freshwater fish, *Cirrhinus mrigala* at different periods of exposure to lethal and sub lethal concentrations of cypermethrin.