CONSUMPTION OF OXYGEN
INTRODUCTION

Pesticides because of their potential toxicity are known to produce morphological behavioral and physiological changes in the vital organ such as respiratory, nervous reproductive and on osmo regulatory, in different animal. These pesticides viz; the organochlorines, organophosphates, carbamates and synthetic pyrethroids that cause pollution are the runoff from the agricultural land, the main source of ground water pollution. Among the pesticides insecticides, molluscides, herbicides, and fungicides are known to reach to all segments of environment due to their indiscriminate usage. The aquatic animals are particularly susceptible to these toxic substances, since their habitats are strictly confined to the water bodies, and hence are exposed there to the toxic compounds that are dissolved in large quantities in the polluted water body.

Respiration in animals is the mostly used test for understanding the physiological action of the toxicants. The rate of respiration is indicative of the physiological state of the organisms and any major change in respiration shows the environmental stress. For the efficient exchange of gas number of factors are responsible, one of them is that large quantities of
water is to be passed over respiratory surfaces such as gill. However gill surfaces are always covered with thick mucous membrane, but are subjected to greater risks as they are exposed to attacks of bacteria, fungi and other toxicants / pollutants present in water.

The aquatic fauna is mostly prone to pesticide that finds the way into water bodies through agricultural sewage effluents and various household uses. These pesticides bring about a series of change in the organism. In general one of the symptom of pesticide toxicity is respiratory distress (O’Brien 1967). Oxygen consumption is very important short-term indicator of general health conditions of a fish and is often measured routinely during pollution toxicity studies. Thereby gills are important as they reflect the metabolic state of fish through respiratory activities.

The respiratory potential of an animal is an important physiological parameter to assess the toxic stress, because it is a valuable indicator of energy expenditure in particular and metabolism in general. This also helps for making valid inferences on its environmental requirements. Hence studies on oxygen consumption induced by the pesticides, have gained lot of importance. Therefore it has been planned to determine the possible effects of commonly used pesticides. Aldrin (organochlorine) and Fevvalerate (synthetic pyrethroid) on the rate of
oxygen-consumption of a teleost fish, *Heteropneustes fossilis* (Bloch.).

Several workers have attempted to reveal the deleterious effects of pesticides and other toxicants on fish, in terms of exchange in oxygen consumption capacity. Increased oxygen uptake in mosquito fish (*Gambusia affinis*) have been reported on exposure to endrin, which decreased gradually before death (Fergusson *et al.* 1966). Physiological function is characteristic of the energetic condition of an animal. Thus in oxygen consumption disruption of oxidative metabolism can obviously have a deleterious effect on the well being of an animal (Vernberg and Vernberg 1972). Pesticides are known to block the respiratory centers of the brain, leading to a condition similar to asphyxia. Change in rate of oxygen consumption was induced in *Labeo rohita* due to endosulfan, and it was reported that this change was one of the earliest symptoms of pesticide poisoning (*Rao et al.* 1980). Thurstan *et al.* (1981) observed increased toxicity of ammonia to *Salmo gairdneri* due to reduction in dissolved oxygen of the medium. The first *Pleuronectes platessa* had a lower oxygen uptake when acclimatized to higher temperature (Jobling 1982). Nagartanamma and Ramamurthi (1982) reported metabolic depression in the freshwater teleost, *Cyprinus carpio* exposed to organophosphate pesticide. Effect of fenitrothion was studied on respiration of *Mystus cavasius* and *Labeo rohita*. Panigrahi *et al.* (1984) observed that oxygen
consumption rate of the fish of lower age group was more to higher age group. Effect of endosulfan and ekalux on oxygen consumption on *Barbus ticto* were studied by Bhusari *et al.* (1985).


In the aquatic environment, biological responses of organisms to pesticides are usually understood by determining their rate of survival and changes in levels of various physiological phenomena. In order to specify the effect of pollutants on the organism, several workers have attempted to study oxygen uptake on tissue level. Lakshmi *et al.* (1990) observed changes in tissue metabolism and the adaptability of the fish *Cyprinus carpio* (Linn) on exposure to environmental acidity and alkalinity. Tilak *et al.* (1991) studied effect of pesticides on a fresh water fish, *Labeo rohita*. Effect of salinity on oxygen
consumption in juveniles of Penaeus merguiensis (Deman) have been studied by Prasad et al. (1991). Singh et al. (1991) observed effect of temperature on oxygen uptake in relation to body weight of Danio spinosus due to pesticide pollution have been studied by, Suryawanshi (1992). Cebrian et al. (1992) observed toxic effects of chlorophyrifos on oxygen uptake and Jabde and Ansari (1993) studied oxygen consumption in Neemachelius aureus (Day) acutely exposed to cypermethrin. Oxygen consumption in Mystus vittatus on exposure to alderex and nivan have been studied by Arasta (1993). Effect on oxygen uptake of rainbow trout in response to 1,2,4,5-tetrachlorobenzene exposure have been observed by, Brauner et al. (1994). Reddy and Bashamohideen (1995) studied oxygen consumption in Cyprinus carpio on exposure to cypermethrin. Yang and Randall (1997) observed effect of tetrachlorobenzene and tetrachloroguaicol on oxygen consumption of rainbow trout. Wagh and Jagtap (1997) have reported significant changes in oxygen consumption in Cyprinus carpio on exposure to thiodon.
MATERIAL AND METHODS

In the present study live specimens of fish *Heteropneustes fossilis* were collected from Sagar lake and other local riverine sources, and were acclimatized to laboratory conditions for about two weeks under normal day night illumination.

Healthy, acclimated fish were exposed acutely to 96 hours LC 50 and LC 0 concentrations of Aldrin and Fenvalerate. The chronic exposure period was of eight weeks and sub-lethal (1/10, 1/15 and 1/20\textsuperscript{th} of 96 hours LC 50 values) concentrations were 0.0004, 0.00027 and 0.0002 ppm and 0.00070, 0.00046 and 0.00035 ppm for Aldrin and Fenvalerate respectively. A group of fish was maintained simultaneously as control without the pesticide in the medium. The amount of oxygen consumed by a group of fish was determined according to Wrinklers Iodometry method as described by Strickland and Parsons (1968).

The rate of oxygen consumption was measured at the interval of 24 hours upto 96 hrs for acute exposure. During chronic exposure period observation on oxygen consumption were recorded at the interval of seven days for eight weeks. The experiments were repeated twice and the results averaged.
The quantity of oxygen consumed by both, the experimental and control groups were calculated in relation to unit wet weight of the fish. The difference in oxygen content of the initial and final samples was taken as the amount of oxygen consumption and the values thus obtained were expressed as the rate of oxygen consumed in $\mu$gm O$_2$ consumed/h/gm wt/Litre. Difference in the value of oxygen consumed by experimental and control fishes has been taken as the measure of toxic effect of the pesticides. Significance of the data obtained was analysed statistically using Students 't' test.
RESULTS

In the present investigation the results of the oxygen consumption of the fish obtained after a acute exposure to the pesticides Aldrin and Fenvalerate are presented in the tables 33-36 and figures 61-64. Values for oxygen uptake have been presented in the form of calculated 't' values for the control and experimental fishes. The significance of the data obtained, have been analysed at 0.05 and 0.01 % probability level. Alteration in the values, in the form of percentage change has been tabulated. The control group of the fish under observation for 96 hour, showed a interesting pattern of oxygen uptake with a gradual decrease upto 96 hour recording in between insignificant increase /decrease.

The exposure of the fish to LC 0 (0.0020 ppm) and LC 50 (0.0040 ppm) concentration of Aldrin showed changes in oxygen uptake of the fish during the acute exposure period. Oxygen consumption decrease for 96 hour exposure to LC 0 (0.0020 ppm) whereas, initial period recorded insignificant change. The fish exposed to LC 50 (0.0040 ppm) concentration showed decreased oxygen consumption with a significant increase in between. Similarly the fish Heteropneustes fossilis when exposed to LC 0 (0.0045 ppm) concentration of
fenvalerate, recorded significant change in oxygen consumption for 96 hour, with initial non significant increase. For LC50 (0.0070 ppm) concentration, oxygen uptake, increase during later hrs, of the experimentation when compared to the control ones.

The effect of prolonged exposure of the fish to the three sub-lethal concentrations of both the pesticides have been studied to understand the physiological response of the fish the results of chronic exposure are presented in the tables 87 & 88-- and figures 63 & 64.

Initial increase has been observed in the oxygen consumption of the fish when exposed to 1/10th (0.0004 ppm) and 1/15th (0.00027 ppm) concentrations of 96 hour LC 50 of Aldrin whereas, change in the values recorded for the concentration 0.0002 ppm were not significant. The fishes when exposed to above mentioned concentrations of the pesticide showed a little rise in oxygen uptake during initial weeks followed by a significant decrease upto VIII week, except in the IV week where the consumption of oxygen increased significantly (<0.05).

The effect of sub-lethal concentrations of Fenvalerate viz. 0.0007,0.00046 and 0.00035 ppm on oxygen consumption of the fish does not show much variation in the pattern of oxygen uptake. Increase in I week was followed by decrease upto IV week. V, VI and VII week period recorded significant increase in
oxygen consumption, thereafter it declined in the VIII week of the experiment.

Thus from the above results it was observed that the fishes showed initial increase in the oxygen consumption followed by sudden decrease and finally increase in later hours for acute exposure period. Fishes exposed chronically to the pesticides revealed a zigzag pattern for oxygen consumption, recording initial increase and decrease upto IV week, then increase in V and VI week, and finally decrease in the last phase of the experiment. The decrease in oxygen consumption can be an immediate response to the toxic environment. Initial increase in the rate of oxygen uptake showed a compensatory phase to enhance the physical activity, but it resulted in continuous decrease, which may be attributed to the failure of respiratory mechanism.
DISCUSSION

Acute poisoning of toxicants has resulted in death of a fish, due to the disruption of respiratory process as stated by Skidmore (1970), Eisler (1971) and Burton (1972 'b'). Nagendran and Shakuntala reported increased opercular activity in Puntius ticto on exposure to sub-lethal concentrations of sodium pentachlorophenate. When treated with low concentration of endosulfan (below LC 50), increase in oxygen consumption in Labeo rohita, was observed, whereas with concentration above LC 50, oxygen consumption decreased with the increase in pesticide concentration. The respiratory metabolism of the fish was greatly affected by endosulfan treatment (Rao et al. 1980). Initial increase and then gradual decline in oxygen consumption indicated that the pesticide acted as an uncoupler. Rao et al. (1981) reported rapid decrease in oxygen uptake of M. aculeateus with the increase in concentration of endosulfan from 1 to 3 ppb and thereafter progressive decline was observed upto 15 ppb.

Thurston et al. (1981) reported that toxicity of ammonia to Salmo gairdnerii increased as the dissolved oxygen in the medium decreased. Malathion exposure to Heteropneustes fossilis caused irregular opercular frequency (Choudhary et al. 1981). Kabeer et al. (1981) have observed that the rate of oxygen consumption increased significantly during first 24 hours of exposure, but decreased afterwards. Oxygen
consumption of mosquito fish (*Gambusia affinis*) and widow tetra (*Gymnocorymbus ternetzii*) under routine active metabolism has been studied by Joshi *et al.* (1981), on exposure to few pesticides. It was noticed that mosquito fish showed no significant difference in oxygen consumption during normal activity. However, widow tetra showed increased oxygen consumption when exposed to the intermediate concentration of the pesticide. On the other hand oxygen consumption was reduced in both the fishes when exposed to intermediate concentration of the toxicants during maximum activity. It was concluded that decreased oxygen consumption, in widow tetra during routine metabolism might be due to the stress induced by the toxicant. Absence of such stress in mosquito fish implies basic difference in the metabolic responses in the two species.

The respiratory rate as a measure of oxygen consumption in *Ophiocephalus punctatus*, showed a general declining trend when exposed to technical and commercial grade elsan (*Rao et al.* 1982). They also reported that there was initial elevation in oxygen consumption, followed by a drop at other time periods. This indicated that this spurt in activity, possibly to boost up its oxidative metabolism is not successful for longer periods. Metabolic depression in *Cyprinus carpio* was caused due to methyl parathion toxicity (*Nagaratanamma and Rammurthy* 1982). They also stated that progressive
decline in respiratory activity of the fish was concomitant with progressive gill damage. Manoharan and Subbiah (1982) reported that respiratory rate of endosulfan treated fish, Barbus stigma dropped by 10% to 16% with the increase in pesticide concentrations. Oxygen uptake in Labeo rohita, was found to be adversely affected by increasing concentration of fenitrothion (Murty 1983).

In Tilapia mossambica, on exposure to malathion, carbaryl and lindane increased rate of oxygen consumption upto 24 hour was observed which decreased afterwards upto 48 hour (Basha et al. 1984). Initial elevation in the rate of oxygen consumption might have been due to acceleration of oxidative metabolism during the first 12 hours of exposure as result of sudden response to the toxic stimulus of the pesticides. But with onset of symptoms of poisoning the rate of oxygen consumption decreased in later periods of exposure. Rasbora daniconius, was found to be affected by increasing concentration of the effluents as evident from the decreased rate of oxygen consumption (Wagh et al. 1984). There was a significant increased in oxygen uptake by fishes, Barbus ticto and Rasbora daniconius when exposed to LC 0 concentration of suquin whereas, when treated with LC 50 concentration, the change in oxygen uptake by the fish was insignificant (Wagh and Khalid 1985). During the present investigation the fish Heteropneustes fossilis exposed
to LC 0 and LC 50 concentrations of the pesticide Aldrin and Fenvalerate for 96 hours showed more or less similar pattern of oxygen consumption. The controls did not show much variation. It seems that defensive mechanism against the pesticides might have come into action only at higher concentrations which is evident from the rise in oxygen consumption during exposure to LC 50 concentration of both the pesticides.

Wagh et al. (1985) while working on Barbus ticto noticed decline in oxygen consumption of CuSO4 treated fishes, which might have been due to higher absorbance of CuSO4 through gills that affected the respiratory epithelium of the gills. Change in oxygen consumption of the Channa punctatus treated with carbaryl and Macrones keletius treated with dimethioate was noticed by, Arunachalam et al. (1985) and Hameed and Vadamalai (1986) respectively. Reduction in oxygen consumption by 43% was reported in Sarotherodon mossambicus on exposure to sub-lethal concentration (0.001ppm) of thiodon for 48 hour whereas, exposure to lethal concentration (0.005 ppm) for 6 hours, resulted in a significant drop in oxygen uptake upto 35% (Vasanthi and Ramaswamy 1987). Mohamed et al. (1987) while working on Oreochromis mossambicus suggested that the aldrin treated fishes successively adopted the same rate of increase in oxygen consumption as the control fish. Similarly, Anabus testudineus, when
exposed to sub lethal concentrations of lindane showed a similar circardian rhythm in oxygen uptake as that of the control. However, in lethal treatment such rhythmic pattern was found to be absent Bakthavathsalam et al. (1987). Roy and Duttamunshi (1988) studied, oxygen consumption and ventilation rate in Cirrhinus mrigala in response to malathion toxicity.

The exposure of Barbus stigma to lindane and nuvian resulted in decreased oxygen consumption by the fish. Decline in the rate of respiration of the fish might have been due to atrophy in gill tissues and alteration in the physiological and metabolic status of the fish under pesticides toxicity (Khillare and Wagh 1988 'a'and'b'). Reddy (1988) observed suppressed oxygen consumption and decreased opercular movement in Cyprinus carpio in response to malathion toxicity and suggested that alteration in gill structure and permeability may be responsible for the depression in oxygen uptake. Inhibition in the rate of oxygen consumption in the fish Tilapia mossambica (Peters) was observed, after acute treatment to chlorpyrifos (Subburaju and Selvarajan 1989). Venugopal et al. (1989) found increased oxygen uptake in Cyprinus carpio with the increase in concentrations of monocrotophos; and the increase was directly proportional to the body weight and dissolved oxygen content in water.
Similar increased oxygen consumption of the test fish, *Heteropneustes fossilis* was observed during the present study. The fish when exposed chronically to sub-lethal concentration of the pesticides showed increased oxygen consumption during midterm phase of the chronic exposure period. But the increased concentration of the pesticides adversely affected the respiratory mechanism and the fish revealed decreased oxygen consumption.

The acclimated fish, *Cyprinus carpio* showed suppressed oxygen consumption in lethal acidic medium to a higher extent than that of non acclimated fish indicating development of higher metabolic tolerance in the hypoxic media. Because of such metabolic tolerance of the tissues the mortality recorded was less even in lethal acidic medium. This can be considered as an instance of development of physiological adaptation of the animals due to tissue metabolic compensation (Lakshmi *et al.* 1990). Therefore decreased oxygen consumption in *Heteropneustes fossilis* due to pesticide toxicity in the present study might be considered as a compensatory adaptation for successful survival of the fish in toxic medium.

Prasad *et al.* (1991) observed the effect of salinity on the oxygen consumption in juveniles of *Penaeus merguiensis* (Deman.), and stated that oxygen consumption increased in lower salinities, and remain almost constant after initial increased during
first hour. Cebrian et al. (1992) reported that there was no change in oxygen consumption in the gills of the fish, *Procambarus clarkii* in low concentration of chlorpyriphos but after 24 hours exposure there were significant difference and the animals physiology was found to be affected. Similarly, Mackinnon and Farrell (1992) have shown that a concentration dependent response in oxygen consumption of juvenile coho salmon (*Oncorhynchus kisutch*) was observed with sub-lethal exposure to 2-thiocyanomethylthiobenzothiazole. Arasta (1993) while working on *Mystus vittatus*, observed adverse effect of pesticides aldrin and nuvan on the oxygen consumption capacity of the fish. Although oxygen uptake of fish has been suggested as index of sub-lethal toxicity, Brauner et al. (1994) stated that there was little influence on oxygen uptake of rainbow trout exposed to 1,2,4,5-tetrachlorobenzene (TeCB). However, Reddy and Bashamohideen (1995) reported significant decreased in oxygen consumption in carp, *Cyprinus carpio* exposed to cypermethrin and the decreased was attributed to inhibition of oxidative enzymes during pesticides stress.

In concurrent with the findings of Mackinnon and Farrell (1992) and Brauner et al. (1994); Yang and Randall (1997) also observed that after being acclimatized for 48 hours rainbow trout when exposed to TeCB and TeCG (tetrachloroguaiacol), did not show any statistically significant
difference in the oxygen consumption through 48 hours exposure period. These results indicated that oxygen consumption might not be good indicator of sub-lethal chemical contaminant stress in fish. Oxygen consumption rate in *Cyprinus carpio (communis)* under stress of pesticide, thiodon was studied by Wagh and Jagtap (1997). They reported slight progressive increase in oxygen uptake in first 24 hours when exposed to 96 hour, LC 50 concentration, and thereafter a decrease upto 48 hours was followed by a slow and steady increase at the termination of the experiment.

In the present study increased and decreased of oxygen uptake in all three sub-lethal concentration were noted except that these changes were more sharp during I, V and VI week i.e. during the mid-term phase of the chronic exposure period. The observation of the present study reveals that initial increase in the rate of oxygen consumption of *Heteropneustes fossilis* in acute as well as chronic exposure might have been due to increased oxidative metabolism whereas, decline in oxygen uptake may be in consonance with the diminished levels of oxidative enzymes. The result of the present investigation on oxygen consumption studies are well supported by the findings of the other workers viz; Wagh *et al.* (1985), Vasanthi and Ramaswami (1987), Reddy (1988), Subburaju and Selvarajan (1989), Lakshmi *et al.* (1990), Tilak *et al.* (1991), Suryavanshi(1992) , Arasta

Fish oxygen uptake, which is easy to measure and is well documented in the literature, may be utilized in modeling oxygen consumption phenomenon. Drop in oxygen uptake of a fish indicate the onset of severe hypoxia following pesticides exposure, which triggers on some biochemical changes in different tissues of the fish body. The depression in oxygen consumption in sub-lethal concentration possibly implies the adaptive response of the fish exposed to a toxic environment.
Table: 33

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**Explanation**: Oxygen consumption of *H. Fossilis* acutely exposed to 96 h LC50 and LC50 concentrations of Aldrin.

**NS** = NOT SIGNIFICANT

* = SIGNIFICANT AT P < 0.05
### Table : 34

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**Explanation**

Oxygen Consumption of *H. Fossilis* acutely exposed to 96 h LCO and LC50 concentrations of Fenvalerate.

NS = NOT SIGNIFICANT  
* = SIGNIFICANT AT P < 0.05
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**Explanation**: Oxygen Consumption of H. Fossilis chronically exposed to three sublethal concentrations of Aldrin.

NS = NOT SIGNIFICANT  
* = SIGNIFICANT AT P < 0.05  
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**Explanatio**

OXYGEN CONSUMPTION OF *H. FOSSILIS* CHRONICALLY EXPOSED TO THREE SUBLETHAL CONCENTRATIONS OF FENVALERATE.

NS = NOT SIGNIFICANT

* = SIGNIFICANT AT P < 0.05

** = SIGNIFICANT AT P < 0.01
FIG. 61: OXYGEN CONSUMPTION OF *H. FOSSILIS* ACUTELY EXPOSED TO 96h LC$_{50}$ AND LC$_{0}$ CONCENTRATION OF ALDRIN.
FIG. 62: OXYGEN CONSUMPTION OF *H. FOSSILIS* ACUTELY EXPOSED TO 96h. *Lc*50 AND *Lc*0 CONCENTRATION OF FENVALERATE.
FIG 63: OXYGEN CONSUMPTION OF *H. FOSSILIS* CHRONICALLY EXPOSED TO SUB-LETHAL CONCENTRATIONS OF ALDRIN.
FIG. 64: OXYGEN CONSUMPTION OF H. FOSSILIS CHRONICALLY EXPOSED TO SUB-LETHAL CONCENTRATIONS OF FENVALERATE.
REFERENCES


