INTRODUCTION
While the man's intelligence has made him the dominant creature on earth today, he remains inextricably tied to his environment. He depends upon the environment for all his needs. And in the process of procuring his escalating wants, he is endangering and threatening the future generations with poison: of every kind from DDT to radio-active wastes and ecological problem from desertification to holes in the precious atmospheric ozone.

The public anxiety about environmental pollution has made the side effects of pesticides one of the principal research activities of biologist since 1962.

The Agrarian economy of our's has resulted in the rapid industrialisation to improve the standard of living and to eradicate poverty. Our planning, consequently favoured setting up large industries in order to make huge profits in minimum time. Unfortunately, this has resulted in hap­ hazard development of industries polluting the air, water and land without rhyme or reason.

In developing countries like India, there is the need to increase the income but this does not mean that rapid & mass exploitation of our resources especially non-renewable ones is the only way to achieve development. Ecological indicators of today foreshadow the economic trends of tomorrow. If we are interested in food prices at the end of the century, we should be looking at soil erosion rates today. The less soil we have, the more the food will cost.

Pollution may be defined as "an undesirable change in the physical, chemical or biological characteristics of our air, land and water that may or will harmfully effect human life or that of our desirable species. Our industrial processes, living conditions and cultural assets or that may or will waste or deteriorate our raw material resources".
According to Webster's unbridged dictionary, Environment can be defined as "Aggregate of all the external conditions and influences affecting the life and development of an organism". The terrestrial environment is the composite of air, land and water. Each can be polluted individually or compositely. Nations are the geographic dominions of the mankind where as environment defies man made geographic limitations. Hence pollution is not the problem of one country, one nation, or one community. It is the concern of every individual.

With population explosion, there is heavy demand for the food production. Inspite of using newer agricultural techniques alongwith the application of fertilisers and pesticides for good harvest, food is not sufficient for the increasing population. Hence man is now turning towards aquatic habitat to increase food production. Even the fresh water bodies like ponds, lakes, pools etc., are now commercially exploited to get maximum fish production. Recently the Government of Andhra Pradesh has also enacted a legislation providing auctioning of such water bodies for commercial utilization of fish production. If this is continued for long there is every possibility that the fish reared in these ponds or pools may be contaminated with pollutants from the nearby agricultural lands and thus becomes unfit for consumption.

In the evolution of the human race, man has reached a stage when he has acquired the power to harness and transform nature in various ways. Our civilization faces a unique crisis in the form of environmental pollution. Hence man has to keep nature happy and smiling or else invite trouble.

In order to boost agricultural production, different types of pesticides are used in ever increasing quantities. The excessive use of these chemicals has resulted in serious
health hazards to plants and animals. The chemical pollution of different ecosystems has turned to be a major problem and impact of chemical pollution is more pronounced on non-target organisms of the fresh water ecosystems leading towards the disruption of the ecological balance. The chemical pollution is known to occur in various ways namely organic and inorganic chemical waste (MCKee & Wolf, 1963), Oil refinery pollution (Dorris et al, 1959), radioactive substances (Klement & Wallen, 1960) and pesticides (Hiltibran, 1967). Besides commercial agricultural & forestry practices together with pest control programmes, the surface runoffs and aerial spraying forms the major sources for translocating pesticides into the aquatic ecosystem (Peterle & Gilette, 1970).

There are about 45,000 registered pesticides in the market (Berry et al, 1974). The annual production of pesticides in India is about 77,840 tonnes. Major classes of pesticides have been grouped into non-persistent or moderately residual and persistent or highly residual (Harris, 1969). The persistent time is the time required to degrade 75 to 100% pesticide residuals from the site of application (John Doll' et al, 1980). The bulk of pesticide residues are generally confined to the soil and transport through soil by water is limited. However water could wash away the soil particles that contain pesticide residues (Lichtenstein et al, 1967).

There has been a considerable increase in agricultural production due to high yielding varieties of seeds, chemicals, fertilizers and insecticides. According to CFTRI 50% of our food is lost to pests and parasites. In order to control this loss, huge quantities of pesticides are used.

A pesticide is a chemical compound which kills insects, harm them, interfere in their reproduction & normal living (MCKee, & Wolf, 1963). Pesticides can be classified into the following seven categories:
a) Insecticides - Used against insects & their near relatives
b) Fungicides - Used to kill fungi, bacteria & viruses
c) Herbicides - Used to kill weeds
d) Fumigants - small moleculed fungicides that have fumigant action.
e) Antibiotics - produced by microorganisms to destroy other microorganisms.
f) Rodenticides - used to damage small mammals
g) Nematicides - to harm nematodes

The three major problems which threaten to limit the continued usefulness of pesticides are:
1. Some pests have developed resistance
2. Some pesticides are not readily biodegradable & tend to persist for many years in the environment. These chemicals move to other parts of the environment.
3. Shows detrimental effects on non-target species.

Of all the pesticides, insecticides occupy the highest position. These insecticides are employed to kill more than 10,000 insects and other pests. The synthetic insecticides are further classified into,
a) organo chlorines
b) organo phosphates; and
c) carbamates.

Organochlorides are the most toxic to fishes than organophosphates and carbamates (Toor and Kaur, 1974). But in many uses carbamates and organophosphates have replaced organochlorides by dint of their rapid biodegradable nature and relatively less persistence in the environment (Duke & Dumas, 1974). Since the present investigation is of the comparative nature of these three kinds of insecticides, some relevant information regarding these three kinds is necessary. The presence of pesticide residues in food, water and organisms may be attributed to the faulty management in its handling which leads to deleterious effects. In India first documented case study in pesticide poisoning
of human being was the death of 150 persons in Kerala due to the consumption of malathion mixed wheat. The worst incident is the Handigodu Syndrome of Karnataka (NIN, 1977). It is the bone degeneration due to the consumption of fish and crab from paddy fields sprayed with pesticides. In twin cities of Hyderabad and Secunderabad many women have suffered with abortions and children showed chromosomal damage. It was found to be due to pesticide residue in grapes.

Pollutants are the inhibitory environmental substances produced by the activities of organism itself. All organisms generate environmental modifications which if they accumulate arrest the organism's growth. Man is not different and his pollution is exceptional only because of its volume, persistence and pervasiveness. Most organisms depend upon a large habitat volume or upon the mobility of themselves or their habitat to dissipate these toxic products. When the rate of pollutant production exceeds the rate of dissipation, accumulation of toxic levels may occur. Pollutant for instance does not effect until they exceed the threshold of tolerance. Hence pollution has also been described as the wrong thing in the wrong place in the wrong quantities at the wrong time.

DEVELOPMENT OF PESTICIDES:

The existing thought of development of chemicals as war-fare against pests in the mind of the man has resulted in the development of a spectrum of organic chemicals. For example, as the use of DDT to control crop destroying insects increased, the insect's resistance to it also increased and many insects became immune to DDT with their detoxifying mechanisms. This stimulated the search for and synthesis of new toxic chemicals. The first to make their appearance were organochlorides, since these were long persistant in the environment, it resulted in the development of organophosphates and carbamates, which are acutely toxic and less persistant.
ORGANOCHLORIDE INSECTICIDES:

These are neurotoxic. They are employed in insect control and malaria control programmes. Persistence is primarily a function of physico-chemical properties of substances, chlorinated hydrocarbons are highly soluble in lipids and most organic solvents and least soluble in water.

The synthetic organochloride insecticide, DDT was discovered to be a remarkable residual insecticide at Basle, Switzerland in 1939. The compound has an affinity for the lipoidal membrane sheaths of nerve axons, causing repetitive discharges in the nerves, which throw the insect into tremours and eventually prostrate it. The instability of the nerve axon is due to the presence of DDT in the axon membrane altering its permeability to Na+ and K+ ions, possibly because of the formation of charge transfer complexes between DDT & certain molecules in the membrane. In the present study the organochloride namely Endosulfan is selected. Endosulfan is neurotoxic, acting at nerve ganglion rather than along the nerves of insects, probably by the formation of charge-transfer complexes within the presynaptic membranes. Endosulfan and Endrin metabolized by microsomal enzymes, to their corresponding epoxides, because these epoxides are equally toxic to their parent compounds. The epoxides of endosulfan and endrin are lipid soluble and are stored in the adipose tissue of man. Great deal of work has been done on these insecticides with reference to their persistence, environmental hazards and toxicological failure due to resistances in fishes (Ferguson, 1967, Willford et al, 1969, Macek et al, 1970, Mayor et al, 1970, Shephard, 1971). Very little work has been done on endosulfan.

ORGANOPHOSPHATE INSECTICIDES:

The OP compounds were discovered during II World War by Gerhard Schrader, German chemist who has engaged primarily
in the search for more powerful agents of chemical warfare (Bowen & Hall, 1952). The first to appear were tepp & para-thion followed by malathion. The OP compounds are water soluble systemic insecticides and they are less persistent in environment. Considerable amount of work has been done on the toxicity of these pesticides on fishes.

These are toxic compounds containing a phosphorus atom (O'Brien, 1967). Where R & R₁ represent short chain hydrocarbons and O₂ group, x,y, either sulphur or O₂. R₁₁ - X is usually the group that is metabolized by the insects. The electrophilic nature of the phosphorus atom depends upon the 'X' group. The greater the positive charge, the greater the susceptibility for degradation (Quraishi, 1977). Melvikov (1971) pointed out the following advantages of OP pesticides, high efficiency as insecticides and acaricide, wide spectrum of action on plant pests, low persistence, breakdown to form compounds non-toxic to man and other non-target species, relatively rapid metabolic breakdown and absence of accumulation in the vertebrate body. But these are found to be highly toxic to aquatic invertebrates. Morgan (1976) reported the acute toxicity of diazonon to crustaceans.

In insects, as in mammals, they act by inhibiting the enzyme Acetyl cholinesterase (AchE) that normally breakdown the neurotransmitter acetylcholines at synapse immediately after its work is done thus they are ganglionic rather than axionic poisons, causing first the facilitation and then the blocking of the reflex arc, so that the initial hyperactivity and the subsequent convulsions are followed by tetanic paralysis. They include malathion, methyl parathion, parathion Dicrotophos, Fonofos etc. It is well establish that the measurement of Ach activity is taken as a good indication of the pollution of aquatic environment by organophosphorus

Malathion is especially used to control pests of paddy, pulses, sugarcane, cotton, oil seeds, vegetables and fruits. Malathion is activated to malaxon by oxidative desulphuration in animals (O'Brien, 1967, Fukuto & Sime, 1971) and Malaxon is potent anticholine ester agent. The wide applicability of malathion provides many occasions for its entry into the aquatic environment and thereby causing great havoc to fishes, resulting in massive fish kills (Darsie and Corriden, 1959, Mulla, 1961). Fishes exposed to malathion showed depressed acetylcholine esterase activity in brain tissue (Coppage and duke, 1971). The studies on the effects of pesticides on fish both marine and fresh water & also on crab are extensive (Allison, et al, 1964, Bashamohideen and Subbarao 1982, Parvathi, 1982).

CARBAMATE INSECTICIDES:

The successful development and understanding of the mode of action of OP Insecticides led to the discovery of carbamates. These are derivatives of carbonic acid.

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\begin{align*}
&\text{H} \\
\parallel & \\
\text{H} & \text{O} \text{-- C -- NH}_2
\end{align*}
\]

The hydrogen attached to the O atom is replaced by a complex organic group. The hydrogen atom attached to the Nitrogen atom in the parent group may or may not be replaced.

They were synthesized and insecticides properties were discovered by M/s. Geigy and Company, 1947. Around 1956 the best known of the present carbamate insecticides namely Carboryl was discovered. They are similar to the acetylcholine and therefore have a higher affinity for the enzyme cholinesterase. These compounds do not accumulate in the system. But are rapidly degraded and eliminated.
They are found to be least toxic to the fish. They rapidly degrade in water by hydrolysis. Some of the carbamates are Sevin, Isolan, Furadan etc. In the present study the carbamate selected is Sevin. Sevin is widely used in wide range of crops like cotton, fruits and vegetable for the control of chewing and sucking insect pests. The acute oral LD$_{50}$ for rats is 850 mg/kg and acute dermal LD$_{50}$ for rats is more than 4000 mg/kg.

In the present investigation, the survey of literature, throws light on the effect of pesticides in general and organochlorine, organophosphates and carbamates in particular on various physiological functions affected due to the pesticides accumulation in fresh water ecosystem with special reference to fishes.

**EVALUATION OF PESTICIDE TOXICITY:**

Fish in standing waters are unable to escape from an insecticide once it has been added to water and have to submit to its physiological insults until it has been removed by absorption and sedimentation or other mechanisms (Kudesia, 1980). The toxicity of a particular pesticide depends upon many factors like animal wt. (Pickering et al 1962), its developmental stage (Kamal deep & Toor, 1977), time of temperature exposure (Macek et al, 1969), pH, hardness of water (Henderson et al, 1960) & dissolved oxygen content of the medium.

Toxicity is the assessment of biological activity of a chemical in terms of its potential hazards to living things. If the selected experimental animals are aquatic, lethality is expressed in terms of lethal concentration (LC) & in the case of terrestrial animals, it is expressed as lethal dose (LD). Most of the investigations have evolved the determination of LC$_{50}$ for the toxic effects of pesticides in aquatic forms and the period of exposure is 48 hrs. because the effects may be consistent in this period (Pickering et al, 1962, Keshavan, 1982, Bashamohideen and Subbarao, 1982, Parvathi, 1982, Jayantharao, 1982, Rafi Ahmed and Bashamohideen, 1985).
This value represents the amount of poison per unit weight which kills 50% of the particular population of the animal species, employed for observation in a specific period of exposure and this in turn represents the medium tolerance limit (TLM) measurement (Finney, 1964). If the pesticide is mixed with water, its concentration is expressed as parts per million (ppm) or (mg/l) and the LD is expressed as micro or milligram per Kg. body weight of the animal (mg/kg.).

The typical test is the evaluation of toxicity of an insecticides is to expose the animal in successive batches to different pesticide concentrations for a constant time and after suitable intervals, score the No. of animals dead and alive. Finney, (1964) has proposed probit method for calculating $LC_{50}$. In this % kill observed for each concentration must be calculated and converted to probit by means of probit table. The probit calculated are then plotted in the graph against concentration as mentioned by him.

Chambers and Yarborough (1974) reported 48 hrs. $LC_{50}$ for susceptible and resistant mosquito fish using methyl parathion. Relative toxicity ($LC_{50}$) values of six OP insecticides in different fishes were reported and found that $LC_{50}$ value of malathion is 10 ppm for *Cyprinus carpio*, 8 ppm for *Labeo rohita* and 6 ppm for *Cirrhinus mrigala*, which indicates that the *Cyprinus carpio* is the most resistant and *Cirrhinus mrigala* is less resistant with *Labeo rohita* intermediate to malathion toxicity (Srinivasa and Swaminathan, 1967). $LC_{50}$ values for fresh water mussels using OP insecticides when exposed to methyl parathion, the $LC_{50}$ and $T_{50}$ values increased with body size, suggesting that smaller animals are more susceptible than larger animals (Meenakshi dass, et al, 1982). A comparative susceptibility of fish families to insecticides by 96 hrs. $LC_{50}$ (TLM) figures were reported by Mecek and McAlister (1970).
It was reported by Subbarao (1980) that commercial grade malathion is more toxic to *C. mrigala* than to *C. carpio* with an intermediate level to *L. rohita*. The same grade of toxicity was also confirmed using technical grade malathion (Parvathi, 1982) to major carps & toxicity evaluation of commercial grade malathion was investigated in *C. carpio* (Bashamohideen and Mallareddy, 1987).

Monoharant *et al* (1983) reported that toxicity and the effects of sublethal concentration of endosulfan on a fresh water fish *Barbus stigma*. Endosulfan was lethal to *B. stigma* at a concentration of 0.01 ppm. The *LC*₅₀ was 0.0043 ppm and the sublethal concentration was 0.003 ppm. Endrin and endosulfan are the most toxic insecticides for the fish, their acute *LC*₅₀ levels being that of the order of parts of billion. Endosulfan in its turn was involved in the die off of 40 million fish in the Rhine river in 1967 near Bonn, Germany (Brown, 1977). Further the comparative evaluation of toxicity with different pesticides in *L. rohita* revealed that endosulfan was most toxic when compared to sevin (Bashamohideen and Nisar Ahmed, 1989). The indiscriminate use of pesticide in certain area has caused cellular damage (Datta and Dikshith, 1973). The effect of pesticides on the ecosystem has been a subject of detailed study by various workers (Khan and Bederka, 1974).

According to Dougherti (1951) classification methyl parathion is considered to be extremely toxic, whereas malathion is moderately toxic to fish population. Matsumara (1976) reported that methyl parathion is much more toxic than malathion to rats. OC compounds like endrin and endosulfan are more toxic insecticides for fish, their acute *LC*₅₀ levels being of the order of parts per billion.

Among the different groups of fishes, the salmonoides are the most susceptible to O.P. compounds while the ictalurids and cyprinids are the most resistant (Mecek & McAllister, 1970).
Thus, the present investigation on the toxicity of insecticides in fishes indicate the importance of the study of immediate and chronic effects of pesticides on fishes which form part of human diet. But very little work has been done on the studies involving the comparative evaluation of pesticide toxicity with reference to economically important food fishes.

**PESTICIDE EXPOSURE - TIME COURSE:**

The fish responds physiologically to pesticide exposure and these physiological responses to the imposed environmental stress may be thermal, osmotic, or any other factor are divided into two types namely 1. immediate or short-term responses, which follow immediately after the transfer of the animal into the stress medium and 2. Stabilized or long term responses which follow after the prolonged exposure of the animal over days or even weeks to the stress (Grainger, 1958, Kinner, 1958, Parvatheswararao, 1968a, Bashamohideen and Parvatheswara Rao, 1976a, Bashamohideen and Kunnemann, 1979, Bashamohideen, 1982, 1984, 1985, 1986, 1987a,b,c).

The short term responses may be in the form of abrupt rise or fall in the respiratory activity. The long term responses involve the recovery or gradual stabilisation of the respiratory rate. This is due to complete adaptation of the animal to the stress medium. It is possible because of long term chronic responses. This is an indicativeness of recoverable change. Great deal of work has been done on this mode of stress with reference to temperature acclimation (Parvatheswara Rao, 1968a, Kunnemann and Bashamohideen 1976, Bashamohideen et al 1978). But very little work has been done with reference to pollution (Fingerman et al, 1981, Srinivasa Reddy, et al, 1982 and Prasad and Bashamohideen, 1985).
Physiological changes are the good indicators of the general condition of an animal. Since pollutants makes its entry through the respiratory surfaces of aquatic animals, the respiratory rate is the first physiological function to be affected (Subbarao, 1980). A conceptional model of possible effects of pesticides and other toxic substances are proposed by Dr. John Couch on biological system (Duke & Dumas, 1974). In this model it is described that the possible impact of stress on a biological system changes from (a) a normal steady state to compensate state (b) from the compensate state to death. Accordingly an adverse affect of pesticide may be temporarily or permanently modified to render homeostatic mechanisms incapable of maintaining an acceptable altered steady state and an acute dose of a pesticide could cause the biological system to oscillate outside its normal range of variation, yet with time, could return to the normal state without suffering lasting effects. Such compensation state was reported by coppage and duke (1972). When malathion was applied aerially to control mosquito vectors, the AchE activity of the fish brain returned to normal within 40 days after application of malathion.

The detoxifying enzymes of the microsomes of liver and gills in the air breathing cat fish Clarius batrachus were enhanced under sublethal exposure of malathion after 30 days showing that the organs are on their way of recovery (Mukhopadhyay and Dehadri, 1978). Subba Rao (1980) and Parvathi (1982) reported that the suppression in O₂ consumption in major carps was recovered after 30 days of exposure to malathion In Labeo rohita there is an initial rise in O₂ consumption has been reported (Rafi Ahmed and Bashamohideen, 1985, Bashamohideen and Nisar Ahmed, 1989). In Sarotherodon mossambicus there is a initial rise in O₂ consumption (Jayantharao,1982).

The above mentioned studies involving time course experiments are of considerable importance because they indicate the sequence of events leading to the compensatory mechanisms in the fish. But very little work has been done on this aspects
especially on commercially important fishes subjected to pollution stress with reference to different pesticides.

**PESTICIDE TOXICITY - O$_2$ CONSUMPTION:**

The rate of O$_2$ consumption is considered as good index for overall physiological activity and an indicator of physiological stress of animal. The insecticides enter the aquatic animals through the gills (Holden, 1962, Premdass and Anderson, 1963, Ferguson and Goodyear, 1967). Consequently the first physiological activity to be affected during pollution stress is O$_2$ consumption. The suppression of O$_2$ consumption is due to morphological gill damage (Bayne et al, 1980, Parvathi 1982). O$_2$ consumption was enhanced both at lethal and sublethal exposure periods to endosulfan in L rohita (Rao, Devi and Murthy 1981). O.P. compounds are reported to inhibit whole animal and tissue respiration in aquatic animals (Hunter et al, 1967, Bashamohideen and Obulesu, 1985, Bashamohideen, 1989). It is well known from the previous studies that the O.P. compounds suppress the rate of O$_2$ consumption thereby depressing the respiration of the whole animal (Bhagyalakshmi et al, 1982, Lee 1969, Subbarao, 1980, Parvathi, 1982, Shanwaz, 1985 & Obulesu, 1985).

Organophosphorus insecticides like parathion and malathion inhibit in vivo O$_2$ uptake of fish liver in the presence of succinate, DDT a well known O.C. compound was also found to inhibit O$_2$ uptake in Blue gill liver mitochondria in the presence of succinate (Hiltibran, 1974). Malathion when administered orally to hen, inhibited O$_2$ consumption of liver and kidney slices (Gupta et al, 1974). The carbamate insecticides such as Sevin, Tillem and Thiram when administered orally to rats decreased the tissue respiration of liver and brain (Prokina, Kaminskaya, 1969). According to Diwan and Nagabhushanam (1982) the decreased level of O$_2$ consumption in Barytelphusa enuicularis exposed to toxic substances. A conspicuous decrease in O$_2$ consumption when exposed to malathion was observed in Paras telphusa Jacquemantii (Kulkarni and Kamath, 1980).
The degree of suppression in the tissue respiration of fish exposed to different insecticides is a reflection of the degree of suppression in the $O_2$ consumption of whole fish which forms a basic criteria for assessing overall physiological process in animals. Hence studies involving $O_2$ consumption of whole fish as well as tissues with reference to pesticides are few and very little attention has been drawn towards commercial fish involving comparative evaluation of different pesticide.

**PESTICIDE TOXICITY - OPERCULAR ACTIVITY (VENTILATORY RATE):**

The respiratory efficiency of the fish depends upon the rate of opercular movements. The pulsatory movement of the opening of mouth and operculum alternated with their closing is easy to watch in a fish kept in aquarium (Chandy, 1970). High rate of activity in short time favours greater flow of water on the gill surface area. This in turn facilitates the greater $O_2$ consumption. Hence opercular movement can be taken as an index to verify the respiratory activity of the fish under environmental stress (Thiede, 1963, Narasimhamurthy, 1983, Bashamohideen, 1984). Thiede (1963) regarded opercular movements as an adequate indicator for heart resistance in fish. The rate of opercular movement can be defined as the time taken for ten down movements by operculum. The $O_2$ consumption has been found to decrease when there is a decrease in the opercular movements of the fish (Koundinya, 1978, Jayantha Rao, 1982, Obulesu and Bashamohideen, 1985).

The Neurotoxic O.P. compounds inhibit AchE activity (Alridge, 1981). Because of this, neurotropical link between nervous system and opercular system might have been impaired and hence the suppression of the opercular activity. O.P. potentially inhibits energy metabolism of tissues. Preliminary studies involving the rate of opercular activity is made in case of common carp subjected to malathion exposure (Indira, 1986). The available work, on opercular movements in fish is confined to environmental temperature where the process
of resistance - adaptation has been reported in the fish, *Rhadena amor us* (Kunnemann, 1973) but very little has been done with reference to pollutants. Hence the present investigation involving the longterm effects of endosulfan, malathion and Sevin has been undertaken.

**PESTICIDE TOXICITY - CARBOHYDRATE METABOLISM:**

Carbohydrate serves as an immediate source of energy in the blood and an important energy reservoir in the liver tissue. It is the chief source of supply of chemical energy in the cells. The carbohydrate metabolism has been observed to impair during physiological disorders and pathological condition (Harper et al., 1978).

Investigations have been carried out on carbohydrate metabolism during pathological conditions in different animals following exposure to pesticides. The effect of malathion on carbohydrate metabolism of the fish, *Tilapia Mossambica* has been studied by Kabeer Ahmed, (1979). Extensive work has been carried out on blood glucose, liver and muscle glycogen with reference to exercise effects as well as salinity and temperature stresses (Heath & Pritetchn, 1965, Dean & Goodnight, 1964, Umminger, 1971, Bashamohideen and Parvatheswara Rao, 1971, 1972). O.P. insecticides have been reported to increase blood glucose and to decrease liver glycogen in animals. The fish, *Cyprinus carpio* exposed to O.P. compounds like malathion, dipterex and DDVP at 5 ppm increased the blood glucose levels whereas DDVP at 1 ppm concentration decreased the liver glycogen content.

Glycogen, commonly known as the "animal starch" is the main reservoir of Polysaccharides and a great source of blood sugar. Disturbances in cellular energetic processes were reported by vasilos et al (1976) and chronic and acute poisoning of rats with Sevin, with marked changes in the carbohydrate metabolism. Liver glycogen decreased and an increase was observed in blood glucose by O.P. insecticides in the animals.
Exposure to O.P. compounds like Malathion, deuterex and DDVP in the fish *Cyprinus carpio* at 5 ppm increased blood glucose levels, while DDVP even at 1 ppm concentration decreased liver glycogen content. A lethal (LC$_{50}$/48 hrs.) concentration of the O.P. pesticide sumithion in *Sarotherodon mossambicus* increased blood glucose level but hepatic glycogen registered a fall, as reported by Koundinya and Ramamurthy (1979) and also a similar trend was reported in *Cyprinus carpio* under exposure to other O.P. compounds like malathion and dipterex & DDVP (Sakaguchi & Hiromi, 1972). Further it was reported by Ramana Rao & Ramamurthy (1981) that glycogen in both food & hepatopancreas of snail, *Pila globosa* was continuously utilised in the sublethal exposure of 0.1 mg. of malathion per litre of water. Changes induced by endosulfan in blood glucose of catfish *Clarias batrachus* were reported by Gopala-krishna et al (1982). It was reported that hyperglycemia was maximum at 48 hrs. The effect of a paired mixture of aldrin & formothion on carbohydrate metabolism was reported by Singh et al (1982) in the fish *Heteropneustes fossilis*. Effect of technical grade malathion was reported by Honnegowda et al (1985) on blood glucose, liver glycogen, plasmacortico-sterone and electrolytes in Adrenal demedullated rats. However, studies involving carbohydrate metabolism with reference to different pesticides are very few in number (Parvathi, 1982 and Bashamohideen, 1984, 1986). Therefore an attempt has been made to know the impact on the effects of different pesticides on blood sugar and liver glycogen in the commercial fish, *Labeo rohita*.

**PESTICIDE EXPOSURE - TISSUE - SOMATIC INDEX**

The tissue - somatic index is the % proportion of the body part to the total weight of the body. In higher organisms, the organisation of the body is complicated and the organs are specialised in their physiology. The varied distribution of physiologically and biochemically important substances and their growth brings about % proportion of the organ weight to body weight. Such index variations
are highly useful to know the condition and health of animal and it varies from season to season. It is also an important index which reflects in the metabolic activities of the tissue level (Philip Borier Hank, 1950).


PESTICIDE EXPOSURE - SYMPTOMS OF POISONING:

The metabolic activities of the fish are manifested in the form of its behaviour. Any change in the metabolism is reflected in its behaviour (Koundinya, 1978, Bashomohideen & Obulesu, 1985). The fish has been found to be highly susceptible even to very low concentration of pesticide in the aquatic medium (Krishnamurthy, 1980). These low concentration of pesticides, have been found to cause subtle bio-chemical and physiological effects in fish (Gouda et al 1981, Rao et al, 1981). Therefore, a thorough analysis of the symptoms of poisoning and a study of fish behaviour in medium containing toxic compound in sublethal doses are very essential for knowing clinical picture of poisoning and also for assessing the nature of the toxicant and the cause of mortality among fish in natural bodies of water.
The rate of opercular movement has been found to indicate the respiratory efficiency of the fish. These opercular movements have been found to be good indicators of environmental stress in fishes (Thiede, 1963). Therefore, any abnormal change in opercular movements during pesticide exposure can be considered as one of the symptoms of poisoning. Another characteristic symptom of poisoning was discharge of mucous in copious amounts at the gills and different parts of the skin including the area near the pupils of the eye, thus effecting the normal eye sight and damaging the pupils. This mucous secretion was found to have much use in protecting the gills and other parts of the body from the easy entry of toxic substances. Swamy et al., (1983) found that the mucous is a polysaccharide in nature and it reduces the flow dynamics of water and thus help the fish in curtailing the inflow of greater quantities of pesticides into the body. The fish exposed to toxic substances has been found to suffocate and to assume a diagonal position in water with its head directed up towards the surface of the water. The fish then dies with its mouth and gills wide open. Blood clot were also seen on the gills. The very colour of the gills has been found to be changing from normal red to either pale red or brown. The colour of the fish also changes from normal grey to black.

The pesticides were found to cause rapid loss of equilibrium in fish because of their direct action on the nervous system. As a result the fish exhibited quick spiralling movements, jerking movements, haphazard springs, drum rolling movements and the fish attempted to jump out of water. According to Metelov et al., (1971) these symptoms of poisoning are classified into different stages like restlessness, loss of sensitivity, enhanced or reduced excitability, loss of equilibrium and regor mortis.
Thus, the survey of the literature indicates the studies involving comparative assessment with different pesticides on a single species to derive knowledge on the relative toxicity, susceptibility, resistance and recovery capacity of the fish are highly scanty. Hence in this investigation some of the basic physiological and biochemical responses of the commercial fish, Indian major carp, *Labeo rohita* has been undertaken to make a comparative evaluation of different pesticide in a single species of fish.