Environmental pollution is the most serious problem today leading our living planet towards the dead end.

Environmental pollution is defined as the unfavourable alteration of our surroundings wholly or partly, as a by-product of direct or indirect activities of man through changes in diverse directions, which may affect the biological kingdom as a whole including Man itself. According to the report of the environmental pollution panel of U.S. President’s Science Advisory Committee, pollution is a resultant of Man’s inverse action through direct or indirect effects on changes in energy patterns, radiation levels, chemical and physical constituents and abundance of organisms (Kudesia 1980).

There is deliberate balance between waste formation and its disposal in nature. Whenever this cycle is disturbed or formation of wastes superceeds the decomposition, the phenomenon of pollution is inevitable.

Man by his intelligence and talent, has acquired the ability to make the use of nature for his material benefits, but because of advanced technology today, pollution is assuming new dimensions and is posing intricate problems that needs our immediate attention. Amongst many, pollution of biosphere is one which needs to be enumerated with priority.

Man has brought about great changes in the natural environment both intentionally and accidently with disastrous consequences, which act as the sources for different types of pollutions as air pollution, water pollution, soil pollution, sound pollution and other.

Particularly, developing countries are facing the problem of environmental pollution to large extent. Many facet advanced techniques, industries and unhygienic habits and habitats mainly contribute to the pollution of developing world.

Most of the pollutants escape from the human control and enter the aquatic environment, where they produce local, regional and global pollution and that interfere with the natural course of biological processes. All over the world more than 30,000 chemicals are manufactured, and most of them adversely affect the environment. They do damage in various ways, cause genetic mutation, birth defects, various diseases like cancer etc. In large doses, they kill instantly and in smaller doses, they affect slowly the living environment for a long period.

Water is one of the primary essentials of life. Water quality is of major concern to all living organisms. Water pollution is defined by some biologists as some measurable changes in water quality due to introduction of foreign substances. Warren (1971) defined water pollution as any impairment of the suitability of water for any of its beneficial use actually or potentially by man that caused changes in quality of water. Water pollution is more dangerous than air pollution. Firstly, the water may contain oxygen supply inadequate to sustain any form of aquatic fauna and may also contain significant amount of toxicants. Secondly, water taken is cycled throughout the animal body and more than 80 delicate organs of the body are exposed to this water. Industries, including pesticide concerns discharge
their wastes directly or indirectly to the rivers and lakes which percolates down into the soil or flows to the sea (Kumavat 1989).

Geochemical and biological processes are involved in pollution together with human activities in the field of technology which resulted in contamination of various water bodies. The problem of water pollution by pesticides is now well known to be of crucial importance all over the world and especially in developing countries like India. The Water Pollution Control Act of 1972 has made it a national goal to eliminate the discharge of pollutants into all navigable waters. The coastal seas all over the world are increasingly being contaminated. As a consequence, in recent years an increased attention has been given to this problem by national Government and international organizations such as CEC, FAO, UNESCO, OBCD, WHO etc. The UN Environment programme has warned, that the dumping of sewage, sludge, wastes from Industries, oil spills and other effluents will sooner or later threaten life everywhere.

Not very many years ago water pollution used to mean as contamination of water by metals like Lead, Mercury, Zinc, Cadmium, Antimony, Copper, Iron, Arsenic etc. The source of these metal pollutants have been found to be earlier insecticides, industrial wastes and sewages. Localized pollution problems with some of these metals have also been found in many countries. Water pollution however received special significance after realization of the implication of agricultural wastes in this respect, particularly DDT and other pesticides.

The impact of science and technology is felt in our everyday life in this century as on food, clothing, housing, health, education etc. Today, to fulfill the increasing demands of food for geometrically increasing population, the production of grains has been given top priority by most of the countries. For this purpose mechanization of agriculture for the increase in agricultural productivity and industrialization in recent years. There has been a great increase in manufacture and utilization of fertilizers, pesticides, petrochemical products, detergents and other synthetic chemicals, various untreated industrial and agricultural wastes cause a serious matter to the quality of water and to aquatic life (Burton et al., 1963, Lewis and Lewis 1971).

Water pollution with pesticides is known to occur mainly due to rain water, drainage from the spread field, surface waters, reservoirs and rivers seepage of pesticides to underground water. Contamination of surface water due to drainage etc. is largely due to unregulated excessive use of pesticides without following good agricultural practices.

Pesticides are an integral part of present day agricultural technology. To contain the insect pests man since long has been employing various strategies which include mechanical, physical, chemical and biological methods among the pest control measures. Tobacco was one of the first material to be used as an insecticide around 1750, that was the first era of pesticide. The start of the second era was the discovery of DDT during second world war was in 1939 as wonder chemical followed by synthesis of other organochlorine, organophosphorous and carbamate and other synthetic insecticides.
and are well tolerated by majority of crops and yield metabolites of insignificant toxicity (Dwivedi and Mathur, 1999). The greatest revolution in the usage of pesticides however came only about 40 years ago, in the wake of development of synthetic pesticides. It is estimated that, on a worldwide basis about 20 million tonnes of organic chemicals enter the environment annually (Visweswaraiah et al., 1975).

In India, pesticides first began to be produced in 1952. Now India stands second in producing largest amount of pesticidal compounds in south-east Asia. Though the consumption of pesticides in India has shown a striking rise from 3,750 tonnes of technical grade at the beginning of second plan to about 14,600 tonnes at the beginning of third plan (Sardar Singh 1967). The consumption estimated for 1983-1984 was 1,49,759 tonnes. Besides there has been a tremendous increase in the areas covered under the insecticidal umbrella. On the average, the pesticides used in India is one tenth of what is applied per unit area of cropped field in the advanced countries (Rangaswamy 1976).

Besides agriculture, pesticides also have significantly contributed in checking diseases like Malaria, Plague, Typhus etc. but today resistant races of pests have appeared in response to intensive "natural selection". As a coin, pesticides also have another side, because there are various side effects to non-target organisms including aquatic fauna, Avian species and also higher mammals.

Pesticidal pollution may be defined as change in one or more components of ecosystem which are harmful to man, animals and wild life through pesticides and other degradation products. Pesticides represent some of the most widespread pollutants raising difficult problem for the environmental protection because they cause hazardous effects upon useful organisms both in aquatic as well as in the land environment. Henderson (1951), Dalela et al. (1978) and Verma et al. (1979) have succeeded to study the toxicity of pesticides to fish and fish food organisms.

Pesticides may enter in water by variety of ways, these include surface run-off from the land, industrial waste discharge, carelessness and accidents and by direct application to control unwanted plants and animal pests (Nicholson 1969). Other sources may be air borne residues, home used products and garbage disposal, dumped products containing residues higher than tolerance, dead animals and animal excreta and decaying plant tissues (Westlacke and Gunthers 1966).

Because of extensive range of biological activities, affinity and stability of pesticides for living system, they create serious problems to the aquatic biota. The main reason for environmental pollution and serious ecological problem with pesticides are, (1) Pesticides are biological poisons, (2) Large quantities are applied to ecosystem, (3) Poor application technology is used, which results in large amount of pesticides being widely spread in non-target areas, (4) Little pesticides (probably less than 1%) overhits target pests and (5) persistence into environment for periods longer than intended or required (Malu 1989).

While the human beings may not directly exposed to water pollution in the form of drinking water, aquatic flora and
fauna are almost constantly exposed to water combination with variety of toxic substances. Large number of these substances through food chain are likely to indirectly affect human and other animal life.


Many deleterious effects of pesticides either directly or indirectly on the target as well as on the nontarget systems. These effects include - (1) Disturbance in equilibrium existing between pests and their parasites, (2) Increased disease susceptibility; (3) Bioaccumulation, (4) Development of pesticide tolerance, (5) Disturbance in reproductive physiology, (6) Behavioural abnormalities in birds and insects, (7) Effect on population of birds, wild life, fish, aquatic invertebrates, bacterial and seed production, (8) Effect on beneficiary insects, (9) changes in chemical make up of the plants and finally contamination of food and human bodies (tissue residues) (Gupta, 1984).

Incidents of intoxication, death and residue problems resulting due to biomagnification of pesticides through the food chain and deposition of the same in the body fat have been reported. DDT and BHC have been banned or severely restricted in very many countries of the world, primarily due to bioaccumulation of their residues and associated risk harm to man and environment. A number of such chemicals banned in west are dumped in third world. International Development Research Centre (Ottawa) has claimed that more than 10,000 peoples die every year and near about 10,00,000 other suffer from various effects of pesticide poisoning in developing countries. Cases of blindness, cancer, deformities, diseases in liver and nervous system from pesticide poisoning have been identified in the cotton growing regions of Maharashtra and Andhra Pradesh. The common cause is in the lack of community awareness about the hazards of these chemicals and availability of very toxic pesticides in conditions where necessary safety precautions are highly unrealistic.

The cases of accidents, contamination and direct contact are usually self evident and are reported extensively. The catastrophic event like Bhopal gas tragedy is the latest accidental case of 1985 and Government of India had already taken some measures in this direction and the latest measure is the Environment (Protection) Bill, 1986. A new provision in this act empowers the central Government to make rules for "the maximum allowable limits of concentration of various environmental pollutants for different areas".

Insecticides are equally useful in typical chemical control programme or in pest management programme. Insecticides have rapid curative action in preventing economic damage. Lethal action is rapid and high mortality of the pest population is usually obtained within
a little period. The use of insecticides is low in cost. Wide spread use of pesticides for pest control is largely a resultant of their convenience, simplicity, effectiveness, flexibility and economy. These properties represent virtues for use in pest management programme.

The insecticides of proven economic potentialities could not do good in the ecosystem when viewed in residual form. The chlorinated hydrocarbons have greatest tendency for their biological concentration or residue formation. They have longer persistence in the environment and tremendous capacity for concentrating pesticides has been illustrated with fishes, oysters and water fleas (Pimental and Goodman, 1974, Gupta and Gupta, 1976). However the effects of pesticides through residue formation in the food chain impact on metabolic processes of organisms, physiological disorders etc., take a long time to manifest and need to be investigated using laboratory methods.

Chlorinated pesticides posses high chemical stability and strong lipophillic properties. Aquatic organisms can accumulate organochlorine residues directly from water through their respiratory process and also from food. The residual level detected in their tissues may reflect the environmental contamination (Eiseman et al., 1979, Hickey et al., 1997).

Edwards (1965) found 80 percent of DDT originally applied, still persisting in the soil after one year. He further reported that 50 percent of the applied chemicals end up in soil by missing the target or run off from the foliage. The persistance of Toxaphene for six years and of chlordane for 12 years with intermediate values of other chlorinated hydrocarbons is reported (Alexander, 1965). Residues of DDT accumulated in body tissues of average Indians is highest in world. A study conducted by Indian Institute of Technology, Kanpur reported that the average Indian daily diet contains about 0.27 mg of DDT. In India, reports of the special committee on harmful effects of pesticide, Hyderabad, Central Food Technological Research Institute, Mysore and Agricultural Universities of Punjab and Pantnagar gave data on pesticidal contamination of cereals, pulses, seeds, oil and vegetables.

Recent studies about drinking water from ponds in Hassan district of Karnataka was found to contain 0.02 to 0.2 ppm of pesticide. The level of B.H.C. in water taken from Cauvery river (Karnataka) was over 1000 ppb and of methyl parathion (1000 ppb). The water of Yamuna river in Delhi contains high DDT residues. (Niraj Kulshrestha, 1991).

Today replacement of older, persistant and high doses organochlorine pesticides (DDT, BHC, Chlordane etc.) with more specific, easily degradable molecules of new generation pesticides (Organophosphate, synthetic pyrethroids etc.) which are more beneficial for integrated pest management programme in the country.

The organophosphates which were the byeproducts of defence research on nerve gases in the second world war were also found to be deadly to insects. Use of these pesticides on a commercial scale in agriculture started in 1946 and since then it is in constant research and progress.

In agricultural operations,
organophosphorus pesticides are applied for pest control and they are preferred to other persistent organochlorine pesticides due to their short half life. The degradation profiles of phosphatic pesticides vary depending upon the chemical nature of water, soil etc. They have lower residual effects on terrestrial and aquatic ecosystems due to faster degradation process (Sattar, 1990). The biological action of organophosphates in mammals and arthropods consist in the attack to neural transmission system which causes the interference with nervous function of the target organisms (Guzzella et al., 1997; Olima et al., 1997). The organophosphates, synthetic pyrethroids, carbamate group of insecticides leave a very little residue because of their quick metabolism and rapid excretion from the system.

Most organophosphate insecticides are regarded as being non-persistant but some reports have indicated that residues of organophosphates persisting for extended period in organic soils and in surrounding drainage system (Harris and Miles, 1975).

In recent years, the synthetic pyrethroids with multiple beneficiary qualities have attracted the farmers to use these compounds in pest control. These are photostable compounds with rapid biodegradability (Elliot and Jones, 1978; Leahey, 1979) having low mammalian toxicity but high toxicity for fishes, aquatic invertebrates and insects. (Shell Dev. Comp., 1978, Nakayama et al., 1979, Coats, et al., 1979, Laxmirajyam, 1986, Bradbury et al, 1986). These are good substitutes to organochlorine and organophosphates.

At present, ecologically safer control system should be developed and utilized. Ideally harmful action of pesticides should be highly specific for undesirable target organisms and not harmful to desirable non-target organisms. New methods known as integrated control systems are being developed to control pests. These methods combine the use of chemical pesticides together with other effective but less harmful techniques like biological controls. The Department of Science and Technology, Govt. of India has brought out a status report on pesticide residues under the scheme called 'Consumer's protection through science and technology' which suggest on integrated pest management (IAM) involving combination of biological, physical and chemical control and development of pest resistant crop varieties (Time of India, 6th March 1988).


Similar studies have been conducted with marine invertebrates also. The crustaceans, crabs, prawns (Johnson and Finley, 1980, Reddy et al. 1995, Sanchez et al. 1995, Tang and Siegfred, 1996, Dwivedi and Mathur, 1999) and molluscs like clams and mussels are also being subjected to these toxicity studies because of their economic importance and their vital position in food chain and food web of aquatic ecosystem. Much of the relevant literature about pesticide residues in invertebrates has been reviewed by Kerr and Vass in a book edited by Edwards (1973).

There were 15 persistent organochlorine compounds detected in pelecypod molluscs during 1965-1972 in Gulf Breeze Environmental Research Laboratory of U.S. Environmental Protection Agency, Florida. Appreciable inhibition of shellgrowth in Osyters *Crossostrea verginica* exposed to 32 µg/L for 96 hours was observed by Parrish et al. (1973).

Adult crabs *Paratelphusa jacquemontii* exposed for 24, 96 hours to DDT by Tankar (1985) gives report, that DDT get absorbed through gills and transported to hepatopancreas via haemolymph and noticed that biotransformation and distribution of DDT and its metabolites were apparently regulated by hepatopancreas. Neerajakumari et al. (1987) reported the behavioural symptoms of fenvalerate poisoning on fresh water crab *Oziotelphusa senex senex*.

Conte and Parkar (1975) concluded that aerially applied malathion (2.0 to 4.0 ppb) caused Brown, and white Shrimps death (*Penaeus aztecus* and *P. satiferus*). In aquatic environment, pesticides may undergo transformation in the water through photochemical and other reactions (hydrolysis, oxidation, reduction). Biological transformation may also occur in fish, invertebrates and micro-organisms. Transformation products may be more or less toxic than the original compound.

Relative toxicity of various pesticides as well as their effects were studied by Verma et al. (1979) on *Sacchohranchus fossilis*. There is wide difference of lethal concentrations of a same chemical for different species. This was calculated by U.S. Environmental Protection Agency. LC₅₀ in some closely related taxonomic groups differ by no more than a factor of 2 or 3 for several chemicals.

Sufficient information on different aspects of pesticidal pollution is also available in the publication edited by Edwards (1973), Vernberg and Vernberg (1972), Vernberg et al. (1977), Goel et al. (1984).

In recent years, molluscs have received attention of researchers to carry out toxicity studies using different pollutants. Information available about toxic effects of various pollutants on molluscs is rather insufficient. Effects of Petroleum hydrocarbons on marine clams have been studied by Dange (1979), Kulkarni (1983), Kabeer et al. (1978) exposed the fresh water mussel *Lamellidens marginalis* to sublethal concentration (5 ppm) of malathion for 48 hours. Kulkarni (1984, 1987) have
used pelecypods for the study of toxicity of pesticide. Shankara Rao et al. (1987) exposed Lamellidens marginalis to methyl parathion and observed depletion in tissue proteins leading to free amino acids and changes in enzyme activities are also noted during exposure period. Influence of sublethal concentration of phosphamidon on body weight, oxygen consumption and heart beat were studied in fresh water mussel Lamellidens marginalis (Senthilmurugan et al., 1998) the weight loss, decreased oxygen consumption, and decrease in rate of heart beat with increasing concentration of phosphamidon was observed.

However there are very few reports on lethal and sublethal toxicity of endocel, phosphamidon and fenvalerate on fresh water gastropods, therefore it was felt necessary to determine the toxicity of these pesticides to the fresh water snail Bellamya bengalensis. The study was undertaken under the guidance of Dr. V.H. Singh to evaluate the acute toxicity of the pesticides endocel, phosphamidon and fenvalerate or sumicidin which are an organochlorine, organophosphate and synthetic pyrethroid respectively, since snails happen to be one of the member of aquatic fauna.

This thesis is divided into following chapters by taking into consideration the different parameters under separate chapters.

CHAPTER II - TOXICITY EVALUATION

The survival and productivity of freshwater organisms in lethal and sublethal concentration of different pollutants however depend upon their adaptability which in turn relies on efficiency of their organs and systems. This study is essential for growing awareness of hazards of indiscriminate water pollution, adverse effects including mortality of organisms and to establish its limit of safety. Before performing full scale toxicity tests, the test snails were exposed to wide range of concentrations of pesticides. Thus toxicity range of each pesticide is determined. By studying the above data, detailed toxicity tests were performed. Static Bioassays for determining acute toxicity is carried out according to the methods recommended by ISI (1971) and EPA (1975, 1978) LC\textsubscript{50} values were determined from direct observations and bioassay results are statistically calculated. Lethal and sublethal concentration of pesticides for 24, 48, 72 and 96 hours are fixed so the acceptable level of toxicant in the environment which is harmless to the snails is decided.

CHAPTER III - RESPIRATORY METABOLISM

Respiratory metabolism is an index of the activity of the snail and its estimation helps to study the environmental influence on the organism. The toxicity of pesticides affect the rate of oxygen consumption. The respiratory potentials of animals are the important physiological parameters to assess the toxic stress because it is important indicator of energy expenditure and metabolism.
The survey of literature shows that though considerable work has been done in this field, the information pertaining to effects of endocel, phosphamidon and sumicidin on oxygen consumption is meagre. Under these circumstances, it was necessary to investigate the effects of lethal and sublethal concentrations of these pesticides. The results are statistically evaluated and correlated. This aspect of investigation is included in this chapter.

CHAPTER IV - BIOCHEMICAL STUDIES

Since organic constituents act as a key substrate for metabolism, higher concentration of toxicants in aquatic environment causes adverse effect on aquatic organisms at cellular or molecular level and ultimately leads to disorder in biochemical composition. During stress condition glucose is the main source to meet the higher energy demand, hence it is felt necessary to study carbohydrate metabolism. The tissue proteins of the body under toxic stress are known play a pivotal role in the activation of compensatory mechanism. Hence it becomes essential to study about proteins, amino acids and lipids in the body of snail. Considering the impact of pesticides on metabolism of aquatic animals, the present work was undertaken. This chapter consists mainly the effect of pesticides on the biochemical constituents of different organs in the body of the snail B. bengalensis. Effect of lethal and sublethal concentrations of pesticides were studied at individual levels. Biochemical constituents were estimated from different tissues such as hepatopancreas, mantle, foot, gill and gonad etc. of the snail exposed to pesticides.

CHAPTER V - ENZYMEOLOGICAL PROFILES

A large system of enzymes is functional at various metabolic pathways and any change, it gets reflected as functional disorders, hence enzymes assays have been proposed as a valid biochemical means to evaluate the extent of toxicity. Pollutants can produce metabolic changes at cellular level by influencing enzyme system. Studies about the influence of pesticides on enzyme activities are necessary because enzymes play a key role in all vital activities of living organisms. Available literature shows that the knowledge about the effect of pesticides endocel, phosphamidon and sumicidin on activities of certain enzymes of B. bengalensis is meager. In present chapter, an attempt has been made to illustrate the investigation results of pesticides on some of the enzymes like Acid phosphatase, Alkaline phosphatase, AAT, ALAT and Protease.

CHAPTER VI - SUMMARY AND CONCLUSION

Results of different aspects studied, their correlation is made in this chapter and probable reasoning is stated. Related references are included under the heading Bibliography.