Introduction
Water is so an essential resource for our life that ancient civilizations have been developed in almost all river valleys of our country. With the growth of the modern civilization, our life is threatened due to pollution of water both from surface and underground. In our country, the scarcity of pure drinking water is so much felt that 50% of urban people and 80% of rural people are affected by water pollution. Historically, people looked at water pollution as a problem affecting people far away. Most people felt they had clean, unpolluted water. However, during the 1970s and 1980s, the general public found that some water sources were in fact polluted. In some areas, the water was unsafe to drink due to high nitrate, pesticide and bacterial levels. Contamination of water supplies was coming not only from cities and industry but from livestock and field runoff as well. Not only there were problems with water on the surface but problems were beginning to show up in water deep below the surface.

Water pollution has emerged as one of the most burning tribulations of this century. The pollution of aquatic ecosystems occurs globally includes an assortment of sources, impacts and is escalating. No other natural resource is more contested than water. Water pollution has been variously distinct commonly involves deprivation follow-on from human actions that cause water to become impracticable for an intended function. It is imperative to differentiate the effects of human actions from natural phenomena, e.g. mud slides, volcanic eruptions etc. natural phenomena signify forces which essentially figure the advancement of natural ecosystems in the dearth of human action. Water pollution linked with anthropogenic activities is characteristically brisk and outstrips the evolutionary potential of ecosystems, leaving them in a depurate state.
Water pollution threatens the survival of life on this planet and efforts to eradicate sources of pollution and reinstate impacted systems become a main concern worldwide. Although over 70% of the planet is hectic with water less than 3% freshwater of that less than 1% is existing to maintain life. Exponential population growth, urbanization, industrialization and getting higher food production amplify the stipulate for water and additional decrease the limited amount obtainable.

With the advent of Green Revolution in the second half of the 20th century when farmers began to use technological advances to boost yields, synthetic fertilizers, pesticides and herbicides became common place around the world not only on farms but in backyard gardens and on front lawns as well. These chemicals were developed in the lab and are petroleum-based have allowed farmers and gardeners of every stripe to exercise greater control over the plants they want to grow by enriching the immediate environment and warding off pests. But such benefits haven’t come without environmental costs namely the wholesale pollution of most of our streams, rivers, ponds, lakes and even coastal areas, as these synthetic chemicals run-off into the nearby waterways. When the excess nutrients from all the fertilizers we use, run off into our waterways, they cause algae blooms sometimes big enough to make waterways impassable. When the algae die, sink to the bottom and decompose in a process that removes oxygen from the water. Fish and other aquatic species can’t survive in these so-called “dead zones” so they die or move on to greener underwater pastures. The related issue is the poisoning of aquatic life. According to the U.S. Centers for Disease Control (CDC), Americans alone churn through 75 million pounds of pesticides each year to keep the bugs off their peapods and petunias. When those chemicals get into waterways, fish ingest them and become diseased. Humans who eat diseased fish can themselves become ill, completing the circle wrought by pollution. Industrial processes produce toxic waste containing heavy metals which are fatal to marine life when filter
into water. The constructions of industries are also at fault for contaminating our water resources with cement, lubricants, plastics and metals. Rivers and lakes are also polluted from heavy silt or sediment run-off from construction sites. Natural catastrophes such as storm, earthquakes, acid rain, floods and volcano eruptions have been known to disrupt the ecological system and pollute water. Farmers use chemicals to hider diseases from crops, these chemicals come through run off into lakes, creeks or rivers and cause water pollution. Agricultural water pollution is caused by fertilizers, pesticides, farm animal wastes and sediments. Research findings indicate that application and heavy doses of fertilizers pollute the water through leaching of nitrate from nitrogenous fertilizers and pesticides. The use of various types of pesticides and insecticides in agriculture cause water pollution. Death of aquatic animals has been reported due to application of pesticides (Sahu et al., 2006) is known to be hazardous. Although there are benefits in the use of pesticides, there are also drawbacks, such as potential toxicity to humans and other animals. According to the Stockholm Convention on persistent Organic Pollutants, 10 of 12 most dangerous and persistent organic chemical are pesticides (Gilden et. al, 2010).

1.1 Pesticides

Pesticides may be a chemical substance, biological agent, antimicrobial, disinfectant or device used against any pest. Pests include insects, plant pathogens, weeds, molluscs, birds, mammals, fish, nematodes and microbes that destroy property, soared disease or a vector for disease or cause nuisance.

Since before 2000 BC, humans have utilized pesticides to protect their crops. The first known pesticide was elemental sulfur dusting used in about 4,500 years ago in ancient Mesopotamia. By the 15th century, toxic chemicals such as arsenic, mercury and lead were being applied to crops to kill pests. In the 17th century, nicotine sulfate
was extracted from tobacco leaves for use as an insecticide. The 19th century has seen
the introduction of two more natural pesticides which are derived from
chrysanthemums and rotenone from the roots of tropical vegetables (Miller, 2002).
Until the 1950s, arsenic-based pesticides were dominant. Herbicides became common
in 1960s, led by triazine and other nitrogen-based compounds and carboxylic acids
such as 2,4-dichlorophenoxyacetic acid, and glyphosate (Ritter, 2009).

The first legislation given that federal authority for regulating pesticides was
enacted in 1910 (Goldman, 2007). However, decades later during the 1940s,
manufacturers began to produce large amounts of synthetic pesticides and their use
became extensive (Daly et al., 1998). Some sources consider the 1940 and 1950 to have
been the start of the "pesticide era" (Graeme, 2005). Although the U.S. Environmental
Protection Agency was recognized in 1970 and amendments to the pesticide law in
1972 (Miller, 2004), pesticide use has increased 50-fold since 1950 and 2.3 million tons
(2.5 million short tons) of industrial pesticides are now used each year (Miller, 2002).
Seventy-five percent of all pesticides in the world are used in developed countries but
use in developing countries is increasing (Miller, 2004). In 2001 the EPA stopped
reporting yearly pesticide use statistics. A study of USA pesticide use trends through
1997 was published in 2003 by the National Science Foundation's Center for Integrated
Pest Management (Ritter, 2009).

In the 1960s, it was discovered that DDT prevented many fish-eating birds from
reproducing, that was a serious threat to biodiversity. The agricultural use of DDT is
now banned under the Stockholm Convention on Persistent Organic Pollutants but it is
still used in some developing nations to prevent malaria and other tropical diseases by
spraying on interior walls to kill or repel mosquitoes (Lobe, 2006).

About 10,000 species of insects from 7,50,000 species are identified as
important pests. Over 50,000 species of fungi are responsible for some 1,500 plant
diseases. Over 1,800 species of weeds out of the known 30,000 cause serious economic loss. About 15,000 species of nematodes produce more than 1,500 serious deleterious effects on plants. Over 1,00,000 species of pests destroy food which could be food for 135 million people. The word pest has no biological meaning. Pests are organisms that diminish the value of resources in which we are interested. In India, crops are affected by over 200 major pests, 100 plant diseases, hundreds of weeds and other pests like nematodes, harmful birds and rodents. About 4,800 million rats cause havoc. Approximately 30% of Indian crop yield potential is being lost due to insects, disease and weeds which in terms of quantity would mean 30 million tons of food grain. The value of total loss has been placed at Rs 50,000 million, represents about 18% of the gross national agriculture production (Kent, 1991).

1.1.1 Uses of Pesticides

Pesticides are used to control organisms well thought-out harmful. Pesticides are used in grocery stores and food storage facilities to manage rodents and insects that infest food such as grain. Each use of a pesticide carries some associated risk to a level deemed up to standard by pesticide regulatory agencies such as the United States Environmental Protection Agency (EPA) and the Pest Management Regulatory Agency (PMRA) of Canada. Pesticides can save farmers' money by preventing crop losses to insects and other pests. In the U.S., farmers get an estimated four fold return on money they spend on pesticides (Kellogge et al., 2000). DDT, sprayed on the walls of houses is an organochloride that has been used to fight malaria since the 1950s. Recent policy statements by the World Health Organization have given stronger support to this approach. Some pesticides are considered too hazardous for sale to the general public and are designated restricted use pesticides. Only certified applicators which have
passed an exam may purchase or supervise the application of restricted use pesticides (Willson, 1996).

The EPA regulates pesticides under two main acts, both of which were amended by the Food Quality Protection Act of 1996. In addition to the EPA, the United States Department of Agriculture (USDA, 1995) and the United States Food and Drug Administration (FDA,) set standards for the level of pesticide residue that is allowed on or in crops (Stephen, 2011). The EPA looks at what the potential human health and environmental effects might be associated with the use of the pesticide (US, EPA, 2011). The consumption of pesticide in India is about 600 gm / hectare, whereas that of developed countries is touching 3000 gm / hectare. There is a wide range of pesticides found used in non-agriculture situations such as industries, public health and for a number of purposes in the home. Domestic use of pesticides is mainly as fly killer, ant killer, moth killer, repellants, rodenticides and fungicides etc. By and large industrial use of pesticide is of vital importance in the industries such as wood and carpet, wood preservation, paint industry, paper and board industry, leather industry, building industry, miscellaneous industrial application e.g. soluble cutting oils, industrial water systems, drilling fluids etc.

For every dollar that is spent on pesticides for crops yields four dollars in crops saved (Pimental, 1971). This means based on the amount of money spent per year on pesticides about $10 billion, there is an additional $40 billion savings in crop that would be lost due to damage by insects and weeds. Farmers benefit from having an increase crop yield and from being able to grow a variety of crops throughout the year. Consumers of agricultural products are also benefitted from being able to afford the vast quantities of produce available year round. The general public also gets benefits from the use of pesticides for the control of insect-borne diseases and illnesses such as malaria. The use of pesticides creates a large job market in the industry. Control of
using methods evolve over time as knowledge and techniques improved. This includes the development of chemical means of control which become very important because of a number of advantages. Farm chemicals are an economical way of controlling pests. They require low labor input and allow large areas to be related quickly and efficiently. A suitable farm chemical is available for most pest problems with variations in activity, selectivity and persistence. The best product can be chosen for the situation. This allows more flexibility in management options and better timeliness of pest control. Farm chemicals ensure a plentiful supply and variety of high quality, wholesome food at a reasonable price.

Pesticides are classified in number of ways.

1.1.2 Classification of Pesticide

Pesticides include herbicides, insecticides, fungicides, rodenticides, pediculicides, and biocides (Gilden, et al., 2010; www.Chromatography-online.org). There can be classified by target organism, chemical structure, and physical state. Pesticides can also be classed as inorganic, synthetic, or biological (Biopesticides). Biopesticides include microbial pesticides and biochemical pesticides (EPA, 2009). Plant-derived pesticides, or "botanicals", have been developing quickly. These include the pyrethroids, rotenoids, nicotinoids and a fourth group including strychnine and scilliroside. Many pesticides can be grouped into chemical families. Prominent insecticide families include organochlorines, organophosphates, and carbamates. Organochlorine hydrocarbons could be separated into dichlorodiphenylethanes, cyclodiene compounds and other related compounds. They operate by disrupting the sodium/potassium balance of the nerve fiber, forcing the nerve to transmit continuously. Their toxicities vary greatly but they have been phased out because of their persistence and potential to bioaccumulate. Thiocarbamates and dithiocarbamates
are subclasses of carbamates. Prominent families of herbicides include phenoxy and benzoic acid herbicides (eg. 2, 4-D), triazines (atrazine), ureas (diuron) and chloroacetanilides (alachlor). Phenoxy compounds tend to selectively kill broadleaved weeds rather than grasses. The Phenoxy and Benzoic acid herbicides function similar to plant growth hormones, and grow cells without normal cell division, crushing the plants nutrient transport system where triazines interfere with photosynthesis (Kamrin, 1997). Many commonly used pesticides are not considered these families including glyphosate. Pesticides can be classified based upon their biological mechanism function or application method. Most pesticides work by poisoning pests (C.U., 2007). A systemic pesticide moves inside a plant following absorption by the plant. Insecticides and most fungicides move usually upward (through the xylem) and outward. Systemic insecticides which poison pollen and nectar in the flowers, may kill bees and other needed pollinators. In 2009, the development of a new class of fungicides called paldoxins was announced. The paldoxins inhibit the fungi's detoxification enzymes. They are believed to be safer and greener (Eurek, 2009).

Though these pesticides are beneficial but always have their impact in environment causing pollution.

### 1.1.3 Pesticide Pollution

Pesticides are carried in rainwater runoff from farm fields, suburban lawns, or roadside embankments into the nearest creeks and streams. Occasionally they are even intentionally sprayed into waterways as part of a pest-control effort. Commonly used pesticides can be harmful to environment and living organisms as they enter into water, air and soil.
1.1.3.1 Pesticides’ effects in Environment

The pathways for pesticides are different for surface water and groundwater. Surface water contamination may occur when pesticides are sprayed near water and drift over waterways. Contamination may also occur when soil and pesticides are washed into surface water by heavy rains. This contamination may come from urban areas, lawns, golf courses, parks or agricultural fields. Runoff pollution is difficult to control. The speed and amount of movement depends on whether the pesticide is water-soluble, the soil type, the amount of rain, and the proximity of the water table to the surface. Over time, nearly all pesticides break down to other chemicals as they are exposed to sunlight and air.

Pesticide use raises a number of environmental concerns. Over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including non-target species, air, water and soil (Miller, 2004). Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. Pesticides are one of the causes of water pollution, and some pesticides are persistent organic pollutants and contribute to soil contamination. Pests can develop a resistance to the pesticide, necessitating a new pesticide. Alternatively a greater dose of the pesticide can be used to counteract the resistance, although this will cause a worsening of the ambient pollution problem.

Physical and chemical properties of a particular pesticide is also instrumental in polluting water such as its biodegradability, binding strength, solubility, vapour pressure, texture, water retention characteristic and organic matter content.

Herbicides administered into the water body to mitigate wild growth such as algae are also quite dangerous. Excess destruction of aquatic plants may deplete food resource of the fishes. The dead aquatic plants start rotting depleting oxygen content of water technically termed as BOD. If fish does not suffer fatality then there is greater
chance that these pesticides may harm indirectly. The fish may abandon their nesting and brooding zone hence reducing population. It may decrease immunity to fight disease. The fish may lose its reflexes and become a predator's delight. It has been found that pesticide run off has killed all the fish in a particular pond or stream. The amphibians are also suffering due to effect of pesticides on water bodies. Ponds are the nearest of all the water bodies and is dependent upon "water seeks its own level" mechanism. Therefore, pesticides enriched water from household kitchen garden, farms and agricultural fields and even from washings from grain storage reach nearby ponds. The most comfortable resort of tadpoles is the pond and murky land. It has been found that due to pesticides enriched water in the ponds, tadpoles take more time to transit into frogs and the frogs lose their size lately (http://EzineArticles.com/expert=PN_Singh). Using herbicides to control crop weeds reduces the need for cultivation, thus reducing land degradation (Colston, 1990).

1.1.3.2 Pesticides’ effects on Health

Pesticides may cause acute and delayed health effects in those who are exposed (EPA, 2007). Pesticide exposure can cause a variety of adverse health effects. These effects can range from simple irritation of the skin and eyes to more severe effects such as affecting the nervous system, mimicking hormones causing reproductive problems, and also causing cancer (http://www.epa.gov/pesticides/health/human.htm). A 2007 systematic review found that most studies on non-Hodgkin lymphoma and leukemia showed positive associations with pesticide exposure and thus concluded that cosmetic use of pesticides should be decreased (Bassil et al., 2007). Strong evidence also exists for other negative outcomes from pesticide exposure including neurological, birth defects, fetal death (Sanborn et al., 2007), and neurodevelopmental disorder (Jurewize & Hanke, 2008). The American Medical Association recommends limiting exposure to
pesticides and using safer alternatives (Jeyaratnam, 1990) Particular uncertainty exists regarding the long-term effects of low-dose pesticide exposures. Current surveillance systems are inadequate to characterize potential exposure problems related either to pesticide usage or pesticide-related illnesses. Considering these data gaps, it is prudent to limit pesticide exposures and to use the least toxic chemical pesticide or non-chemical alternative. The World Health Organization and the UN Environment Programme estimate that each year, 3 million workers in agriculture in the developing world experience severe poisoning from pesticides, about 18,000 (Miller, 2004). According to one study, as many as 25 million workers in developing countries may suffer mild pesticide poisoning yearly (Jeyaratnam, 1990), through one study it was found that the pesticides are self-poisoning the method of choice in one third of suicides worldwide and recommendations were made for restrictions on the types of pesticides which were most harmful to humans (Gunnell et al., 2007). If safe handling procedures are not followed the excessive exposure of operators get renown consequences.

Non-target organisms, including predators and parasites of pests, can also be affected by chemical application. The reduction of these beneficial organisms can result in changes in the natural biological balances. Losses of honeybees and other pollinating insects can also be a problem.

Due to indiscriminate use of farm chemicals also concern many people in the community problems result from misuse, abuse and overuse. Farm chemicals can be used safely and effectively without these undesirable effects although there is always a risk associated with any activity.

The uncontrolled use of pesticides has played havoc with human and other life forms. There is a grave obstacle in credentials because of lack of systematic and authentic data on poisonings. Pesticides explanation for a small but significant fraction
of discriminating human poisonings. There are number of outbreaks of unintentional poisoning by pesticides. The World Health Organization (1990) estimated annual worldwide total of some 3 million cases of acute severe poisonings matched possibly by a greater number of unreported, mild-to-moderate intoxications, with some 2,20,000 deaths. Dasgupta (2001), in a national survey of hospital cases in Sri Lanka reported an incidence of 1 lakh persons admitted to hospitals for acute intoxications annually with almost 1,000 deaths, out of a population of 12 million. In Thailand in 1983, an estimated 8,268 pesticide related intoxications occurred within an agricultural community of 1 lakh workers (Boon et al., 1986).

In India, the first report of poisoning due to pesticides was from Kerala in 1958, when over 100 people died after consuming wheat flour unhygienic with parathion (Karunakaran, 1958). In the same year poisoning in Kerala caused deaths of 102 people. This was mainly due to careless handling and storage of wheat. Consequently quite a lot of cases of human and animal poisonings besides deaths of birds and fishes have been reported (Sethuraman, 1977; Banerjee, 1979).

The Poison Information Centre in National Institute of Occupational Health at Ahmadabad reported that pesticides were conscientious for the maximum number of poisonings (73%) among all agricultural chemicals (Dewan and Sayed, 1998). In a study of 190 patients of acute organophosphorous pesticide poisoning muscrinic manifestations were recorded (Bhatnagar, 2001). In Indore out of the 35 cases of Malathion poisoning reported during 1967–1968 five died (Sethuraman, 1977). In another report from Madhya Pradesh 12 humans who addicted wheat for 6–12 months unhygienic with aldrin dust and gammexane developed symptoms of poisoning which consisted of myoclonic jerks, indiscriminate clonic convulsions, and weakness in the extremities. Two dogs and two bullocks were also affected with generalized seizures and myoclonic jerks (Gupta, 1975).
In another outbreak in 1977 eight cases of grand mal seizures were reported from a village of Uttar Pradesh following accidental ingestion of HCH contaminated wheat (Nag et al., 1977; Anonymous, 1981). From time to time several such cases of poisonings have been reported in human, cows, buffaloes and heifer calf. Six persons died in Bhopal in the year 1978 due to phosgene gas exposure (Gupta, 1989). There have been abundant suicidal deaths due to expenditure of aluminum phosphide but no recognized reports are available in the literature that can be cited.

Cypermethrin is among the most effective pyrethroid preparations. Cypermethrin is registered for agricultural use as a foliar application on food and feed crops including cotton, pecans, peanuts, broccoli and other brassicas and sweet corn. Cypermethrin can be applied to livestock in eartags and to horses. Cypermethrin is also registered for use on industrial, commercial and residential sites.

1.2 Cypermethrin

Cypermethrin [(R,S)-alpha-cyano-3-phenoxybenzyl (1RS)-cis, trans-3-(2,2-dichlorovinyl)-2, 2-dimethylcyclopropane-carboxylate] is a synthetic, pyrethroid pesticide that is available in several formulations as an emulsifiable concentrate or wettable powder.

Fig. 1 Chemical Formula of Cypermethrin
Some physical and chemical properties of cypermethrin are given in Table 1.1. Cypermethrin is used as an insecticide in large-scale commercial agricultural applications as well as in consumer products for domestic purposes. It behaves as a fast-acting neurotoxin in insects. It is easily degraded on soil and plants but can be effective for weeks when applied to indoor inert surfaces. Exposure to sunlight, water and oxygen accelerate its decomposition.

1.2.1 Mode of Action

Cypermethrin is a synthetic, pyrethroid insecticide that has high insecticidal activity, low avian and mammalian toxicity, and adequate stability in air and light (Kaufman et al., 1981). It is used to control many pests including lepidopterous pests of cotton, fruit and vegetable crops and is available as an emulsifiable concentrate or wettable powder. According to the label for Ammo 2.5 EC insecticide which contains 2.5 pounds of Cypermethrin per gallon, the product not be applied directly to water or to areas where surface water is present. Also, Cypermethrin cannot be applied when wind may cause drift beyond the intended treatment area. Due to its extreme toxicity to fish and aquatic organisms, Ammo 2.5 % EC is registered as a “restricted use pesticide”, and is for sale to, only Certified Applicators.

In invertebrates and vertebrates, Cypermethrin acts mainly on the nervous system. Cypermethrin is both a stomach poison and a contact insecticide (Jin and Webster, 1998). In the peripheral nervous system of the frog, its primary action is to induce noticeably repetitive activity and produce chains of nerve impulses as a result of altering ion permeability of nerve membranes. These long-lasting chains can cause hundreds to thousands of repetitive nerve impulses in the sense organs. This repetitive activity is induced by pyrethroid damage to the voltage-dependent sodium channel,
causing sodium channels to stay open much longer than normal (Vijverberg and Bercken, 1990).

Cypermethrin has been shown to inhibit ATPase enzymes involved in movement of ions against a concentration gradient which are regulated by active transport. This action is especially critical to fish and aquatic insects where ATPase enzymes provide the energy necessary to active transport, and are very important at sites of oxygen exchange. ATPase inhibition and disruption of active transport, possibly affect ion movement and the ability to maintain ion balance, and disrupt respiratory surfaces, indicating that Cypermethrin is inherently more toxic to aquatic organisms (Siegfried, 1993).

1.2.2 Environmental Fate of Cypermethrin

Cypermethrin has a very low vapor pressure and is not readily volatilized into the atmosphere. A low Henry’s Law Constant (H), $2.5 \times 10^{-7}$ atm-m$^3$/mol at 20ºC, indicates that Cypermethrin has almost no tendency to volatilize from an aqueous solution. According to Lyman et al. (1982), if the H is less than about $3 \times 10^{-7}$ atm-m$^3$/mol, as it is for Cypermethrin, the substance is less volatile than water and can be considered virtually nonvolatile. Experimental results indicate that there is practically no movement of Cypermethrin from contaminated soils to the surrounding air (Bacci et al., 1987), unless bound to air-borne particulates. Aside from drift that may occur with spray applications, Cypermethrin is not expected to be found in air.

Cypermethrin occurs as a mixture of both the cis and trans isomers. The cis/trans ratio in technical grade Cypermethrin is 1:1 (Kidd, 1991). The cis isomers are more active than trans by a factor of two. No significant difference was observed between the photo degradation rates of the two isomers in soil, although the trans-isomer was hydrolyzed 1.2-1.7 times faster (Takahashi et al., 1985). Hydrolysis and
photolysis play major roles in the degradation of 4 Cypermethrin in soil. Hydrolysis of the ester linkage is the principal degradation route and leads to the formation of 3-Phenoxybenzoic acid (PBA) and Cyclopropanecarboxylic acid derivatives (Sakata et al., 1986), principally, 3-(2,2-dichlorovinyl)-2,2-dimethyl cyclopropanecarboxylic acid (DCVA) (Kaufman et al., 1981). Cypermethrin also photo degrades rapidly on soil surfaces to many byproducts, with half-lives of 8-16 days (Walker & Keith, 1992). Many photoreactions are involved in photo degradation and the photo degradation rates are closely correlated with the organic matter content of the soil (Takahashi et al. 1985). As with hydrolysis, the principal photoproducts of Cypermethrin are PBA and DCVA with >15% recovery of each after 32 days of irradiation (Hall et al., 1981). Under aerobic conditions, these metabolites may undergo further breakdown to CO2 at a much slower rate (Kaufman et al., 1981). The persistence of the metabolites is unknown (Walker & Keith, 1992).

Cypermethrin is a non-polar pesticide and readily adsorbed onto the soil surface and bound there. According to Kaufman et al. (1981), very little cypermethrin insecticide would move through the soil profile, although all of the degradation products are more mobile than the parent product. Degradates PBA and DCVA are organic acids which are often mobile in soil. The carbon content of the soil greatly affects the amount of chemical that is adsorbed. Cypermethrin was found to have an average $K_{oc}$ of $6.1 \times 10^4$ cm$^3$/g for five different soil types (USDA, 1995) indicating that Cypermethrin is immobile in soil. The major metabolites, on the other hand, are very polar, and move readily through the soil. These organic acids varied in their mobility from intermediate (in silty clay or loamy sand) to mobile (in silty clay loam). For PBA and DCVA, a low pH suppressed ionization, thus increasing adsorption and decreasing mobility in more acidic soils. Therefore, these metabolites would be fairly mobile in neutral to alkaline soils (Kaufman et al., 1981). Microbes play a significant role in the
degradation of cypermethrin. Cypermethrin degrades more slowly under anaerobic and waterlogged conditions (Walker and Keith, 1992). The anaerobic half-life reported at <14 days is similar to the half-life in aerobic soils ranging from 6-20 days (USDA, 1995) but the major metabolite, PBA, does not continue to break down anaerobically (Leahey, 1985). The chemical also degrades more slowly in sterilized versus natural soils which illustrates the importance of microorganisms (Chapman et al., 1981). In sterile aerobic soils, the half-life was 20 to 25 weeks (Walker and Keith, 1992).

Cypermethrin is relatively non-persistent in soils with the typical half-life in sandy soils of 2-4 weeks. Increased Cypermethrin persistence was observed in soil with high organic matter, high clay content, reduced microbial activity and anaerobic conditions (Chapman et al., 1981). In humans, urinary excretion of cypermethrin metabolites was complete 48 hours after the last of five doses of 1.5 mg/kg/day. Studies in rats have shown that cypermethrin is rapidly metabolized by hydroxylation and cleavage, with over 99% being eliminated within hours. The remaining 1% becomes stored in body fat. This portion is eliminated slowly, with a half-life of 18 days for the cis-isomer and 3.4 days for the trans-isomer (Ray, 1991).

Cypermethrin is extremely hydrophobic and will quickly moves from an aqueous solution to suspended particulates (Fitzpatrick, 1982). Thus, relatively small amounts of suspended matter in natural bodies of water may remove a significant amount of cypermethrin from the aqueous phase. Kidd and James (1991), reported that in river water, rapid degradation occurred with a half-life of about 5 days, which is three to four times faster than degradation in distilled water.

According to Agnihorti et al., (1986), the reduction in Cypermethrin aqueous concentrate was rapid, with about 95% lost within 24 hours after application to water and sediment contained in open trenches. Reduction in concentration was primarily due to rapid sorption to sediment and suspended particles and not degradation. The partition
Coefficient of Cypermethrin is very high \( (K_{ow}=3.98 \times 10^6) \), consequently it binds strongly onto organic matter (Crossland, 1882). Because of its strong affinity for soil, Cypermethrin may be carried away to nearby water bodies in suspended sediment by rain and irrigation. Yet, once the pesticide was adsorbed to soil particles, bioavailability was reduced, diminishing the toxicological risk to aquatic animals (Agnihorti et al., 1986). In pond experiments, fish had survived in pond water that contained apparently lethal concentrations of cypermethrin (5 ppb) because the chemical was sorbed onto suspended solids (Crossland, 1982).

### 1.2.3 Toxicity of Cypermethrin

The oral LD\(_{50}\) for cypermethrin in rats was 250 mg/kg (in corn oil) and 4123 mg/kg in water (Ray, 1989). According to EPA reports, an oral LD\(_{50}\) of 187 to 326 mg/kg in male rats and 150 to 500 mg/kg in female rats was observed (U.S. EPA, 1989). The oral LD\(_{50}\) varies from 367 to 2000 mg/kg in female rats, and from 82 to 779 mg/kg in mice, depending on the ratio of cis/trans- isomers present. This wide variation in toxicity may reflect different mixtures of isomers in the materials tested. The dermal LD\(_{50}\) in rats was 1600 mg/kg and in rabbits was greater than 2000 mg/kg (Ray, 1989).

No adverse effects on reproduction were observed in a three-generation study with rats with given doses of 37.5 mg/kg/day, the highest dose tested (U.S. EPA, 1989). No birth defects were observed in the offspring of rats given doses as high as 70 mg/kg /day or in the offspring of rabbits given doses as high as 30 mg/kg /day (U.S. EPA, 1989).

Cypermethrin is not mutagenic, but tests with very high doses on mice caused a temporary increase in the number of bone marrow cells with micronuclei. Other tests for mutagenic effects in human, bacterial and hamster cell cultures and in live mice have been negative (Ray, 1989).
EPA has classified cypermethrin as a possible human carcinogen because available information is inconclusive. It caused benign lung tumors in female mice at the highest dose tested (229 mg/kg/day), however, no tumors occurred in rats given high doses of up to 75 mg/kg/day, (U.S. EPA, 1989).

Pyrethroids like cypermethrin may cause adverse effects on the central nervous system. Rats fed high doses (37.5 mg/kg) of the cis-isomer of cypermethrin for five weeks exhibited severe motor incoordination while 20 to 30% of rats fed 85 mg/kg died 4 to 17 days after treatment began (Ray, 1989). Long-term feeding studies have shown increased liver and kidney weights and adverse changes in liver tissues in test animals (U.S.EPA, 1989). Pathological changes in the cortex of the thymus, liver, adrenal glands, lungs, and skin were observed in rabbits repeatedly fed with high doses of Cypermethrin. Synthetic pyrethroids are extremely effective against insects but are relatively safe to mammals and birds. One potential problem of pyrethroids is their extreme toxicity to aquatic organisms where <1 µg/L produced toxic effects (Siegfried, 1993). According to Bacci et al., (1987), high lipoaffinity and very low water solubility of Cypermethrin suggest a strong bioconcentration potential in aquatic organisms when present in a contaminated aquatic environment. Siegfried (1993) suggested that aquatic insects show higher susceptibility to cypermethrin than terrestrial insects because of lower levels of exposure to lipophilic compounds in an aquatic environment which leads to lower potential to detoxify lipophilic xenobiotics such as insecticides.

According to Muir et al., (1985), in laboratory and field studied, Cypermethrin concentrations decreased rapidly by adsorbing to sediment, suspended particulates and plants. Also, there was rapid photochemical and microbial transformation. In these experiments, Cypermethrin degraded much more slowly in sediment than in water above sediment. This suggested that sediment may act as a reservoir to add intact chemical to the water for a long period of time. The amount of chemical that will
partition from sediment to water varies among types of sediment. In the study conducted by Muir et al. (1985), 55% of trans-Cypermethrin moved to the water above sand, and only 4% moved to the water above silt or clay in a 24 hour period. Larvae (Chironomus tentans) that were kept in direct contact with sediment had bioconcentration factors (BCFs) up to two times greater at high concentration exposure (174 ng/g and 640 ng/g for cis and trans isomers, respectively) than those held in water above sediment. All larvae held in sand or water above sand had higher BCFs than those held in silt or clay systems. The BCF of Cypermethrin in rainbow trout (180-438) was far lower than expected when considering its $K_{ow}$ value. One possible explanation is the inefficient uptake of hydrophobic chemicals via the gills. Cypermethrin’s hydrophobicity and strong adsorption ability affect its bioavailability to fish (Muir et al., 1994). Therefore, in systems with more dissolved organic carbon (DOC) and suspended particulates cypermethrin displays lower bioavailability to aquatic organisms and fish than systems that are relatively particulate-free.

Cypermethrin is readily excreted by rats and mice, leaving low residues after 8 days. Even though cypermethrin has a high lipoaffinity, it is not significantly stored in the fatty tissues and is excreted primarily intact. The metabolism of cypermethrin involves a wide range of pathways, with the primary pathway being cleavage of the ester bond. Cypermethrin is primarily a mixture of cis and trans isomers, with a cis configuration greatly reducing the cleavage rate. Therefore, cis-Cypermethrin is more metabolically stable, but is still efficiently metabolized for rapid excretion. The major metabolites formed are PBA and 4’-hydroxy-3- phenoxybenzoic acid. Although there have been no detailed reports on the metabolism of Cypermethrin by insects, the data suggests that the pathways are similar to those in mammals. Leahey (1985) has suggested that Cypermethrin is much more toxic to insects than mammals because the insect metabolism rate is much slower.
In aquatic ecosystems, pesticides cause fishery losses in several ways. These include high pesticides concentrations in water that directly kill fish; low doses that may kill highly susceptible fish fry; or the elimination of essential fish food, like insects and other invertebrates.

In plants, the metabolic Cypermethrin degradation pathways have been studied in lettuce and cabbage plants. The primary metabolic reaction is ester cleavage which produces \(\alpha\)-cyano-3- phenoxybenzyl alcohol. Hydroxylation also occurs in various positions but is a fairly minor pathway. Studies were conducted under field and greenhouse conditions. Degradation occurred more rapidly under field conditions with the greenhouse half-life reported to be approximately 8 days (Leahey, 1985). Furuzawa et al. (1981) reported different half lives for cis- and trans Cypermethrin isomers in cabbage. The initial degradation half-lives on and in cabbage leaves were 4-5 and 7-8 days for trans and cis isomers, respectively. Therefore, cis isomers remain active longer and degrade more slowly than trans isomers.

1.3 Proposed Study

As per statistic, production and productivity have increased. However, the high chemical usage of pesticides to bring about these spectacular increases in food production is not without its problems. A visible parallel correlation between higher productivity, high chemical input use and environmental degradation effects is evident in south Gujarat where commercial agriculture is widespread. Crops like rice, maize, jowar, cotton, banana, mangoes, cheeku, pomegranate and all types of vegetables are grown in south Gujarat to get more production farmers use various types of pesticides. Cypermethrin is most commonly used pesticide which is used as an insecticide. With this component the water runoffs into Tapi river and affect the health of aquatic organisms including fishes.
Therefore present work is aimed to evaluate the toxic effects of widely used pesticide, Cypermethrin on a commercially important fresh water fish *Labeo rohita* locally known as Rohu. It is one of the major carps, column feeder and widely accepted for its delicate taste. According to Day, (1967) the classification of *Labeo rohita* is

**Phylum** – Chordata  
**Sub phylum** – Vertebrata  
**Class** – Teleostomi  
**Sub class** – Actinopterygii  
**Order** – Cypriniformes  
**Sub order** – Cyprinoidei  
**Genus** – *Labeo*  
**Species** – *rohita* (Ham.)

*Labeo rohita* is easily illustrious from other carps by its comparatively small piercing head approximately incurable mouth with fringed lower lip. Body is stretched out with reasonably rounded belly. Color of the dorsal side of the fish is brownish grey with gleaming scales and sides of the fins are pink or redish. Sexual adulthood is attained towards the end of the second year. It grows over 90 cm in length. *Labeo rohita* is a fresh water riverine fish extensively disseminated in India and transplanted in many reservoirs and ponds of the country. It is an exceedingly relished fish with attractive high price. The fish is proved exceptional in composite fish culture.

Appraisal of Cypermethrin toxicity was designed to carry out with TLm (Median Tolerance Limit) test for 96 hrs. The median tolerance limit (TLm) is the attentiveness which is used to articulate the result of toxicity test (bioassay) to point to the endurance of 50% survival of the test animals throughout precise experimental
epoch. At the same time, behavioural changes of the fish and some parameters of physico-chemical properties from normal and treated water with the Cypermethrin were undertaken. Based on TLm three concentrations viz., sub lethal, lethal and acute lethal of Cypermethrin were selected and used to check the damage through histopathological, heamatological [quantitative and qualitative (RBC structure and micronuclei test)] and cytogenetic (chromosomal preparation and Comet Assay) observations. For the histopathological study vital organs such as gills, liver kidney and brain (optic tectum) were selected with justification.

The respiratory system provides the most extensive interface of a fish with the aquatic environment and the gill epithelium is the first overstated by pollutants. Death occurs as results of respiratory homeostatic during acute exposure of fish. The liver is the major and solitary most vital organ in the metabolism of a vertebrate (Hoar, 1993). Any change or effect in the metabolic test organisms due to its exposure to the Cypermethrin can be noticed. It is also most important organ in the detoxification procedure of body in a vertebrate. Kidney absorbs foreign substances from the blood with a view to send out them out from the body. The central nervous system is sheltered from toxicants by the blood brain blockade. Not much on the other hand is acknowledged about the effects on the brain of fishes.

Fish heamatology is a possible means of estimating the health status of fish stock (Conroy, 1972). Blood is a major circulating medium. It transports different substances from one organ to another (Verma et al., 1991). Being very essential for assessing the effects, RBC count, Hb, WBC count, Hct, MCV, MCH, MCHC and change in erythrocytes were incorporated in the present study.

Micronuclei test (MNT) which is incorporated here can be used as gauge to monitor aquatic pollution arising under experimental conditions. Micronuclei test is
also used to monitor the pollution under natural ecological condition as well as experimental set up.

Fish corresponds to a good cytogenetic model (Denton, 1973). Disproportionate levels of Cypermethrin once made obtainable to the aquatic environment are not frequently uninvolved quickly or are willingly detoxified by metabolic activity, as a result they build up in the organisms present in the water and may cause mutagenic effects by altering structure of DNA leading to genetic effects which may reflect in chromosome as chromosomal aberrations. Thus chromosomal study has also been undertaken.

Based on simplicity and sensitivity, the Comet Assay has become an important tool in scientific disciplines such as environmental biomonitoring, medicine and molecular epidemiology. A standardized protocol was used for the present study. To check the effects of Cypermethrin on single and double standard break in DNA, COMET assay has also been undertaken.
### Table No. 1.1 Properties of Cypermethrin

<table>
<thead>
<tr>
<th>Property</th>
<th>Value/Description</th>
</tr>
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<tbody>
<tr>
<td>Physical state</td>
<td>varies from a viscous yellow liquid to a semi-solid crystalline mass at ambient temperatures</td>
</tr>
<tr>
<td>Relative molecular mass</td>
<td>416.3</td>
</tr>
<tr>
<td>Melting point</td>
<td>up to 80 °C depending on purity <em>and cis: trans</em> ratio</td>
</tr>
<tr>
<td>Boiling point</td>
<td>decomposes at 220 °C</td>
</tr>
<tr>
<td>Density (22 °C)</td>
<td>1.12 g/ml</td>
</tr>
<tr>
<td>Solubility in water (20 °C)</td>
<td>0.009 mg/L</td>
</tr>
<tr>
<td>Solubility in organic solvents: hexane, xylene</td>
<td>103 g/L, &gt; 450 g/L, also comparable solubility in cyclohexanone, ethanol, acetone, and chloroform</td>
</tr>
<tr>
<td>Vapour pressure (20 °C)</td>
<td>1.9 x 10^{-7} Pa (1.4 x 10^{-9} mmHg)</td>
</tr>
<tr>
<td>Molecular formula</td>
<td>C_{22}H_{19}Cl_{2}NO_{3}</td>
</tr>
</tbody>
</table>