CHAPTER 1

INTRODUCTION

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The mad rat race among nations over the globe for development, has jeopardized the health of man itself. Progress in agriculture and industry is taken as the general criterion of the development of any country. This craze has resulted in the unlimited exploitation of each and every bit of natural resources.

Water is a prime natural resource, a basic human need and a precious national asset. It is one of the fundamental media in which life exists. It covers nearly 70% of the earth's surface. However fresh water forms relatively a small percentage of the total water on earth. Additions of undesirable substances from various sources into the water bodies cause alteration to the physical, chemical and biological characters of water and give rise to conditions, which disturb the ecological balance (Wisdom, 1956).

Pollution; a serious environmental problem degrades the delicate balance of the nature. Environmental deterioration is a natural outcome of rapid population growth, increase in agricultural practices, industrialization, mechanization and mobilization of society. Though the industry contributes significantly to the national endeavour towards self reliance, all the subsequent activities have a degrading effect on planetary resources. The development of mankind was achieved through man's intellect but his arrogance and lack of wisdom to live in harmony with nature are responsible for all the harmful effects on the environment. In order to recognise and

predict hazardous effect caused by human activities, effective and reliable monitoring systems are required. Since living organisms are affected by pollution it is logical that it should be measured biologically (Cairns and Dickson, 1971).

Waste water is an unavoidable by product of any industry. There will always be an aqueous liquid as a by product. If the waste water is put straight in to surface waters, wells, streams, lakes or even sea without any treatment it will inevitably pollute that water (Asia and Akporhonor, 2007). Fifty five years of extensive industrialization has landed India bang in the middle of an ecological crisis. We have lost half of our forests, poisoned our water and eroded our lands. Chemical industry has its fair share of the blame.

Fertilizer industry is one of the major water consuming industries, responsible for water and soil pollution of considerable magnitude (Sundaramoorthy *et al*., 2000, 2001). Industrial effluents are constantly adding up toxic substances into the ground water reservoir at a very high rate especially in industrial zones. Many regions all over the globe are heavily depending on ground water for various purposes (Babiker *et al.*, 2004). Ground water contamination by nitrate is a growing problem all over the world, due to intensive use of nitrogenous fertilizers in agriculture (Mc Lay *et al*., 2001). Considerable literature is available on the effect of fertilizer factory effluent on crop plants (Adhikary *et al*., 1992; Agarwal and Hemlatha, 1992;

Goswami, 1993; Singh, 1994; Tiwari and Mahapatra, 1999; Behera and Reddy, 2002; Ghosh, 2005; Prabhakar *et al*., 2006).

In the last two decades, most of the industrially and technologically advanced countries of the west and east alike felt an urgent need to combat the environmental pollution, with all their might. Many factors such as population explosion, unplanned urbanization (Chhatwal *et al*., 1989) and deforestation, profit oriented capitalism and technological advancement have caused pollution crisis on earth (Odum, 1971; Southwick, 1976; Smith, 1977).

Industrialisation is believed to cause inevitable problem of pollution to water, soil and air, based on the type of industry, the nature of raw materials, processes involved and types of equipment used (Billings and De Hass, 1971; Hodges, 1973). This has prompted many countries to limit the discharge of polluting effluent (Singh *et al*., 2002).

Most of the industrial units discharge their effluents either in nearby field or water bodies. The treated effluent was also found unfit for irrigation purpose because of reduced plant growth and hence low productivity. Analysis of plant samples revealed that the long term use of this effluent increased Na and K contents. It disturbed the anionic-cationic balance in plants which inturn has reduced the yield and quality of crops. Slight increase in trace element content of plants was also observed (Narwal, 2006). High levels of phosphorus increases phytoplankton density and productivity of

aquatic ecosystem (Gopinathan *et al.,* 1984; Axier *et al.,* 1991; Foellimi, 1994; and Gemza, 1995). Phosphorus and nitrogen cause algal blooms by acting as nutrients for a luxuriant algal growth which raises the BOD and destroy the aesthetic beauty of water bodies imparting foul smell and odour. (Nixon and Pilson, 1983). In the recent years the rate of eutrophication of rivers, lakes and estuaries due to the release of nitrates and phosphates from excess of fertilizers and sewage effluents is increasing alarmingly (O' Neill, 1985).

Industrial effluents rich in organic matter and plant nutrients are finding agricultural use as a cheaper way of disposal. The evaluation of toxicity of these wastes by biological testing is therefore extremely important for screening the suitability of waste water for land application (Fuentes *et al*., 2004). For environmental testing, bioassays provide an integrated picture of overall toxicity of an effluent, reacting in a predictable way to various types of environmental contaminants. The inhibition of plant growth and crop production by toxic pollutants is a global agricultural problem. Plants adapt to pollution stress by different mechanisms, including changes in morphological and developmental stresses as well as physiological and biochemical processes (Zhu, 2001). In addition to the knowledge of uptake, translocation, or accumulation of pollutants in plants, understanding of the tolerance mechanism of plants is also important (Salt *et al.,* 1998). The bioassays of phytotoxicity have received great attention by environmental institutes of the world. Phytotoxicity is described as an intoxication of living

plants by substances present in the growth medium, when these substances are taken up and accumulated in plant tissue (Chang *et al*., 1992). The phytotoxicity effects by organic wastes are the result of a combination of several factors, like presence of heavy metals, ammonia, salts and low molecular weight organic acids. Fertilizer industry generates huge quantities of organic nutrient rich effluent. An interesting option for its disposal is the spreading on agricultural land, provided that phytotoxic effects are neutralized.

Inorganic pollutants such as free chlorine, ammonia, hydrogen sulphide and other sulphides, salts of metals like Ag, Cd, Cu, Cr, Ni, Zn *etc*. are usually found in metal plating liquid waste, alkali producing units and fertilizer industries. Large quantities of free acids and neutralized chemicals are produced by pharmaceutical industries. The effluents from fertilizer factories contain chemicals like chromates, chlorides, phosphates, sulphates, ammonia and urea.

1.1 Review of Literature

Pollution effects due to the discharge of industrial effluents in to the Indian rivers have been studied by many workers. Bhimachar and David (1946) reported the effects of factory effluents on the Bhadra river fisheries of Bhadravati. The impact of industrial and urban wastes on river Cauvery was analysed by Sreenivasan *et al*. (1980). When the industrial effluents are discharged into the aquatic system, the oxygen content of the water will be

depleted and this will interfere with the respiratory metabolism of animals (Quasim and Siddiqui, 1960; David and Ray, 1966; Venkataraman, 1966; Chockalingam and Balaji, 1991).

The selection of the location of an industry is based on both the availability of reasonably good water for industrial processes and the facility for discharging the waste water. The rivers, estuaries *etc* which supply fresh water and receive effluents from most of the industries constitute the major pathways of natural and anthropogenic material from land to sea compared to other geological agents such as wind, glaciers, ground water *etc.* The total amount of material carried by the river is remarkably high.

Alterations in the physico-chemical parameters of the river water have been reported by many investigators (Jayapalan *et al.,* 1976; Paul and Pillai, 1978). Most of the Indian rivers and fresh water streams are seriously polluted by industrial water, which come out of different factories. Although volume wise the domestic sewage constitutes about 75% of the total effluent generated, it is the industrial effluent which contain high concentrations of pollutants, either toxic or non toxic that is of greater concern (Bhavanisankar, 1994).

Effects of Ganga water contaminated with industrial effluents on root tip mitosis of *Allium cepa* L. was indicated by Malka Azam and Biswas (1987). Results indicated that water from Ganga can cause mitotoxicity in higher plants. Reports are available regarding the cytogenetic damage

induced by industrial effluents (Shekhar Banerjee and Malabika Ray, 1984; Somasekhar *et al*., 1985; Malabika Ray and Shekhar Banerjee, 1986; Mossmann, 1989; Chaurasia, 1992; Ray and Saha, 1992; Tandi *et al*., 2004).

Abnormalities in cell division in root tip cells of *Vicia faba* L. (Abraham, 1988) and morphological abnormalities in flowers and somatic mutations in staminal hairs of *Tradescantia* clone O_2 (Abraham, 1989) were observed as a result of Titanium factory effluent treatment. Toxic effects of pollutants in the environment were manifested in the plant *Crotalaria laburnifolia* L. growing near the Titanium factory. The abnormalities observed were growth retardation, inhibition of cell division, chromosome clumping and a variety of chromosomal aberrations (Abraham and Abraham, 1991). Cytogenetic effects of Agricultural Chemicals on *Capsicum annuum* L. are reported by Srihari Reddy and Madhusudana Rao (1982).

Monarca *et al.* (2003) reported that pollutants of water result in many by products with potential genotoxic and/or carcinogenic activity. Rajaguru *et al.* (2003) studied the genotoxic properties of water and sediment collected from the Noyyal River, which is polluted with industrial effluent and sewage.

Many workers have made studies on the cytotoxicological effects of sewage water on number of vegetable and fodder crops (Abraham and Cherian, 1976, 1978; Kabarity and Malallah, 1980; Banerjee and Sharma, 1981; Misra, 1982; Shehab and Adam, 1983; Patnaik *et al*., 1984; Shehab *et*

al., 1984; Manimozhi, 1987; Santhi, 1987; George and Geethamma, 1990; Saggoo *et al.,* 1991; Saggoo and Poonam 2001; Ateeq *et al*., 2002).

The effect of pollutants on the biological community can be considered as an early warning system for potential pollutants (Walsh *et al*., 1980). The impact of industrial wastes on aquatic flora was observed by different researchers (Palmer, 1980; Rishi and Kachroo, 1981; Re Boredo and Carlos, 1984; Ahluwalia *et al*., 1989; Ambros *et al.,* 1994) and fauna (Sprague and Mc Lease, 1968; Blinski and Jonas, 1973; Shumway and Palensky, 1973; Thomas, 1973; Verma and Delda, 1975; Misra *et al.,* 1985). Many algae are indicators of water pollution (Palmer, 1957; Shotriya and Dubey, 1987; Gunak, 1991). The bioaccumulation of chemicals and their concentration in certain organisms reflect the environmental pollution over time (Mason, 1990). Polluted water in addition to other effects directly affects soil not only in industrial areas but also in agricultural fields, as well as the beds of rivers, creating secondary sources of pollution (De Anil, 1980). Patel and Ramesh (1991) studied the effect of pharmaceutical effluents on the growth pattern of mustard seedlings.

Literature is available with regard to the effect of paper mill effluents on various crop varieties like rice seedlings (Mishra *et al*., 1991; Dutta and Boissya 1997, 1999, 2000; Sundari and Kanakarani, 2001) Pigeon pea (Karande Ghanvat, 1994); *Oryza* seeds (Baruah and Das, 1998); *Phaseolus aureus* Roxb. (Luna and Mohanty, 2005).

The effluent of plywood industry shows significant effect on seed germination and seedling growth of *Cicer arietinum* L. (Ashok and Pankaj, 2000). Muthuswamy and Jayabalan (2001) studied the effect of Sago sugar factory effluent on *Gossypium hirsutum* L. var. MCU 5 and MCU ll.

Pradhan *et al.* (2001) studied the impact of biologically treated domestic sewage water on the growth and yield attributing characters of wheat and blackgram under different fertilizer level in the field condition. There was no significant difference on the yield and yield attributing characters of wheat. In the case of black gram, treated sewage water had no significant effect on the growth and yield attributing characters, rather sewage water had some negative effect on these parameters.

Physico-chemical analysis of the rubber factory effluents revealed high amounts of total suspended and dissolved solids along with sulphate, phosphate and total nitrogen. It causes retarded seed germination in *Vigna,* while diluted effluent favoured seedling growth. Length of root system, shoot system and number of lateral roots were increased by low concentrations of the effluent (Augusthy and Sherin, 2001).

Bioassay studies were carried out to assess the toxicity of distillery effluent on seed germination, seedling growth and pigment contents. Higher concentrations of effluent were found to be toxic but however, it can be used for irrigational purpose after proper dilution (Sharma *et al*., 2002).

Tomar and Aery (2000) studied water relations and stomatal frequency in three months old plants of *Vigna sinensis* Endl. and *Triticum aestivum* L. The high stomatal frequency was associated with 800 mg/g of fluoride contents indicating the movement of fluoride through the plants in the transpiration stream. Water potential and turgor potentials increased in lower concentrations and decreased in higher concentrations of fluoride. In both the test crops osmotic potential showed an opposit trend.

Environmental pollution plays an important role in deciding the destiny of chlorophyll synthesis. Many scientists have done extensive work in this field. Sahai and Srivastava (1986), Gupta and Ghouse (1987), Jha and Gupta (1988), Nirmala Rani and Janardhanan (1988, 1989), Khandelwal and Aery (1993) and Taghavi and Vora (1994) are a few who need special mention.

Effect of treated dairy effluent on seed germination, growth and chlorophyll content of *Capsicum annuum* L. was studied by Indira *et al*. (2001). Genda *et al*. (2001) have worked on the impact of textile industry effluent on the growth of forest trees and associated soil properties.

Vascular aquatic plants like alligator weeds and water hyacinth are able to modify the quality of water by removal of lead and mercury from polluted water (Wolverton and Mc Donald, 1975; Tokunaga *et al*., 1976 ; Greger, 1999; Maine *et al.*, 2001). Many aquatic macrophytes are found to be the potential scavengers of heavy metals from aquatic environment and are being used in waste water renovation systems (Kadlec *et al.*, 2000). *Salvinia*

is used for the removal of heavy metals (Banerjee and Sarkar, 1997; Siriwan *et al.,* 2006). Recycling of waste water cannot supply the much needed water to irrigate the crops, but can as well supply most of the nitrogen for crop growth thus reducing the usage of expensive inorganic chemical fertilizers (Clapp *et al*., 1983). In addition to providing large quantities of water, some effluents contain considerable amount of nutrients like nitrogen, phosphorous and potassium which may prove beneficial for plants (Gautam and Bishnoi, 1992; Aziz *et al*., 1993). Narwal (2006) studied the effect of paper mill effluent on soil and plant health. When used in lower dilution levels sugar and distillery factory effluents were found to be toxic to crop plants but the higher dilution levels of treated effluent could be used for irrigation (Nighat *et al*., 1991; Goel and Kulkarni *et al*., 1994; Om *et al*., 1994; Patil *et al*., 2001; Sharma *et al*., 2002; Kamlesh *et al*., 2007).

The perusal of literature shows that the long term use of treated or untreated industrial effluents may prove detrimental to life.

1.2 Genesis of the problem

Many of the industrial effluents were reported to bring about serious pollution aspects to the environment. Considerable works were carried out in India and abroad on the treatment of wastes from factories. Characterization of effluents of various industries, effects of effluent on soil and crops and management strategies to be adopted have been discussed by Yadav *et al*. (2006). Serious damages have occurred in the developed countries due to

pollution caused by the discharge of untreated wastes from the factories and excess chemicals from the agricultural operations (Singh and Mishra, 2004).

In the course of past 50 years the rate of inflow of industrial effluents has increased from negligible level to 260 million liters per day. During the last few years the rate of discharge of domestic sewage water has increased to 80 million liters per day in Cochin area alone.

Rivers in the state are being increasingly polluted by industrial and domestic waste, pesticides and fertilizers in agriculture, according to a report prepared by the Kerala State Council for Science, Technology and Environment (KSCSTE), under the State Government. The State Environment report, Kerala, 2005, brought out by KSCSTE has also cited *Periyar* and *Chaliyaar* rivers as the examples of pollution of water bodies by industrial effluents. According to the report, nearly 260 million litres of trade effluents reach *Periyar* esturary each day from the Kochi industrial belt. *Periyar* in Kerala has been contaminated at 50 points and carries the effluent of 15 chemical industries. The *Eloor – Udyogamandal* industrial complex is a living monument of human sufferings due to dumping of industrial waste into river *Periyar*. In 1999, International NGO, Green Peace declared the Eloor Industrial area as one of 35 Global Toxic Hot spots based on a study.

Frequent incidents of mass mortality of fishes have become common in major rivers such as *Periyar*, *Chitrapuzha*, *Chaliyar* and *Kallada* and lakes like *Vembanad* and *Ashtamudi*. *Periyar* discoloured two hundred times in

between 1998 to 2007. Presence of radioactive waste materials has also been reported from these areas (Nandan and Azis, 1995; Venkataraman, 1966; Shynamma *et al.,* 1981; Naha, 2003; Malayala Manorama daily, 2004, 2006, 2007; The Hindu daily, 2006, 2007).

The stream and other similar effluent drains from *Eloor* Industries eventually empty either directly or indirectly into Kerala's lifeline – the River *Periyar*. A number of industries situated on the banks of rivers and backwaters discharge their effluents into the wetland system. These effluents contain a large number of toxic ingredients such as acids, alkalies, heavy metals, suspended solids and a number of other chemicals. Among various industrial pollutants, heavy metals require special considerations due to their non-degradable nature. Analysis of particulate metal content indicates high concentration of Zinc, Chromium *etc.* due to industrial pollution in Kochi backwaters. Highest concentration of heavy metals in sediments was observed during pre-monsoon.

Hence it was thought worthwhile to evaluate the cellular damage induced by the effluent released from FACT Ammonium Sulphate plant at *Udyogamandal.* The rate of effluent discharge from ammonium sulphate plant alone is 4800m^3/day. This study is an attempt to test whether FACT effluents can be used for irrigation. The study also broadened the understanding of the physico-chemical characteristics and role of various concentrations of the effluent on cytological, morphological, physiological and biochemical content

of *Capsicum annuum* L. and its varieties Ujwala, Jwalamukhi, Jwalasakhi and Wild

1.3 The source of effluent for the present study

The Fertilizers and Chemicals Travancore Ltd., (FACT) was incorporated in 22nd September, 1943 and India's first large-scale Fertilizer plant was set up on the banks of the river *Periyar* at *Udyogamandal* near Alwaye (Ernakulam District of Kerala State).

From the modest beginning, FACT has over the years grown and diversified into a multi-functional corporation. The main activities involve manufacturing of straight fertilizers: ammonium sulphate and urea; complex fertilizers: factomfos and diammonium sulphates; fertilizer mixtures: NPK mix, rose mix, vegetable mixture and caprolactum; chemicals like anhydrous ammonia, sulphuric acid, nitric acid and soda ash. The parent division at *Udyogamandal* underwent 4 stages of expansion until the year 1972 by upgrading the technology and by increasing the capacity.

The company's main business is manufacture and marketing of (a) Fertilizers (b) Caprolactam and Engineering Consultancy and (c) Fabrication of Equipment. The latest addition to this unit is a 900 tonnes per day ammonia complex set up with an investment of Rs.642 crores. FACT *Udyogamandal* Division is 14001 certified.

The steps taken to minimize air and water pollution and to keep environment and ecosystem in and around the unit of the company sound, the plants have been designed taking in to account the statutory requirements for the environment protection and pollution control. Waste from the factory is treated in the effluent treatment plants to bring down the level of pollutant to permissible levels before disposal following the guidelines of Indian standards for industrial and sewage effluent discharge (IS: 2490-1981) (Appendix-1).

1.4 Importance of *Capsicum*

Chilli (Capsicum annuum L.) is an indispensable spice-cum-vegetable, used as a 'food adjunct' reported to be a native of South America and is widely distributed in all tropical and sub tropical countries including India. In India it is cultivated in all the states and Union territories of the country. The important states growing chilli are Andhra Pradesh, Orissa, Maharashtra, West Bengal, Karnataka, Rajasthan and Tamil Nadu. Andhra Pradesh alone commands 46 per cent of the chilli production in India. India ranks first in the world production of chilli. As per the latest statistics, India produced 8,00,100 tonnes of dry chilli from the area of 9,30,000 hectare. No country in the world has so much area and production of chilli as in India.

Capsicum is a genus of the night shade family Solanaceae. Total number of *Capsicum species* is 20. There are only five cultivated species. *Capsicum annuum* L. is a short-lived perennial herb but is cultivated as an

annual herb. The leaves are oblong and glabrous. The flowers are solitary, rarely in pairs, pure white to bluish white, very rarely violet in colour. The berries are green, maturing into yellow, orange to red grading into brown or purple, pendant, rarely erect, very variable in size (up to 20 cm long and 10 cm in dia.), shape and pungency and sometimes lobed. The seeds are white or cream to yellow, thin, almost circular, having long placental connections.

Chilli has two important commercial qualities. If some varieties are famous for red colour because of the carotenoid pigment capsanthin, others are known for biting pungency attributed by a phenol compound capsaicin (C_{18} H_{27} O_3N). They often contain essential oils which give a good flavour and aroma to food and add greatly to the pleasure of eating. They stimulate the appetite and increase the secretion and flow of gastric juices. For this reason they are commonly known as "food adjuncts". Chilli also contains calcium, phosphorous, iron, ascorbic acid, vitamin A, riboflavin and niacin. India is the only country rich in many varieties with different quality factors.

While consumption of chilli is the highest in India, maximum export is also from this country. India made the record export of 51,900 tons of dry chill in 1996-97. Oleoresin of chilli with low, medium or high pungency is also exported in large quantities. Chilli powder is another important item of export. Indian chilli and its products are bought by a number of countries. Important among them are Sri Lanka, Bangladesh, South Korea and USA for dry chilli and USA, Germany, Japan, UK and France for oleoresin. India can

supply chilli in whole, crushed, powder or oleoresin forms in consistent colour and required pungency.

As a medicine it is used as counter irritant in Lumbago, Neuralgia, and rheumatic disorders. *Capsicum* has a tonic and carminative action. Taken inordinately it may cause gastro-enteritis. The enzyme isolated from chilly is used in the treatment of certain type of cancers. Oleoresin is used in pain balms and vaporubs. Dehydrated green chilly is a good source of vitamin 'C'. Now it is grown all over the world except in colder parts. Blessed with rich diversity in quality, Spices Board India and Kerala Agricultural University have projects to produce specific varieties of chillies for different international markets on committed demand, small or big.

High yielding varieties of chilli breeded in the Kerala agricultural University include Jwalasakhi, Jwalamukhi, Ujwala, Pant C-1, K-2 *etc*. The present investigation concentrated on *Capsicum annuum* L. varieties Ujwala, Jwalamukhi, Jwalasakhi and Wild.

Ujwala is a clustered variety with erect and dark green fruits turning to deep red on ripening. It was released by single line selection developed in the college of Horticulture *Vellanikara* in the year 1986-1997. Jwalamukhi and Jwalasakhi were developed by the Department of plant breeding, College of Agriculture *Vellayani* through recombination breeding methodology (*Vellanochi* x *Pusajwala*). In Jwalamukhi, the immature fruit colour is dark

green turning to red on ripening. In Jwalasakhi, the immature fruit colour is sulphur green turning to red on ripening.

1.5 Objectives of the study

The study was designed based on the following objectives:

1) To analyze the physico-chemical characteristics of the effluent.

2) To study the effect of effluent on following parameters of *Capsicum annuum* L:

   2.1 Morphological

   2.2 Cytological

   2.3 Biochemical

   2.4 Yield

3) To find the tolerance limit of the effluent with respect to *Capsicum*

4) Evaluation of the utilization of the effluent for irrigation purpose by estimating toxicity in *Capsicum*

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