# INTRODUCTION

During the last few centuries man has acquired immense knowledge about science and technology. The application of man's scientific knowledge to meet his ever increasing needs has not left any part of the biosphere untouched, making his own survival precarious. Our planet, once free of all pollutants, is now being modified extensively by the shifting of materials from one place to another, converting them to less degradable forms or into toxic substances. The symbiotic relationship with the environment is thus tampered by human mismanagement.

The rapid revolutionization in industry and agriculture and urbanization are inseparably linked with some or other form of pollution. These in their wake lead to the discharge of large number of pollutants causing environmental pollution and serious ecological imbalances. The indiscriminate disposal of the

industrial and other wastes into the environment, increases the concentration of toxic pollutants and the very existence of our mother earth may become questionable. All living beings are preys of this hazard. Plant and animal lives which depend entirely on the characteristics of the environment are showing the signs of deterioration only because of the polluted atmosphere in which they exist. It is a fact that due to the stress imposed on the environment, the rate of exploitation of resources exceeds nature's capacity to reproduce them, and the amount of chemical and industrial effluents dumped into the environment exceeds its assimilatory capacity.

In broad perspective 'Pollution' means "such contamination of water or such alternation of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural, or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms" (Govt. of India 1974).

Water, like air is a precious resource which is taken for granted by most people except in areas where this commodity is scarce. Since most of the industries are situated on the banks of rivers or other water bodies, they become the final sinks into which the various pollutants find their way. The water thus becomes unfit for drinking, irrigation or even for bathing and various health problems are caused by this polluted water.

In India not a single water body is devoid of one or other form of pollution. Water pollution is mainly caused by dissolved inorganic materials, organic materials like proteins, fats, carbohydrates and substances found in domestic and industrial wastes and physical factors such as turbidity, colour, temperature of effluent, associated radioactivity, etc..

Inorganic pollutants such as alkalies, acids, inorganic salts, other chemicals etc. are discharged mainly from industries like paper and pulp, tanneries, textiles, coke ovens and many others. Inorganic chemicals like 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 wastes, alkali producing units, polyvinyl chloride, coke oven and fertilizer industries. Large quantities of free acids and neutralized chemicals are produced by phrmaceutical industries. The effluents from fertilizer factories contain chemicals like chromates, phosphates, ammonia and urea.

High molecular weight compounds like sugars, oils and fats, and proteins obtained from distillery, canning, sugar and other food processing units contribute to organic pollution. They impart a high BOD load to the liquid waste, because a large quantity of dissolved oxygen is necessary to degrade these organic substances. When dissolved oxygen is reduced below a certain limit aquatic life becomes threatened. Oil spillage, liquid effluents from industries manufacturing drugs, dye stuff, pesticides and detergents also can be toxic. The anionic detergents leading to a lot of foaming and frothing are also worth mentioning.

The ceramic, paper and pulp mill industry effluents, fine clay particles, milk wastes, sewage, free peroxides from iron and other metal salts impart turbidity to water. Turbidity inhibits light penetration and will adversely afffect the photosynthetic rate of aquatic flora, consequently the life of aquatic fauna too. The liquid effluents from pickling, paper and pulp, dye stuff, tanning and textile industries cause colour pollution. Colour too cuts off the sunlight required for photosynthesis. Synthetic detergents and effluents from industries such as paper and pulp give rise to foams which are quite stable due to the presence of surfactants. Stable foam makes the treatment of liquid waste highly ineffective. They also carry suspended solids and pathogenic bacteria. Thermal pollution of water is also dangerous as the hot effluents discharged into the water, causes the temperature to rise there by decreasing the equilibrium content of dissolved oxygen even below the critical level.

Various types of insecticides and pesticides too cause serious environmental pollution. The alarming fact is that they are capable of undergoing biological magnification.

The nitrates in the polluted water cause many serious problems. The main sources of nitrate pollution are nitrogen fertilizers, garbage, industrial effluents, septic tank etc. When the nitrate in drinking water becomes excess, a disease called "methemoglobinemia" or "bluebaby" will be caused in children. Another environmental nuisance is phosphorus. Here too the main source is fertilizers. Phosphorus and nitrogen cause algal blooms, by acting as nutrients for a luxurient algal growth

which rise the BOD and destroy the aesthetic beauty of water bodies imparting foul smell and odour.

The sulphurdioxide and nitrogen oxide in the atmosphere will reach the soil as their respective acids during rain and will release heavy metals such as Mn, Fe, Hg, Cd etc. from their compounds which in turn destroy plant cells.

The water pollution problems become more prevalent during the dry season, when there is no rain and the water bodies get saturated with the waste matter. Pollution effects due to discharge of industrial effluents in the indian rivers have been studied by many workers. Bhimachar and David (1946) studied the effects of factory effluents on the Bhadra river fisheries at Bhadravati. Ganapati and Alikunhi (1950) studied the factory effluents of Mettur Chemical and industrial Corporation Ltd., Mettur Dam, Madras along with their pollutional effects on the fisheries of Cauvery river. Ganapati and Chacko(1951 a) observed the physical, chemicaland biological conditions of Pambam, Kodiathanar and Gundur river. Ganapati and Chacko (1951 b) reported the effect of pollution on Godavari river due to wastes of paper mills at Rajahmundry. Motwani et al. (1956) studied the pollution of river Sone by factory effluents of the Rohtas Industries at Dalmianagar. Bhaskaran(1959) studied the effect of industrial waste on river water in Uttar Pradesh and Bihar. Quasim and Siddiqui (1960) made some preliminary observations of river Kali affected by effluents from industrial origin. Venkateswarlu (1969 a,b,c) studied ecology of algalflora of the Moosi river, Hyderabad,with special reference to water pollution. He studied the physico-chemical characteristics affecting the

distribution and periodicity of algae. Pollution studies of Chambal river and tributaries at Kota was made by Dlaniya et al. (1976). Agarwal et al. (1976) studied physico-chemical characteristics of the Ganga river at Varanasi. Rama Rao et al. (1978) studied the effect of pollution on river Khan (Indore) and made assessment of river water by biological community. Govindan and Sundaresan (1979) carried out works on the pollutional aspects of Adayar river in Madras and its effect on the aquatic life with special reference to algae and their seasonal succession over a period of one year. Sreenivasan et al. (1980) studied pollution effect of industrial and urban wastes on river Cauvery. Prasad and Saxena (1980) extended their study on the blue green algae in relation to industrial pollution of the river Gomati at Lucknow. The changes in algal flora in the Cauvery river due to industrial and domestic pollution was studied by Parmasivum and Sreenivasan(1981). Effect of industrial effuents on phyto plankton communities of the river Ganga at Barauni was studied by Bilgrami and Siddiqui (1980). Boralkr et al.(1982) studied the pollution among Krishna river. Balachand and Nambisan (1986) extended their study on the effect of pulp and paper mill effluent on the water quality of Muvattupuzha river emptying into Cochin backwaters. Jeyraj et al.(1992) studied the impact of heavymetal pollution on the productivity of water body.

Plants are the saviours of the environment and they help to maintain the balance and good health of natural ecosystem. When the undiluted waste water is used for irrigation, plant growth will be adversely affected. Many scientists have worked out the

effect of industrial effluent on seedling growth and seed germination of higher plants (Singh et al. 1985; Mishra and Singh 1987; Bahadur and Sharma 1988; Manoharan and Lakshmanan 1988;Sahai and Srivastava 1988; Tripathi et al. 1990; Swaminathan and Vaidheeswaran 1991; Swaminathan et al. 1992; Vijayakumari et al. 1993; Balasouri and Prameeladevi 1994; Hari et al. 1994; Muthukumar and Arockiasamy 1994; Taghavi and Vora 1994). Hari et al. (1994) studied the combined effect of wastes of distillery and sugar mill on seed germination, seedling growth and biomass of Okra. According to them, in higher concentrations of effluent the growth of the seedlings was affected adversely and at lower concentrations the growth was favoured. The same view is shared by Sahai and Srivastava (1986), Kumar et al.(1990), Patel and Kumar (1990), Swaminathan and Vaidheeswaran (1991), Gautam et al. (1992), and Taghavi and Vora (1994).

The effects of industrial effluents on germination growth and yield of crop plants have become a field of study for many workers like Singh et al. (1970,1985), Behera and Misra(1982), Lokhande and Bhosale (1983), Somasekharan et al. (1984), Dixit et al.(1986), Singh and Misra (1986), Saxena et al. (1986), Nirmala Rani and Janardhanan(1988, 1989), Rajaram et al.(1988), Sundarmoorthy and Lakshmanachary(1989); Subramaniyan et al. (1990); Vijayakumari and Kumuda(1990) and Vijayakumari et al.(1993).

Sewage and industrial waste waters sometimes contain considerable amounts of salts which may serve as nutrients for plants. Soils have the greatest capacity for receiving and decomposing wastes and pollutants (Bouwer 1970; De Vries 1972;

Young et al. 1975). Tripathi et al. (1990) have studied the influence of chemical and fertilizer factory effluent on physico-chemical properties of soil and germination and mineral composition of wheat. They observed high concentration of N,P and K in the effluent treated soil. But the porosity and water holding capacity of the soil were reduced by the effluent. The germination of wheat was negatively affected.

In recent years the use of industrial effluents, after proper dilution for irrigation is the most commendatory approach. The use of industrial wastes for irrigation as an alternative to other disposal methods can be attractive (Thabaraj et al. 1964; Day 1973; Pound and Critis 1973; Bauwer and Chaney 1974; Hedge and Patil 1983) . Many workers have captivated their attention on the effect of industrial waste water on soil and crop plants (Piper 1950; Steel and Bey 1954; McCermic 1959; Day et al. 1972; Soon et al. 1978, 1980; Rajannan and Oblisamy 1979; Feign et al. 1979; Behera et al. 1980; Ajmal and Khan 1983, 1984, 1985; Ajmal et al. 1984; Somshekhar et al. 1984; Singh and Misra 1987; Swaminathan and Ravi 1987).

The most important process in plant life is photosynthesis. In this respect the chlorophyll pigments proved to be of prime concern. The photosynthetic productivity of plants can be elucidated by the quantitative analysis of the chlorophyll pigments. Various enviornmental factors like light, temperature, oxygen, moisture content, metallic ions and nutrients control the synthesis of chlorophyll and any undesirable changes in these factors may decline the process.

Environmental pollution plays an important role in deciding the destiny of chlorophyll synthesis. Many scientists have done extensive work in this field. Singh and Rao (1981), Sahai and Srivastava (1986), Satyakala et al. (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.

Many workers have studied the impact of industrial wastes on aquatic flora ( Palmer 1980;Rishi and Kachroo 1981; Re Boredo and Carlos 1984; Ahluwalia et al. 1989; Ambros et al. 1994) and fauna (Ray 1961; Sprague and MC Lease 1968; Blinski and Jonas 1973; Shumway and Palensky 1973; Thomas 1973; Verma and Delela 1975; Johnson 1977; Misra et al.1985).

When the industrial wastes 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 Rav 1966; Venkataraman 1966; Chockalingam and Balaji 1991).

The pulp and paper industry is one of the oldest and major industry in India. There are 123 paper mills in the country and India ranks 20th among paper producing countries of the world (Mahajan 1989). Most of the paper producing units in India are integrated pulp and paper mills. Paper mills are believed to consume 230 - 500$M^3$ of water per tonne of paper produced (Wagh mare et al. 1986). The volume and characteristics of the pulp and paper mill effluent depend on the type of manufacturing process adopted and the extent of reuse of water emlpoyed in the plant. The process of manufacturing paper has two phases, pulp making

and the making of final products of paper. Most of the units utilise different cellulosic materials like bamboo, bagasse, straws, grasses etc. as raw materials in pulp mills. In the pulp making process, the chipped cellulosic raw materials are digested with different chemicals in one tank under high temperature and pressure. The commonly used methods for pulping are ground wood process, Kraft or sulphate process, Sulphite process, Soda process and Neutral Sulphite semichemical pulping (NSSC) process.

In ground wood process the debarkened wood is ground against a rough and abrasive surface using large quantities of water. In Kraft or Sulphate process the raw materials are digested with a solution containing sodium hydroxide and sodium sulphate. The Kraft process has been widely employed in India and this process is especially adopted for bamboo in Indian paper mills. The BOD discharge from a Kraft papermill is about 25kg/tonne of pulp produced. In Sulphite process, magnesium or calcium bisulphite and sulphuric acid are used as digesting chemicals. The BOD level of the spent liquor is around 450 kg/tonne of pulp produced which is very high compared to Kraft process. In Soda process the digestion of the raw material is in a cooking liquor consisting mainly of sodium hydroxide under pressure. In NSSC pulping process the pulping liquor is made of sodium sulphite solution at a pH of 7-9 which is maintained by using sodium carbonate buffer.

The liquid waste from paper and pulp industry is generated from two different sources, from the pulping process and from the paper making unit. The characteristics of the two waste

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waters are quite different in both quality and quantity. The liquid waste from pulp industries is black in colour and is known as black liquor. It mainly consists of organic as well as inorganic dissolved solids, suspended solids and excess of chemicals. The suspended matter contains fibres, quit and sand. The black liquor in sulphate and soda process is highly alkaline with pH in the range of 10-12, but the spent sulphite liquor is highly acidic with pH varying between 3 and 4. The COD to BOD ratio may be high ranging between 2.5 and 4.5 and is mainly due to lignin and fibres which are not easily biodegradable. Lignin is an amorphous polymer of phenyl-propane derivative found in woody parts of plants. The lignin content may vary in the range of 7,000 to 90,000 mg/l.

The pulp mill effluent contains a high concentration of suspended solids.Based on the figures given by Waldichuk(1962) and Webber (1969) a typical sulphite process mill may discharge effluent with total solid concentration of about 6000 ppm. They accumulate at the bottom and destroy the benthic community to a great degree.

A good example of destruction of the benthos by pulpmill sludge has been provided at Cousins In let, British Colombia. A pulpmill at the head of the inlet began discharging effluent into the estuary in 1913. The effluent consisted of a mixture of waste water from the production of Sulphite and Kraft pulp newsprint and speciality paper (Waldichuk 1962). The particulate materials in this effluent settled to the bottom of the inlet, due in part to the flocculating effect of salt water on the suspended solids (Waldichuk 1962). The decomposition of this precipitated sludge

produced anerobic conditions both in the sediments and in the bottom waters of the inlet. No living animals were found in the area of these sludge deposits and the odour of $H_2S$ was apparent when a sediment sample was brought to the surface (Hoirston and Herlinveaux 1957).

The suspended solids of pulpmill waste may exert direct toxic effect on certain organisms. Sprague and Mc Leese (1968) reported that pulpmill suspended solids may plug the gills of the fish, leading to extreme cases of suffocation.

A survey by Ghosh et al. (1973) revealed that 96 industries discharge their effluents into the Hooghly estuary. f these 41 include pulp and papermills employing sulphite, sulphate and soda processes. Pulp and paper industry contributes 28.59 tonnes $BOD_5$ (43.2%), 547.40 tonnes total solids (61.2%), 299.20 tonnes suspended solids (72.5%) and 24.20 tonnes dissolved solids(51.5%). Extensive studies on the impact of paper and pulpmill effluent on Hooghly estuary have been done by various scholars (Basu 1966; Basu et al. 1973; Ghosh et al. 1977, 1980; Ray et al. 1977; Ray 1980; Ray and Mitra 1980).

The hazardous impacts of paper and pulpmill effluents on the biological world have been worked out by various scientists. Among them those who need special mention are Spulnik (1940), Verma and Dalela (1975), Rajannan and Oblisamy (1979), Balachand and Nambisan (1986), Ghosh and Konar (1980), Reddy and Venkateswarlu (1987). Misra and Behera (1991), Pritchard et al. (1991), Sudhakar et al. (1991 a,b), Rao and Rao (1992), Haupt and Folger (1993) and Pinkerton (1993), Rao et al. (1994), Rajannan

and Oblisamy (1979) reported that though the paper and pulpmill effluents are detrimental to plant growth at higher concentrations they can promot plant growth at lower concentrations. Reddy and Venkateswarlu (1987) opine that the organic content, nitrites, phoshphates, solids etc.from the paper mill effluent will alter the ionic composition of the river water and the flora and fauna. Pulp and papermill effluents are generally found to be toxic to many aquatic organisms, specially to the primary producers algae by reducing the available light, changing the pH and decreasing the nutrients due to increased bacterial activity and toxic compounds (Kuievasniemi et al. 1986).

The germination percentage, water imbibing capacity, growth, pigment, carbohydrate and protein contents of rice seedlings showed a decreasing trend when treated with effluents from paper industry (Misra and Behera 1991). Pritchard et al. (1991) reported that dehydroabietic acid, a major anionic contaminant of pulpmill effluent reduces both active P-amino hippurate transport and passive membrane permeability in isolated renal membranes. Effect of papermill sludge disposal on the yield and mineral nutrition of oats was studied by Dolar et al. (1972).

Rao and Rao(1992) studied the impact of effluent water from paper board industry on alluvial soils and crops. Santhamurthy and Rangaswamy (1979) studied the effect of papermill effluent on cytological characters of plants. They observed vacuoles in the root tip cells of *A. cepa* exposed to papermill effluent and the chemicals produced clumping of chromosomes and caused acute chromosomal damage. Pinkerton (1993) reported how the emissions

of $SO_2$ and NO from pulp and paper mills cause the pollution of atmosphere.

A number of surveys have demonstrated that the industrial effluents produce striking changes in the biotic community. Some species may be unable to survive and others may persist in reduced number. Some species of algae, fungi and bacteria can develop and survive in the papermill effluent and these can be implicated in the biological treatment of pulp and papermill effluent and as the indicators of the polluted nature (Whitton 1975; Kawakami and Kanda 1976; Somashekhar and Ramaswamy 1983; Reddy and Venkateswarlu 1986; Manoharan and Subramanian 1992).

The objective of the present work is to bring out the impact of the effluent from the Hindustan Newsprint Ltd. Velloor, Kerala on four economically important plants - Abelmoschus esculentus (L.) Moench, Cucumis sativus L., Lycopersicum esculentum, Mill. and Sesamum indicum, L.. The factory is situated on the banks of Muvattupuzha river emptying its effluents into it . Many vegetable crops are cultivated on the river banks and the water is used for irrigation. The extent of damage done by the polluted river water to the crop plants could be evaluated by the present study.

Hindustan paper corporation was established in 1970 by the Govt. of India to meet the vastly growing demand for different kinds of paper in India. In 1983 Hindustan newsprint Ltd. was established as a subsidiary of HPC. HNL is the largest newsprint factory in the whole of Asia. Newsprint is made from 75 percent chemi-mechanical pulp (CMP) and 25 percent chemical pulp (CP).

The raw materials for the pulp are bamboos, reeds and Eucalyptus trees.

As the demand for paper is increasing daily, new pulp and paper mills are being established in India. The pollution generated by pulp and paper mills are equivalent to that generated by a population of 5 million. But in a developing country like India, industrial prosperity is very important. At the same time one cannot be blind towards the environmental pollution caused by these industries. Therefore prime concern should be given to establish proper steps to abate pollution from existing mills and incorporate pollution control measures in proposed mills at their planning stage itself, so that a healthy industrial growth takes place and both the wealth and health of the country and countrymen prosper.