Review of Literature
REVIEW OF LITERATURE

Properties of dyehouse effluent

The quality of water is pivotal for living system which has been greatly affected by the indiscriminate discharge of industrial and domestic effluents into natural aquatic ecosystem. Water pollution has created a number of hazards to the living system (Kankal et al., 1996; Neelam and Sharan, 1998). The dyehouse waste water is one of the major effluents discharged into river, sewage system and on land without proper treatment (Ravikumar and Dutta, 1996).

The normal dyeing processes of a textile plant varies from day to day and batch to batch, and results in considerable variations in the waste water characteristics, particularly colour, pH and COD (Gurunhaur, 1965; Kothandaraman et al., 1976; Lin and Lin, 1993). The hazards of uncontrolled release of dye toxicants into water bodies and land have been assessed through several parameters.

The dyehouse effluents were highly coloured and also had high COD, total dissolved solids and sodium and alkali salts (Kothandaraman et al., 1976; Solazenzo et al., 1995). The maximum pH (11-12) was in sulphur dye section (Kothandaraman et al., 1976). Badrinath et al. (1983) observed that dyeing section generated maximum waste water while printing and reactive dye section generated the minimum. Effluent from saree printing industry had higher value for all the parameters except dissolved oxygen. The chemical oxygen demand was very high (688 mg/l) while the maximum limit of COD for effluent to be discharged into inland surface water had been recommended as 250 mg/l (Jain and Agarwal,
1989). Effluents of kota saree printing industry were alkaline (pH 8.7 - 11.2) with high total suspended solids and dissolved solids (Agarwal and Agarwal, 1990).

The dyeing factory effluents of Selvapuram, Coimbatore had different colours and contained high amounts of total suspended and dissolved solids and significant amounts of nitrate, phosphate and potassium (Swaminathan and Vaidheeswaran, 1991). The coloured dye wastes frequently contained a spectrum of heavy metals and other toxic organic pollutants (Mckey et al., 1985; Ray, 1986). Many dyes used as colouring material might be toxic to some aquatic organisms (Judkin and Hornsby, 1978; Raiyani et al., 1994; Doctor et al., 1998).

The effluents were disposed either in land or water course, as a consequence the receiving stream water was deeply coloured affecting photosynthesis of plankton (Rao et al., 1993). Suspended impurities made the receiving water highly turbid and the water became alkaline or acidic depending upon the nature of chemicals in the effluents. The presence of sodium salts in the dyeing waste water makes it unsuitable for irrigation (Rao et al., 1993). Most of the textile effluents did not have high BOD but they exhibited wide range of pH (2-12) and colour variation. They also had high COD (Ravikumar and Dutta, 1996).

**Effect on soil characteristics**

Soil is used as a medium for waste disposal. Soil has greater capacity for receiving and purifying the anthropogenic pollutants. At the same time excess inputs of the pollutants would result in the alteration of physico-chemical properties of soil environment Rao et al. (1993) noted that the irrigation of Bandi with river water receiving continuous discharge of effluent from textile industries degraded 1000 ha of land.
Somesekar et al. (1984) also studied the effect of textile, paper and automobile industry on soil properties. The effluents contained plant nutrients like N, P, K, Ca, Mg, B, Fe and Cu in varying concentrations. The raw effluents affected soil physico-chemical properties. The movement of pollutants through soil had also enhanced ground water pollution.

**Effect on soil microorganisms**

Industrial effluents are rich in a variety of organic and inorganic chemicals depending upon the type and nature of the industrial products and manufacturing process. The type and number of microorganism in the effluent directly depend on the nutrient concentration. Microbial population and their activity in soil were increased by addition of dyeing factory effluent (Swaminathan and Ravi, 1987). The toxic substances such as chromium salt and aniline dyes drastically reduced the beneficial microbial load (Raiyani et al., 1994). In contaminated soil, the rhizosphere microbial populations increased after remediation (Nicholas et al., 1996).

**Effect on crop plants**

Textile industry requires large volume of water for their processes and waste water discharged was also in large volume. In majority of cases, the wastes are discharged into river without any pre-treatment that highly polluted the ecosystem (Fraser and Clark, 1984). At higher concentrations, the dyeing and textile effluents inhibited the seed germination in *Cicer arietinum* where, the inhibitory effect was more pronounced in radicle growth. The nodule number and dry weight of shoot and root were also inhibited (Dayama, 1987). Jain and Kumari (1990) observed that the germination of *Spinacea oleracea* was enhanced with increasing concentration upto 5% thereafter, it decreased. At 75% concentration, the seeds failed to germinate.
The diluted dyeing factory effluents increased the seed germination of *Arachis hypogaea* and stimulated the seedling growth. The root/shoot lengths, total biomass and chlorophyll content increased with concomitant increases in the effluent concentration up to 50 per cent. But above 50%, the effluent became toxic (Swaminathan and Vaidheeswaran, 1991). The textile dyes, navy blue MBR and direct brown 2G, not only reduced the percentage of seed germination in *Vigna radiata* (L.) Wilczek, but also influenced various morphological, biochemical and physiological parameters. Of them, the former had higher adverse effects. The adverse effects of the said dyes were higher in black soil than red soil (Sujatha et al., 1992).

The impact of dyeing and sewage effluents on germination of green gram and maize seeds was evaluated by Shanmughavel (1993). The dyeing effluent delayed the commencement of germination and also reduced both the germination percentage and germination value. Soil analysis after the experiment indicated that in addition to increased nutrients and minerals, the pollutants like alkali dyes and oil were notably rich in the polluted soil.

Jain and Khan (1996) observed that the adverse effect of textile industry effluent on plants was due to use of synthetic dyes. Observation on root and shoot lengths and dry weight of the test seedlings showed an overall decrease with effluent treatment. Contents of chlorophylls a and b, total chlorophyll, proteins and carbohydrates also showed significant decreases. Ponmurugan and Jayaseelan (1999) assessed the impact of fire work and dye industrial effluents at 1, 2, 3, 4 and 5% concentrations on the seedling growth of *Typha angustata*. The germination percentage decreased with the increasing effluent concentrations. Reduction in root...
and shoot lengths and biomass accumulation of the seedlings treated with higher concentrations of the said effluents indicated that dye factory effluent was more toxic than fire work industry effluent.

Other effluents

A comprehensive account on the environmental impact of other industrial effluents is beyond the scope of this review. However, some recent literature on the effluents pertaining to a cross section of industries are summerised here for comparison.

Physico-chemical properties

The paper mill effluent had higher suspended and dissolved solids, COD and BOD (Dhaneshwar et al., 1970). The major pollutants observed from the tannery effluent were high levels of sulphides, chromium, BOD and COD (Mbuthia et al., 1989). Vijayaram et al. (1989) observed the physico-chemical characteristics of slaughter house effluents. Quantities of solids, BOD, COD, oil and grease, ammoniacal and organic nitrogen and alkalinity were higher, while the amount of DO was low. Rubber factory effluent was highly acidic with fluctuating pH and dissolved oxygen (Crossbell, 1990). Tannery industry discharged solid and liquid toxic chemicals into the surrounding environment (Dhanapal et al., 1990).

Gautam and Bishnoi (1992) found that the diary effluent was highly alkaline and saline with no dissolved oxygen. The values of oil, grease, TDS, BOD, COD and basic nutrients were beyond the permissible limits. The long-term effects of irrigating digested Palm Oil Mill Effluent (POME) in oil palm plantations was reported by Hamdam et al. (2001).

The briquetting and carbonization waste water showed high amount of suspended and dissolved solids (Sundaramoorthy and
Lakshmanachary, 1992). Continuous application of sewage effluent changed the soil to alkaline and also increased the salt content (Chang and Cline, 1993). Baruah et al. (1996) found higher values of pH, COD, BOD, DO, alkalinity, hardness, chloride, sulphate and calcium from Nagaon Paper Mill effluent. The bicycle manufacturing industry effluent exhibited high concentrations of chromium, cyanide, oil and grease (Sastry et al., 2000).

Ramana et al. (2002) conducted experiments to study the effect of different concentrations (5, 10, 20, 25, 50, 75 and 100%) of distillery effluent on germination value in some vegetable crops (tomato, chilli, bottle gourd, cucumber and onion). Based on the tolerance to distillery effluent, the crops studied were arranged in the order cucumber > chilli > onion > bottle gourd > tomato.

**Effect on soil characteristics**

Mahida (1981) reported a reduction in infiltration rate and pore size which directly affected the movement of air and water in a soil when irrigated with industrial and domestic waste water. A significant increase in soluble salt (EC and CEC) of the soil receiving fertilizer factory effluent was reported by Singh and Mishra (1987). Sewage irrigation raised the NPK contents in the soil (Kilmo and Fekette, 1990). The effect of phosphate factory effluent on black and red yellow soil was studied by Mamta and Naik (1990). No significant change in soil temperature and pH was evident due to application of alcohol and chemical factory effluents (Manonmani et al., 1990). Conductivity, organic matter, water holding capacity, available phosphate, total phosphate, megnesium and total nitrogen were found to be rich in the steel mill effluent polluted soil for many years (Archana and Naik, 1991). Irrigation of sewage effluent for 67
years resulted in increased total and available heavy metals like Pb, Cd, B and Zn in surface layers of soil, but did not reach the toxic level (El-Hassanin et al., 1992).

Report of Palanisamy and Sreeramulu (1994) revealed that after 15 years of continuous irrigation with paper mill effluent, the soil showed a pH of 8.28 and increased range of EC, available micronutrients and enzyme activities in the surface and subsurface soil. Further, the available nitrogen content was more in the second and third year effluent irrigated soils than 15 years irrigated soil. Different organic amendments with paper mill effluent treated soil showed considerable decrease in bulk density.

Elevated EC, soil acidity and salt content were observed in soils treated with industrial effluent and distillery effluent wastes by Prasad (1996). Arenholt et al. (1996) revealed that discharge of waste water from dental clinic showed high accumulation of Hg posing serious ecological risk. Liv et al. (1996) analysed the sugarcane soil receiving short and long-term application of swine lagoon effluent. They noted more amount of Ni, Cd, Cr, Pb and Zn. The soil irrigated with industrial effluent was found to have high amounts N, P, K and micronutrients like Zn, Mn and Fe (Vasu et al., 1998). Prabhakara Rao and Prasada Rao (2002) studied the pollution potential on environment by Sago industry. They confirmed that this effluent might bring about severe ecological imbalance in the near by agro-ecosystem.

**Effect on soil microbial population**

Land application of waste waters (industrial and domestic) is believed to stabilize the organic materials in the soil by microbial
population and their activity. The addition of sewage (Cooke, 1976) and distillery effluent (Manonmani et al., 1990) enhanced microbial population in soil. The population composition and activity of microorganisms were largely regulated by soil physico-chemical parameters such as nutrient availability, moisture and toxicity (Tiwari et al., 1987).

Many industrial effluents had heavy metals such as Pb, Cd, Cr, Ni and Hg as effluent constituents. These heavy metals increased their concentrations and thereby reduced soil microbial process and microbial biomass (McGrath et al., 1988). Aafea Juwarkar et al. (1989) showed that bacterial, fungal and actinomycete populations increased with the application of sewage effluent. The growth of Rhizobium was suppressed by application of raw sewage, diluted sewage and settled sewage but the population increased in soil irrigated with treated effluent.

The application of decomposed paper mill sludge at the rate of 10 – 20 t ha\(^{-1}\) improved the biological activities (Ityatdinov et al., 1990). Rajannan and Kandasamy (1990) noted that the protein industry waste harboured considerable number of bacteria, actinomycetes and fungi. Application of the pulp and paper mill wastes increased the microbial population and soil fertility (Chauhan and Kaur, 1991). The effect of domestic waste water irrigation on VAM population was studied by Srinivasan et al. (1995). Plants growing in the waste water irrigated soil had higher VAM fungal colonization compared to plants in ground water irrigated soil.

Gostowaska et al. (1996) observed that tobacco industry waste was rapidly decomposed and contained large amounts of minerals especially N. When applied to soil, it stimulated CO\(_2\) evolution and increased the
number of bacteria and fungi. The industrial (metal smelting and petroleum production) Yanbu city released various heavy metals. The lowest concentrations encouraged the fungal populations on polluted soil (Abdul Rahman et al., 1996). Sandana (1995) reported that microbial population increased with increasing rate of deoiled rice bran waste to soil whereas the application of acid alkali sludge and chrome sludge at higher rates partially inhibited microbial activity. Sanjeeda and Menta (1996) recorded maximum populations of bacteria and fungi in February from the sugar mill effluent irrigated soil.

**Effect on plant growth parameters**

Much information is available in India on the growth and yield of various crops as influenced by different industrial effluents (Tietjan, 1977; Rajannan and Oblisamy, 1979; Sahai et al., 1979; Behera et al., 1980; Agarwal et al., 1981; Rameshkumar et al., 1990; Subramaniam et al., 1990; ). The effective utilization of the effluents as irrigation water for their fertilizing value has also been suggested.

According to Mishra and Sunanda (1989), the chlorophyll content, shoot length and grain yield of paddy were increased by paper and pulp mill effluent irrigation. Reduction in growth of rice, maize, cotton, black gram and tomato crops due to irrigation with paper mill effluent has been reported by Somesekar et al. (1984). The reduction could be attributed to high amounts of dissolved solids resulting in the osmotic imbalance of the root system. The raw paper mill effluent significantly altered the seedling growth in maize but failed to have any significant effect on later growth and production. However, the results were encouraging in soil treated with 50% effluent concentration.
Rajendrababu (1987) studied chromate factory effluent which was highly toxic to plant growth and inhibited germination even at lower concentrations. The reservoir and well water near the industry were also polluted by the effluent, leading to plant growth inhibition. A favourable yield response due to presence of macro-nutrients in industrial effluent, which served as additional potential source of liquid fertilizer for the plants in diluted form, was suggested by Sundaramoorthy and Lakshmanachery (1992) in groundnut and Patel and Ramesh (1991) in *Brassica juncea*. On the other hand, the higher concentrations of distillery effluent inhibited the wheat crop growth (Ravi and Srivastava, 1988). Rajannan and Kandasamy (1990) studied environmental pollution in Pykara river by the discharge of protein industry effluent. Jabeen and Saxena (1990) found that the lower concentrations of distillery effluent upto 5% and fertilizer factory effluent at 2.5% were more favourable for plant growth and enhanced dry matter production, pigment content and protein content.

Irrigation with combined raw effluent from paper mill reduced the germination vigour indices of crop plants. After dilution, however, it did not significantly affect the seed germination and plant growth. Following aerobic treatment, the effluent was directly used for irrigation without any dilution and it favoured the growth of crop plants (Kannan and Oblisamy, 1992). Ozair Azis *et al.* (1993) noted the effect of refinery waste water on nitrate reductase activity where, the enzyme activity was stimulated by effluent application in *Vigna radiata* L. The seeds of *V. mungo* failed to germinate in undiluted distillery effluent and very few seeds germinated in 75% concentration. The morphological and biochemical parameters exhibited low values in 10, 25 and 50% concentrations. Other lower
concentrations (1%, 2.5% and 5%) were found to be optimum with sufficiently rich nutrients (Kannabiran and Pragasam, 1993).

The effect of match factory effluent on the primary productivity of *Hydrilla verticillata* was studied by Arunachalam and Pandiaraj (1994). The various concentrations of the effluent reduced significantly the primary productivity and total chlorophyll content. Patra and Panigrahi (1994) observed the drastic depletion of chlorophyll content in the leaves of *Pistia* and *Hydrilla* when treated with chlor-alkali industry effluent. IFFCO industry effluent contained major elements like Na, Ca, Mg. Its higher concentration reduced chlorophyll, protein and amino acid contents in guar (Manuchehr Taghavi and Vora, 1994). Singh and Arya (1994) studied the combined effect of distillery and sugar mill effluent on okra where the germination percentage, seedling growth and biomass were promoted by the effluent upto 25% concentration. Balashouri and Prameeladevi (1994) recorded increases in the germination percentage, seedling growth, chlorophyll content and phytomass accumulation with corresponding increase of tannery effluent concentrations upto 15% for *Vigna radiata* L. and *Cajanus cajan* L. and 75% for *Sorghum bicolor* L. The higher concentrations showed inhibitory effect.

Jameson and Rana (1995) observed the effect of industrially polluted Kharvi water on bajara, radish and mustard crops. The fresh weight, dry weight, root and shoot lengths and root shoot ratio of seedlings were adversely affected by hyper concentrations of the polluted water. The higher concentration (50 to 100%) of the alcohol and chemical factory effluent reduced the germination rate and also suppressed the storage products in the cotyledons. The metallic ions of the effluent were attributed for the inhibition of the aforesaid process resulting in the
overall inhibition of seedling growth (Janardhanan, 1998). Sundaramoorthy et al. (2001) studied the effect of different concentrations (1, 2, 5, 10, 25, 50, 75 and 100%) of fertilizer factory effluent on seed germination and seedling growth in four varieties of groundnut. The percentage of germination and the seedling growth increased from 1 to 10% concentration of the effluent and other higher concentrations decreased germination percentage, seedling growth, fresh weight and dry weight.

The copper-ore effluent had favourable effect on cereals (wheat, maize and paddy) but the 100% effluent showed deleterious effect. The peculiar effects of the effluent were traced to xanthate (143 mg/l) (Shivhare and Pandey, 1995). The germination, seedling growth, concentrations of photosynthetic pigments and nutrient uptake in wheat were studied in response to sugar mill effluent application in aqueous medium vs soil medium. The germination was not affected in both but the seedling growth was reduced in aqueous medium (Kaushikbala et al., 1996). Prasannakumar et al. (1997) observed that 25% concentration of diary effluent supported maximum growth in green gram and black gram. Joshi et al. (1999) noted maximum reduction in growth of root and shoot, dry mass, total chlorophyll and chlorophyll a and b by many industrial effluents (electroplating, leather, tanning, paint and textile industries). Ghosh et al. (1999) showed negative correlation by distillery and sugar mill effluents on the growth of some legume crops.

The negative influence of higher concentrations of carbonaceous sugar mill effluent on chlorophyll a, b and total chlorophyll was examined by Arindam (2000). However, the 10% concentration showed stimulatory effect on pigment content of Hordeum vulgare. The periodic effluent
treatment (carbonaceous sugar mill) also adversely affected plant height, number of leaves, spike length, number of grains per spike and yield per plant. At higher concentrations, the plywood industry effluent significantly reduced seed germination, seedling growth and dry weight of *Cicer arietinum* (Ghosh and Pankajkumar, 2000). According to Pragasam and Kannabiran (2001), 50 to 100% distillery effluent concentrations inhibited growth and yield of a number of crop plants.