2. REVIEW OF LITERATURE

India is primarily an agricultural based country and its economy depends upon the rural developments. Among the various industrialized nations of the world, with the rapid growth of industries in India, the pollution had increased tremendously. There had been a general view that, the more industrially advanced country was the most polluted and it was likely to be. Water is one of the prime necessities of life, without it no life is possible.

Water is an important natural resource essential for all living beings. The important water resources are ponds, lakes, rivers, stream, etc. These water bodies provide water for drinking, irrigation, cooling for industrial machines and other domestic purposes. So any harmful change in the water causes many ill effects on the life of man and animals. The undesirable changes in water, that harmfully affect man, plants and animals is called water pollution. Urbanization is due to population explosion and industrialization is the main causes for water pollution.

Water pollution is a large set of adverse effects upon water bodies such as lakes, rivers, oceans and groundwater caused by human activities. Industries discharge a variety of pollutants in their wastewater including heavy metals, resin pellets, organic toxins, oils, nutrient and solids. Discharge can also have thermal effects, especially those from power stations, and these too reduce the available oxygen. Silt bearing runoff from many activities including construction sites, deforestation and agriculture can inhibit the penetration of sunlight through the water column, restricting photosynthesis and causing blanking of the lake or river
bed, in turn damaging ecological systems. Water pollution is a major problem in the global context.

The surface water is the main source of industries for waste disposal. It is found that almost all rivers are polluted in most of the stretches by some industry (Lenin and Thamizhiniyan, 2009). Although natural phenomena such as volcanoes, algae blooms, storms and earthquakes also cause major changes in water quality and the ecological status of water, these are not deemed to be pollution. Water is only called polluted when it is not able to be used for what one wants it to be used for. Water pollution has many causes and characteristics. Increases in nutrient loading may lead to eutrophication. Organic wastes such as sewage impose high oxygen demand on the receiving water leading to oxygen depletion with potentially severe impacts on the whole eco-system.

Industrial wastewater contaminates rivers and streams by discharging effluents directly and indirectly to our precious water sources. Generally wastewater from many industries such as textile, sugar, fertilizers, oil refineries, rubber, plastics rayon, paper factories, distilleries, tanneries, sago, dye, dairy etc., and other chemical factories produce all sorts of chemical contaminants. These polluted water irrigation reduces the yield of the crop. The demands upon Indian rivers for irrigation are already great, so the use of effluent for agriculture is in practice. The growing awareness of environmental issues and their potential health hazards caused by industrial waste water has prompted many countries to impose limits on the discharge of certain improperly or untreated effluents.
BIOLOGICALLY TREATED EFFLUENT

Biological invaders such as water hyacinth (*Eichhornia crassipes*) have become widespread on a global level (Drake and Mooney, 1989). Although policy to control the spread of invasive species is becoming more common, the congruent ecological impacts of specific organisms are less well known. Exotic species can alter the population dynamics and community structure of native ecosystems (Luken and Thieret, 1997). They tend to be most successful in disturbed habitats, consistent with the intermediate-disturbance hypothesis (Moyle and Light, 1996). Ecological concern over non-indigenous species considered as the most modified by human activity in the United States and may be the most invaded estuary in the world (Cohen and Carlton, 1998).

EICHHORNIA

Water hyacinth is native to Brazil and was first introduced to North America at the Cotton Centennial Exposition in New Orleans in 1884 (Gopal 1987). Water hyacinth is a South American native that has attained a very broad global distribution in tropical and semi-tropical countries. Its established distribution in North America is limited mainly to the southeastern United States and California, although non-permanent populations occur farther north in Illinois, Wisconsin, New York and Pennsylvania (USGS 2010). Water hyacinth is helophyte plant growing best in warm waters rich in macronutrients. Optimal water pH for growth of this aquatic plant is neutral but it can tolerate pH values from 4 to 10. This is very important fact because it points that *Eichhornia crassipes* can be used for treatment of different types of wastewater. Optimal water temperature for
growth is 28-30. Temperatures above 33 °C inhibit further growth (Center et al., 2002).

PISTIA

Common name is water lettuce. Origin is Africa or South America. *Pistia stratiotes* was first reported from Florida by J. and W. Bartram in 1765 (Stuckey and Les, 1984), which led to the belief that this plant could be a native to North America. The presence of co-evolved herbivorous insects in South America (Dray et al., 1993; Cordo and Sosa, 2000) suggested, however, that *Pistia* originated from South America. Today, the earlier descriptions from antiquity (Stoddard, 1989) and recent studies based on chloroplast- and mitochondrial-DNA sequences, including those from other aroids, together with fossil evidence, point to a palearctic origin (Renner and Zhang, 2004)

CHEMICAL COMPOSITION OF SUGAR MILL EFFLUENT

The higher concentrations of effluent contained higher amount of organic compounds such as calcium, iron, magnesium, sodium, sulphate and chromium which inhibits the growth metabolism. These effluents not only increase the nutrient level but also exceed the tolerance limit and cause toxicity (Mishra and Sahoo., 1999). The sugar mill effluent analyses showed that it was acidic in nature; it contained a large amount of suspended solids and dissolved solids resulting in high BOD and COD values (Thamizhiniyan et al., 2000). (Rathore et al., 2000) analyzed the chemical parameters such as considerable amount of calcium, magnesium, chloride, sulphate, fluoride, nitrate and silica.
(Senthilkumar et al., 2001) reported that total hardness and high level of acidity in the sugar mill effluent. Total potassium content present in the sugar mill effluent and the high toxic effect of heavy metals like Hg, Pb, Na and Mn present in sugar mill effluent were analyzed by (Ramakrishnan, 2001). The higher concentration of effluent decreased the shoot length and root length of groundnut. The same trend was observed in other crops treated with various industrial effluents (Mishra and Pandey, 2002). Fertilizer factory effluent contained considerable amount of nitrogen, chloride, sulphate, calcium and magnesium. Fertilizer factory possessed environmental problems due to discharge of effluents consisting of higher pH, EC, BOD, COD, TDS, total nitrogen, phosphate and sulphate content (Amathussalam et al., 2002).

The effluents contain high amount of total hardness, total dissolved solids, biological oxygen demand (BOD) and chemical oxygen demand (COD). The effluent not only affects the plant growth but also deteriorate the soil properties when used for irrigation, (Maliwal et al., 2004). In addition to that, some traceable amount of heavy metals such as zinc, copper and lead were also present in the effluent, (Borale and Patil, 2004). Studies on the physico-chemical characteristics of (Nomulwar et al., 2005) the sugar factory effluents revealed that most of the parameters such as colour, odour, total dissolved solids, chemical oxygen demand, total alkalinity, pH, temperature, phosphate and sulphate have exceeded ISI limits. (Kaushik et al., 2005) reported that the physico-chemical characteristics of untreated textile effluent was brownish black in colour, deficit in dissolved oxygen, rich in total solids, total alkalinity, BOD, COD with considerable amount of total
nitrogen, phosphate, chlorides, sulphates, sodium and calcium, but the potassium content was negligible.

Physico-chemical parameters such as BOD, COD, TDS and TSS were recorded to be higher than the permissible limits of CPCB in untreated dairy effluent (Thirugnanamoorthy, 2006). The sugar mill waste is a quite concentrated organic waste whose composition and volume may vary widely from factory to factory depending upon the availability of water maintenance and operational practices (Yadav and Minakshi, 2006). Fertilizer factory effluent contained considerable amount of nitrogen, chloride, sulphate, calcium and magnesium. Fertilizer factory possessed environmental problems due to discharge of effluents consisting of higher pH, EC, BOD, COD, TDS, total nitrogen, phosphate and sulphate contents (Ayyasamy et al., 2008). Vijayaragavan et al. (2011) reported that the substance high toxic effect of heavy metals Hg, Pb, Na, Mn were presented in sugar mill effluent. The effluent contained higher amount of suspended solids, which are responsible for the higher amount of BOD and COD. High amount of COD may be due to high amount of organic compounds which are not affected by the bacterial decomposition (Selvi et al., 2012)

SEED GERMINATION

The germination and growth behaviour of three varieties of rice grown under effluent treatment were reported. The variety Cauvery tolerated the pollutant effect much better than the varieties of Jaya and Ratna for tolerance to sugar mill and distillery effluents (Singh et al., 1985). The germination of kidney bean (Phaseolus aureus) and lady’s finger (Abelmoschus esculentus) seeds were
affected adversely due to 75 and 100 per cent treatment of the textile mill effluent when compared to control (Mohammad and Khan, 1985). Chandrasekar et al., (1998) reported that the 10 per cent concentration of sugar mill effluent irrigated on Vigna mungo the germination percentage was higher than the control.

Dhevagi and Oblisami., (2000) reported that the low concentration (10 per cent) irrigated, the germination percentage was high with paper mill effluent treatment on agricultural crops. (Arindam, 2000) reported that the 10 per cent dilution of the effluent was suitable for stimulating growth and it might be used as a liquid fertilizer. Six varieties of cowpea were screened for tolerance to dye industry effluent. The effect of fly ash pond effluent on seed germination of two varieties of legumes was reported (Das et al., 2000). The higher concentrations of the various industrial effluent inhibited germination percentage on Vigna radiata (Augusthy and Sherin, 2001), ragi crops (Kumawat et al., 2001) and Trigonella foenum graecum (Reddy and Borse, 2001). Sharma et al., (2002) studied the effect of fertilizer factory effluent (0, 1, 2, 5, 10, 25, 50 and 100 per cent) on seed germination of tomato cultivators PED, Pusa, Ruby and Rupal. Ramana et al., (2002) observed 15 per cent distillery effluent irrigated with cucumber, bottle gourd, onion, tomato and chilli were increased the germination percentage.

Singh et al.,(2005 b) reported that the lower concentration (10 per cent) of polluted water showed acceleration and beyond it retarded seed germination of duck weed. Among the six varieties, Co - 4 was reported to be the tolerant variety than the other varieties tested (Sumathi et al., 2006). Sundaramoorthy et al., (2006) reported that the 10 per cent concentration of sugar mill effluent increased the
germination percentage in tomato seedlings. Yadav, and Meenakshi, (2007) assess the toxicity of effluent on seedling germination, growth, biomass and yield of *Raphanus sativus* var. *Pusa chetki* (Radish) and *Abelmoschus esculentus* var. *Versha upha* (Bhendi). The germination per cent was decreased with rising of the effluent concentration.

Soundarrajan and Pitchai, (2007) found that, the application of spent wash, diluted at higher level (50 times) had increased germination percentage, growth, fruit yield and fruit quality of bhendi in a pot culture experiment. (Kannan and Upreti, 2008) reported that, germination percentage of *Vigna radiata* seedlings were increased due to distillery effluents and they pointed out the variation in germination percentage of mung bean (*Vigna radiata*) at various treatment. The maximum seed germination was observed in the seeds presoaked with untreated effluent for 6 h. At the same time, the germination percentage was inhibited in lower concentration of distillery effluent. Specific effects of distillery effluent on seed germination of mung bean had been reported and the observations revealed that lower concentrations of distillery effluent did not show marked inhibitory effect on seed germination.

The effect of undiluted and diluted (50 per cent) distillery effluent on seed germination and seedling growth of *Zea mays* and *Oryza sativa* was studied by Pandey et al., (2008). Khilji and Barbeen, (2008) were studied, the growth pattern and accumulation of *Hydrophyte umbellata* on treatment with diluted tannery effluent (20, 40 and 60 per cent) sludge. Diluted tannery effluent caused poor
germination of wheat but the germination percentage was increased on using diluted effluent in the study done by Tayyar and Yapici,(2009).

Indira and Ravimycin, (2009) reported that the germination percentage of five varieties of blackgram with increased tannery effluent treatment reduced the seed germination percentage. Kalaiselvi et al., (2009) reported that soap factory effluent was toxic for seed germination and seedling growth of finger and pearl millet, but when the effluent was diluted to 2.5 to 5.0 per cent it was improved the seed germination and seedling growth. Gaikar et al., (2010) studied the 10 per cent dilution of effluent enhanced the seed germination and 100 per cent effluent completely inhibited both seed germination and seedling growth. Yasmin et al., (2011) reported that higher concentration of industrial effluents caused the reduction of germination percentage of *Lens esculentum* varieties.

**SEEDLING GROWTH**

To protect the existing water resources, the reuse of waste waters and industrial effluents had become a common practice. (Agarwal and Agarwal, 1990). Rani and Srivastava, (1990) reported that the 75 and 100 per cent concentrations of distillery effluent proved to be lethal in the case of *Citrus maxima*. Srivastava et al., (1995) had reported the adverse effect of ordinary factory effluent on seedling growth in *Pisum sativum*. The high level of nutrients in the effluent has been reported to inhibit seed germination and seedling growth at lower dilutions of effluent while might be due to the presence of excess amount of dissolved solids, chlorides, sulphides chromium, high BOD and COD in the effluent (Mishra and Bera, 1995). Arora Rajni and Chauhan, (1996) reported that tannery effluent on
seedling growth and germination percentage and total biomass in some varieties of *Hordeum vulgare*. Zalawadia *et al.*, (1996) reported the inhibitory effect of distillery effluent on seedling growth of onion. The 5 to 10 per cent concentration of tannery effluent would higher the seedling growth of *Vigna radiata* (Bera and Kanta, 1999).

The higher concentrations of sugar mill effluent reduced the seed germination percentage in *Abelmoschus esculentus* (Om *et al.*, 1994), *Hordium vulgare* (Lalitha Kumari and Singaracharya, 1998), *Triticum aestivum* (Rajesh and Bhargava, 1998) and soybean (Rathore *et al.*, 2000). (Nath and Sharma, 2002) reported that the lower concentration of sugar factory effluent increased the germination and growth of green gram.

Kumar, (2000 a) reported that the effect of higher concentrations of sugar mill effluent harmfully affected the seedling growth of *Hordeum vulgare*. Kumar, (2000 b) reported the toxic effect of higher concentration of carbonaceous sugar mill effluent on growth, attributed in *Hordeum vulgare* IB 65. Augusthy and Sherin, (2001) reported that the higher concentrations of dye factory effluents decreased the seedling growth of *Vigna radiata*. Mariappan and Rajan, (2001) reported that the maximum seedling growth was observed at 10 per cent tannery effluent. It was observed that alone 10 per cent concentration of effluent, plants showed inhibition of growth. Hence more dilutions were required for the utilization of effluents in a beneficial way.

The seedling growth of *Oryza sativa* and *Heliotropium curasavium* decreased with increasing concentrations of tannery effluent (Jayabalans *et al.*, 2001). Higher degree of toxicity was noticed at higher concentration of factory
effluents. Kumawat et al., (2001) reported that the South India viscose factory effluent significantly inhibited the plumule development in *Arachis hypogaea*. Growth inhibitory effect in wheat, garden pea, blackgram and mustard were invariably observed in all the concentration levels of effluent mixture when compared to control (Ramana et al., 2002). Crowe et al., (2002) studied the industrial effluent on the germination and post terminative growth of seeds of terrestrial and aquatic plant species. Pandey and Sharma,(2003) reported that the high concentration of marble slurry on germination and seedling growth of *Vigna radiata*. Vijayarangan, (2003) studied the effect of textile mill effluent respectively on seed germination and seedling growth of some crop plants.

Palanivel et al., (2004) reported that low concentration of the dye effluents promoted the seed germination and early seedling growth in *Hordeum vulgare* and *Zea mays* whereas the high concentration caused detrimental effects on the overall plant growth. Thorat and Chaudhari, (2004) reported the dilution of tannery effluent up to 50 per cent was found to have better influence on growth. On the other hand, 25 per cent effluent concentration was observed to impart overall beneficial influence on plant growth. Raja sekarapandian et al., (2005) had reported that the germination percentage of *Lablab purpureus* in various concentrations of textile effluent. The value increased at lower concentration (25 per cent) and it decreased continuously up to higher concentration (100 per cent). Samyuktha et al., (2005) reported that distillery effluent on *Oryza sativa* plant, low concentration of effluent increased the seedling length.

Kaushik et al., (2005) reported that textile effluent on seed germination had good performance, seedling growth of wheat cultivated high concentration of
distillery effluent, the seedling growth reduced in *Vigna radiata*. Raina *et al.*, (2005) reported that the seeds of *Cicer arietinum* exhibited decreased in the percentage of germination with an increase of the concentration of paper and pulp mill effluent. The seedling growth of *Cicer arietinum* increased at lower concentration of the sugar mill effluent and they decreased with the increase of effluent concentrations (Singh *et al.*, 2005 a). The effect of sugar mill effluent inhibited germination, growth and biochemical changes of ragi (*Eleusine coracana* L.) seedlings were reported. The shoots of the seedlings were found to be resistant whereas root of the seedlings were susceptible to sugar mill effluent treatment (Indira and Mohanty, 2006). The results of various studies showed that dilution of effluents brought down the toxic effect, indicating the fact that suitably diluted effluents could be used for irrigation (Jamal *et al.*, 2006).

Sundaramoorthy *et al.*, (2006) reported that 10 per cent concentration of sugar mill effluent increased the *Oryza sativa* seedlings. Raut *et al.*, (2007) reported that the average shoot and root length of *Vigna radiata* was more for raw pharmaceutical effluent compared to treated effluent but not more than control. The seed germination of *Eluesine coracana* increased at lower concentrations of sugar mill effluent when compared with control plants (Lakshmi and Sundaramoorthy, 2000) and tomato (Sundaramoorthy *et al.*, 2007).

There was slight and gradual reduction in plumule and radicle length from lower to higher concentrations of sugar and distillery effluents on seedlings of different plant species (Nath *et al.*, 2007). (Nagajyoti *et al.*, 2008) reported that a percentage of groundnut seed germination and growth at different concentration of power plant effluent. The maximum seed germination was recorded at 25 per cent
and the minimum at 100 per cent concentration of the effluent. Purohit et al.,
(2003) reported that the shoot length of tomato plant decreased when the
concentration of the tannery effluent was increased. Babu and Vishnuvardhan,
(2006) reported that the shoot and root lengths of Vigna mungo was retarded and
inhibited at higher effluent concentration. Gaikar et al., (2010) reported that the 10
per cent dilution of dairy effluent enhanced seed germination and seedling growth
of soybeans.

Hussain et al., (2010) found that tannery effluent caused a reduction in
germination, growth of sunflower parameters along with other parameters like
chlorophyll, protein, carbohydrate contents etc. Study of (Panaskar and Pawar,
2011 a and 2011 b) textile effluents was not inhibitory at low concentrations but
with the increase in concentration growth of seedlings were affected.

**VIGOUR INDEX AND TOLERANCE INDEX**

Somasekhar et al., (1984) seedlings were significantly poor in undiluted
paper mill effluent when compared to control. These vigour index and tolerance
index values were found to be increased with decreased the effluent treatment. The
vigour index values of Pisum sativum, Oryza sativa, Vigna sinensis, Trigonella
foenum-graecum and Vigna radiata seedlings were recorded due to tannery

The increase of vigour index was reported 10 and 20 per cent of dye
industry effluent treatment when compared with the control (Swaminathan and
Vaidheeswaran, 1991). Manonmani et al., (1992) reported the changes in vigour
index values of groundnut and maize seedlings due to photo film factory effluent.
(Gomathi and Oblisami, 1992); (Dhevagi and Oblisami, 2000) reported the vigour index values of neem, pungam, tamarind seedlings and also for maize, groundnut, soybean, sunflower, castor and gingelly seedlings treated with paper mill effluent.

Kumawat et al., (2001) reported the changes in vigour index values of groundnut grown under different treatment of dye industry effluent. Chinnusamy et al., (2001) studied the effect of treated distillery effluent on two cultivars of *Oryza sativa* Saka-4 and Pusa 44 after diluting with tap water viz., 25, 50 and 100 per centage using petri plates over the control. It was observed that root, shoot lengths fresh and dry weights of root and shoots germination, relative index, vigour index, emergence index and chlorophyll content were higher in 25 per cent than 50 per cent over control. Krishna and Leelavathi, (2002) reported that the lower concentration of sugar factory effluent increased the vigour index values when compared to the higher concentration of effluent. (Rani and Alikhan, 2007) noticed that the percentage of germination and seedling energy of rice and wheat reduced significantly with a raise in spent wash concentration. Pandey et al., (2009) reported that the increase of vigour index of pea and wheat plant at 25 per cent of distillery effluent concentration when compared to control.

**SEEDLING WEIGHTS**

The seedling fresh weight and dry weight increased in the lower concentration and decreased in higher concentration of tannery effluent. The seed might have required some nutrients and trace elements. The effluent also contains these nutrients, which are essential for plant growth. The presence of optimum level of nutrients in the lower concentrations of tannery effluent might have increased the growth as well as fresh weight and dry weight of seedlings. The
growth promoting effect of the lower concentrations of effluent was attributed to the decrease in concentration of various chemicals present in the effluent (Sahai et al., 1979; Mishra and Singh 1987). The higher concentrations of tannery effluent decreased the fresh weight and dry weight of seedlings. The reduction in seedling weight may be due to the poor growth of seedlings under effluent stress.

Arokiasami and Gnanarathanam, (1980) reported the inverse relationship of dry weight of Pistia, Hydrilla, Eichhornia and Saluinia with distillery effluent. The polluted water from distillery effluent increased the dry weight of Eichhornia (Kalam and Bhosale, 1985). The lower concentration of sugar mill effluent was reported to decrease the dry weight, and sugar effluent treatment in rice seedling was observed by Singh et al.,(1985).

The decreased values in fresh and dry weight with an increase of paper mill effluent concentration were reported in various crops (Bishnoi and Gautam, 1991; Nandi et al., 1995). Powel et al., (1996) reported that reduction in fresh weights of seedlings, while dry weights remained unaffected under the pollution stress. Dutta and Biossy, (1999) pointed out the responses of fresh and dry weights of paddy seedlings due to paper mill effluent treatment. The lower concentration increased the fresh and dry weights of paddy seedlings while the higher concentrations inhibited the seedling weight. Das et al., (2000) reported that the fly ash pond effluent reduced the fresh weight and dry weight of leguminous plants. The reduction in dry weight of Hordeum vulgare at high concentrations of carbonaceous sugar mill effluent had been reported by Kumar, (2000 b). The reduction in dry weight of Hordeum vulgare at higher concentrations of
carbonaceous sugar mill effluent had been reported by Arindam and Kumar, (2000).

Both increase and decreased in shoot and root dry weights of various seedlings in lower and higher concentration of industrial effluents also reported in paddy (Ramakrishnan et al., 2001). The average root and shoot lengths of the seedlings grown in wastewater of five sampling sites were slightly reduced in comparison with those of control through the year. The seedling weight of groundnut and paddy were increased at low concentration of tannery effluent (Lakshmi and Sundaramoorthy, 2001). Misra and Pandey, (2002) reported that 10 per cent concentration of distillery effluent increased the fresh and dry weights of Vigna mungo and Cicer arietinum seedlings while the higher concentrations reduced these parameters.

Singh et al., (2005 b) reported that the response in dry weight of Lemna minor due to sugar waste at 1 to 7 days’ time interval. Lemna minor plant had maximum changed in biomass at 25 per cent of sugar factory leachate concentration. The changed in biomass was nearly 17 at 100 per cent concentration when compared to initial biomass. Malla and Mohanty,(2005) reported that the low concentration of paper mill effluent on seedling, dry and fresh weights also increased in green gram plant.

The total dry matter production varied significantly among the treatments. The treated pots were having significantly greater shoot dry matter with increasing effluent stress (Sarathchandra et al., 2006). (adav and Minakshi, (2006) reported that Triticum aestivum, Raphanus sativus, Sorghum vulgare and Abelmoscus
esculantus seedlings weight decreased when treated with different dilution of diary effluent except for 25 per cent concentration which showed better growth and biomass over control. For treated effluent, the increased in shoot and root dry weight had been recorded up to 25 per cent dilution for WH 147 and PHW 343 wheat cultivars. Sundaramoorthy et al., (2007) reported that 10 per cent concentration sugar mill effluent irrigated. The tomato seedlings weight was increased. Vidya and Usha, (2007) stated that the dry weight of Ocimum basilicum was lower in plants treated with tannery effluent than in control.

Chidarambam et al., (2009) in their work on black gram (Vigna mungo) reported a gradual decreased on root, shoot lengths, fresh and dry weights with increase in chromium solution concentrations. Decreased in the fresh weight might be the outcome of a decreased water uptake or enhanced water loss, both of which might occur following membrane damage since plant cell membranes are generally considered as the primary sites of metal injury (Diwan et al., 2010 b). Both increase and decrease in the weight parameters were also reported by Nawaz et al., (2006; Yousaf et al., (2010) and Chandraju., et al., (2012 a).

**SHOOT AND ROOT LENGTHS**

Anjum, (1990) reported that the 25 per cent concentration of the tannery effluent increased the plant height of Vigna radiata. The higher concentrations of effluent adversely affected the plant height of mustard (Patel et al., 1991). Irrigation with paper mill effluent increased the height and diameter of Eucalyptus, Pongamia, Acacia, Lucaena and Dendrocalus (Kannapiran et al., 1997). The
reduction in plant height of *Hordeum vulgare* was observed due to the influence of periodic watering with sugar mill effluent (Kumar, 2000b).

The seedling growth of *Oryza sativa* and *Heliotropium curasavium* decreased with increasing concentrations of tannery effluent (Jayabalan *et al.*, 2001). The seedling growth was reduced on *Phaseolus aureus* and *Pennisetum typhoides* due to distillery effluent (Kannan, 2001). Growth characteristics such as plant health (i.e. radicle and plumule lengths) and seed vigour index increased with 50 per cent effluent irrigation and decreased with 100 per cent (undiluted) effluent irrigation at all soil column height reported by Singh *et al.*, (2002).

Decreased plant height (root and shoot lengths) of green gram was recorded due to the treatment of high concentrations of sugar mill effluents (Baskaran, 2005). The growth parameters such as number of secondary root, shoot and root length of *Cicer arietinum* registered either equal or lower values in all the treatments. The increased seedling growth of *Cicer arietinum* was recorded at lower concentrations than in higher concentrations (Raina *et al.*, 2005). The plant height of both control plants and effluent treated plants were recorded. The increase in root and shoot lengths of groundnut were increased at lower concentration of power plant effluent (Nagajyoti, 2008).

Ukaegbu and Odeigah, (2009) reported that the reduced in the root length of *Allium cepa* in high concentration of sewage treatment. (Dhanam, 2009) reported that the seedling growth was decreased with an increase of dairy effluent treatment. Albino and Murugan, (2010) reported that the 25 per cent textile mill effluent concentration, the plant (*Vigna mungo*) showed maximum root and shoot
length after 96 hours than the control. But at higher concentration of effluent, the length of root and shoot lengths were inhibited.

**BIOCHEMICAL STUDIES**

**Pigment content studies**

The lower concentrations of sugar mill effluent enhanced the total chlorophyll content of blackgram, groundnut and paddy (Goel and Kulkarni, 1994). Chidambaram Pillai et al., (1996) studied effect of chemical industry wastewater on germination, growth and some biochemical parameters on green gram and black gram. The plant treated with 10 per cent effluent showed higher values of chlorophyll ‘a’, chlorophyll ‘b’, total chlorophyll and carotenoid. These pigments decreased progressively with increased of effluent concentration (Pandit et al., 1996). Prasanna kumar et al., (1997) examined on the effect of dairy effluent on seed germination, seedling growth and pigment contents of green gram and black gram.

In higher concentration of sugar mill effluent reduced the total chlorophyll content of ragi (Lakshmi and Sundaramoorthy, 2000). Kumar, (2000 a) reported that a high concentrations of carbonaceous sugar mill effluent has an inhibitory effect on chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll of *Hordeum vulgare*. The decreased chlorophyll content with increased of various industrial effluents concentration on paddy plants (Krishna and Leelavathi, 2002). Distillery effluents showed a significant favourable effect in increase in the total chlorophyll content when compared to control. The chlorophyll content increased up to 75 DAS and declined later (Ramana et al., 2002). Sinha et al., (2002) reported that
the effect of tannery effluent on the chlorophyll content of *Alternanthera sesillis* showed decreased in total chlorophyll and carotenoid contents in leaves when compared to control plants. Reduction of pigment contents in higher concentration of dye industry effluent on some crop plants (Ameta Suresh *et al*., 2003).

Rajesh, (2004) reported that the chlorophyll content on paddy seedlings increased at lower concentration and it decreased at high concentration of sugar mill effluent treatment. Kaushik *et al*., (2004) and Dhankhar *et al*., (2005) were reported that the variations in the total chlorophyll contents in different experimental sites may be attributed possibly due to edaphic factors as well as due to different concentrations of the effluents. Chlorophyll ‘a’, chlorophyll ‘b’ and carotenoid content of *Lablab purpureus* were gradually increased at 25 per cent effluents concentration and declined at high concentration of textile mill effluent (Rajasekarapandian *et al*., 2005).

The total chlorophyll contents were found to decrease from lower to higher concentration of treated combined effluent in wheat, barley, garden pea and blackgram (Nath *et al*., 2007). Nagajyoti *et al*., (2008) reported that the chlorophyll ‘a’, chlorophyll ‘b’, total chlorophyll contents of groundnut increased at 25 per cent concentration and decreased at high concentration of power plant effluents. Dhanam and Arulbalachandran, (2009) reported that the increased briquetting and carbonization plant effluent reduced the chlorophyll ‘a’, chlorophyll ‘b’, total chlorophyll and carotenoid contents of groundnut. Baskaran *et al*., (2009 a) reported that the best chlorophyll content was observed at 10 per cent concentration of sugar mill effluent.
Three different effluent treatments (R.E, B.T.E (*Eichhornia*) and B.T.E (*Pistia*) the seedlings were increased in lower treatment and then it decreased. This may be due to the optimum levels of the micro and macro nutrients present in the effluent that may serve as an additional potential source of liquid fertilizer favourable to the seedlings development. (Noorunisa Begam *et al.*, 2010)

**PROTEIN**

The protein content increased under the lower concentration of dyeing factory effluent while the higher concentrations decreased the protein content (Swaminathan and Vaidheeswaran, 1991). The higher concentrations of IFFCO factory effluent inhibited the protein content of *Cyamopsis tetragonoloba* (Taghavi and Vora, 1994). The lower concentrations of tannery effluent increased the protein content of *Oryza sativa, Gossypium hirsutum, Vigna mungo* and *Vigna unguiculata* (Karunyal *et al.*, 1994). The 10 per cent was found to be more effective promote to the protein content of *Vigna radiata* and *Vigna mungo* and the higher concentrations of effluent decreased the protein content (Chidambaram Pillai *et al.*, 1996). The higher concentrations of fertilizer factory effluent decreased the protein content of soybean (Amutha, 1998).

The increased concentrations of tannery effluent were decreased the protein content of *Phaseolus mungo, Abelmoschus esculentus* and *Vigna radiata* (Mariappan *et al.*, 2001). The untreated paper mill effluent significantly decreased and protein content in the roots of *Allium cepa* (Baskar and Usharani, 2002). The distillery effluent showed a marked influence on protein content of groundnut (Ramana *et al.*, 2002). Sinha *et al.*, (2002) stated that the effect of tannery effluent
on the protein content of *Alternanthera sesillis* leaves. It showed a decreasing trend in protein content at higher concentrations of effluent. The highest amount of protein content was recorded in blackgram at 10 per cent concentrations tannery effluent. Lakshmi and Sundaramoorthy, (2004) reported that lower concentration of sugar mill effluent increased the protein content of ragi and the higher concentration it decreased. The highest amount of protein content in *Vigna mungo* was recorded at 10 per cent sago effluent concentration and the lowest content was recorded at 75 per cent (Sivaraman and Tamizhiniyan, 2005).

Guo *et al*., (2007) reported that stress induced a declined in soluble protein contents in plants but increased in soluble sugar contents. Raut *et al*., (2007) reported that the protein content of *Vigna radiata* was higher in pharmaceutical effluent treatment than in control plants. Vidya and Usha, (2007) reported that the reduction in protein content of *Ocimum basilicum* was recorded at higher concentrations of tannery effluent. A significant effluent concentration dependent increased the protein content of mung bean was reported by Kannan and Upreti, (2008). Mishra *et al*., (2008) studied the levels of chlorophyll and protein decreased in *Eichhornia crassipies* when the metal levels increased.

Dhanam and Arulbalachandran, (2009) reported that the lower concentration of briquetting and carbonization plant effluent increased protein content of groundnut plants. Baskaran *et al*., (2009 b) reported that the increase in protein content of green gram at lower concentration of sugar mill effluent. Gill and Saggoo, (2010) reported reduction of carbohydrate and protein contents in turnip plants due to higher concentration of cadmium, chromium and lead.
AMINO ACIDS

The leaf portion had more content than the root. The amino acid contents of cowpea increased at lower concentration of sugar mill effluent (Thiyagarajan, 1996). Subramani et al., (1998) reported that amino acid content of Vigna unguiculata was increased at lower concentration and it decreased in higher concentrations of fertilizer factory effluent. The increasing of amino acid contents in lower concentration of sugar mill effluent was reported by Kumar, (2000).

The lower concentration of sugar mill effluent increased the amino acid contents in Hordeum vulgare and Eleusine coracana (Lakshmi and Sundaramoorthy, 2000). The higher concentrations of sugar mill effluent reduced the amino acid contents of ragi and paddy (Lakshmi and Sundaramoorthy, 2001; Rajesh, 2004). It has been reported that the lower concentrations of tannery effluent increased the amino acid content while the higher concentrations it decreased (Muthusamy and Jayabalan, 2001). The lower concentration of sugar mill effluent increased amino acid contents in Hordeum vulgare and Elusine coracana (Lakshmi and Sundarmoorthy, 2004).

SUGAR AND STARCH

The carbohydrate content of groundnut and green gram seedlings increased under lower concentration and it decreased under higher concentrations of dye factory effluent (Swaminathan and Vaidheeswaran, 1991). The effect of photo film industry effluent on physiological components of Arachis hypogaea and Zea mays seedlings were reported by Manonmani et al., (1992). Subramani et al., (1998) reported that the lower concentration of fertilizer factory effluent increased
reducing and non-reducing sugar contents of cowpea seedlings while at higher concentrations of effluent it decreased

Vidya and Usha, (2007) reported that the starch and sugars (reducing and non-reducing) contents of *Ocimum basilicum* was higher in lower concentrations of tannery effluent when compared to control. Raut *et al.*, (2007) reported that the carbohydrate content of *Vigna radiata* was higher in control plants than the plants treated with higher concentrations of pharmaceutical effluent. The higher carbohydrate content of mung bean was higher in distillery effluent treatment when compared to control (Kannan and Upreti, 2008). Lal, (2009) reported that the higher concentration of tannery effluent caused the reduction in total sugars and starch contents of *Lemna minor*. The subsequent biochemical changes of the plant samples due to waste water irrigation were studied by Gupta *et al.*, (2010).

**MINERAL CONTENTS**

**Nitrogen**

There was an increased in the uptake of nitrogen due to irrigation of soil with tannery waste (Thabaraj *et al.*, 1964). Increased of total nitrogen content in maize, rice and green gram was recorded in relation to the treatment of various concentrations of sugar mill effluent (Kesindra, 1978). Sahai *et al.*, (1979) reported that the total nitrogen content of *Phaseolus radiatus* was directly proportional to the concentration of the fertilizer factory effluent up to the level of 25 per cent, when the seeds were soaked in effluent up to 10 per cent solution for 6 hours. There was an inverse trend when the seeds were soaked for 18 h and beyond.
The increased nitrogen content was recorded in *Dichanthium annulatum* plants irrigated with distillery waste (Lokhandle and Bhosale, 1983). The nitrogen content of ragi and wheat decreased at higher concentrations of tannery industry boiler feed effluent (Thiyagarajan and Oblisami, 1983) and oxalic acid effluent (Kumar and Agarwal, 1984). The percentage of the soluble nitrogen of seeds increased with increase in the effluent concentration up to 30 per cent. Both the soluble and insoluble nitrogen decreased at higher concentrations of the fertilizer factory effluent (Neelam and Sahai, 1985). However, there was no uniform pattern of distribution of nitrogen content in the plants treated with tannery effluent (Debreczeni and Izsaki, 1985). More amount of nitrogen in shoot than in root of finger millet was recorded in lower concentrations of alum factory effluent (Appalaraju, 1986). More amount of nitrogen in shoot than root of paddy was recorded due to fertilizer factory effluent treatment (Mishra and Singh, 1987).

However, reduction in the nitrogen content in *Vigna mungo* due to distillery effluent were reported Muthukumar and Arokiasamy, (1994) and Karunyal et al., (1994). The nitrogen content of groundnut plants was higher in fertilizer factory effluent irrigation than the control plants (Sundaramoorthy, 1995). Bioaccumulation of elements and the metabolic concentrations in the component part of *Hordeum vulgare* was reported in relation to the treatment of rubber factory effluent (Sharma and Habib, 1997). Pandey *et al.*, (2008) observed that low effluent concentration (50 per cent) showed the low inhibitory effects and indicated that various metallic and nonmetallic elements act as nutrients but show toxic effects in plants at higher effluent treatment (100 per cent).
Phosphorus

The phosphorus content of wheat seedlings grown in chemical and fertilizer factory effluent polluted soil was more than that of wheat grown in control soil (Tripathi, 1978). The amount of phosphorus content of the seedling in rice shoot system was more or less similar to that of root system in control and in distillery effluent treated seedlings (Behera and Mishra, 1982). Increased phosphorus content was noticed in Dichanthium annulatum irrigated with distillery waste (Lokhandle and Bhosale, 1983). The decreased phosphorus content in wheat and ragi was recorded in the plants grown in tannery effluent treated soil (Thiyagarajan and Oblisami, 1983; Debreczeni and Izsaki, 1985).

The lower concentrations of alum factory effluent increased the phosphorus content of finger millet (Appalaraju, 1986). The phosphorus content of groundnut plants was higher in fertilizer factory effluent irrigation than in control plants (Sundaramoorthy, 1995).

Potassium

Increased in the potassium content in maize, rice and green gram was noticed due to various concentrations of sugar mill effluent (Kesindra, 1978). The potassium content in root and shoot system of rice was same in control and distillery treated seedlings whereas, the rice seedlings grown at 5, 10, 20 and 50 per cent concentrations showed relatively high potassium content (Behera and Mishra, 1982). The potassium content of ragi decreased with the increase of tannery industry boiler feed effluent (Thiyagarajan and Oblisami, 1983). The uptake of potassium by ragi and paddy plants was significantly reduced by
increased concentrations of tannery effluent (Kamalam and Raj, 1980; Wilson, 1998; Lakshmi and Sundaramoorthy, 2001). The nutrient uptake by the groundnut crop was significantly higher in distillery effluents irrigation when compared to control (Ramana et al., 2002).

**PHYTOREMEDIATION**

Phytoremediation is the name given to a set of technologies that use plants to clean contaminated sites. Many techniques and applications had been called phytoremediation, possibly leading to confusion. This document used the term phytoremediation to refer to a set of plant-contaminant interactions, and not to any specific application. Many of the phytoremediation techniques involve applying information that has been known for years in agriculture, silviculture, and horticulture to environmental problems.

The term phytoremediation (phyto = plant and remediation = correct evil) is relatively new coined. Basic information for what is now called phytoremediation comes from a variety of research areas including constructed wetlands, oil spills, and agricultural plant accumulation of heavy metals. The term has been used widely since its inception, with a variety of specific meanings. In this document phytoremediation is used to mean the overall idea of using plant-based environmental technologies, not any specific application.

Water hyacinth (*Eichhornia crassipes*), was a floating macrophytes whose appetite for nutrients and explosive growth rate had been put to use in cleaning up municipal and agriculture wastewater (Gupta, 1980). A reduction of 56 per cent of sodium and 99.39 per cent potassium respectively with 100 per cent and 25 per
cent concentration of textile industry waste treated with *Eichhornia crassipes* after four days of treatment had been recorded by Trivedi and Gudekar, (1987).

Aoyama and Nishizaki, (1991) evaluated the practical use of water hyacinth grown in natural water channels or ponds for water purification. Water hyacinth has drawn attention as a plant of rapid growth and high biomass production, and capable of removing pollutants from domestic and industrial waste effluents. Water hyacinth could grow in oil-refinery wastewater after the water had undergone an initial treatment of oil-separation, flotation and aeration (Tang and Xian-wen, 1993). Water hyacinth (*E. crassipes*) has demonstrated its ability to remove nutrients and other chemical elements from sewage and industrial effluents (Akcin and Saltabas, 1994). Lenzi *et al*., (1994) evaluated the removal of chromium (III) from aqueous solution by water hyacinth. Nor, (1994) investigated the removal of phenols in the presence of copper and zinc by *Eichhornia crassipes* was in order to assess its ability to clean up industrial wastewaters. Studies were conducted to determine the phytotoxic effect and uptake capacity of heavy metals by water hyacinth (Delgado *et al*., 1993; Akcine *et al*., 1994, Abdel-Sabour *et al*., 1996 and Lytle *et al*., 1998). Zhu *et al*., (1999) demonstrated the potential of water hyacinth for the phytoremediation of six trace elements.

The use of plants to degrade, assimilate, metabolize, or detoxify contaminants is cost-effective and ecologically sound. Four mechanisms are involved in phytoremediation of organic pollutants: direct uptake and accumulation of contaminants and subsequent metabolism in plant tissues; transpiration of volatile organic hydrocarbons through the leaves; release of exudates that stimulate microbial activity and biochemical transformations around the root system; and
enhancement of mineralization at the root–soil interface that is attributed to mycorrhizal fungi and microbial consortia associated with the root surface (Schnoor et al., 1995).

Jebanesan, (1997) indicated that water hyacinth was found to be more effective in the treatment of dairy wastewater. Another important usage for water hyacinth was its use as biological treatment for raw sewage effluent. Ayade, (1998) reported that pioneering research efforts in the handling of municipal sewage in developing countries had involved the use of water hyacinth to purify sewage for possible domestic purposes re-use. Water hyacinth (*Eichhorina cassipes*) had drawn attention as a plant capable of removing pollutants, including toxic metals from surface water (Kelley et al., 1999). Reduction of heavy metals in situ by plants may be a useful detoxification mechanism for phytoremediation.

Phytoremediation is an emerging technology that is rapidly gaining interest and promises effective and inexpensive cleanup of hazardous waste sites contaminated with metals, hydrocarbons, pesticides, and chlorinated solvents (Macek et al., 2000; Susarla et al., 2002; Xia et al., 2003). Kamal et al., (2004) have been studied to determine their potential in accumulating heavy metals. Recently, macrophyte *Potamogeton pectinatus* was used for bio accumulating heavy metals from distillery effluent (Singh et al., 2005).

The economic success of phytoremediation largely depends on photosynthetic activity and growth rate of plants. Water hyacinth (*Eichhornia crassipes*), due to its fast growth and large biogas production (Singhal and Rai, 2003) has potential to cleanup various wastewaters. It is important to emphasize that *E. crassipes* has a huge potential for removal of the vast range of pollutants
from wastewater (de Casabianca and Laugier, 1995; Chua, 1998; Maine et al., 2001; Sim, 2003; Mangabeira et al., 2004).

Phytoremediation is rapidly gaining interest and promises in effective and inexpensive cleanup of hazardous waste sites contaminated with metals, hydrocarbons, pesticides and chlorinated solvents (Kumar and Chandra, 2004; Liao and Chang, 2004; Saratale et al., 2011). Several plants species, such as water lettuce (*Pistia stratiotes*) water lilies (*Nymphaea spontanea* Choo et al., 2006), (Mishra et al., 2007) *E. crassipes*.

Zimmels et al., (2006) noticed 360 per cent reduction in COD in a pilot study with *E. crassipes* and *Pistia stratiotes* for treatment of urban sewage in Israel. Zhang et al., (2007) reported that the efficiency of COD removal varied a lot for various species to different contaminants. Different effluent samples from *Eichhornia sp.*, *Salvinia sp.*, *Pistia sp.* and *Typha sp.* showed marked reduction in BOD where maximum reduction of BOD in undiluted effluent was with *Eichhornia sp.* (Santos et al., 1987) (Kirzhner et al., 2008) working on phytoremediation reported that BOD of industrial effluents was removed by 65 to 70 per cent after four days of retention period by floating macrophytes. Several cases of accumulation of heavy metals such as Zn, Cu, Pb, Cd, Ni and Cr, have been thoroughly studied in several wetland plant species, such as *E. crassipes*, *Typha latifolia*, *Spartina alterniflora* and *Phragmites australis* (Liau et al., 2005).

Several aquatic macrophytes such as *Eichhornia*, *Pistia* and *Salvinia* were found to scavenge inorganic and organic compounds from waste waters. (Boyd, 1969). *Ipomea aquatica* showed good Cr (VI) scavenging ability from contaminated waste effluent. Duckweeds also play a substantial role in nutrient removal (Nihan and Elmaca, 2007).
SOIL PROPERTIES

Avnimelech and Ravesh, (1976) also reported that while studying the soil nitrate leakage from soils of varied texture and column height. The application of diluted spent wash increased the uptake of zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) in maize and wheat as compared to control and the highest total uptake of these were found at lower dilution levels than at higher dilution levels (Pujar, 1995) and (Chidankumar et al., 2009).

There was a remarkable change in the physico-chemical properties of the soil due to the treatment of various industrial effluents. The irrigation with various industrial effluents affected the texture and fertility of the soil through biochemical processes (Chou et al., 1978).

Sago factory wastewater, irrigated soils have lower apparent and absolute specific gravity and water holding capacity and have slightly higher porosity than the corresponding control soil. Available forms of nitrogen, phosphorus, potassium, magnesium were increased many fold due to effluent irrigation (Singaram, 1995). Increase in soil pH, organic carbon, P, K, Ca and Na contents and decrease in water holding capacity due to the addition of textile effluent had been reported Somasekhar et al., (1984).

Variations in physico-chemical properties of the soil due to the irrigation with sugar mill (Ajmal and Khan, 1983; Kumar, 2001) tannery effluent (Perumal and Singaram, 1996) and leather industry effluent (Lalitha Kumari and Singaracharya, 1998) had been reported. The pollution load of sugar mill effluent
had altered the physico-chemical characteristics of soil. The amount of available phosphorus and chloride were higher than in control.

Baruah and Das, (1998) reported that the paper mill effluent irrigation altered the colour, texture, pH, organic carbon and available K and P content of soil. The increase in sodium content and decrease in calcium and magnesium content with the increase of the dairy effluent concentration had been reported by Srikantha et al., (1998). The increase in the available NPK and organic carbon was observed in paper mill effluent irrigated soil profiles when compared to the soil without effluent irrigation (Srinivasachary et al., 1998). However, available sulphur content remained unchanged, but it was markedly reduced in control due to the presence of oxalic acid industry effluent (Vishwakarma et al., 1998). The application of dairy effluent irrigation increased the EC of the soil and decreased the soil pH. The organic matter, available P$_2$O$_5$ and K$_2$O were recorded significantly high in the soil treated with dairy effluent (Singh et al., 1999).

The available nitrogen content showed slight rising trend over its initial status under all treatments, but available P and K content exhibited the declining trend. The available nitrogen, phosphorus and potassium contents in the soil samples were higher than the control due to contamination of soils with industrial effluents (Dhevagi and Oblisami, 2000; Prasanthi et al., 2001). It is generally accepted that the continuous use of industrial wastewater may deteriorate the quality of the soil and make it unfit for crop production. However, no significant
change was observed in the physico-chemical characteristics of soil due to the effluents of oil refinery (Hayat et al., 2002).

**Soil microbial population**

Soil provides habitats colonised by a staggering variety of microorganisms. All these forms of life interact with one another and with the soil to create continually changing conditions. This allows an on-going evolution of soil habitats. The activity of living organisms in soil helps to control its quality, depth, structure and properties. The climate, slope, locale and bedrock also contribute to the nature of soil in different locations. The interactions between these multiple factors are responsible for the variation of soil types. Consequently, the same fundamental soil structure in different locations may be found to support very different biological communities. These complex communities contribute significantly to the continuous cycling of nutrients across the globe.

Plants are the major producers of organic material to be found in soil, and plant matter accumulates as litter. Animal faeces and the decomposing bodies of dead animals complement this organic supply. Artificially added fertilizers, herbicides and pesticides all affect the biological component and hence the organic content of soils. Horse dung and chicken manure are beloved of gardeners. Microbes play a central role in re-cycling such material. Besides re-cycling of naturally occurring organic compounds, soil microbes are responsible for the chemical degradation of pesticides. Not all pesticides are easily broken down, however. Those compounds that resist microbial decomposition and that consequently accumulate in the environment are known as recalcitrant pesticides.
According to the incubation studies conducted by Neves et al., (1983), application of various rates of stillage resulted in substantial but temporary increase in the population of bacteria and fungi. The *Cyanobacterium* grew photo heterotrophically and chemo heterotrophically in the medium supplemented with sucrose and lower concentrations (10 per cent v/v) of neutralized distillery effluent (Adhikary, 1989). (Baath, 1989) reported that soils with high cation exchange capacity and more organic matter were known to bind metals and made them less available to microorganisms.

But, actinomycetes were inhibited until population of other microorganism decreased. (Khan and Malik, 1992) also reported a high incidence of antibiotic resistance in *E. coli* and Staphylococci strains from foodstuffs. (Sarnaik and Kanekar, 1995) reported alteration and reduction in number of *Pseudomonas* species from soil samples collected from the premises of a dye factory in India. Excess of soluble salts in water resulted in low crop yields, and if sodium was in excess, soil deterioration would occur as well. A change in soil microbial diversity or a shift from bacterial to fungal population has also been reported in metal contaminated soils. Goyal et al., (1995) also observed an increased microbial biomass and dehydrogenase activity due to application of distillery effluent and established a close relationship between the number of micro-organisms and enzyme activity in soil.

The effluent particularly at low concentrations (1-10 per cent v/v) and neutral pH increased the growth of organism. Nirmala and Krishnamoorthy, (1996) stated that the distillery effluent reduced the nematode population to the extent of 46 to 89 per cent. The maximum reduction of nematode population was noticed in the effluent irrigated field compared to the effluent non applied field.
Similarly increase in the population of micro-organisms and their activities due to application of distillery effluent had been noticed by Doddagoudar, (1996). Oved et al., (2001) reported that irrigation with wastewater altered ammonia oxidizing bacterial (AOB) population in soil and Nitrosospira and Nitrosomonas species became dominant.

Earlier studies also reported development of metal resistance with continuous exposure to metal ions due to release of untreated effluent (Neves et al., 1983; Fillip and Muller 1984; Lal et al., 1990; Schmidt et al., 1991). (Goyal et al., 1995; McLean and Beveridge, 2001 and Vainshtein et al., 2003) and many other workers had reported similar effects of spent wash microbial biomass confirming the results of our investigation. Aleem et al., (2003) isolated 57 Azotobacter chroococcum from wheat (Triticum aestivum) rhizospheric soil irrigated with industrial wastewater and tested for their resistance against 11 commonly used antibiotics/drugs.