Environmental protection and rational use of natural resources and other industrial raw materials has become an important sphere of mankind’s advancement in the 20th century. Mankind’s demand for resources and raw materials has intensified the ecological and economic contradictions in the industries (Sen and Chakraborty, 2009). This wide spread industrialization in urban areas has drastically reduced land area for waste disposal. Disposal of untreated industrial and domestic wastes into the environment affects both soil and ground water quality. Soil and streams have been used for multifarious purposes including waste disposal. Our careless dumping of wastes has affected these precious resources (Quazilbash et al., 2006).

Actuality of ecological problems is emphasized by mankind’s growing concern for the damage caused to the environment. The main aspect of this concern is linked with the preservation of living being on our planet (Kolomaznik et al., 2008). The industrial effluents consist of organic compounds along with inorganic complexes and other non biodegradable substances. These pollutants not only alter the quality of ground water and soil but also pose serious problems (Karthikeyan et al., 2010).

The review of literature pertaining to the study, “Effect of tannery effluent on water and soil profile, plant growth and human health” has been presented under the following headings.

2.1 Environmental pollution
2.2 Industrialization
2.3 Tannery industry
   2.3.1 Process of tanning
   2.3.2 Tannery effluent
   2.3.3 Heavy metals
2.1 Environmental pollution

Environmental pollution has become a major concern of developing countries in the last few decades. There is a growing sense of global urgency regarding the pollution of our environment by an array of chemicals used in various activities (Palaniappan et al., 2009). Pollution of water and soils by heavy metals is an emerging problem in urbo industrialized countries. Since the advent of development through mining and smelting, metallurgical industries, sewage, warfare, and tanning the survival of plants and animals are much affected (Xi et al., 2009).

Soil, water and biodiversity are fundamental elements of ecosystem and are the subject of many agrarian, ecological, biological and hydrological studies. A high percentage of ecosystems consist of arable land which is treated with agrochemical products forms the upper layer of the soil. Large quantities of chemical elements infiltrate the water running off of the cultivated soils thereby entering the animal and human food chain (Nolten et al., 2005).

The quality of life on earth is inextricably linked to overall quality in the environment. Currently there are two fundamental pollution related problems, the disposal of large quantities of wastes that are continually being produced and the removal of toxic compounds that have been accumulating at dump sites in the soils and in water system over the last few decades (Hsua et al., 2006).

2.4 Effect of tannery effluent

2.4.1 Effect of tannery effluent on soil

2.4.2 Effect of effluent on water

2.4.3 Effect of effluent on the plant growth

2.4.4 Effect of effluent on the human health

2.5 Common treatment strategies of the effluent

2.6 Dilution studies

2.7 Vigna radiata and Vigna mungo
Pollution is defined in various ways. It is considered as the release of unwanted substances to the environment by man in quantities that damage either the health or the resource itself (Tripati et al., 2007). Environmental pollution caused by heavy metals is increasing along with the increase in the usage of chemicals in industry and agriculture. Such pollution is apparent in streams and lakes and in ground water which is replenished directly from surface water (Huget et al., 2009).

2.2 Industrialisation

Since the beginning of the industrial evolution, pollution of the biosphere with toxic metals has accelerated dramatically. Increasing industrialization and population develops the standard of living, which results in highly contaminated atmosphere due to the drainage and wastage from these industries (Tiwari et al., 2008).

Rapid industrialization plays an important role in polluting the environment and causes severe degradation in pedosphere, hydrosphere and atmosphere. Water used in industries creates a waste that has potential hazard for our environment because of the introduction of various contaminants such as heavy metals into soil and water resources (Azumi and Bichi, 2010).

Environmental contamination with metals through industrial wastes is one of the major health concern of developing countries. Metal pollutants can easily enter the food chain if heavy metals contaminated soils are used for the production of crops (Principi et al., 2006). The accumulation of metals in an aquatic environment has direct consequences to man and ecosystem (Alam and Mahbub, 2007).

The release of pollutants differs from industry to industry. The waste from the pulp industry mainly contain carbohydrates, textile industry contain dyes, plating industry contain nickel and leather tanning wastes contain mainly
chromium, zinc, copper, sulphides, carbonates, sodium and many other toxic organic compounds and inorganic compounds (Nouri et al., 2009).

### 2.3 Tannery industry

Tanning industry contributes significantly towards exports, employment generation and occupies an important role in Indian economy on the other hand, tannery wastes are ranked as the highest pollutants among all the industrial wastes (Soyalsan and Karaguzel, 2007).

Global environmental regulation is challenging the leather processing industry. There are 80 tanneries that can be found along Madurai, Batalgundu, and Ponmadurai roads. The process of tanning involves the use of large amounts of fresh water and various chemicals. Every 10 kg of raw skins tanned require about 350 litres of fresh water. Dindigul is a drought affected area and the water sources are minimal. The water table is deep due to over exploitation for irrigation and tanning through dug wells, dug cum bore wells and borewells (Bhaskar, 2000; Mondel and Singh, 2004). Various chemicals used in tanning are lime, sodium bicarbonate, common salt, sodium sulphate, chrome sulphate, fat liquors, vegetable oils and dyes. The waste water discharged for 100 kg of skins and hides and skins processed, varies from 3000 litres to 3200 litres. The largest polluting material in the tanning industry which was very difficult to rid off is common salt. For every 10 tons of salted hides and skins processed 2-3 tons of salt is removed and in addition another one ton of salt is removed, while pickling (Altaf et al., 2008).

The waste water, after processing raw hide/skin into finishing leather, is highly alkaline and decomposing organic matter, sulphide and organic nitrogen with a high amount of other toxic chemicals (Tadasse et al., 2007). Pre-tanning processes contribute 80-90 percent of the toxic pollution in the industry and generates noxious gases such as hydrogen sulphide, as well as solid wastes and chrome sludge (Thanikaivelan et al., 2004). About 20-30 litres of effluent is discharged per kilogram of skin/hide processed, and in the case
of finishing units, this quantity is about 40 liter per kilogram of skin/hides (Verma et al., 2007).

2.3.1 Process of tanning

Leather tanning is the process of converting raw hides or skins into leather. Hides and skins have the ability to absorb tannic acid and other chemical substances that prevent decaying, make them resistant to wetting. Tanning is essentially the reaction of collagen fibers on the hide with tannins, chromium, alum or other chemical agents. The most common tanning agents are chromium and vegetable tannins extracted from specific tree barks (Verma et al., 2008).

Figure 1 and Plate 1 represents the general flow diagram for leather tanning and finishing process (De Nicola et al., 2007).

Trimming, soaking and fleshing

The hide of any cattle, cow, goat, sheep, pig and horse are selected. The skin is carefully removed from the dead animal. Care should be taken to prevent even a bit of meat and fleshy part remains on the skin. To remove the meat and flesh from the hide, the skin is soaked in water for several hours. The preserved raw hides regain their normal water contents. Unhairing is done by chemical dissolution of hair and epidermis with an alkaline medium of sulphide and lime. After skinning at the slaughter house, the hide appears to contain excessive meat, fleshing usually precedes unhairing and liming.

Liming and bating

To remove the hair on the hide quicklime was applied on the wet surface and rubbed. This makes easy removal of hair by loosening. The unhaired, fleshed and alkaline hides are neutralized with acid ammonium salts and treated with enzymes, similar to those found in the digestive system, to remove hair remnants and to degrade proteins. During this process hair roots and pigments are removed. The hides become soft by this enzyme treatment.
FIGURE 1
GENERAL FLOW DIAGRAM FOR LEATHER TANNING AND FINISHING PROCESS

Beam House Operation
- Receiving and storing hide
  - Trimming
  - Soaking and washing
  - Fleshing
  - Unhairing
  - Rating

Tannery Process
- Pickling
- Vegetable
- Chrome Tanning
- Winging / Slicing
- Splitting
- Sharing
- Relining
- Bleaching and Colouring
- Fatliquoring (Chrome)
- Setting Out
- Drying
- Conditioning
- Staking, Dry Milling
- Buffing
- Finishing and Plating

Sulfide, Ammonia

Grain Portion

Flesh Portion

Finishing Process
Pickling

The hide should be processed to prevent it from getting rottened or stiffened. Pickling increases acidity of the hide to a pH of 3, enabling chromium tannins to enter the hide. Salts are added to prevent the hide from swelling. For preservation purposes, 0.03 – 2 weight percent fungicides and bactericides are applied. Soaked the hide in water for a whole night. After this step, the hide will be ready for tanning.

Tanning

There are two types of tanning

1. **Chrome tanning**
   After pickling when the pH is low, chromium salts are added. For the fixating of the chromium, the pH is slowly increased through addition of a base. The process of chromium tanning is based on the cross linkage of chromium ions with free carboxyl groups in the collagen. It makes the hide resistant to bacteria and high temperature. The chromium tanned hide contains about 2-3 dry weight percent chromium.

2. **Vegetable tanning**
   Vegetable tanning usually accomplishes a series of vats with increasing concentrations of tanning liquor. Vegetable tannins are polyphenolic compounds of two types namely hydrolysable tannins which are derivatives of pyrogallols and condensed tannins which are derivatives from catechol. Vegetable tanning results from hydrogen bonding of tanning phenolic groups to the peptide bonds of the protein chains. In some cases 50 percent by weight of tannin is incorporated into the hide.

**Finishing - Wet blue**

Chromium tanned hides are often retanned during which the desirable properties of more than one tanning agent are combined and treated with dye and fat to obtain the proper filling, smoothness and color.
PLATE 1
DIFFERENT PROCESS CARRIED OUT IN THE TANNERY INDUSTRY

Collection of skin

Soaking of hides in the tank

Liming
Results and Discussion

Effect of tannery effluent on water and soil profile, plant growth and human health

PLATE 1 (Contd…)

Pickling

Tanning

Setting out and drying
Before actual drying is allowed to take place, the surplus water is removed to make the hides suitable for splitting and shaving. **Splitting** and **shaving** is done to obtain the desired thickness of the hide. The most common way of drying is vacuum drying. Cooling water used in this process is usually circulated and is not contaminated.

**Crust**

The crust that results after retanning and drying is subjected to a number of finishing operations. The purpose of these operations is to make the hide softer and to mask small mistakes. The hide is treated with an organic solvent or water based dye and vanishes. The finished end product has between 66 and 85 percent of drymatter.

**2.3.2. Tannery effluent**

The damage to the environment by the hazardous tannery effluent is becoming an acute problem in the country. The chrome tanning process results in toxic metals, especially chromium III passing to wastewater and are not easily eliminated by ordinary treatment process (Franco et al., 2005). Tannery wastewaters are mainly characterized by high salinity, high organic loading and specific pollutants such as chromium (Colak et al., 2005).

Various chemicals used in tanning are lime, sodium carbonate, sodium bi-carbonate, common salt, sodium sulphate, chrome sulphate, fat liquors, vegetable oils and dyes (Tudunwada et al., 2007). The tannery waste water was found to contain higher concentrations of total dissolved solids, chromium, chloride, ammonia, nitrate and sulphates when the samples where collected from the outlets of the industry (Calheiros et al., 2008a). Besides these, chemicals such as zinc chloride, mercuric chloride and formaldehyde are used as disinfectants, sodium chloride in curing and as bleaching powder and sodium fluoride to prevent putrefaction, lime in liming, sodium sulphate, ammonium chloride, borax and hydrochloric acid in deliming, sodium for decreasing and basic or acidic dyes in leather finishing (Amita et al., 2005).
Hence, the tannery waste is always characterized by its strong colour (reddish dull brown), high BOD, high pH, and high dissolved solids. The other major chemical constituents of the waste from the tanning industry are sulphide and chromium. These chemicals mixed with water are discharged from the tanneries and pollute the ground water permanently and make it unfit for drinking, irrigation and general consumption. Therefore there lies an urgent need to determine the pollution levels in the waste waters from these industries (Kumar and Mani, 2007).

2.3.3. Heavy metals

The term heavy metals has generally been used to describe those metals having an atomic number greater than iron or having a density greater than 5 g/ml. Plants require certain elements for their normal growth, which are called essential elements (micro and macro elements). But there are also some elements which are not vital for plant growth. Such elements are called non essential elements, which include heavy metals which cause toxicity to plants (Velaiappan et al., 2002).

The contamination of the environment with heavy metals is a serious problem because of industrial activities and sewage sludge applications have largely contributed to the wide spread of these elements in the terrestrial environment (Viti et al., 2003).

The presence of heavy metals in industrial and urban waste water is one of the main causes of water and soil pollution (Wang et al., 2005). Heavy metals are ubiquitous environmental contaminants in an industrialized society. Concern over the possible health and ecosystem effects of heavy metals has been increased in recent years (Srivastava and Thakur, 2006). Tremendous increase in the use of heavy metals over the past decades has inevitability resulted in an increased flux of metallic substances in the environment. Some metal ions are cumulative poisons capable of being assimilated and stored in the tissues of organisms causing noticeable adverse physiological effects (Garg et al., 2007).
The most commonly occurring metals at the discharge sites are lead, chromium, arsenic, zinc, cadmium, copper, and mercury. Presence of these metals in the water and soil may cause serious threat to human health and ecological systems (Sundar et al., 2010).

Problem of pollution by metals have aggravated and affected the ecological balance and caused serious health hazards because of the release on land as well as dumping on the surface water. Ultimately metallic components leach to ground water and lead to contamination due to accumulation and resulted in a series of well documented problems in living things (Malarkodi et al., 2007).

Heavy metals used in various industrial activities find their way into the physiological system of the living being. Exposure to heavy metals results in acute and chronic toxicity. The functions of kidney, liver and lungs are mainly affected by these metals (Alsaleh et al., 2006).

2.4. Effect of effluent on the components of the biosphere

2.4.1. Effect of effluent on water

Ground water is the prime source of drinking water in urban and rural areas of our country. The quality of drinking water in Indian cities has been deteriorated in the recent years mainly due to growth of population and improper disposal of waste water from industries (Venkatasubramani et al., 2007).

The groundwater in industrial areas across the country has undergone severe contamination by industrial waste, effluents and emissions which are discharged indiscriminantly without any regulatory system (Samina et al., 2004; Parvaze et al., 2007). Compared with other kinds of water, groundwater is normally preferred because it tends to be less contaminated directly by wastes and organisms. However in the wake of recent industrialization and fast urbanization the quality of groundwater has become an increasing concern due to contamination by various toxic chemicals (Meena et al., 2004;
Abskharan et al., 2009). The surface water quality is affected by both anthropogenic activities and natural processes (Mokaya et al., 2004).

Most of the hazards coming to human and ecosystem are mostly due to ground water pollution. The untreated sewage, industrial effluents and agriculture wastes are often discharged into the water bodies. This contaminated water spread wide range of water borne diseases. The agricultural fields around these water bodies are affected (Chandra and Kulsheshtha, 2004; Tung et al., 2009).

The different types of heavy metals carried from waste water effluent are liberally let out into the nearby rivers causing contamination in them. Drinking water may be contaminated by various toxic metals. The impact of the effluents is so stupendous that the water has become unfit for drinking and irrigation. The total dissolved solids of the ground water is 17,000 mg/l. Sodium chloride is the major dominant chemical present in ground water which makes it unsuitable for drinking and irrigation (Waziri, 2006). A single tannery can cause the pollution of ground water around the radius of 7-8 kilometers. In Tamilnadu more than 60 percent of India’s economically important tannery industries are located, tannery waste water containing chromium and sodium compounds have contaminated more than 55000 hectares of agricultural and nearby water beds (Mahimairaja et al., 2005).

2.4.2. Effect of tannery effluent on soil

Soil pollution by metals is essentially different from air or water pollution because the persistence of heavy metals in soil is reportedly much longer than in other compartments of the biosphere. Removal of heavy metals from polluted soil is difficult. Once deposited on the soil certain metals such lead and chromium may be virtually permanent (Okeyode and Moshood, 2010).

Heavy metals emitted either from anthropogenic or natural activities can disperse in environment and may ultimately get deposited in the soil. Plants growing in such areas may absorb heavy metals in their body. Although heavy
metals like iron, molybdenum, manganese, zinc, copper, magnesium, copper, selenium and nickel have a major role for growth and development of plants, but may be toxic beyond certain level (Eddy et al., 2006). The most common heavy metals found in soil are cadmium, chromium, copper, mercury, lead and zinc (Marques et al., 2008).

Reducing the availability of heavy metals in sludge is therefore one of the major concerns associated with land application, particularly in agronomic contexts. Though land application of sludge has been practiced, only relatively small amounts of sludge have been utilized in other industries such as forestry despite its recommendation of its value as a fertilizer (Xiamei et al., 2005).

Red and black soil

Soil contains four major components, mineral material, organic matter, water and air, the proportions of which vary with respect to time, site and depth. The soils of India are derived from a wide variety of minerals. They differ physically, chemically and biologically. Their distribution does not follow any regular pattern. The soils of India are broadly divided into five major groups: - Alluvial soil (Entisol, Inceptisol, Alfisol), black soil (Vertisol, Inceptisol, Entisol), red soil (Alfisol, Inceptisol, Ultisol), laterite soil (Alfisol, Ultisol, Oxisol), and desert soil (Entisol, Aridisol) (Esu et al., 2008).

The typical soil derived from the Deccan trap is the regur or black cotton soil. These soils vary in depth from shallow to deep. It is common in Maharashtra, western parts of Madhya Pradesh, parts of Andhra Pradesh, parts of Gujarat and some parts of Tamil Nadu. Many black soil areas have a high degree of fertility. They are darker, deeper and richer and are constantly enriched by the additions washed down from the hills. In the uplands, these are poor, light-colored and thin. Black soils are fine-grained and dark and contain a high proportion of calcium and magnesium carbonates. These soils have high plasticity and stickiness. They are very tenacious and exceedingly sticking when wet. Due to poor drainage of excess water, water logging conditions occur in
these soils, hence proper drainage should be provided to minimize the damage caused due to excess water. Frequent irrigation prevents the development of small cracks and tearing of roots of the soil. Legumes should be used as rotation crops to improve the productive capacity of the soil (Parthasarathi et al., 2008).

Red soil is an important resource for the exploitation and utilization of agriculture and forestry in the tropics and sub tropics of India. Clay content in deep soil profile can be more than the upper layer. Water characteristic of red soil and its ability to defeat drought is closely related with the soil capacity to accept rainfall, holding capacity of available water and absorbing ability of crop roots (Sailajakumari and Ushakumari, 2002). Irrigation is essential for good upland crop growth in red soil. Hence, more water management patterns and cropping systems need to be developed in order to alleviate the seasonal drought and for better use of deep layer water storage. Most of red soils were characterized by high content of clay and sub angular blocky and granular natural structures. It is rich in iron, small amount of humus and do not retain moisture. It is widely distributed in countries like Tamil Nadu, Southern Karnataka, parts of Madhya Pradesh, Maharashtra, West Bengal, Eastern Rajasthan, and North eastern States. The crops usually cultivated are ragi, groundnut, millet, tobacco, potato, legumes, rice, wheat and sugarcane (Chaoi et al., 2003).

2.4.3. Effect of effluent on plant growth

Industrialization has its inevitable effect on pollution of air, water and soil based on the type of industry, nature of raw materials used and the manufacturing processes involved. Industrial effluents not only contain nutrients that enhance the growth of crop plants but also have other toxic materials. Therefore it is essential that the implications of the use of industrial effluents in the crop field and their effect on soil characteristics should be assessed before they are recommended for use in irrigation.
Effect of toxic chemicals on plants and environmental impact of tannery effluents on plant and animal kingdom has been extensively studied. The phytotoxic impact of the heavy metal was observed on crop such as cabbage, water chestnut, tomatoes, chilies and rice (Upreti et al., 2004). Repeated metal exposure of plants affect its physiological processes such as photosynthesis, water relations and mineral nutrition (Patton et al., 2007). The impact of toxicity was evident as visible symptoms of chlorosis, yellowing and immature fall of leaves, poor growth and retarded flower, fruit and green yields. Metabolic alterations by metal exposure have also been described in plants either by direct effect on enzymes or other metabolites. This was possibly attributed to the imbalance of nutrients and nutritional disorders in the plants due to metal interactions with plant nutrients (Chunillal et al., 2005).

Metal ions play an important role in the antioxidant network of plants grown with industrial effluents. Metal alterations by heavy metal exposure also have been described in plants either by a direct effect on enzymes or other metabolites or by its ability to generate reactive oxygen species which may cause oxidative stress (Shanker et al., 2005). Heavy metals are present at elevated levels in the environment and leads to an impairment of the metabolic activities resulting in reduced growth of the plants (Rajkumar et al., 2005).

The effluent is an inevitable consequence of industrial process. In arid and semi-arid regions of the country, where shortage of water becomes limiting factor, the effluent is being used for irrigational purposes by the farmers in agriculture and agro-forestry practices. Since the production of wastewater is a continuous process, it can cater for substantial irrigation requirements. This alternative use of wastewater will not only prevent the waste from becoming an environment hazard but also will serve as a potential source of fertilizer if used rationally and at appropriate concentration (Saxena and Srivastava, 2002).

2.4.4. Effect of effluent on the human health

During the past 20 years, a number of studies have examined the possibility that occupational exposure to hazardous chemical substances
increases the risk for various diseases (Karipidis, 2007). The incidence of environmental exposures on the general status of health has been increasingly acknowledged for numerous diseases (Melissa et al., 2006). The industrious hazardous waste may show effects in terms of death and morbidity. This may manifest as respiratory diseases, skin reactions, allergies, diminution of vision, corneal opacity, abortion, malformation of pregnancy, stunted growth, neurological disorders, mental depression, psychiatric changes, altered immune response, chromosomal aberrations and cancer (Kilivelu and Yatimah, 2008).

Health related studies have shown that excessive intake of toxic trace metals results in neurological and cardiovascular diseases as well as renal dysfunction (Mehra and Juneja, 2005). Hepatitis, cholera, dysentery and typhoid are the most common diseases, which affects large population (Aswathi and Rai, 2005).

It is understood through documented evidence that the primary pathways of toxic metal accumulation in humans are through the ingestion of contaminated water and food (Brown and Longoria 2009). Wastes may pose a problem to human health either through drinking water or indirectly through food chain or via fish (Chen et al., 2004).

Approximately 1.2 billion people in developing nations lack clean water because most household and industrial wastes are dumped into rivers and lakes without treatment contributing to many waterborne diseases in humans (Branco et al., 2005). Environmental changes including increased water pollution have fostered much of the increase and high incidence of malaria (Pimental and Ajayi, 2007). Despite the toxicity of the effluents, the microbial flora of tannery wastes was relatively rich with the organisms such as bacteria, yeast, algae, protozoa and fungi causing irritation and corrosion of the skin and respiratory tract (Adarsh et al., 2007). Hexavalent chromium is toxic and mutagenic to most organisms and is known to cause, it also causes lung carcinoma in human beings (Yewalkar et al., 2007). The exposure of metals like chromium,
pentachlorophenol and other toxic pollutants increases the risk of dermatitis, ulcer, nasal septum, perforation and lung cancer (Guidotti et al., 2008).

**Routes of exposure**

Tannery workers are handling more than 250 chemicals used in leather tanning process. There are 3 routes of entry of the chemicals in to their physiological process 1) Inhalation 2) Ingestion and 3) Skin contact. Inhalation takes place through nose, while operating the chemicals in the form of fumes or dust, ingestion is possibilities of consumption of the chemicals while eating in production area itself and also due to usage of unwashed hands and skin contact occurs while handling the chemicals during various process such as wetting, skinning, liming, tanning and drying (Rastogi et al., 2007).

The chances of contact with chemicals occurs during loading, unloading and handling of chemical containers in the chemical store, transfer of chemicals from containers in the chemical store, transfer of chemicals from chemical store to workplace, handling of chemicals in the workplace, loading or unloading of raw material/pet/leather into/from pits, paddles, drums, machines, removal of chemical waste and effluent from the workplace, disposal of chemicals or effluent and washing and disposing of chemical containers.

As chemicals emit fumes, mist, vapours or dust during storage and handling any worker may be exposed to these airborne pollutants in any part of the workplace. Chemicals in liquid and gaseous form also affect the immediate neighbourhood, when released into drains or removed from the workplace by exhaust blowers and chimneys (Issever et al., 2007).

People working in pre tanning and tannin department were prone to be exposed to chromium at a higher risk compared to the finishing department. Continual skin contact with organic solvents during wetting and finishing stage leads to defatting of the skin and eventual dermatitis. Aluminium sulphate and carbon black used as tanning agent and pigment respectively, causes
respiratory disorders for the workers. Perchloroethane employed as degreasing agent causes narcosis and drowsiness. The white spirit is used in open drum tanning process of sheep skins which is flammable in nature (Zhang et al., 2008).

### TABLE 1

**COMMON HAZARDS CAUSED DUE TO METALS RELEASED FROM INDUSTRY**

<table>
<thead>
<tr>
<th>Metals</th>
<th>Health hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>Inhibits functioning of enzymes, affects gastro intestinal tract, lungs and bones, causes renal problems</td>
</tr>
<tr>
<td>Mercury</td>
<td>Headache, intestinal problem, blood malfunctioning</td>
</tr>
<tr>
<td>Chromium</td>
<td>Carcinogenic, leads to kidney disorders, ulcer, nervous disorder</td>
</tr>
<tr>
<td>Lead</td>
<td>Anemia, abdominal pain, damage to nerves, convulsion, hypertension</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Liver damage, ulcers, kidney problems, dermatological disorders</td>
</tr>
<tr>
<td>Copper</td>
<td>Mental stress, coma, uremia</td>
</tr>
<tr>
<td>Zinc</td>
<td>Kidney problems, pain in legs, vomiting</td>
</tr>
<tr>
<td>Nickel</td>
<td>Decreases body weight, damages heart and liver, causes skin irritation</td>
</tr>
<tr>
<td>Fluoride</td>
<td>Fluorosis</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Weakens nervous system</td>
</tr>
</tbody>
</table>

(Mashi and Alhassan, 2007)

### 2.5. Common treatment strategies of effluent

Waste generation and the disposal of waste forms part of everyday lives which is more for industries especially tanneries because of the tremendous volume of waster and chemicals used. Pollution remediation of these tannery wastes is of great need since they damage the normal functioning of the ecosystem. To reduce the toxicity of soil, water, air and the atmosphere as a whole caused due to the discharge of heavy metals and contaminants from
the industries, various treatment procedures are widely followed. These methods aim at reducing the toxicity of the metals before letting into the land.

Nanotechnology, microbial technology, cycloning, flotation, micro flotation, electro flotation and filtration processes are some of the chemical methods for removing the toxicity in the effluents to make them available for further practical uses. Continuous flow and fixed film bioreactors were used for the reduction of chromium compounds. Batch reactors were also used to remove a particular metal from the effluent. A modified batch reactor called as sequencing batch reactor was also used for the purpose of removal (Dermou et al., 2005). These conventional methods for removal of metal causes secondary pollution and adverse effects on biological activities, soil structure and fertility (Ghani et al., 2009). Biosorption is another effective and versatile method and can be easily adopted in low cost to remove heavy metals from large amount of industrial wastewaters. Recent studies have showed that heavy metals can be removed using biomaterials (Singanan et al., 2008; Farooq et al., 2010). The use of plants for extraction of contaminants from the environment or for lowering their toxicity defined as phytoremediation is yet another method for toxicity removal (Rai, 2010).

2.6 Dilution studies

Tannery effluent was reported to cause adverse effect on plant growth when used as such. In semi arid country like India there lies a threat of complete scarcity of water in near future. With all the river basins having deficit volume of water for irrigation, the effluent from industries can reduce the pressure on water scarcity for irrigation (Thirunavukarasu and Lourdraj, 2005).

To protect the existing water resources, the reuse of waste waters and industrial effluents had become a common practice. The results of various studies show that dilution of effluents brings down the toxic effect indicating the fact that suitably diluted effluents could be used for irrigation (Jamal et al., 2006).
A number of studies have been done on growth of plants using 10%, 20%, 25%, 50% and 75% effluents. The effect of undiluted and diluted (50%) distillery effluent on seed germination and seedling growth of Zea mays and Oryza sativa was studied by Pandey et al. (2008). Calherios (2008a) observed the root and shoot development in plants using diluted tannery effluent. Effect of 25, 50, 75 and 100% tannery effluent on seed germination of Oriza sativa, Acacia holosericea and leucoenes leucocephate was studied by Karunayal et al.(1994). Khilji and Barbeen (2008) studied the growth pattern and accumulation of Hydrocyte umbellate on treatment with diluted tannery (20, 40 and 60%) sludge.

Agricultural irrigation with these dilutions of effluent is used as a readily available and inexpensive option to fresh water.

When plants are grown using diluted effluents, the roots

a. reduce soil bound metal ions by specific plasma membrane bound metal reductases

b. solubilise the heavy metals by acidifying their soil environment with protons extruded from roots.

c. adsorb the solubilised metal ions through extracellular (apoplastic) and intracellular (symplastic) pathways.

d. once the metal ions enter the roots it can either be stored or exported to the shoot

e. transport occurs in the xylem but redistribution occurs in shoot via phloem

Hence industrial effluents could be used for irrigation of crops after suitable dilution depending on the concentration of mineral nutrients and other toxic substances.
2.7. *Vigna radiata* and *Vigna mungo*

**Vigna radiata:**

It is also called as mung bean, mung dhal, moong dal, mash bean, mungo or monggo, green gram, golden gram and green soy. It is native to India. The beans are small, ovoid in shape and green in colour. The English word ‘mung’ derives from Hindi ‘mung’. In the South Indian Tamil language it is known as ‘payiru’, in Kannada as hesaru bel, in Telugu as pesalu and in Philippines and mungo. The mung bean is one of many species recently moved from the genus *Phaseolus* to *Vigna* and is still often seen cited as *Phaseolus aureus* or *Phaseolus radiatus*.

Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Order : Fabales
Family : Fabaceae
Genus : Vigna
Species : V. radiata
Binomial name : *Vigna radiata* (L.) R. Wilczek
Synonyms : *Phaseolus aureus* Roxb

**Vigna mungo:**

It is also referred as urad dal, urd bean, urd, urid, black matpe bean, black gram, black lentil or white lentil. It is bean grown in southern Asia. It is also transferred from Phaseolus to Vigna. It belongs to same species as mung bean. Its cultivation originated in India and has been introduced to other tropical areas by Indian immigrants. It is an erect, sub – erect or trailing, densely hairy annual herb. The white lentils are called ‘ulundu’ in Tamil. Black gram is a tropical leguminous plant which belongs to the Asiatic vigna species along with *Vigna*.
radiata, V. triobol, V. aconitifoliata, and V. glabrescense. It is cultivated as follow up crop after rice cultivation in India. It is grown in various agro ecological conditions and cropping systems with diverse agricultural practices (Javid, 2009).

Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Order : Fabales
Family : Fabaceae
Sub family : Faboideae
Tribe : Phaseoleae
Genus : Vigna
Species : V. mungo

Binomial name : Vigna mungo (L.) Hepper

Vigna radiata and Vigna mungo are the important pulse crops occupying unique position in Indian agriculture. Among the pulses they stand fourth in production and acreage (Deepalakshmi and Anand kumar, 2004; Mandal et al., 2009). They are the staple crop in central and South East Asia but extensively used in India and now grown in the southern United states, the West indies, Japan and other tropics and sub tropics. They are the summer pulse crops with short duration and high nutritive value (Karamany, 2006). Are much valued for their high digestibility and freedom from flatulence effect (Fary, 2002). They are used for human food, green manure, cover crop, forage, silage, hay and chicken pasture. Although grown mostly as food for seed production they could be cultivated in the form of double cropping after barley, wheat and oat (Imrie, 2005; Karamany, 2006). They are sown on most soil but can grow on heavier soils. Among legume, they are more useful because they are the main sources of amino acid as well as protein (Imrie, 2005; Kulsem et al., 2007)
Several works have been documented on growth pattern of *Vigna* species using different dilutions of industrial effluent. Jamal *et al.* (2006) studied the growth effect of *V.*sinensis and *V.*radiata on application of chromium and aluminium. *Vigna mungo* was used by Chidambaram *et al.* (2009), to study the chromium cytotoxicity. Diluted tannery effluent caused poor germination of wheat but the germination percentage increased on using diluted effluent in the study done by Tayyar and Yapict (2009).