REVIEW OF LITERATURE
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"Pollution is nothing but the resources we are not harvesting. We allow them to disperse because we've been ignorant of their value."

Buckminster Fuller

Soil is the complex mixture of the decomposed organic material and eroded rock textures on of earth’s surfaces that support plants they underlie the foundation of houses and factories and determine whether the foundations are adequate. They are having miscellaneous properties with the integrated effects of climate and living matter acting upon parent material, as conditioned by relief, over period of time (USDA, 1951). People are dependent on soil, and conversely, good soil is dependent on people and the uses they make of the land soil also have other meaning of human kind. Soil is used to absorb wastes from sewage systems, wastes from other municipal, industrial, and animal sources. Unfortunately misused and unprotected soil can be deposited in municipal reservoirs, impairing water quality and shortening the usefulness of the reservoir (Brady, 2000). Modern society discharges many waste products and chemicals in the water, which enter the soil, and affects all forms of life. The release of solid waste to the environment may lead to contamination of water supplies, endemic disease, offensive smell and eutrophication of waterways. In addition to these solid waste is also known for its potentially elevated organic pollutants (e.g. phenols, polychlorinated biphenyls) (Lottermoser, 1995).

Phosphorus in Soil and Plants

a) Literature of abroad

P is an essential nutrient for plant growth, required in relatively large quantities by plants, and considered relatively immobile in soils. Normally P becomes "sorbed" on soil particles, and this makes P less available for plant uptake or leaching. In time, as less soluble compounds are formed, P becomes less available, and P adsorption sites subsequently may be regenerated. Several investigations with waste products have indicated that, even though organic P may be more mobile than inorganic P in the soil profile, the extent of P movement is limited compared to the movement of N. (Miller et al 1976)
reported that soluble P levels were higher immediately below hog manure lagoons but decreased to background levels within 20 to 30 cm.

Land application of organic wastes obtained from different sources (Municipal, Industrial, or zoo technical) has two advantages: it avoids accumulation of wastes in the environment and it provides organic matter and nutrients for soil. It is also widely accepted that the nutrient content and organic matter content of any wastes are its primary desirable properties relative to its utilization on land. Because they are enriched in N and P, so supposed that they can increase crop yield (Narwal et al., 1983, National Research Council, 1996).

Kelling et al. in 1977 applied the liquid digested sludge at different rates in a sandy loam soil and found that sludge applications resulted in immediate marked increased in Bray’s extractable P. However, the extractable P levels decreased with time after sludge application, probably as a result of P fixation. Significant amounts of P remained available for at least 2 years at the higher treatment rates.

Soon et al. (1978) found significant increase in 0.5M NaHCO₃ extractable P in soils with increasing rates of P addition of lime, Fe, and Al precipitated sludge.

Johnston (1981) on the Woburn Market Garden experiment and indicated that sewage sludge applications from 1942 to 1967 resulted in increase in plant available P as measured by 0.5M NaHCO₃ extraction.

A long term experiment using corn was initiated on calcareous stripe mines spoil to evaluate the effect of anaerobically digested sewage sludge on spoil crop system. They found that grain yields were significantly affected by sludge application, but Stover yields were not affected. Concentrations of N, P, K, Ca, and Mg min corn tissue varied in response to sludge applications. Leaf and grain P and grain K declined with higher rates of sludge application (Peitz et al. 1982).

Gastring and Jarrell (1982) studied the plant availability of phosphorus and heavy metals in three soils (acid, neutral and alkaline) amended with chemically treated \( \text{Al}_2(\text{SO}_4)_{3} \), \( \text{FeCl}_3 \) and \( \text{Ca} (\text{OH})_{2} \) sewage sludge. They observed that bicarbonate extractable P increased with the addition of sludge. However, no discernible
trends in P uptake by the Chard were observed for any of the fertilizer treatments or application rate.

Inman et al. (1982) applied treatments of 0, 150, and 300 metric tons/ha (dry weight basis) of fresh-composted sludge material to a Chester silt loam in Maryland with no detrimental effects. In fact, the subsurface soil solution was generally below 0.08μg/ml, and the compost-treated plots were equal to or lower in soluble P than were samples taken from the control plots.

Robertson et al (1982) applied 0, 87, 174, 241, 288, and 355 metric tons/ha of dry matter from liquid-digested sludges over a 6-year period. They noted that, even though the amount of P added to the soil was large, P did not move appreciably. Most of the P remained in the top 90 cm of the soil profile, and P accumulation decreased with depth.

Wong (1985) in an experiment found that trace metals content in the roots were increased most by a combined application of NPK and digested sewage sludge. NPK alone had an intermediate effect and digested sewage sludge alone had least effects on these contents.

McCoy et al in 1986 carried out a greenhouse and field studies to compare the effectiveness of Blue plain sewage sludge compost, Parkway sewage sludge compost, and triple super phosphate (TSP) as source of P for corn. They noticed that application of TSP stimulated corn growth much more than applications of containing equivalent total P.

Seeda et al (1990) in an experiment found that acid sludge amendment in sandy soil increased the P uptake by V. sativa up to 1.0% of sludge; after it decreased and at more than the 3.0% amendment plants died.

Chrenykh (1991) in a pot culture experiment studied the effects of Zn, Pb and Cd on major and trace elements by barley and Vicia sativa. They reported that increase of soil Cd to 5ppm, Zn to 250 ppm and Pb to 125 ppm didn’t alter the plant mineral uptake, but higher heavy metal concentration disrupted the mineral
uptake and translocation. Reduction in uptake of P, Ca, mg, Fe and Cu were found in both plants but it was more pronounced in *V. sativa* than the barley.

The sewage sludge can be used as a fertilizer source to maintain crop productivity. It can improve the physical properties of soils (Sirisukhdom, 1998) by increasing soil porosity, and the stability of soil aggregation (Pagliai et al., 1981). Sludge application can increase the complexation and adsorption capacity of soil, enhancing the ability of soil to retain metals (Karapanagiotis et al., 1991).

Zhou et al (1994) analyzed undigested sewage sludge and showed that it contained high level of organic matter, N and P. When they added sludge to sandy loamy soil, sewage derived N and P were readily taken up by cauliflower and cabbage and yields were increased.

Frossard et al in 1996 when assessed the quantity of P that can be released from sludge and taken up by English ryegrass grown on sludge amended soil found that sludge increased soil available P and contribute to the P nutrition of the test crop. The utilization P derived from the sludge was systematically lower than the utilization of P derived from a water soluble fertilizer.

Mohammad and Battikhi (1997) studied the effect of sewage on some soil properties and barley plant growth in field study. They found that incorporation of sewage sludge significantly decreased the pH of soil and increased the EC and organic matter. Sludge application increased extractable P in soil and P content in straw and grains of barley.

A greenhouse study (Angela et al 2003) was conducted to assess P avoid availability from feces with low, medium, and high P concentrations from a dairy feeding study, whole (unfractionated) manure, fiber manure from a liquid solid separator, biosolids from a municipal waste treatment facility, and calcium phosphate (CaHPO₄). This observation emphasizes the importance of growing media characteristics in greenhouse experiments to assess P availability. These results suggest that soluble P sorption by soil, available P contribution from soil, and mineralization of organic P from the P source treatments masked initial differences in P availability among these P sources.
Connor et al in 2004 conducted a greenhouse studies with a common pasture grass grown in two P-deficient soils amended with 12 biosolids and a commercial fertilizer (triple superphosphate, TSP) to quantify P uptake and to assess the relative phytoavailabilities of the P sources. They have classified biosolids on the basis of P availability in 12 classes. The entire biosolid has more P availability but two of them have more P than fertilizer.

Bar-Tal (2004) conducted a greenhouse study to determine the loading rate of compost to land. They found that total dry matter (DM), grain production, and the amount of N, P, and K taken up by plants increased with increasing compost rate.

b) Indian Literature

Due to rapid industrial development during the last two decades in India, the disposal of industrial effluents and solid waste has become a serious problem. The tannery and textile are two important industries in the country. The application of these industrial effluents to land has started in recent years as an alternative means of treatment and disposal. This supplies not only water (a source of irrigation) but also manorial ingredients and plant nutrients like N, P, K, S and Ca etc. If these effluents are treated properly and reused judiciously in agriculture, they may serve as a source of irrigation and source of plant nutrients.

In a pot culture studies (Lal et al, 1996) with acid Alfisol (pH 4.9) amended with fly ash, highest dry matter yield of soybean was obtained in treatment receiving 16% (w/w) fly ash. A drastic reduction in plant growth was observed at higher levels. Fly ash application increased pH, organic carbon as well as available P and K status of the acid soil.

Giri and Bhattacharyya (1999) analyzed the solid wastes generated in Wazirpur Industrial Area of Delhi, dumped on the road sides of three blocks (A, B, C). Twenty-four representative samples were collected from three different blocks for the analysis of 12 physico-chemical parameters to characterize these solid wastes. The results revealed that the generated wastes were acidic (pH-3.48) in nature with electrical conductance (EC) 75 mS/cm, moisture content 35.67%, water holding capacity 52.85%, organic carbon 2.518%, available N 216 ppm,
total N 0.292%, available P 42 ppm, total P 0.182%, C/N ratio 9.33. The total concentration of nutrient elements were K 0.230%, Mg 0.420%, Ca 1.900%, Na 1.510%, Fe 12.300%, Zn 0.040%, Cu 0.210% and Mn 1.15%. The total concentrations of toxic metals were Cr 9643 ppm, Cd 83 ppm and Pb 100 ppm.

A field experiment was conducted by the application of industrial wastes like, fly-ash, paper sludge, and rice husk ash, which improved the physico-chemical properties of soil in terms of decrease in bulk density, increase in pH, organic carbon and available nutrients like, N, P, K, Ca, Mg, Cu and Co (Mittra et. al, 2000). This study indicates that ample scope of using industrial wastes on agricultural land. As it can help to overcome the problem of environmental pollution at industrial sites while maintaining ecological balances.

Mishra and Das (2000) in a pot culture study found that available P in Farmyard Manure mixed soil increased up to 15th day but after that it decreased up to 45th day and then again increased up to their study period that is up to 75th day. They also found that maize yield was high in Farmyard Manure mixed soil, having more organic matter in compared to control soil. On the basis of this study they concluded that organic matter helps in P amount in maize plant and soil.

When wheat was grown on contaminated soil Zahangren et al (2002) found that soil pH and available P affect the uptake of Cd in grain. P content of grains and P uptake is linearly related to concentration in soil.

**Heavy Metals in Soil and Plants**

**a) Literature of abroad**

Heavy metals usually refer to elements having densities greater than 5. Metals (Zn, B, Cu, Fe, Mn and Mo), which are required in small quantity to plants, are termed as micronutrients. But sometimes trace elements are synonymous for heavy metal. There are several sources of trace element in environment both natural and man-made: soil parent material, sewage sludge, fertilizer, liming materials, animal wastes, irrigation water, fly-ash, metal smelting industries, auto emissions and others. Some heavy metals are micronutrients, essential for plant
growth and therefore are beneficial to the crop (e.g., copper and zinc), however, in excess they can reduce growth or can be toxic to plants. Other heavy metals are not essential for plant or animal nutrition but are toxic to animals and humans above defined levels (e.g., arsenic, cadmium, lead, and mercury). Heavy metals are a concern because:

• they do not degrade over time,
• they are relatively immobile in the soil, and
• they accumulate in the plow layer of the soil.

Thus, the use of waste can be problematic because causes addition of harmful components such as pathogenic organisms, chemical pollutants or excess inputs of N and P (Vander Berg, 1993). A limiting factor to use waste on land is its heavy metal content like Zn, Cr, Ni and Cd, which can produce phytotoxicity (Webber, 1972; Saurbeck, 1985).

Numerous studies have been conducted to determine the effects of potentially toxic metals in sewage sludge on crops, since the accumulation in plants poses a potential health hazard to plants, animals, and humans. Limited information is available on the reactions of metals in municipal sewage sludge with soils, so reactions between metals in sludges and soils are not completely understood. Many researchers have reported that after municipal sewage sludge is incorporated into soil, portions of the metals revert to non-extractable, less available chemical forms (Beckett et al., 1979; Wollan and Beckett, 1979; Lagerwerff et al., 1977; Silviera and Sommers, 1977; Dowdy and Larson, 1975).

On the one hand, with time, these ions form inorganic compounds or stable organic complexes, which resemble the "native" soil forms of these metals (Beckett et al., 1979; Wollan and Beckett, 1979; Lagerwerff et al., 1977; Cunningham et al., 1975c). On the other hand, for example, some metals change only slightly in chemical character after addition to soil. Chromium, which is present as a colloidal precipitate in municipal sewage sludge, changed little in its chemical form. It remained mostly insoluble after incorporation of sludge in soil (Grove and Ellis, 1980).
In England, Patterson (1971), Chumbley (1971), and Webber (1972) observed through greenhouse and field trails with sewage sludge-amended soils that Cu, Ni, and Zn accumulated under certain conditions in soils to phytotoxic concentrations. They also noted that, in general, Cu and Ni were 2 and 8 times more phytotoxic, respectively than, Zn, which led them to propose the "zinc equivalent" for assessing the phytotoxic, from these metals in soils.

Bingham et al. (1975) observed that spinach, soybeans, lettuce, and curlycress were injured by soil Cd levels of 4 to 13 μg/g soil. These plants tend to accumulate Cd in shoots; whereas, lower shoot accumulators like tomato and cabbage could tolerate soil Cd levels of 170 μg/g without injury.

Cunningham et al. (1975) also conducted a green house experiment with soil amended with sewage sludge enriched with various combinations of heavy metals. Their treatments consisted of there concentrations each of Cr, Cu, Ni and Zn added to a pH 6.8 soil cropping with corn (Zea mays L.) and rye (Secuele cereal L). Multiple regression analysis of the metal treatments showed a number of metal combination reducing yields, with the Cu-Zn interaction accounting for as much of the yields variation as any combinations expect the four way interaction (Cr-Cu-Ni-Zn). They called attention to the complex nature of such interactions occurring in ultimate experiments.

Dowdy and Larson (1975) mixed municipal sewage sludge into two topographically associated soils with different pH levels of 5.9 and 7.9 (with free carbonates). After incubating the sludge-soil samples for one growing year, the researchers grew barley (Hordeum vulgare L.) to measure the quantities of plant-available potentially toxic metals. Incubation, sludge application rate, and soil pH affected metal accumulation within the roots and tops of barley seedlings. As sludge application rates increased, an increase in the removal of Cr, Ni, Zn, and Pb occurred when barley was grown on the acid soil. However, there was no change in the uptake of these metals when barley was grown on the high pH soil. Thus, with different levels of soil pH, metals released by the decomposition of sewage sludge either increased or decreased in availability for plant uptake.
The Council for Agricultural Science and Technology (CAST, 1976) classified Cd, Cu, Mo, Ni, and Zn as potential hazards in land application of municipal sewage sludges. These metals tend to accumulate in plants and cause either reduced yields or health problems to animals or humans that ingest the plants.

Lagerwerff et al. (1977) reiterate that the formation or the strengthening of metal complexes with higher soil pH levels and incubation affects their availability.

Kelling et al. in 1977 in a field experiment studied the metal concentration in soil and plant tissue resulting from land application of liquid digested sewage sludge. They found that addition of sludge increased the concentration of Cu, Zn, Cd and Ni in the vegetative tissue but the addition had little effect on the metal content of corn grain. Cr didn’t accumulate in tissue or grain. In their study concentration of metals were below the toxic level.

Ham and Dowdy (1978) determined the Cd and Cu concentrations in the aerial portions of soybeans and reported that these two elements were primarily located in the leaves, stems, and husks. In wheat, concentrations of trace elements in plant parts followed a similar pattern with the concentration in roots > leaves > stems > grain. Sims and Boswell, 1978 also found the same trend for Cd. Thus, the potential hazard from metals is reduced if only the seed is harvested and used as a food source. The specific amount of a trace element taken up by a plant species is directly proportional to the amount of sludge-borne metals added and the growth stage of the crop Lagerwerff et al, 1977 also reported the same thing.

The concentrations of Cd, Cu, Mn, Ni, Pb, and Zn in the edible parts of lettuce tops (Lactuca sativa L.) and onion bulbs (Allium cepa L.) were generally much higher when the plants were grown on sludge-amended soils in the greenhouse rather than when the plants were grown in the field (De Vries and Tiller, 1978).

Dowdy et al. (1978) reported that the concentration of Zn and Cu in bean leaf tissue increased with amount of metals supplied to soil through additions of sludge, until they reached a maximum concentration which did not respond to further applications of metals.
Although plants can absorb large quantities of heavy metals. The roots generally accumulate the most and often serves as storage sites preventing toxic dosages from reaching the stem and grain was illustrated by Kirkham (1978) in an experiment with chrysanthemum (Chrysanthemum morifolium Ramat.) roots accumulated almost 10 times more Cd than the stem and the leaves when grown in a culture solution supplemented with Cd.

pH near to 6.5 reduces the metal uptake by plants in sludge-amended soil. Increases pH generally enhances the sorption of Cu, Zn and Cd by soils and reduce plant uptake of Cd and Zn (Street et al., 1978). Increasing pH generally enhances the sorption of Cu, Zn, and Cd by soils (Cavallaro and McBride 1978; Kuo and Baker 1980; Soon 1981;) and reduces plant uptake of Zn and Cd (John et al 1972; Anderson and Neilson 1974; Street et al 1978).

Mitchell et al. (1978) evaluated uptake and phytotoxicity characteristic of Cd, Cu, Ni, and Zn with a greenhouse experiment consisting of an acid soil and a calcareous soil amended with 1% sewage sludge enriched with low to phytotoxic concentrations of these metals added alone (separate experiment for each metal) using lettuce (Lactuca sativa L. var. Longifolia) and wheat (Triticum aestivum L. Inia) as test crops. The order of toxicities by test plants was not the same for all soil and crop species combinations but in general, Cd was the most toxic, followed by Ni, Cu, and Zn. A subsequent investigation on the interactive effects of Cd, Cu, Ni and Zn when present tighter at low, intermediate, and high phytotoxic concentrations.

Sewage sludge is the solid byproduct of domestic and industrial waste, water/treatment plant. Philadelphia has developed a system of composting and of land application of sewage sludge on a basis for its sources (Lochar, 1979). Heavy annual application of sludge on land can increase the organic matter and nitrogen content of the soil (Sheaffer, 1979).

Crops grown on the sludge-treated soils, however, can contain higher concentrations of accumulated metals than those grown on uncontaminated soils (Carlton-Smith and Davis, 1983; Dowdy and Larson, 1975; Keefer et al.; 1986). Many climatology, soils property and crop cultivars related factors can affect the
ability of a land to absorb metal elements (change et al, 1987 and Corvey et al (1987) reviewed interactions between these factors. Based on its concentrations in the municipal sludges its chemistry in the soils and the ability of plants accumulates it Cd is regarded as potentially the most hazardous metal element when sludge are applied on land (Burai, 1980; Council for Agricultural Science and Techonology 1980; Logan and Chaney 1983; Pahren et al; 1979; Ryan et al 1982). Plant uptake may allow Cd to enter the human food chain.

Bowen (1979) estimated the general residence time of metals in the soil system to be between 75 year to 380 year for Cd, and between 1000 yrs to 3000 yrs for Cu, Pb, and Zn.

Gastring and Jarrell (1982) studied the plant availability of phosphorus and heavy metals in three soils (acid, neutral and alkaline) amended with chemically treated (Al₂(SO₄)₃, FeCl₃ and Ca(OH)₂ sewage sludge. They found that the increased plant level of Zn, Mn and Cd appear to be the result of lower pH produced up on the addition of Al-treated sludge. No significant difference in Fe, Ni and Pb concentrations were found in plant tissue for any of the treatments or application rates.

Mahler et al (1982) when Cd enriched sewage sludge applied to acid & calcareous soils found that Cadmium additions to the soils generally decreased Zn and Mn concentrations in saturation extracts in calcareous soils. These decreases were reflected in reduced concentrations of Zn and Mn in leaves of the test crops. The relationship between saturation-extract compositions of Cd, Zn and Mn and their plant compositions were found to be different for the acid as compared with the calcareous soil groups.

Higgins (1984) in his study applied sewage sludge at rates of 0, 22.4 and 44.8 mg of dry solids /hat. He found that Zinc and copper get accumulated in the soil horizon; however no accumulation occurred in the B-horizon. Corn (Zea mays) and rye (Seale cereale) yields were greatly enhanced by the addition of sludge but there was little difference in yield between the sludge loading rates. Uptakes of heavy metals in the corn and rye occurred in response to sludge application. Zinc was the only metal that consistently appeared at levels above the control.
In 1985 Kau et al showed that soil with high iron oxide content, in conjunction with soil liming, may give the best control of metal availability for accumulator species. Such as Swiss chard when grown in soil amended with sludge. They also found that increasing sludge application reduced soil pH, increased the amount of Cd and Zn extractable by DTPA and decreased metal uptake by plants.

Heckman in 1987 showed that excessive applications of sewage sludge and manure have led to the accumulation of heavy metals, in particular Pb, Cd, Cu, and Zn, in many agriculture soils. The contamination of soil with these elements can result in phytotoxic effect and the increased entry of toxic metals into the food chain, along with in the deterioration of surface water and ground water (Yingming and Corey, 1993). Furthermore, adverse effects on soil microbial activity were found even at very low concentrations of heavy metals in soils (McGrath et al 1995). However metals may become more available to plants with time depending on the biological and chemical conditions in soils after termination of sludge application. In particular, Cd and Zn are easily mobilized by soil acidification. Zinc was found to reach phytotoxic concentration and Cd and exceed food quality tolerance values in crop plants (Bidwell and Dowdy, 1987). Metal input into agricultural soils must be maintained at levels that minimize adverse phytotoxicity and risk to consumers through the food chain. Furthermore, the bioavailability and mobility of heavy metals in polluted soils should be controlled, giving special attention to the effects of soil pH and organic matter content (Smith, 1994B).

Abdel-Sobber et al (1988) noticed that when Municipal and industrial waste were applied to soil Cd significantly increased the Cd/Zn ratio in both crops especially in Swiss chard and Cd and Zn ratio in plants (Zea maize and Swiss chard) was affected by both Cd and Zn in soil.

When supplemented in a culture solution at a level above 28.1μg/L, Cd was found to decrease the concentration of K, Zn, and Mn in wheat biomass but did not affect the absorption of Fe and Cu (Jalil et al 1994). Zinc enhanced Cd uptake by spring wheat grown in sand when applied at levels of 1.042 and 1.542 g/kg (Dudka et al.; 1994). Abdel-Sabour et al, (1988) found for corn (Zea mays
L.) that Zn reduced Cd uptake, while Williams and David (1976) found that Zn generally enhanced Cd plant uptake.

All experiments dealing with sewage sludge application to soil have not shown positive results. The chemical properties of sludge make the positive or negative results of its impacts on land. Negativity can overcome by submitting the residues, like high heavy metals or phytoxic substances, excess labile organic matter, pathogenic microorganisms etc, to a suitable composting process (Witter and Lopez, 1988).

Kim et al in 1988 selected twelve food plants and grown them in greenhouse pots to determine relative concentration of Cd and Zn in the plants grown in sludge treated soils. They found that, in general, the conc. in the leaf tissue was the highest and followed by root/tuber then followed by fruit/seeds/flowers come last. The relative Cd and Zn conc. Of a food plant grown in sludge treated soils were significantly different.

In a pot trails (Seeda et al; 1990) V. faba was grown on sandy soil treated with acid sludge (pH) to give a final concentration of 0-5% sludge in soil DM. They noticed that electrical conductivity increased but pH and plant dry matter yield/pot decreased with increasing percent of sludge. Plant tissue concentration of Fe, Cu, Mn, Ni, Pb and Cd increased with sludge up to 3%. Uptake of Cu, Zn, Mn and Pb increased with sludge up to 1.0% sludge and than decreased.

Tadesses and Shuford in 1991 found that Zn accumulation is more in wheat tissues when they grew wheat in sludge amended soil at low pH and high rate of sludge.

Sauerbeck 1991 showed that while the uptake of Cd by six different crop plants increased linearly with metal concentration in the soil at concentrations of Cd less than 4 mg kg\(^{-1}\), the uptake of Cd by the plants was independent of Cd in the soil was greater than 5 mg kg\(^{-1}\).

Andersoon and Simon (1991) reported increasing levels of Cd in plants with increase in levels of P fertilization. Zinc is another interesting heavy metal
because of its relatively high abundance, its enhancement of Cd mobility, and its high mobility in soil and plant system.

Gorlach and Gambus (1991) studied the effect of liming, adding peat and phosphorus fertilization on the uptake of heavy metals by plants. They reported that liming reduced the uptake of Ni and Zn most; adding peat of Cd, Cu and Pb, reduced uptake the most while the effect of phosphorus fertilization was the least in nearly all cases.

Mench at al in 1993 conducted a study to see the effect highly metal polluted sludge on Maize growth. They found that plant yield decreased remarkably in the highly metal-loading soil should be attributed to 3 major factors: Mn deficiency in leaves, and increase concentrations of Cd and Ni in plant especially Ni in roots.

Heavy-metal polluted soils have for long been recognized as a serious problem in industrialized part of Western Europe (Alloway 1993) and North America (Hutchinson and Whitby 1997), and it has recently become apparent that the problems in Eastern Europe and Russia are in many cases even more extensive (Kozlov et al. 1993). In heavily polluted areas of this sort there are usually two main forest damage zones (Tikkanen and Niemela 1995): an industrial barren zone relatively close to the point emission source where the tree and ground vegetation are completely destroyed, and an outer zone where the vegetation is progressively suffering from serious damage but is capable of slow recovery if its emissions are drastically reduced.

In field study Mohammad and Battikhi (1997) found that sewage sludge increased the extractable micronutrient and heavy metals in soil and barley plant straw and grains also.

Smith (1994) found that sequence of metal concentration in the plant tissues from sludge-amended soils was Zn>Cu>Ni>Cd>Pb for wheat grain and carrot roots, and Zn>Cu>Cd>Ni>Pb for spinach leave. The concentrations of metals in wheat, carrots and spinach grown on sludge-amended soils in this study clearly showed that metal uptake is plant-species dependent. (Schaurer et al 1980; Vigerust and...
Selmer-Olsen 1986; Lubben and Sauerbeck 1991.). This implies that, for a given level of metals in soils, spinach leaves accumulate far greater amounts of metals than wheat grain and carrot roots. This is primary because of their very low soil-to-plant transfer rations compared to those of Cd, Ni, and Zn.

Lur et al (1995) investigated the uptake of Cd and Zn by cereal crops from soil fertilized with sewage sludge. They found that yield of barley and oats increased. Cd, Zn and P content of plants increased due to sludge addition. Sewage sludge had more available Cd and Zn in compare to soil. Coefficient of accumulation of C and Zn from sludge decreased in the order roots>shoots>grains.

Miller et al in 1995 studied the heavy metal in crops as affected by soil types and sewage sludge rates. For this they carried out a lysimetric test with barley and Swiss chard at different anaerobically digested sludge rates. In their study they found that metal content in plants increased with increasing sludge loading. The concentration of Cd, Zn, Cu, and Ni in barley (Hordeum vulgare L.) straw was higher than in grain. But the conc. of all these metals in Swiss chard (Beta vulgaris L.) were generally greater than those in barley, especially Cd and Zn were exceptionally high.

In green house experiment conducted to evaluate the availability of metals from sewage sludge and inorganic salts, and the effect of pH and soil type in yield and metal uptake (Cd, Zn, Ni and Cu) by wheat, Tadesse et.al. (1995) found that by both applications plant tissue concentration increased. However, increased pH cause decrease in heavy metal concentration in plant tissues.

Tsadilas, et al (1995) studied the influence of sewage sludge applications on some soil properties and on the growth of wheat and corn plants were studied with pot experiments. The results showed that sewage sludge application significantly influenced pH, organic matter content, electrical conductivity and available phosphorus. Soil pH increased and tended to hold steady near neutrality while organic matter content, electrical conductivity and available phosphorus (P) increased. For the heavy metals investigated only total copper (Cu) and Zinc increased but were below the limits given by the EC. A significant increase was
observed in the concentrations of Cd, Ni, Cu, and Zn extracted by DTPA while iron and manganese (Mn) were reduced showing a strong relationship to soil pH.

Several soil-related factors, namely pH, organic mater, Mn and Fe oxides, and clay content determine the chemical associations of heavy metals and their availability to plants (Narwal and Singh 1998). Among these factors, pH has been regarded as major variables regulating the metal mobility in soil (Heckman at al. 1987). The sorption and the precipitant of heavy metals are enhanced by increasing soil pH (Kiekens 1984; Alloway and Jackson 1991). These processes help to explain the decreased mobility normally found in soils with a basic pH.

There are several mechanisms, which may act concurrently, that could explain the observation that the plant uptake of metals increases with the increasing soil metal concentration until it reaches maximum and there after is independent of the total concentration in the soil.

Firstly, in soils which have received inputs of metals as the results of applications of sludge, there is evidence to suggest that chemistry of the sludge may be important in controlling subsequent metal availability in the soil (Corey et al. 1987). This is because sewage sludges typically contain a high proportion of organic and amorphous oxide components which have a high capacity for specific sorption of metals (Haenam Hyun et al; 1998; Jing and Logan 1992; Luo and Chrisite, 1998).

Secondly, precipitations reactions could limit metal solubility (Christensen and Tjell, 1984; Mahler et al; 1978). Increases in the total metal concentrations in the soil above a critical limit for metal precipitation would not lead to further increases in metal concentrations in the soil solution, and therefore there would be no further increase in absorption of metals by the plants roots.

Finally, McBride (1995) postulated that root avoidance of a surface contaminated soil layer might be involved in reducing metal uptake by plants growing in sludge amended soils in which, for the field studies that have been performed, typically only the top 20 cm have been heavily contaminated with metals. (Williams and
David (1977) clearly demonstrated this effect on Cd uptake in pot studies with subterranean clover.

Eleiwa et al (1996) studied the effect of two sewage sludge on the growth of faba bean. They found that no of nodules/plant, plants height and leaf area increased significantly with the application of both sludge up to 5%. Root and shoots dry weight and N, P content of plants also increased with both sludge at lower concentrations. Zn and Cu content of roots and shoots increased by increasing the rate of sludge, while Fe, Mn, Ni and Cr contents of roots were slightly effected and they remained unchanged in the shoots.

Hooda et al (1997) grow wheat and spinach and carrot in previously sewage sludge amended soil found that plant availability of heavy metal differed widely among the crop species. The accumulation of Cd, Ni and Zn in the plants showed the greatest increase compared to their background levels. The Cu and Pb accumulation in the plants grown on sludge amended soils showed only small increase compared to those grown on uncontaminated soils. Multiple regression analysis of various soil properties showed that the surest way to control the accumulation of metals in food plants is by controlling their concentrations in the soils. Furthermore, soils with a non-acidic pH and a clayey texture tended to achieve better control of metal accumulation in food plants compared to those with an acidic reaction and a coarse texture.

When Hamon et al (1999) grew Raphanus satives L. in a soil historically amended with sewage sludge at different rates and examined concentrations of Cd and Zn in the plants and in corresponding rhizosphere soil solution, metal concentrations in the plant displayed a plateau response. However, concentrations of total or free metals in the soil solution did not display a similar response, therefore the pre-requisite for determining that metal uptake by plants was limited by sludge chemistry was not met.

Begonia et al, 2000 grew wheat in a Cd contaminated soil and identified that wheat as a potential phytoextraction species because of its high biomass yield under elevated Cd levels and its ability to translocate high amounts of Cd into its shoots.
Sherif et al (2001) found that potato yield was high when they grew it in sludge amended soil. Increasing rates of sludge increased concentration of trace elements (Fe, Zn, and Mn), organic matter and P availability in sludge amended soil but did not reach the critical level of toxicity.

Wong et al in 2001 evaluated the feasibility of using a domestic (Tai Po sludge) and an industrial (Yuen Long sludge) sewage sludge produced in Hong Kong for the growth of vegetable crops. The acidic loamy soil with or without lime treatment was amended separately with each sludge at application rates of 0, 5, 10, 25 and 50% (v/v) for the growth of a common local vegetable crop, *Brassica chinensis*. The plant available metal contents, as indicated by the DTPA extraction, increased with an increase in sludge amendment, but decreased with lime amendment at each sludge application rate due to the reduced metal availability at a higher pH. Sludge amendment enhanced the dry weight yield of *B. chinensis* and the increase was more obvious for the soil with lime treatment. The industrial sludge caused a lower yield than that of the domestic sludge amendment and a significant reduction in yield at high application rates of Yuen Long sludge was also noted. Tissue heavy metal contents, except for Fe, increased as the sludge amendment rate increased while plant grown in Yuen Long sludge amended soil contained higher Cr and Zn contents at each sludge application rate. Liming the soil reduced the heavy metal contents in the plant tissues, except for Fe, which were all below the allowable levels for vegetable crops.

An experiment was conducted by Moral et al (2002) to estimate the contribution of sewage sludge application to the input and availability of Fe, Mn, Cu, and Zn in amended soils. In order to study the dynamics of these essential elements, the experimental design was based on the incubation of two calcareous soils having different textures (sandy clay loam and clay loam) amended with composted and non-composted sewage sludge. A significant increase in available Fe, Cu, Mn and Zn was observed. The application of increasing rates of sewage sludge slightly increased the available fraction of the micronutrients studied. The influence of soil texture was to increase the available fraction in the clay loamy
soil compared to the sandy clay loamy soil. Availability of Fe, Cu, Mn and Zn continued to increase throughout the incubation period.

Antoniadis and Alloway (2002) studied the movement of heavy metals down the soil profile and found that risk is greater in case of heavy loading of mobile metals in soils, such as Cd, Ni and Zn, where metals have applied at low sportive capacity soil.

Kipling et al (2003) applied different doses of poultry litter & municipal solid waste on 13 different soils. They found that poultry litter increased yield of peanut from all 13 sites while municipal sludge increased yield in 1 soil.

Antoniadis and Alloway (2003) opted two sites to see the leachability of heavy metals by sludge application. The first site (SI) was field receiving heavy loads sludge from a nearby wastewater treatment plant, and the second (S2) was a farm applying normal sludge rates of 8 t ha\(^{-1}\) y\(^{-1}\) of the same sludge. Soil samples were also taken by a nearby untreated control site. In S1 the movement of heavy metals was significant even down to 80cm depth compared to the control. In S2 the concentrations of lead (Pb) and Zinc and the organic mater content were higher than the control down to 20cm, while nickel moved significantly down to 80cm.

Clucas et al. in 2003 studied the extent of metal (Cd, Cr, Cu, Ni, Pb, Zn) leaching from soils treated with metal-spiked sewage sludge was examined using large undisturbed soil lysimeters. Metal leaching from the soils were monitored continuously over a period of 3 years after sewage sludge application. Application of the sludge resulted in decreased pH and increased concentrations and total amounts of Cd, Ni, and Zn in drainage leachates from some of the soils, but had little effect on, or decreased concentrations of, Cr, Cu, and Pb. In some cases, Ni and Zn concentrations in drainage leachates exceeded drinking water and/or environmental standard; the leaching of these metals would seem unlikely to pose a major environmental threat.

Speir et al. in 2003 conducted an experiment to see the heavy metals in soil, plants and groundwater following high rate sewage sludge application to land. They observed that soil, pH was by far the greatest determinant of metal solubility and
that the metal source, whether sewage sludge or geochemical, had little influence. Results from extractant that solubilise other metal phases, i.e., NaNO₃, EDTA and HNO₃, are also presented and discussed.

Bülent (2004) in his two years study, conducted a greenhouse experiment to compare the effects of repeated applications of sewage sludge, MSW compost and manure on the heavy metal accumulation in the leaf and fruit of tomato and total and bioavailable heavy metal accumulation in greenhouse soil. They found that sewage sludge and MSW compost amendments significantly increased Zn, Cu and Pb contents both in leaf and fruits of tomato. Plant tissue concentrations of Cd and Cr were low and not detectable. Sewage sludge and MSW compost increased both total and DTPA extractable concentrations of Zn, Cu, and Pb and also total concentrations of Ni and Cd in the greenhouse soil. Cr content of soil was not changed with the applications of sewage sludge and MSW compost. Total and bioavailable metal contents of soil in sewage sludge and MSW compost applications were higher in comparison with manure application. Results suggest that the increase in soil metal loadings resulting from sewage sludge and MSW compost amendments has affected bioavailable metals.

Chantachon et al in 2004 conducted a study to investigate the phytoextraction of lead (Pb) by two species of vetiver grass ( Vetiveria zizanioides and V. nemoralis) irrigated with an increasing level of Pb for 12 weeks. In a laboratory study, the removal of lead from soil was correlated with lead accumulation by roots and shoots of both species of vetiver grass. High concentration of lead resulted in decrease of growth, total chlorophyll content and biomass of V. zizanioides, while V. nemoralis died after one week of application. A simulated field experiment was conducted to examine the efficiency of vetiver grass in removing lead from contaminated soil. The vetiver grasses, V. zizanioides and V. nemoralis, were grown in soil contaminated with Pb(NO₃)₂ for 3 months. The removal of lead from soil was correlated with lead accumulation by roots and shoots of both grass species. The grass roots took up more lead than the shoots.

Henning et al in 2004 conducted a glasshouse experiment to characterize soil-plant interactions of the main sludge-borne heavy metals (Pb, Cd, Zn and Cu) in
two sludge (low metal and high metal) to different soil types (clayey, loamy and sandy) on maize seedlings. The low metal sludge treatment showed the highest yield for maize seedlings when compared to controls. The amendment of sludge to the soil did indicate higher heavy metal content. Except for Cd, heavy metal values in the soils (at the beginning and end of experiment) exceeded guidelines due to very high background values in the soil. They have not found any negative effects of heavy metal contamination in plant parts of the crops.

Ni, Sung and Yang in 2004 studied the effect of phosphorus application on Zn accumulation in S. alfredi H. For this they gave five doses of P like 0, 31, 62, 124 and 248mgP/kg of soil. They found that shoot dry weight was significantly affected by P application (except the 248mgP/Kg treatment) than for no P application. Highest biomass of shoot was found at 31mgP/Kg treatment. Zn concentration in shoots with 31mgP/Kg treatment higher than for no P application after that with increasing doses of P, Zn concentration was found to decrease.

Wang et al (2004) conducted a study to evaluate the effects of different modifier (lime, humic acid and acids) application rates on crop growth and metal accumulation through rice and soybean plants, and the joint effect of Cd, Pb, Cu and Zn on migration and accumulation in soil plant system and found that all four metals with lime and humic acids raised the height of rice plants in comparison to only heavy metals treatment. While the height of rice was found to be lowest with heavy metals with acid treatments. The height, dry weight of aboveground plant parts, and yield of soybean were lower than the rice plants.

Adams et al in 2004 have done a study to investigate the relationship between soil properties and the concentration of Cd in wheat (Triticum aestivum L.) and barley (Hordeum vulgare L.) grain. For this they collected wheat and barley grain samples from two long-term sewage sludge applied soil. Cadmium concentrations were much lower in barley grain than in wheat grain under comparable soil conditions. Multiple regression analysis showed that soil total Cd and pH were the significant factors influencing grain Cd concentrations.
A growth room experiment (Zheljazkov and Warman, 2004) was conducted to evaluate the bioavailability of Cu, Mn, Zn, Ca, Fe, K, Mg, P, S, As, B, Cd, Co, Cr, Hg, Mo, Na, Ni, Pb, and Se from a sandy loam soil amended with source-separated municipal solid waste (SSMSW) compost. Basil (Ocimum basilicum L.) and Swiss chard (Beta vulgaris L.) were amended with 0, 20, 40, and 60% SSMSW compost to soil (by volume) mixture. Basil plants in 20 or 40% compost treatments reached flowering earlier than plants from other treatments. Additions of SSMSW compost to soil altered basil essential oil, but basil oil was free of metals. The results from this study suggest that mature SSMSW compost with concentrations of Cu, Pb, Mo, and Zn of 311, 223, 17, and 767 mg/kg, respectively, could be used as a soil conditioner without phytotoxic effects on agricultural crops and without increasing the normal range of Cu, Pb, and Zn in crop tissue.

Solubility and fractionation of P and heavy metals (Zhang et al. in 2004) were evaluated in media containing 0, 25, 50, 75, or 100% compost derived from biosolids and yard trimmings for potential impacts on the environment. As compost proportion in peat-based media increased from 0 to 100%, concentrations of total P, Cd, Cu, Ni, Pb, Zn, and Mn in the media increased whereas concentrations of total Co and Cr decreased. Except for Cu, all heavy metals in the water-soluble fraction decreased with increasing compost proportion in the media, because of higher Fe, Al, and Ca concentrations and pH values of the composts than the peat. When the media pH is controlled and maintained at normal range of plant growth (5.5–6.5), leaching of the heavy metals is minimal. However concentration of all forms of P were still higher in the media amended with compost because of higher total P concentration in the compost.

Schlossberg et al. in 2004 conducted a 2-yr field study and evaluated environmental and technical parameters associated with CCB (coal combustion by-products)—organic waste utilization as growth media in turf grass sod production. In both years, sod biomass was greatest in media containing biosolids and fly ash. Using CCB–organic waste mixes at the rates 200 to 400 m³ ha⁻¹ is a rapid and environmentally safe method of Bermuda grass sod production.
Simmons and Pongsakul in 2004 done a study on cadmium (Cd)-contaminated soils, to predict Cd and zinc (Zn) uptake in crops as determined by readily measurable "indicators" of Cd and Zn phytoavailability would be a useful management tool to rapidly evaluate and prevent food chain Cd contamination risk. For the soils and soybean bean tested, the results indicate that readily exchangeable (0.01 M CaCl₂-extractable) and sorbed + organically bound (0.005 M DTPA-extractable) forms of Zn and Cd are dependent on soil pH.

Karamanous et al in 2004 carried out a study to see whether near maximum yields can be obtained with lower Cu rates. Two experiments were carried out in 1999 and 2000 to address these two issues, one with 4 rates of Cu (0, 1, 2, and 4 kg Cu ha⁻¹) and one with 12 rates (0, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 kg Cu ha⁻¹) in the form of CuSO₄·H₂O. A total of 16 trials were carried out with hard red spring wheat on two groups of soils, namely, one containing soils that are considered Cu deficient (<0.4 mg DTPA-Cu kg⁻¹) and one sufficient (>0.4 mg DTPA-Cu kg⁻¹). There was a significant wheat seed yield increase to Cu fertilization in deficient soils only with the application of up to 5 kg Cu ha⁻¹. Near maximum yields were obtained with application of 2 kg Cu ha⁻¹, thus providing a more economic alternative to prairie producers. Application of rates greater than 5 kg Cu ha⁻¹ led to a gradual yield reduction and at 10 kg Cu ha⁻¹ as CuSO₄·5H₂O, the yield was actually lower than that of the control. Hence, over fertilization with CuSO₄·5H₂O results not only in an economic waste but a danger of toxicity.

When lime is added, solubility of aluminum decreases and the soil pH is raised. Aluminum is soluble at pH values below 5.5 and toxic levels are frequently encountered in Florida mineral soils with a pH of less than 5.0. Organic soils contain little aluminum; therefore, plants can tolerate low pH levels on these soils without adverse effects. Lime also affects the solubility of other elements; therefore, some plant nutrients are made more available by liming while toxicities caused by excessive concentrations of other nutrients are reduced. (Chambliss et al, SS-AGR-46, edis.ifas.ufl.edu).

Liming soils offers a means of minimizing the risk of food chain contamination by reducing the plant uptake of sludge-borne heavy, metals (Wiiliams et al 1987;
Jackson and Alloway 1991; Smith 1994). Several studies, however, have indicated that liming may not always have a significant effect, and that the effectiveness of liming could also vary depending on the soil, metal, pH value of the limed soils and crop species (Humphill et al 1982; Peper et al 1983; Kuo et al 1985; Erikson 1989).

Tsadilas et al conducted a field experiment in a strongly acid Typic Haploxeralf (pH 4.9) with winter wheat. They applied fly ash at two rates and also with sewage sludge and found that fly ash and SS (sewage sludge) significantly increased soil pH and in a lesser degree organic matter content. As a consequence of soil pH improvement, grain yield was significantly increased especially in the treatments including FA at the higher rate or FA plus SS. Total concentrations of the metals studied were not significantly influenced (data not presented). However, soil pH significantly affected —available “forms and some fractions of the metals studied. —Available” Ni and Zn concentrations were decreased in the treatment with the highest FA rate. The same was true for exchangeable Ni Zinc extracted by DTPA was positively correlated with organic matter content. (http://www.eom.slu.se/icobte/additional/SP5orTsadilas.pdf)

(b) Literature related to India

Mishra et al (1995) investigated the effect of sewage sludge and Mussoorie rock phosphate (MRP) on biomass production and uptake of heavy metals by spinach. They found that sludge treated plants grew slightly more than control plants but accumulated more Cd, Pb Cu and Cr than the control plants. Plants grew best in presence of both sludge and MRP; these plants did not accumulate heavy metals to the same extent as the sludge treated.

Srivastava et al (1995) have done an experiment to see the effect of ordnance factory effluent on seed germination and early growth performance of pea seeds was studied. They found that the ordnance factory effluent was highly deleterious for the germination where early growth performance of seeds and as the concentration of effluent increases the deleterious effect also increases thereby showing positive correlation.
Arora and Chauhan in 1996 conducted a study with the tannery effluents to see the effect on seed germination percentage, seeding growth and total biomass in some varieties of *Hordeus vulgaris*. Effluents collected from Mahajan Tannery, Agra caused a significant reduction in germination percentage, length and total biomass in almost all the varieties.

When Rao and Shantram (1996) grew maize in soil amended with Urban Solid Waste (USW) no visual deficiency or phytotoxic symptoms were evident. Fe uptake by maize was decreased at all levels and that was due to low Fe content of USW. They also reported that Zn uptake by maize increased by application of USW compared to control. Heavy metal uptake by plant was also high in their study.

Karpate and Choudhary (1997) carried out a study to of the effect of fly ash and fly ash water was studied on *Triticum aestivum*. Plants were either irrigated with 25%, 50%, 75% and 100% fly ash water or grown in 50%, 70%, 90% fly ash amended soil. At lower concentrations the fly ash water and fly ash had stimulatory effect on the crop. However, at higher concentrations the treatment showed deleterious effect. Moreover, all concentrations of fly ash water and fly ash were found to have damaging effect on cytology and genetic material.

A study was carried out to (Dutta and Boissy, 1997) investigate the effect of effluent of the Nagaon Paper Mill (Hindustan Paper Corporation Ltd.) on the germination of rice (*Oryza sativa L. var. Masuri*) seed and subsequent growth of seedlings. They found that effluents particularly at higher concentrations inhibit germination and growth of seedlings. Further, it was observed that rice seeds collected from effluent affected area are less viable and even the viable seeds show delayed germination in comparison to the ones collected from control areas.

Prasanna et al (1997) were studied the effect of dairy effluent on seed germination, seedling growth and pigment contents of green gram (*Phaseolus aureus L.*) and black gram (*Phataseolus mungo L.*). A gradual decrease in the germination of seeds, seedling growth and pigment contents with increase in effluent concentration was observed. The best germination, seedling growth and pigment contents were observed in 25% effluent concentration. Thus effluent can
be used safely for irrigation purposes at proper dilution (25%) for beneficial cultivation.

In Calcutta municipal solid waste application in field also increased the toxic heavy metal concentration. It was found that heavy metal accumulate maximum in root region than other (Olaniya et al., 1998).

Barman et al (1999) investigated heavy metal accumulation in fields receiving fly ash from a thermal power plant and subsequent uptake in the different parts of the crop plants growing in the respective field. The metal content (Cd, Cu, Zn, Fe, Ni, and Pb) in the soil samples are higher than that in the control soil and lower than that in the background value. In case of Cd, Zn and Pb the concentration is either below or within the critical concentration. In the edible parts of plant Cu, Zn Pb the concentrations are within the recommended permissible limits, whereas Cd Cr and Ni show a little higher concentration.

Solid waste is a scourge in all-Indian mega-cities. The quantity of solid wastes generated in urban areas, ranges from 0.3 to 0.5 Kg/capita/day, depending upon the lifestyle of the people (Ahsan 1999). In Delhi alone, more than 5000 tones of municipal solid waste are generated every day. An integrated solid waste management should include the following components; waste minimization, material recovery and recycling, waste processing and energy recovery, waste transformation and waste disposal.

Siddiqui et al in 2000 conducted an experiment to study the effect of fly ash on growth and yield of mustard (Brassica juncea Czern and Coss). Study revealed that application of lower concentrations (20 and 40%) of fly ash significantly enhanced the growth and yield parameters. 40% level of fly ash proved to be optimum for all the parameters studied. It can be concluded that soil amended with 40% level of fly ash proved best in enhancing the yield of mustard and seeds were safe for human consumption.

The effect of sewage biosolid composites as a nutrients source for the food and non food crops was studied under green house condition with varying levels of composites, namely 0, 22.7, 45.5 and 91.0 gm composites pot -1. The results showed
that increasing levels of compost addition increased the yield of all the crops. (Chitdeshwari, 2001).

Barman et al in 2001 studied the effects of industrial water of an electronic component manufacturing unit with electroplating and its subsequent effects on soil and plants receiving the effluent. The physico-mechanical parameters of the soil samples were not changed, but the concentration of metals were comparatively higher than the control soil. Higher accumulation of metals was found in the plant parts in naturally growing weeds and cultivated crop plant irrigated with treated effluent. Elevated accumulation of metals in *Eichhornia crassipes* and *Marsilea* sp. growing along the effluents channel has been identified as a potential source of biomonitoring of metals particularly for Cu and Ca and can be utilized for the removal of heavy metal from wastewater.

It has been shown that germination rate, root shoot length dry matter yield reduced by the application of electro plating effluent on the germination of maize (Selvakumari et al, 2002).

Ramachandran and D’Souza (2002) carried out an experiment on the uptake of Cd, Zn and Mn from soils amended with Cd enriched sewage sludge. They noticed that the dry matter yields of both maize and mung bean shoots decreased with increased Cd content of sewage sludge added to different soil types.

Khan and Bhardwaj (2002) did a green house experiment to evaluate the effect of fly ash (FA) on the growth, development and metal ions uptake by board bean (*Vicia faba*) and chilli (*Capsicum frutescens*) plants. The results indicated that the lower doses of FA upto 15 gm Kg-1 soil had a beneficial effect with regards to growth, development and nutrient uptake by both the plants grown in FA amended soil. At higher doses beyond this dose posed a significant phytotoxic effect with the increasing concentrations of FA.

The accumulation of As, Cd, Cu, Hg, Ni, Pb and Zn in industrial solid waste amended soil has been studied. The soil samples were taken at the depth of 15 cm from the surface. The concentration of some metals was found to be higher.
detected concentration of metals has also been correlated with the organic matter and chemical demand of the samples. (Pande and Shrivastava, 2002)

Ritesh & Sihorwala in (2003) studied the industrial waste from rolling and picking industries and found that this waste is acidic, comes under hazardous waste & also have leach ability of heavy metals like Ni, Cr, Co Fe & Cu in sludge.

A sequential extraction procedure used to study the changes in the distribution and mobility of Cd, Cr, Cu, Ni, Pb and Zn in an acid lateritie soil amended with alkaline coal ash and neutral sludge individually and with their mixture of equal proportions at 25, 50 and 75 mg/ha application rates and grow with peanuts. The vegetative plant parts showed maximum accumulation of metals indicating a physiological barrier in the transfer of metals from the root to the kernel. Linear relationships of total concentrations of heavy metals in soil with that in the crop were observed (Kumar et al 2003).