I. INTRODUCTION
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Man has made great strides towards industrial development and civilization which undoubtedly improved the living conditions and comforts of life. But in the process he has inadvertently upset the crucial environmental balance established by nature over a millenium; which also brought about the degradation of all facets of the natural environment-physical, chemical, biological and social.

Human well-being depends on the biological as well as material environments. Plant growth is the outcome of many factors among which pollutants must clearly be counted (Holdgate, 1980). A wide range of environmental pollutants such as poisonous gases, agricultural chemicals, solid-wastes, radioactive materials, industrial effluents, sewage water etc. are known to pollute air, water, soil and bring about hazardous effects on plants, animals and human beings.
Risk of heavy metal contamination on vegetation by industrial waste, sewage sludge and motor-vehicle exhaust has been revealed through the explorations of Metzger et al. (1983), Sterrett et al. (1996), Tsvetkova and Nikolina (1996), Voutsa et al. (1996), Lee et al. (1997) and Olajire and Ayodele (1997).

The study of heavy metal pollution specifically in agro-system becomes more important due to their non-biodegradable nature leading to the tendency of being accumulated in the soil environment. Agricultural plants represent an important pathway for the movement of potentially toxic trace elements from soil to human beings. WHO (1984) has recognised health hazards of metal in food chain even at low concentrations. Studies have been conducted to evaluate the transferred elements from soil to plants (Cataldo et al., 1988). Naturally occurring chelating agents have been known to interact with the metal ions and increase their availability to the plants (Wolterbeek et al., 1988). The low molecular weight organic acids released as root exudates were reported to be efficient phytochelators of metals (Stevenson and Ardakani, 1972 and Rashmi Nigam et al., 2002). The chelated metal compounds are found to be more soluble than inorganic precipitates and have different rates of mobilization (Sposito et al., 1976).

Environmental pollution with heavy metals perhaps began with the discovery of fire and gradually aggravated to its present alarming level with industrial development and advancement of society. High consumption, frequent disposal and replacement of disposable items are generating diverse types of metallic wastes which are discharged
into the environment and thus poisoning the biosphere. Rapid industrialization is greatly contributing to the metal loads in our natural water system. According to Klein (1972), heavy metals like Hg, Cd, Zn etc. are abundant in industrial areas than in residential or agricultural areas. Bisessar et al. (1983) recorded the concentration of copper in soil near a nickel refinery as 2000 ppm, which is indeed a very high value.

Heavy metals are elements having a density greater than five and atomic number greater than twenty in their elemental form and comprise about thirty-eight elements. Some heavy metals like Cu, Fe, Mn, Mg, Zn and Cr are beneficial to plant life in microquantities, hence are trace nutrients. But they become toxic at higher concentrations (Clement et al., 1974; Foy, 1974; Tadana, 1975 and Chaney and Giordana, 1977). Metals like Hg, Cd, Ni, Sn etc. are in no way good for living organisms. There are ample references for their action as agents of biological abnormalities (Bergh, 1952; Foy, 1974; Clement et al., 1974; Tadana, 1975; Chaney and Giordana, 1977; Judith et al., 1978; Takkar and Mann, 1978; Baishnab et al., 1980; Balch et al., 1991; Barcellos et al., 1991; Boon and Soltanpour, 1992 and Liza, 1997). Several analytical studies indicate that metal pollutants have dose related, organ specific and cultivar specific differential effects in plants (Corradii et al., 1993). Iqbal and Khudsar (2000) were of opinion that at supraoptimal concentrations, heavy metals inhibit various metabolic processes and thereby retarding growth and developments in plants. Toxicity of trace elements in vegetables and in corn plants were studied by Yousef and Chino (1996) and Bulinski et al., (1997) respectively.
Metallic cations and anions which include all heavy metals find their way into the environment through various natural and man made sources; leading to several undesirable effects on water, air and soil components of the environment. Global metal pollution is more prominent in aquatic ecosystem followed by soil ecosystem and atmosphere. Toxic action of most of the trace metals stems from the fact that they are capable of interacting and forming strong bond with metabolically active groups within living systems.

The magnitude of the danger of environmental pollution by heavy metals was realized from the Minamata disaster caused by Hg and Itai-Itai Byo by Cd. Broman et al., (1991) and Sudhakar et al., (1991) have studied the heavymetal toxicity in Mytilus and algae respectively. The problems of heavy metal pollution in soil and plants in waste water irrigated areas of Tiajn were studied and the critical value of six heavy metal elements in soil were recorded as Hg-0.5 ppm, Cd-1-2 ppm, Pb-6-20 ppm, Cu-160ppm, Zn-300 ppm and Ni-30 ppm.

There are substantiative references on the impact of heavy metals on photosynthetically active plants (Agarwala et al., 1977; Misra and Biswal, 1980; Jana and Choudhury, 1982; Weigel, 1985; Schlegel et al., 1987; Somasundaram et al., 1994; Uzunova and Veticova, 1996; Obata et al., 1996; Chaoui et al., 1997; Skorzynska et al., 1997; Ewasis, 1997 and Liza, 1997).

Considerable studies were carried out on the effect of heavy metals on enzyme systems which include differential action of $\text{Cu}^{2+}$
Cd$^{2+}$ on the nitrate reductase in *Vigna sinesis* L. (Muthuchelian *et al.*, 1988), inactivation of phosphoenol pyruvate carboxylase by Cu, Pb, Zn and Cd (Marie Stiborova and Sylvate Leblova, 1985), influence of Cr on root associated Fe$^{3+}$ reductase in *Plantago lanceolata* L. (Marie Stiborova and Sylvate Leblova, 1984), role of Ni and Cd on the activity of glucose-6-phosphate dehydrogenase, glutamate dehydrogenase and malic acid/isocitrate dehydrogenase (Mattioni *et al.*, 1997), Hg as a hydrolytic enzymes in seedling growth of *Pisum sativum* (Sharma, 1985) and inhibition of nitrate reductase by vanadium (Somasundaram *et al.*, 1994).


The deleterious effect of heavy metals on plants was further proved by the incidence of morphological, anatomical, biochemical and histochemical changes on treated plants as observed by Hemalatha *et al.* (1997), Liza (1997) and Bianchi (1998). Bazzaz *et al.* (1974) were of opinion that the toxic action of heavy metals even
extends to the gaseous exchange system. Influence of Cd in the sensitivity of soybean to iron utilisation (Smith et al., 1985), phytotoxic burden of Co, Cd, Ni and Zn in white beans (Rausor, 1978), and tolerance of Zn in finger millet (Maury and Verma, 1997) were extensively studied.

Impact of heavy metals on seed production and seed viability (Ostrolucka et al., 1997), on the ecosystem (Wu et al., 1975 and Hattori and Hiroyuki, 1992) and their genotoxic effects (Sengupta and Ghosh, 1995 and Misra and Singh, 1999) were well traced.

The results of the experiments undertaken with medicinal plants and heavy metals by Grun et al. (1993), Zheljazhov and Nikolov (1995), Zheljazhov and Fair (1996) and Zheljazhov and Nielsen (1996) have revealed undoubtedly the potentiality of these toxic elements in altering the quality and quantity of various plant products of medicinal importance.

and Kannan and Ramteke (2002). It has been found that soil pollution
by heavy metals can restrict the growth of plants or produce farm
products containing high levels of heavy metal which could cause
harmful effects on life. High concentrations of heavy metals in soil may
lead to uptake by plants but there is no close relationship between
the concentration of heavy metals in soil and in plants (John et al.,
1972; John, 1973; Kuboi et al., 1986). The solubility sequence of heavy
metals in soil can be related to their chemical forms which stimulate
their mobility and uptake. In general, the toxicity of a heavy metal to
plants is related to its electronegativity of the specific metal ion and it
increases proportionately with higher values of electronegativity
(Chino, 1972 and Honma and Hirata, 1976).

The present study deals with the impact of three heavy metals
Cu, Zn, and Cr on three medicinal plants, Emilia sonchifolia DC.,
Eclipta alba Hassk. and Spilanthes acmella Murr.

Copper is an essential trace element which is ubiquitous in
earth crust. The main source of copper is its sulphide and oxide ores
from which the metal is extracted by roasting, smelting, electrolysing
and refining. Copper is used widely in the manufacturing of dyes,
paints, pigments, ceramics, pesticides and in therapeuticals. Copper
contamination of the environment is largely due to its release from
industrial units producing non-ferrous metals, fertilizers and disposal of
tailings or the solid wastes from mines. The flyash produced by
combustion of coal and organic matter further contribute to Cu
contamination. Copper is an essential element for biological activities
and forms an essential component of most of the oxidative enzymes like catalase, peroxidase, tyrosinase superoxide dismutase, amine oxidase and cytochrome oxidase. Although lower levels of copper is necessary for normal life activities in plants, at higher concentrations it becomes a toxic element. It is considered as the second most toxic element after mercury. In majority of plant species inhibition of growth occurs at less than 1ppm concentration. Normal level of copper in soil has been stated as 2-60 mg/kg. In circumstances of contaminated land redevelopments excessive level of these metals are considered in connection with phytotoxicity. Effect was well marked only when low pH and a lack of soil binding sites exist.

The competitive interactions among heavy metals during absorption are complex and have been studied very little. However there is evidence that the absorption of Zn$^{2+}$ by wheat from solutions is reduced strongly by Cu$^{2+}$ (Chaudhary and Loneragen, 1972). According to Loneragen (1975), Zn inhibits copper uptake from soil due to competitive interactions rather than through soil effect. It has been shown that absorption of heavy metals including Co, Cu, Ni and Zn by mustard plants can be reduced by EDTA or other chelating agents in nutrient solutions (De Knock and Mitchell, 1957).

Experiments reflecting the acute toxicity of copper have been done in marine copepod (Arnott and Ahsanullah, 1979), in rainbow trout (Howarth and Sprague, 1978), in human being (Murphy and Rhea, 1971), in plants (Oberlander and Roth, 1978; Rhoads et al., 1989; Fernandes and Heriques, 1991; Asha and Katewa, 1999 and Basak et al., 2001) and in aquatic macrophytes (Gupta et al., 1996).
Zinc is nutritionally an essential element and is required for the activity of enzymes. Maze (1919) and Sommer (1928) showed that Zn is essential for plant growth. In nature Zinc is of wide occurrence in the form of zinc blend (ZnS), zincite (ZnO), smithsonite (ZnCo3) etc. Zinc forms about 0.004% of the earth crust and ranks 25th in the order of abundance and it finds a variety of application in metal plating, alloys, catalysts, tyres etc. Chief source of zinc pollution in environment is municipal wastes, sewage effluents, waste oil trash from automobiles, batteries, construction materials, paints and pigments, pesticides, combustion of coal and organic matter, etc. The uptake and distribution of Zn by plants have been well studied (Rathmore et al., 1970; Mathys, 1977; Oberlander and Roth, 1978 and Sieghardt, 1990). Toxic level of Zn on maize and wheat was noted by Takker and Mann (1978). Judith et al. (1978) in their study on corn grown in zinc rich soil found severe chlorosis and stunting of plants. Effect of zinc on growth, yield and metabolic process of various plants were explored by Gupta and Singh (1972), Bruce et al. (1978), Jenerdan Reddy and Rao (1979), Robson and Pitman (1983), Marie Stiborova and Sylvate Leblova (1984), Cakmak et al. (1989), Greger and Kautsky (1991) and Liza (1997).

Chromium is generally an abundant element on earth crust which occurs in oxidised forms ranging between Cr3+ and Cr6+. Chromium metal and its salts are used in production of stainless steel, ferro-chromium, chrome pigments, explosives, tanning of leather, photography, dyeing, in wood preservation, as an anticorrosive agent in cooling system and in the combustion of fossil fuels. Phytotoxicity of
chromium which is generally released from industries of tanning, ferro-chrome pigment etc. were described by Koening in 1910. Cr\textsuperscript{3+} is the most common form of metal in nature and living system; and was considered less toxic than Cr\textsuperscript{6+}. According to the present view both forms, Cr\textsuperscript{3+} and Cr\textsuperscript{6+} are equally potent carcinogenic agents (Norseth, 1981). Varying concentrations of chromium were found to influence the growth, chlorophyll contents, mitotic activities, photo-oxidative activities etc. (Bonnet et al., 1991; Poschen-rider et al., 1991; Jayaprakash et al., 1994; Barcello and Poschen-rider, 1997; Nagalakshmi and Prasad, 1998).

Sewage - sludge and effluents from industrial unit forms important reservoir of the heavy metals. Heavy metals once entered the environment get accumulated in the food chain. In medicinal plants these heavy metals do not produce any change in the constituents and medicinal properties; but the quantity and production were found to have been affected (Zheljakov and Nielsen, 1996).

Plants selected for the study include, *Spilanthes acmella* Murr., *Eclipta alba* Hassk. of the tribe Heliantheae and *Emilia sonchifolia* DC. of Senecioneae both coming under the family Asteraceae.

*Spilanthes acmella* Murr.: The plant is erect and later ascending, stem and branches hairy, leaves ovate, petioles 0.6-1.6 cm long, heads 0.6-1.3 cm in length, ovoid solitary or sometimes subpanicled. Flower heads are the most pungent part, they are chewed to relieve toothache, used as fish poison, applied to soothe the itching,
to provoke salivation, decoction of leaves is used as a bath in rheumatism, scabies, psoriasis and as a diuretic and lithotrophic. Flowers contain mainly a sterol, a non reducing polysaccharide, spilanthol, a resin pyrethrin, an astringent organic acid, glucose N-isobutylamides etc.

**Emilia sonchifolia DC.**: It is a herbaceous pubescent plant, leaves variable, and with small branches, head reaching 1.3 cm long, corymbose, abracteolate, flowers purplish, and peduncle slender. Decoction of the plants is said to be used as a fembrifuge, mixed with sugar in bowel complaints, juice of leaves used in night blindness, eye inflammations and sore throats. It is used as a folklore medicine against inflammation, rheumatism, cough, cuts and wounds in India (Warrier et al., 1995). In China the leaves are used in fever and dysentery (Perry, 1982). It is also used as an analgesic and antibiotic (Autor collective, 1969). The aqueous extract of this plant showed antimicrobial activity (Srinivasan and Subramanian, 1980). The aerial parts were found to contain alkaloids (Chen and Roder, 1984) and flavanoids (Srinivasan and Subramanian, 1980). The plants belonging to Asteraceae were reported to have anticancer properties (Roussakis et al., 1984; Beutler et al., 1993 and Kupchan and Bauerschmidt, 1971). Cytotoxic and antitumor property were also explained by Shylesh and Padikkala (2000).

**Eclipta alba Hassk.**: It is a plant with erect, herbaceous branched stem, branches strigose with appressed white hairs, leaves sessile 2.5-7.5 cm long, variable breadth, oblong lanceolate and acute. Heads solitary or on unequal axillary peduncles, plant has a bitter hot
sharp dry taste. The plant parts are used raw or indirectly as an anthelmintic, alexipharmic, good for complexion, hair, eyes and teeth. It cures inflammation, hernia, eye disease, bronchitis, asthma, leucoderma, anaemia, disease of heart, skin itching, night-blindness, syphilis, uterine pains after delivery, leaves are used in scorpion sting and as a remedy for cataract in infants. The plant contains mainly wedalo-lactone, saponin, alkaloids like ecliptine and nicotine.

Medicinal plants in the vicinities of smelting, refining and electroplating industries have a high risk of contamination with heavy metals. The present study was undertaken with the intention of exploring the degree and extent of contamination.