REVIEW OF LITERATURE

To solve the burning problem of heavy metal pollution, researchers have found easy, low cost and ecofriendly method. The published work of many scientists are available in the form of research articles, review articles and case study in different journals, books and book chapters, Patents, Government reports etc. Few of them have been used to study and design the present investigation. The literature studied have also used as a background of present work and discussed with findings. The literatures reviewed are summarized below with suitable subheadings.

Pollution of lead and other heavy metals in different part of World

The industries, automobile, paint, batteries are major causes of lead pollution so that pollution of lead have been recorded different part of world. Lead, copper, cadmium and zinc pollution in Port Phillip Bay and western Port Bay in Victoria, Australia due to industrial release was studied by Phillips (1976). Anthropogenic emissions of trace metals to atmosphere were studied by Nriagu (1979). Lead pollution from household dust was investigated by Rundle and Dugga (1986). Pollution of lead, cadmium, mercury and arsenic due to petrol and coal combustion was studied in UK environment by Hutton and Symon (1986). Wadge and Hutton (1987) studied the pollution of lead by coal combustion and refuge incineration. Assessment of worldwide contamination of air, water, and soils by metals ions was studied by Nriagu and Pacya (1988). Heavy metal pollution including iron, manganese, nickel, cobalt, zinc, copper, chromium, mercury and cadmium was investigated by Sahu and Bhosale (1991). Environmental lead pollution of Agra city was studied by Srivastava et al. (1992). Simpson and Xu (1994) studied the atmospheric lead pollution over Brisbane, Australia. Pollution of lead in Varanasi was studied by Tripathi (1994). Lead pollution in lake sediment of Switzerland was studied by Moor et al. (1996).
Atmospheric lead pollution over Natal province South Africa was studied by Nriagu et al. (1996). Pollution of lead due to battery recycling and lead smelting industry in Trinidad was studied by Mohammad et al. (1996). Lead and zinc pollution due to release of industrial effluent was studied by Kelly et al. (1996) in Wolverhampton industrial area Britain. Atmospheric lead pollution in peat and lake sediment in Sweden was recorded by Brannvall et al. (1997). Atmospheric lead pollution in Lucknow city was studied by Singh et al. (1997). Environment lead exposure was studied in Africa by Chukwuma (1997). Pollution of lead in peat and freshwater lake sediment of Scotland was studied by Farmer et al. (1997).

Pollution of lead, zinc, copper and cadmium in harbor site of Vishakhapattnam was studied by Sultana and Rao (1998). Lead and other heavy metal pollution in dust and steam sediment due to industrial and traffic practices was investigate in Taejan area of Korea by Kim et al. (1998). Brich and Tylor (1999) studied the heavy metal in sediment of Port Jackson estuary in Australia due to nearby industrial applications. Li et al. (2001) studied the lead and other metal pollution in urban parks of Hong Kong due to industrial and automobile activity. Lead pollution in soil and water of Ontario, Canada was studied by Darling and Thomas (2003). Pollution of lead, chromium, nickel and zinc in lake of Bhopal was studied by Shrivastava et al. (2003). High level of lead, nickel, copper, and chromium was found in street dust sample of New Delhi by Banerjee (2003). Nicholson et al. (2003) studied the lead and other metal pollution in Agriculture soil due to sewage and industrial discharge in England and Wales. Nam et al. (2004) studied the Monitoring of lead pollution using feather of feral pigeons of Korea. Contamination of lead, chromium, copper, zinc, strontium and vanadium in soil of Pali industrial area of Rajasthan was studied by Krishna and Govil (2004). Pollution of lead, copper, nickel and zinc in dust and soil samples of Karak industrial area of Jordan was studied due to industrial emission by Al-
khasman (2004). Heavy metal pollution including lead, cadmium, chromium, nickel and iron was studied by Khillare et al. (2004).

Release of heavy metals from a petrochemical industry was studied in Tarragona city Spain by Nadal et al. (2004). Heavy metals lead, cadmium, chromium, copper, iron, manganese, nickel and zinc has been found in Santagarh and Atali site of Hindon River in Uttar Pradesh by Jain et al. (2005). Study of lead, zinc, iron, copper, manganese and cadmium pollution in soils of Denzili city of Turkey due to industrial and traffic applications was done by Celik et al. (2005). Atmospheric lead pollution in particulate matter over Shanghai City, China was studied by Tan et al. (2006). Pollution of heavy metals including lead was studied due to industrial practices in Kenting National Park, Taiwan by Hsu et al. (2006). Pekel (2006) studied the lead and other metal pollution in Izmit Bay Marmora Sea Turkey due to paint industry and coal combustion. Atmospheric lead pollution in Guangzhou city China was studied by Nurdan and Aydin (2007). Concentration of lead in respiratory particulate matter in Madurai was studied by Bhaskar et al. (2008). Pollution of lead and other heavy metals in Mangrove plants of Tamil Nadu was studied by Agoramoothy et al. (2008).

Contamination of lead in soil and water sample of Ebonyi state Nigeria was studied by Oje et al. (2010). Pollution of lead, chromium, copper, zinc, iron and manganese was studied due to industrial effluent in Challawa River of Kano Nigeria by Azumi and Bichi (2010). Abiola (2010) studied lead pollution in potable groundwater of Ibadan, Nigeria. Gayathri and Senthil kumar (2010) used Spectroquant Nova60 for detection of chromium in aqueous solution. Spectroquant Nova60 was used to detection of nickel in water sample by Herve et al. (2010). Aydin et al. (2010) used Spectroquant for detection of chromium in water sample. Industries and mining were found as a source of lead and other metal pollution in an estuary of Spain by Perez-Lopez et al. (2011). Lead pollution in rural groundwater of Benue state Nigeria was studied by Ocheri and Ogwuche
Vegtable oil industry was investigated as a source of lead and other metal pollution in Nigeria by Ibrahim et al. (2012). Sankpal and Naikwade (2012) investigated the pollution of lead, iron, cobalt, cadmium and chromium in industrial site of Ratangiri district, Maharashtra, India due to Pharmaceutical industry. Iron and steel industries were found as source of heavy metal pollution in Bhandara, Maharashtra. India by Ladwani et al. (2012).

Pollution of lead and other toxic substance over Environment of Chhattisgarh

Raipur, capital of Chhattisgarh is among the topmost polluted city of India. Some researchers have contributed to find out the pollutant in Chhattisgarh including heavy metals, respiratory particles and fluoride. A high level of atmospheric Arsenic was reported by Deb et al. (2002) in which industrial atmosphere was found highly polluted followed by traffic site in Raipur. Lead in RSPM was investigated by Sharma and Pervez (2003) at National highway no. 6 Durg-Bhilai sites of Chhattisgarh state and blood lead level of citizens living in road site was studied. High concentration of lead along with other heavy metals was found in Respirable suspended particulate matter (RSPM) of a cement plant in Raipur city by Sharma and Pervez (2004). Sharma and Pervez (2004, b) studied the dental fluorosis in worker of a phosphate fertilizer plant in Raipur city. Heavy metal has been studied in airborne dust particles of Raipur city by Thakur et al. (2004) in which Pb was found fourth most abundant metal in air and high metal concentration was studied in industrial sites followed by heavy traffic, commercial and residential sites of city. A high concentration of lead was investigated in road site of Raipur and Bhilai by Kamavisdar et al. (2005).

Arsenic contamination in ground water of Ambagarh- Chowki, Chhattisgarh was investigated by Acharyy et al. (2005). Patel et al. (2006) studied the lead pollution in water, soil and sediment of Raipur city. High level of particulate matter was investigated in Raipur city by Dubey and Pervez (2008).
Lead was investigated in high concentration in Particulate matter of residential sites of Raipur by Patel et al. (2008). Particulate matter from 42 sponge iron industry located in Raipur industrial area were studied by Rao et al. (2009) and its impact on air quality was also investigated. The concentration of lead was found several folds higher than the permissible limit of standard and it has found higher than in other part of India. Lead pollution in central India including Raipur, Bhilai and Korba was studied by Patel et al. (2010). Dental and skeletal fluorosis was observed due to high fluoride in groundwater of Tamnar, Raigarh district Chhattisgarh by Beg et al. (2011). Water soluble ionic composition of particulate matter was reported by Deshmukh et al. (2011) in Raipur city. Particulate matter as atmospheric pollutant in Raipur city was investigated by Deshmukh et al. (2012).

**Effect of Lead on living organisms**

Effect on growth, metabolism and nodulation in soybean with response to lead metal ion was investigated by Huang et al. (1974). Effect of water content and transpiration was studied in response to lead and other heavy metal by Barcelo and Poscherieder (1990). Mesmar and Jaber (1991) studied the effect of lead on seed germination, growth, chlorophyll and protein content of wheat and lens. Singh et al. (1997 a) studied the effect of lead on growth, photosynthesis, nitrogen fixation and productivity in some higher plants. Valverde et al. (2001) studied the direct DNA and metal interaction including lead and cadmium, the interaction found to cause genotoxic damage and mutation of DNA. The genetic toxicity of plant system in response to mercury, lead and arsenic was studied by Patra et al. (2004). Effect of lead and copper exposure on immune cells of mice was studied by Markeviejus and Dringeliene (2004).

Tomulescu et al. (2004) studied the effect of lead on germination of cereals. Destruction of ultrastructure of chlorophyll due to high concentration of lead was
studied by Elzbieta and Mirosawa (2005). Sheng et al. (2005) studied the effect of high concentration of lead in growth and shoot length of rice. Effect of lead on seedling of wheat was investigated by Dey et al. (2007). Effect of lead in growth of Cowpea was investigated by Kopittke et al. (2007). Gichner et al. (2008) studied the DNA damage and mutation in tobacco induced by lead. Translocation of essential nutrient in plants in the presence of high lead concentration was studied by Gopal and Rizvi (2008). Arshad et al. (2008) studied the uptake of lead in Pelargonium through root system. Qufei and Fashui (2009) studied the biosynthesis of photosynthetic pigments and photosystem in the presence of lead metal ion. Cenkei et al. (2010) studied the effect of lead on biosynthesis of chlorophyll in Brassica rapa L. Effect of lead on growth and chlorophyll content of Maize was investigated by Ghani (2010). Effect of lead in biomass and shoot length of wheat was studied by Shao et al. (2011). Pourrut et al. (2011) studied the uptake of lead, toxicity and detoxification in plants.

Metabolism and function of vitamin D was studied in response to Pb in rat by Smith et al. (1981). Apostoli et al. (1988) studied the effect of lead on red blood cells. Wadi and Ahmad (1999) studied the effect of lead on the male reproductive system in mice. Silbergeld et al. (2000) found the carcinogenic effect of lead damaging DNA and affecting repair system of DNA. Steenland and Boffetta (2000) found the carcinogenic effect of lead affecting chromosome aberrations and sister chromatid exchange in human. DNA damage in lead exposed workers was investigated by Danadevi et al. (2003). Study of impair rural development and neurotoxicity due to high lead level was tested by Lidsky and Schneider (2003). Carcinogenic effect of lead was studied by Silbergeld (2003). An adverse reproductive effect due to lead toxicity was studied by Tang and Zhu (2003) causing abnormal menstruation and spontaneous abortion in females. Mishra et al. (2003) tested the effect of lead on immune response and immune cells in lead exposed individuals. Olifa et al. (2003) studied the toxic effects of
lead on African Catfish. Zheng-Yan *et al.* (2004) studied the impaired immune function of T lymphocytes and erythrocites in children exposed to lead. Toxic effect of lead on freshwater invertebrates was studied by Grosell *et al.* (2006). Effect of lead poisoning on bone mineralization was studied by Gangoso *et al.* (2009).

Kim *et al.* (2009) studied the effect of lead on intelligence of school aged children. Impact of lead exposure on immune system was studied by Mishra (2009). Effect of lead on antioxidant enzyme activity and lipid peroxidation in mice was found by Parashanthi *et al.* (2010). Effect of lead on apoptosis and related genes in mice was studied by Liu *et al.* (2010). Jastrzebska (2010) investigated the effect of cadmium and lead pollution on freshwater fishes. Lead toxicity on testes, sperm morphology and fertility reduction in mice was studied by Sharma and Garu (2011). Barber *et al.* (2011) studied the effect of lead on white blood cells of Swiss albino mice. Neurotoxicity of central nervous system due to lead poisoning in children was studied by Hsiang and Diaz (2011). Effect of lead on white blood cells on Swiss mice was studied by Sharma *et al.* (2012).

**Resistance of heavy metal by some fungal species**

The adaptive behavior of fungi living in contaminated waste water contains potency to tolerate the metal ions. Response of fungi towards the heavy metal ions was studied by Gadd (1987). Interaction of fungi with toxic metals was studied by Gadd (1993). Tolerance of copper, zinc and cadmium by *Trichoderma atroviride* isolated from sewage of water treatment plant was studied by Errasquin and Vazquez (2003). Tolerance and lead uptake of *Paecilomyces lilacinus* was studied by Zucconi *et al.* (2003). Bellion *et al.* (2006) studied the cellular mechanism of metal tolerance in ecto-mycorrhizal fungi. Lead metal tolerance of *Aspergillus flavus*, *Candida utilis*, *Fusarium* sp. and *Penicillium* sp. was studied by Atunya and Oseghe (2006). The fungi *Aspergillus niger* RH17 and *A. niger* RH18 isolated
from soil contaminated with textile mill effluent were tested for tolerance against different concentration of lead nitrate by Faryal et al. (2007 a). The resistance of lead and copper metal ions by some genera of Aspergillus, Penicillium, Alternariai, Cephaloaphora and Eurotorium isolated from electric meter manufactory industry has been investigated by Siham (2007). The fungi Aspergillus niger, Aspergillus sp., Penicillium sp. and Fusarium sp. isolated from industrial and sewage pollute water were studied for heavy metal tolerance by Iram et al. (2009).

Ezzouhri et al. (2009) studied the tolerance of lead, chromium, copper and zinc by Aspergillus niger, Penicillium sp. and Fusarium sp. isolated from industrial and municipal waste contaminated soil. Purchase et al. (2009) investigated the tolerance and accumulation of zinc and lead by Beauveria bassiana and Rhodotorula mucilaginosa isolates from urban runoff. Parameshwari et al. (2010) studied the tolerance of Phenerochete chrysosporium and Trichoderma viride isolated from municipal sewage contaminated soil against nickel and chromium metal ions. Tolerance of heavy metal by Aspergillus niger, A. foetius and Penicillium simplicissimum was studied by Anahid et al. (2011). Aspergillus niger and Penicillium chrysogenum isolated from municipal sewage were found tolerance against copper, cadmium and lead by Al-Sohabani (2011). Aspergillus niger, A. fumigatus, Penicillium notatum and Cladosporium sp. were tested for heavy metal ions which were isolated from sewage treatment plant by Siokwu and Anyanwn (2012). Li et al. (2012) investigated the lead and zinc tolerance of Phoma, Alternaria and Peronellae species isolated from lead-zinc mining sites.

**Biosorption of lead and other metal ions**

Use of biological material for removal of lead from aqueous solution is ecofriendly and advantageous method. Both the living and dead biomass of
biological material were studied for removal of lead and other heavy metals from water.

Somers (1963) studied the biosorption of copper in spores of *Penicillium italicum*. Townsley and Ross (1985) investigated the uptake of copper by living cells of *Penicillium spinulosum*. Dead biomass of *Penicillium chrysogenum* was studied for removal of lead metal ions by Niu *et al.* (1993). Brady and Tobin (1995) investigated the biosorption of metal ions in *Rhizopus arrhizus*. Various physical and chemical pretreatment was applied to *Aspergillus niger* for removal of lead by Kapoor and Viraraghavan (1998a). Kapoor *et al.* (1999) investigated the biosorption of lead, cadmium, copper and nickel metal ion by living biomass of *Aspergillus niger*. Removal of lead from aqueous solution by living and dead biomass of *Phenerochete chrysosporium* was studied by Yetis *et al.* (2000). Physically and chemically pretreated biomass of *Mucor rouxii* was used for removal of lead by Yan and Viraraghavan (2000). Dead biomass of *Phenerochete chrysosporium* was studied for removal of lead metal ions by Say *et al.* (2001). Modified waste biomass of *Penicillium chrysogenum* was studied for removal of heavy metals was done by Skowronski (2001). *Mucor rouxii*, treated with sodium hydroxide was used for the removal of lead by Yan and Viraraghavan (2003). Heat treated biomass of *Penicillium purpurogenum* was studied for lead by Say *et al.* (2003b). Removal of heavy metals using the pretreated biomass of *Penicillium canescens* was investigated by Say *et al.* (2003a). Autoclaved biomass of *Verticillium marquandii* was studied for uptake of lead metal ions by Slaba and Blugonski (2004).

*Aspergillus versicolor* and *Penicillium vericullosum* was pretreated with various physical and chemical methods for biosorption of lead by Cabuk *et al.* (2005). Fungal biomass modified by acrylic acid was studied for copper and cadmium by Deng and Ting (2005). Lead biosorption by pretreated biomass of *Rhizopus arrhizus* was studied by Naja *et al.* (2005). *Aspergillus flavus* treated
with sodium hydroxide, acetic acid, detergent and DMSO was studied for removal of lead from aqueous solution by Akar and Tunali (2006). Sodium hydroxide treated biomass of *Aspergillus niger* was used for biosorption of lead by Dursun (2006). Oven dried biomass of *Aspergillus niger* was studied for removal of lead from aqueous solution by Quazilbash *et al.* (2006). Chemical modification using oxalic acid, malic acid and EDTA on *Aspergillus niger, Penicillium austurianum, Mucor arcinoloides* and *Tricherma reesi* for sorption of lead was investigated by Awofolu *et al.* (2006). Biosorption of lead and zinc by using living biomass of *Aspergillus oryzae* was studied by Patil *et al.* (2007). The uptake of cadmium by living biomass of *Aspergillus flavus, A. fumigatus, A. niger, A. sydowii, A. ustus, A. versicolor, A. terrus, Cladosporium cladosporides, Fusarium oxysporium, Penicillium chrysogenum, P. citrinum, Trichoderma viride, Phoma humicola* was studied by Al-Garni *et al.* (2009). Dried dead biomass of *Aspergillus niger* was used for biosorption of lead by Kumar *et al.* (2010). Sarkar *et al.* (2010) studied the biosorption by chromium by living cells of *Trichoderma viride. Mucor indicus* pretreated with autoclaving and sodium hydroxide was used for removal of lead by Javanbakht *et al.* (2011). Dead and immobilized biomass of *Aspergillus* sp., *Penicillium* sp. and *Cephalosporium* sp. was studied for removal of lead metal ions by Hemambika *et al.* (2011). Heat and sodium hydroxide treated biomass of *Aspergillus niger* was studied for removal of lead by Gazem and Nazareth (2012).

**Biosorption research done in Abroad**

Key findings were obtained by some abroad scientist with low cost biomass for removal of heavy metals and radionucleoid. Volesky and Tsezos (1982) patented the removal of Uranium from aqueous solution of *Rhizopus arrhizus*. Gadd and White (1985) studied the uptake of copper by biomass of *Penicillium ochro-chloron*. Rome and Gadd (1987) investigated the biosorption of copper by *Rhizopus arrhizus, Cladosporium resinae* and *Penicillium italicum*. Volesky and Kuyucak (1988) patented the work on Gold biosorption by biomass of sea-water
algae *Sargassum*. Acid treated fungal biomass was used to remove thorium by Gadd and White (1989). *Rhizopus arrhizus* and *Aspergillus niger* were used to remove radionuclide thorium by White and Gadd (1990). Waste mycelium of *Rhizopus arrhizus* from fermentation industries was used to remove lead, nickel, cadmium and zinc by Fourest and Roux (1992). Volesky *et al.* (1993) studied the biosorption of cadmium using bakery yeast *Schachromyces cerevisiae*. Fourest *et al.* (1994) studied the effect of pH on biosorption of lead, nickel, zinc, cadmium and silver by *Rhizopus arrhizus*, *Mucor miehei* and *Penicillium chrysogenum*. Seaweed *Sargassum fluitans* was used to remove copper metal ions using biosorption in a fixed bed column by Kratochvil *et al.* (1995). Biosorption of copper, cadmium and zinc by *Rhizopus arrhizus* and *Trichoderma viride* was done by Morley and Gadd (1995). Living and nonliving biomass of brewery’s yeast was studied for removal of uranium, zinc, cadmium and copper by Volesky and May (1995).

The contribution of functional group sulfonate and alginate to biosorption by lead and cadmium was studied in *Sargassum* biomass by Fourest and Volesky (1996). Alginate component of seaweed marine algae were tested for removal of lead, cadmium, zinc and copper by Fourest and Volesky (1997). Live and chemically pretreated biomass of *Aspergillus niger* was tested for removal of lead, cadmium, copper and nickel by Kapoor and Viraraghavan (1998). Immobilized *Aspergillus niger* was studied for removal of cadmium, copper, lead and nickel metal ions by Kapoor and Viraraghavan (1998 b). Biosorption of mercuric compounds by *Phenerochete chrysosporium* was studied by Saglam *et al.* (1999). Biosorption of iron and cyanide complex on *Rhizopus arrhizus* was studied by Aksu *et al.* (1999). Immobilized *Mucor rouxii* was studied for removal of lead, cadmium, nickel and zinc by Yan and Viraraghavan (2001). Biosorption of lead by waste biomass of *Aspergillus niger* was done by Wang *et al.* (2001). Chemically pretreated waste biomass of *Schachromyces cerevisiae* was investigated for
removal of copper metal ions by Wang (2002). The *Aspergillus niger* was investigated for bioaccumulation of copper, lead and chromium by Dursun *et al.* (2003 a). Bioaccumulation of copper and cadmium using *Rhizopus arrhizus* and *Aspergillus niger* was studied by Dursun *et al.* (2003 b). Bioaccumulation property of *Rhizopus arrhizus* was studied in presence of cadmium, lead and copper by Uslu *et al.* (2003). Regenerable *Sargassum* was used to remove copper metal ion by Volesky *et al.* (2003) using continuous flow column.

Biosorption research done in India


*Aspergillus niger* and *Penicillium* sp. isolated from municipal and industrial effluent contaminated soil was studied for biosorption of nickel, chromium and cadmium by Ahmad *et al.* (2006). Biosorption of copper and cobalt using crab shell was investigated by Vijayaraghavan *et al.* (2006). The fungal species *Aspergillus, Penicillium, Alternaria, Geotricum, Fusarium, Rhizopus, Monilia* and *Trichoderma* isolated from industrial effluent contaminated soil were studied for metal tolerance against cadmium, nickel, chromium, copper and cobalt by Zafar *et al.* (2007). The mechanism of adsorption of mercury on *Aspergillus versicolor* was done by Das *et al.* (2007). The uptake of lead from aqueous solution by seaweed was studied by Senthilkumar *et al.* (2007). Biosorption of lead by green alga *Spirogyra* was studied by Gupta and Rastogi (2008a). Biosorption of lead by algal biomass *Oedogonium* and *Nostoc* was studied by Gupta and Rastogi (2008b). Vijayaraghavan *et al.* (2009) studied the biosorption
Adsorption of lead metal ions by *Mucor rouxii* was studied by Majumdar *et al.* (2010). Biosorption of nickel by pretreated algal biomass was studied by Gupta *et al.* (2010). Biosorption of lanthanum, cerium, europium and ytterbium by marine algae was investigated by Vijayaraghavan *et al.* (2010). Das *et al.* (2012) studied the biominalization of gold by *Rhizopus aoyzae*. In Chhattisgarh state, India, some scientist worked on lead and other heavy metal pollution but no research has been done still in relation to environmental friendly removal of these pollutants from water samples.