Chapter II

REVIEW OF LITERATURE

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The last few decades witnessed an increasing emphasis on studies with environmental concern through multidisciplinary approaches all over the world. These types of studies not only provide an introduction to the chemical dynamics, but also identify those aspects that jeopardize the resources encompassing both land and water domains. Under the ambit of industrialization and population growth, a continuous monitoring on such studies towards its eco-friendly relationship becomes a vital key. In India, our attention towards environment has drawn only very recently, but even now, the same has not been properly appreciated and due recognition has not been paid to them. The environmental geochemical studies on soil/water systems with special reference to life sustaining processes in relation to technological development and population growth have not yet been received proper attention. The characterization of natural attributes through baseline studies and anthropogenic inputs to them can be considered as a frontier area of study for this naturally rich part of NE-India. The complex interactions of soil, water, air and life systems represent a very wide subject of critical debate within the framework of environmental perspectives, which in turn is related with the scope to find out remedial objectives towards planning, policy formulation and execution for a greener environment towards development of sustainable ecosphere for all the life forms associates with the concerned system.

The northeast region of India occupies a prominent position in the history of natural resources and it contributes a huge amount towards the growth of national economy. The environmental problem relating to the people of this region has become a subject of concern and it is felt that such study is an urgent necessity in realization of precise knowledge base.

2.1. International Scenario

The environmental degradation is a contributed attribute of modern civilization. The developmental activities have affected both the developed and the developing countries. The developed countries became aware of this problem much earlier and a good amount of work has been done in the area. Oil exploration and production activities if not attended properly may have significant environmental consequences. The search for oil in Nigeria begun in 1937 (Awobajo, 1981; Ifeadi and Nwankwo, 1980), with increasing production of crude oil and discovery of major oil reserves, more effort was added to exploit this resource. Oil spillage was still there through tanker accidents, well blow out, sabotage and accidental rupture of pipelines, resulting in release of crude and refine oil into terrestrial and aquatic environments (Atlas, 1981; Colwell and Walker, 1977). The spill of oil on the surface of soil during operation, the hydrocarbons gradually penetrate into the soil system. It has been found that the oil hydrocarbons can infiltrate up to a depth of 50 cm (Ilangovan and Vivekanandan, 1992). It is known that rainfall prior to or during the spills reduces oil infiltration in the soil and washes petroleum components away to runoff waters (Francke and Clark, 1974).

Crude oil is not a single chemical but a collection of hundreds of widely different properties and toxicities (Holcomb, 1970) and when mixed with soil, it changes the physico-chemical characteristics of soil and affected the growth of plant system and production of crops (Jong, 1980). Heavy metals are among the important toxicants those accompanied with crude oil. These metals are important environmental pollutants and many of them are toxic even at very low concentration (Menon et al., 2001). Therefore, the study of heavy metal contamination is one of the important aspects in the study of affected areas due to oilfield activities.

There are scores of report about the levels of heavy metals in polluted areas. Removal of such metals from the polluted land and water bodied by chemical processes is not so simple and economically not viable. Therefore, in the recent years, environmental studies have gained significant momentum towards phytoextraction of heavy metals, critically utilizing "Green clean technology" over and above the applicable chemical principles, especially in case of the reclamation of polluted lands. It has already been established that certain plants have the ability to retain heavy metals much above the prescribed human tolerance (Baker and Brook, 1989; Raskin et al., 1997; Brooks, 1998; Pitchai et al., 2001; Banks et al., 2003; Jones et al., 2004; White et al., 2006; Brandit et al., 2006; Muratova et al., 2008). Variation in metal accumulation by plants is affected due to variations in plant species, the growth stage of the plants and element characteristics that control absorption, accumulation and translocation of metals (Guilizzoni, 1991). Tolerance of higher metal concentrations than the toxic level and the existence of internal detoxification metal tolerance mechanisms, and possibility of their utility in phytoremediation have also been studied for certain plants (Lorestani et al., 2009). Hyper-accumulator plants can be grown to scavenge heavy metals from water bodies and land areas considered to be environmentally destabilized (Salt et al., 1995; Buszewski et al., 2000; Menon et al., 2001; Peraltavidea et al., 2004; Alkhateeb et al., 2005). This type of study is referred as 'Phytoremediation' or 'Bioremediation'. Extensive work on phytoremediation through the process of phytoextraction has been reported globally and has taken a significant momentum (Ebbs and Kochins, 1998; Prasad, 1998; Cunningham et al., 1995; Salt et al., 1998; Lasat, 2000; Lombi et al., 2001; Lombi et al., 2001a; Sharma and Dubey, 2005, Kramer and Chardonnens, 2001). The technique is comparatively cost effective and ecologically preferable since it reclaims the site by recycling it in a biologically stable state. The effectiveness of hyperaccumulator plants, like *Thalspi caeruescens* and *Sebera acuminate* is experimentally proved as the effective clean up agent against the pollution created by Zn, Cd and even U (Cunningham and Ow, 1996; USDA, 2008). Parry (1994) has demonstrated that *Thalspi* can extract 34.3kg/ha of Zn in one cropping, corresponding value of other metals are 0.16kg/ha for Cd, 0.25kg/ha for Ni, 0.22kg/ha for Pb, 0.40kg/ha for Cu, 0.02kg/ha for Co, 0.27kg/ha for Cr. The study of Keller et al., (1997) reported that Cadmium, Zinc and Nickel uptake by plants is high and closely related to the total heavy metal content of the soil. The most efficient plants in taking up heavy metals are spinach, salad, potatoes shoots and above all beet shoots which contained a maximum of 56 ppm in dry matter (Larsen, 1984). These plants may also be used as good bio-indicators of heavy metal pollution. Successful work has already been done in Australia and South Africa by using hyperaccumulator plant species for the rehabilitation in gold, platinum, coal and other mine areas (Truong, 1999). *Typha latifolia* and *Phragmites australis* have been successfully used for phytoremediation of Pb/Zn mining areas (Ye et al., 1997a; Ye et al., 1997b).

A glance on the publications has shown that heavy metal studies in water and soil began in USA in 1963, the Netherlands in 1966, USSR in 1968, Poland in 1969, Hungary in 1970, Austria in 1972, Israel and Japan in 1973, Switzerland in 1974, UK in 1975, Yugoslavia in 1976 and so on (Mehrotra, 1986; Kabata-Pendias and Pendias, 1992). The bibliography of Forstner and Wittman (1983) has given the salient work on the study of sediment and soil pollution. Klein (1972) investigated 264 surface soil samples from industrial, agricultural and residential areas (Metropolitan areas of Grand Rapids, Michigan, USA) for heavy metal like Hg, AS, Cu, Cd, Co, Cr, Fe, Ni, Pb and Zn and observed that compared to others, samples from industrial areas contain considerably higher amount of these metals.

Contamination of soil with heavy metal is now one of the world's major environmental problems, posing significant risks to human health as well as ecosystems (Menon et al., 2001). Recently, phytoremediation, using plants to remove metal pollutants from contaminated soils, is being developed as a new method for the reclamation of contaminated land. This environment friendly, cost-effective and plant-based technology is expected to have significant economic, aesthetic, and technical advantages over traditional engineering techniques (Baker et al., 1994; Cunningham et al., 1995; Chaney et al., 1997; Salt et al., 1998; Leblanc et al., 1999; Garbisu and Alkorta, 2001).

As the heavy metals in soils are generally bound to organic and inorganic soil constituents or alternatively, present as insoluble precipitates, a large proportion of metal contaminants are unavailable for root uptake by field-grown plants (Raskin et al., 1994). Methods to evaluate increasing heavy metal contaminant's bioavailability in soil and its transport to plant shoots are vital to the success of phytoremediation in the field (Ernst, 1996; Kumar et al.1995). Studies on dissociation of heavy metals from soil compartments into a soil solution for uptake by plants and the solubility processes of soil bound metals including the application of soil acidifiers, commercial nutrients or some chelates such as EDTA, DTPA, CXDTA, EGTA, or citric acid etc. have already taken a wide spectrum of study (Ebbs et al., 1997; Chen and Cutright, 2001). Among these chelates, EDTA has been shown to be the most efficient in mobilizing Pb from various soil compartments (Huang et al., 1997; Shen et al., 2002; Wenzel et al., 2002). EDTA is a low toxicity multi dentate chelating agent, and is able to form stable complexes with a wide variety of metals (Khan et al., 2000). However, the mobilization process can increase the migration of heavy metals downwards into groundwater causing further environmental concern in the surrounding areas (Kedziorek et al., 1998; Barona et al., 2001; Romkens et al., 2002).

Consideration on methods to prevent the leaching of mobilized heavy metals down the soil profile have also been attempted in the phytoremediation design including the optimum chelate concentration, time and locations of the chelate application to soils (Romkens et al., 2002). Apart from the soil amendment approaches, the root systems of plants may also help to reduce metal leaching in soil profiles. Recently, many high-biomass plants of Brassicaceae (mustard) family have been used in phytoremediation studies to which most metal-hyperaccumulator species belong, represents a potential and promising source of plants to be used in phytoremediation along with other high biomass plants, such as corn, peas, sunflowers, ragweed, and goldenrods etc. in chelate-assisted phytoextraction studies

(Blaylock et al., 1997; Chen and Cutright, 2001). However, the root systems of these plants are mainly located in the top 5–20 cm layers of soil and very few root systems can penetrate to deeper soil layers. Therefore, the root systems of these plants are unable to absorb the heavy metals that may possibly have leached in soil profiles.

Vetiver grass (*Vetiveria zizanioides*) has a long (3 - 4 m), massive and complex root system and can penetrate to the deeper layers of the soil (Dalton et al., 1996; Truong, 2000; Pichai et al., 2001). The grass has been found to have significant utility in case of soil conservation as well as phytoremediation. Significance of Vetiver grass technology as one of the leading biological systems of soil and water conservation, land rehabilitation, and embankment stabilization has drawn great attention in 21st century (Grimshaw, 1997; Truong, 2000). The interest in Vetiver grass has increased in recent years because of its unique morphological, physiological and ecological characteristics with massive and deep root system, and its tolerance to a wide range of adverse climatic and edaphic conditions, including elevated levels of heavy metals (Pinthong et al., 1998; Truong, 2000; Chen et al., 2000). The positive effects of Vetiver (*Vetiveria zizanioides*) in purifying urban garbage leachate of landfills (Xia et al., 2000) and efficient removal of phosphorus and nitrogen from eutrophic water have been investigated in China (Zheng et al., 1998). Specific study is available on the effect of Vetiver as phytoremediating agent for decontamination of pesticides to prevent their accumulation in crops or other parts of the agro-ecosystem, from Thailand (Pinthong et al., 1996). Roongtanakiat and Chairoj (2001a, 2001b) studied the use of Vetiver grass for remedying soil contaminated with heavy metal. Extensive studies on anti-oxidant, anti-carcinogenic and termiticidal activities of Vetiver oil content extracted from the Vetiver grass after phytoremediation of heavy metal contaminated soils and their economic market acceptability have also been reported (Zheijazkov and Nielsen, 1996; Scora and Chang, 1997; Chen et al., 2003; Zheljazkov and Warman, 2003; Zheljazkov et al., 2006, 2008a).

Limitation of mobility of heavy metals within soil horizon and thereby enhancement of nutrient level has also been studied by application of Vetiver grass with a possibility of bio-recovery of metal from metal mining areas (Dudka et al., 1995, 1996; Ernst et al. 1996; Cobb et al., 2000; Marseille et al., 2000; Bouwman et al., 2001; Wong, 2003; Fetz and Wenzel, 2002; Whiting et al., 2004). Investigation on the application of a specific phytoremediation approach (phytodegradation) by which contaminants are taken up from soil water by roots and then metabolized in plant tissues and broken up to less toxic or non-toxic compounds within the plant by several metabolic processes via the action of compounds produced by the plants has been successfully carried out (Newman et al., 1997; Salt et al., 1998; Burken et al., 2000; Maeck et al., 2000; Meagher, 2000; Suresh and Ravishankar, 2004). Removal of substances from soil or water with a view to release them into the air by phytovolatilisation employing Vetiver plants has also been studied by several authors (Cunningham et al., 1995; Banuelos et al., 1997; Chaney et al., 1997; Burken and Schnoor, 1999; Meagher, 2000; Lin et al., 2000; Garibisu and Alkorta, 2001; Mc Grath et al., 2001; Lasat, 2002; Ernst, 2005).

Contamination by the pollutants in the form of heavy metal has warranted global interest and extensive literature is visible about the impact of heavy metals on tea plants along with its potential health hazards (WHO, 2004; Jackson and Lee, 1988; Kalita and Mahanta, 2006; Street et al., 2006; Mehra and Baker, 2007; Han et al., 2007; Abanuz and Tuysuz., 2009; Magalhaes et al., 2009). The study by Kabata-

Pendias (2000) on sources of heavy metals in tea plants and its impact is a specific attribute. Apart from normal agricultural practices related to increase of productivity unattended industrial activities on soil system with acidic characteristics where tea plants generally grow have also contributed significantly in that direction (Marcos et al., 1998; Han et al., 2007; Karimi et al., 2008; Borah et al., 2009; Abanuz and Tuyuz, 2009; Magalheaes et al, 2009). Various studies have demonstrated the relationship between concentration of elements in tea plant and soil samples and their toxic impact at conditions favourable for uptake of elements (Sposito, 1984; Kabata-Pendias and Pendias, 1992; Wong et al., 1998; Kabata-Pendias, 2000; Krauss et al., 2001; Kalita and Mahanta, 2006; Han et al. 2007; Seenivasan et al., 2008; Shi et al., 2008; Abanuz and Tuysuz, 2009; Magalheaes et al., 2009).

2.2. National Scenario

The environmental geochemical studies on soil/water systems in relation to technological development and population growth have not yet been received proper attention. The characterization of natural attributes through baseline studies and anthropogenic inputs to them can be considered as a frontier area of study for this naturally rich part of India. "A Decade of Environmental Geo-scientific Study (1970-1980)" by the Geological Survey of India (GSI), the "National Seminar on Minerals and Ecology" (1982); followed by several symposia and workshops go to show our increasing awareness to such problems (Mehrotra, 1986). The notable contribution made through studies on Ganga-Jamuna-Brahmaputra systems has opened up a new era and probably filled up a gap in environmental geo-scientific studies. The work in such areas by Dasgupta, (1984), Mehrotra, (1986), Prasad et al. (1986), Tiwari et al.

(1983), Mukharjee, (1991), Dubey and Pandey (1980), Sadewarte et al. (1980) have been able to throw insight towards the need of environmental study.

The studies on contamination of soil/water systems in oil field areas are relatively less and have not yet gain momentum specifically in the areas of NE-India. In NE-India the National Symposia (1986) under the banner of Assam Science Society, Guwahati, have been able to create an environment of growing awareness towards the problems relating to coal and oil industries. The oilfield development programme in Assam, India, different companies is engaged in exploration, production and transportation of crude oil. During the course of entire activities a large number of contaminants including hydrocarbons and heavy metals enter into the nearby areas of an oil collecting station (gathering station) through spills, leaks as well as through emissions from gas flaring and from effluents and thereby enhances in degradation of environmental perspectives (Sharma and Agnihorti,1992).

Contamination of soil-water systems by crude oil is concomitant with the oil exploration/exploitation activities in the oilfield areas as well as the areas through which oil transportation pipelines carries crude oil to the oil refineries (Baruah and Sarmah, 1975, 1993a, 1993b, 1996a, 1996b). Several studies on impact of oilfield activities on soil system have indicated the possible environmental destabilization in oil bearing areas of Assam (Sharma et al., 1995; Barua et al., 2011; Kotoky et al., 2012; Kalita et al., 2007). Impact on soil pH and development of a suitable measure in restoring the soil fertility in oilfield areas has been discussed in a recent work (Kalita and Devi, 2012).

Rai and Pal (1999) have given an excellent effort to understand the phytoremediation studies. The knowledge regarding the up taking of Pb, Cu, Cd, Fe and Hg from contaminated soil/water by some aquatic or semi-aquatic vascular plants, such as – water hyacinth (*Eichhornia crassipes)*, pennyworth (*Hydrocotyle umbellta*), duckweed (*Lemna minor*) and water velvet (*Azolla pinnata*) is available since long time back (Leung et al,. 2007; Zheljazkov et al. 2008). In India, aquatic vascular plants like *Hydrilla verticillata*, *Spiridela polyrrhiza*, *Bacopa monnierrii*, *Phragmites karka* and *Scirpus lacustries* have been used to treat chromium contaminated effluent and sludge from leather tanning industries. Agarwal and Goyal (2007), Leung et al. (2007) and Zheljazkov et al. (2008) have given a significant review with relevant information on applicability of agricultural crops for metal extraction as an alternative for the removal of excess heavy metals from soil. Handique (2001) and Deka Baruah et al., (1999, 2000) have made significant contribution in bioremediation studies by utilizing Lemongrass (*Cymbopogon flexuosus*) and Java citronella (*Cymbopogon winterianus*). Barua et al., (2011) studied the impact of petroleum crude oil that reduced the seed germination of four crude oil resistance species. He observed that spilled crude oil not only destroyed the seed bank through mixing in soils but also lowers the species diversity by degrading the soil environment. Basumatary et al., (2012) reported that *Cyperous odoratus* and *Cyperus laevigatus* plants could be used for phytoremediation in hydrocarbon contaminated soils of Assam.

Rao (1979) and Khan (2003) in their studies reported that Vetiver is an ideal plant for phytoremediation of degraded and contaminated land by Hg, Pb, Cd, and Cu around industrial area of Mumbai. Lavania (2004) reported that Vetiver system has come to an age as a low cost eco-technology measure for a host of environmental problems as the Vetiver oil is one of the most valuable and important raw materials in perfumery and has extensive industrial applications. Lavania (2004) in his study attributed that Vetiver is native to India and has been in traditional use since ancient times for its perfumery root oil. However, in its homeland vetiver still remains the choice of industrialists for its multifarious applications including extensive applicability in phytoremediation perspective.

Chemical composition of Vetiver oil is extremely complex, containing over 100 sesquiterpinene types of compound (Akhila and Rani, 2002). Lavania (2003a) mentioned that Vetiver oil with high vetiverol concentration and higher ester value is considered superior from perfumery point of view. Prakash Rao et al., (1993) have given an important attribute towards the environmental and economic aspects of the application of Vetiver grass in South India. Natural variability and application potential of Vetiver grass around Bharatpur, India, has been successfully demonstrated by Sethi et al., (1986). Shukla (1957), Virmani and Dutta (1975), Pareek et al., (1992), National Research Council (1993), Sahoo and Patra (1998), Lavania and Kumar (1998), Lal and Shama (2000), Lavania and Lavania (2000), Lavania (1991, 2002, 2003a, 2003b), Lavania et al., (2004) and Lavania et al., (2006) have reported many salient aspects in the utilization of Vetiver grass in India. Extracts of vetiver grass roots oil possess several biological properties, such as antifungal (Sridhar et al., 2003), anti–inflammatory (Jagtap et al., 2004) and anti oxidant activities (Kim et al., 2005). Potent topical irritant activity on cockroaches and flies (Jain et al., 1982) and powerful repellent and toxic activities against Formosan subterranean termite (Zhu et al., 2001a, 2001b) have been reported for vetiver grass oil extracts. Vetiver oil is also used as anti-microbial and anti-fungal agent (Singh et al., 1978; Dikshit and Husain, 1984; Jain et al., 1982). Bulletin of Botanical Survey of India (1976) has compiled a beautiful compendium with extensive literature on the study of Vetiver grass in India.

The rapidly growing body of literature on vetiver has been divided into six topical areas based on its multifarious applicability and concept. The ultimate goal is to have references for all published information on vetiver and the uses of vetiver-grass.

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