CHAPTER – I
INTRODUCTION

1.1 INTRODUCTION

Medicinal plants originated in India more than 2000 years ago. It is well known that there are number of plants which are being used from time immemorial for curing various diseases. (Srivastava S, et al., 2006). Elements with specific gravity, five times greater than that of water have been considered as heavy metals such as, Copper, Cadmium, Arsenic, Lead and Mercury. Heavy metals as environmental contaminants have become a menace worldwide. They are released to the environment through various sources. In the past few decades concentrations of these metals increased in all types of environment i.e., soil, water and air at many places it reached up to toxic levels. Trace elements, especially heavy metals, are considered to be one of the main sources of pollution in the environment, since they have a significant effect on its ecological quality. Human activities often mobilize and redistribute natural substances in the environment so much so that they can cause adverse effects. (Sastre J et al., 2006),

Metals classified in biological and environmental studies into two categories: Essential metals (Fe, Cu, Zn and Mg) and non essential or toxic metals (Pb, As, Cd and Hg) essential metals can also produce toxic effects when the metal intake is high concentrations. For e.g., Fe is essential for formation of Hemoglobin, Myoglobin and many enzymes, involved in the formation of red blood cells and helps fight stress and disease. On the contrary, an excess in Fe concentration causes vomiting, diarrhea, and damage to the intestine, whereas non essential metals are
toxic even at very low concentrations for human health and environment. For e.g. Cd is absorbed by many plants. However because of its toxicity, it presents major problems for food stuffs (Abdul-Wahab O et al., 2008) WHO 1998, 2005 recommends that medicinal plants which form the raw materials for the finished products may be checked for the presence of heavy metals (Hussain I et al. 2006).

Medicinal plants are the basic raw materials for many of the herbal formulations and popular nutrient supplements sold over the counter. Thus it becomes absolutely essential to ensure the quality of the plant material and detect the presence of contaminants and to establish the identity, purity, and quality assurance of herbal drugs in order to have full efficacy and safety of the herbal products. Adverse effects of these elements when present in greater quantities, effects human health. It is known that lead is health endangering metal for human and its effects include blood-enzymes changes, anemia, and hyperactivity and neurological disorders. Excessive Cadmium exposure may give rise to renal, pulmonary, hepatic, skeletal, reproductive effects and cancer. Arsenic is known to cause skin cancers, hypertension and peripheral arteriosclerosis. Mercury is known to cause neurological disorders and kidney damage (Haider S et al. 2004).

Certain formulations are prepared with heavy metals such as mercury and arsenic after specific processing steps. These products called bhasmas will therefore contain heavy metals. The heavy metals in such auyurvedic products are generally not present as contaminants but are added intentionally and processed.

The equilibrium of lead, copper, gold, iron, mercury, silver, tin and zinc are seen in ayurvedic and as essential for normal functioning of human body and an important component of good healthy in addition, some products contain
other heavy metals such as arsenic. One needs to first ask the question if the medicines were herbal. If the products reported were herbal, then one needs to know the basal level of heavy metal accumulation by the herbs. Therefore the objective of this work was to investigate heavy metal content in selected Indian medicinal plants.

There is a need to ascertain whether the increased levels of the toxic element in the ayurvedic medicine can be due to increased uptake of the toxic elements by the plants during their growth in polluted soils, (due to setting up of industries such as mining smelting of metals, surface finishing industry near the vegetation) or due to indiscriminate use of toxic elements during the preparation of the medicine. In some of the industrial belts, there are reports of increased metal content in plant specimens, when compared with the metal contents in plants grown in non-industrial zones. Therefore, a preliminary data on the various heavy metal content of the plant will be desirable, before it is taken up for the preparation of the herbal medicine. Therefore suitable analytical techniques have to be made use of the determination of these elements taken up for the study.

The heavy metal content determination in some medicinal plant species collected from different sources and their comparison has been made in the present work. The heavy metals content has been estimating using Atomic Absorption Spectrometric technique. Since iron, magnesium, sodium and zinc are nutrient elements, which contents in different plants and also plants collected from the different sources, has also been made.
The work reveals that there is a need for preliminary data on the elemental content of the plant collected from various sources, in view of the fact that there is considerable variation in the toxic elemental content.

Herbal medicines are also known as botanical medicine or phyto-medicine, lately phytotherapy has been introduced as more accurate synonym of herbal or botanical medicine. In the early twentieth century herbal medicine was prime healthcare system as antibiotics or analgesics were not as yet discovered. With the advent of allopathic system of medicine, herbal medicine gradually lost its popularity among people, which is based on the fast therapeutic actions of synthetic drugs (Singh A, 2007).

Medicinal plants have been known for millennia and are highly esteemed all over the world as a rich source of therapeutic agents for the prevention of diseases and ailments (Sharma A et al., 2008). The search for eternal health and longevity and for remedies to relieve pain and discomfort drove early man to explore his immediate natural surroundings and led to the use of many plants, animal products, minerals etc. and the development of a variety of therapeutic agents (Nair R., et al., 2007).

Medicinal plants are widely and successfully used on every continent (Hoareau, L., et al., 1999). They play a vital role in human health worldwide. Almost 80 % of the population relies heavily on traditional medicines (WHO 1993).

In Asia, the practice of herbal medicine is extremely well established and documented, as a result, most of the medicinal plants that have international recognition come from China and India. Many people now take medicinal plant
products on a daily basis, to maintain good health as much as to treat illness (Nadro, M. S., et al., 2014).

The importance of medicinal plants and traditional health systems in solving the health care problems of the world is gaining increasing attention. Because of this resurgence of interest, the research on plants of medicinal importance is growing phenomenally at the international level, often to the detriment of natural habitats and mother populations in the countries of origin. Most of the developing countries have adopted traditional medical practice as an integral part of their culture. Historically, all medicinal preparations are derived from plants, whether in the simple form of raw plant materials or in the refined form of crude extracts, mixtures, etc., (Farnsworth, N.R., et al., 1991).

In the early development of modern medicine, biologically active compounds from higher plants have played a vital role in providing medicines to combat pain and diseases. For example, in the British Pharmacopoeia over 70% of organic monographs are on plant-derived products. However, with the advent of synthetic medicines, and subsequently of antibiotics, the role of plant derived therapeutic agents significantly declined (mostly) in the economically developed nations.

This recent resurgence of interest in plant remedies has been spurred on by several factors (Kong J M., et al., 2003).

- The effectiveness of plant medicines,
- Source of direct therapeutic agents,
- Affordable by the people,
- Raw material base for the elaboration of more complex semi-synthetic Chemical compounds,
- Models for new synthetic compounds,
- Taxonomic markers for the discovery of new compounds,
- Renewable source,
- The preference of consumers for natural therapies, a greater interest in alternative medicines and a commonly held belief that herbal products are superior to manufactured products,
- A dissatisfaction with the results from synthetic drugs and the belief that herbal medicines may be effective in the treatment of certain diseases where conventional therapies and medicines have proven to be inadequate,
- The high cost and side effects of most modern drugs,
- Improvements in the quality, efficacy, and safety of herbal medicines with the development of science and technology.

Investigation of the chemical and biological activities of plants during the past two centuries have yielded compounds for the development of modern synthetic organic chemistry as a major route for discovery of novel and more effective therapeutic agents (Nair R., et al., 2007).

1.2 SAFETY AND QUALITY CONTROL OF INDIAN MEDICINAL PLANTS

Herbal medicines are generally regarded as safe based on their long-standing use in various cultures. However, there are case reports of serious adverse events after administration of herbal products. In a lot of cases, the toxicity has been traced
to contaminants and adulteration. However, some of the plants used in herbal medicines can also be highly toxic. As a whole, herbal medicines can have a risk of adverse effects and drug–drug and drug–food interactions if not properly assessed. Assessment of the safety of herbal products, therefore, is the first priority in herbal research. There are various approaches to the evaluation of safety of herbal medicines. The toxic effects of herbal preparation may be attributed mainly to the following:

- Inherent toxicity of plant constituents and ingredients
- Manufacturing malpractice and contamination

Evaluation of the toxic effects of plant constituents of herbal formulation requires detailed phytochemical and pharmacological studies. It is, however, safe to assume that, based on human experiences in various cultures, the use of toxic plant ingredients has already been largely eliminated and recent reports of toxicity could largely be due to misidentification and overdosing of certain constituents (Balammal G., et al., 2012).

Quality control for efficacy and safety of herbal products is of paramount importance. Quality can be defined as the status of a drug that is determined by identity, purity, content and other chemical, physical, or biological properties or by the manufacturing processes. Quality control is a term that refers to processes involved in maintaining the quality and validity of a manufactured product.

The term “herbal drugs” denotes plants or plant parts that have been converted into phytopharmaceuticals by means of simple processes involving harvesting, drying, and storage (EMEA, 1998). Hence they are capable of variation;
this variability is also caused by differences in growth, geographical location, and time of harvesting. A practical addition to the definition is also to include other crude products derived from plants, which no longer show any organic structure, such as essential oils, fatty oils, resins, and gums. Derived or isolated compounds (e.g. strychnine from *strychnous nux-vomica*) or mixtures of compounds.

In general, quality control is based on three important pharmacopeial definitions

- Identity- it should have one herb
- Purity – it should not have any contaminant other than herb
- Content or assay-the active constituents should be within the defined limits.

It is obvious that the content is the most difficult one to assess, since in most herbal drugs the active constituents are unknown. Sometimes markers can be used which are, by definition, chemically defined constituents that are of interest for control purposes, independent of whether they have any therapeutic activity or not (WHO, 1992). Identity can be achieved by macro and microscopically examinations. Voucher specimens are reliable reference sources.

Outbreaks of diseases among plants may result in changes to the physical appearance of the plant and lead to incorrect identification (WHO, 1998). At times an incorrect botanical quality with respect to the labeling can be a problem. Purity is closely linked with safe use of drugs and deals with factors such as ash values, contaminants (e.g. foreign matter in the form of other herbs) and heavy metals. World Health Organization (WHO) encourages, recommends and promotes
traditional/herbal remedies in natural health care programmes because these drugs are easily available at low cost, safe and people have faith in them.

The WHO assembly in number of resolutions has emphasized the need to ensure quality control of medicinal plant products by using modern techniques and applying suitable standards (Sunita Panchawat , et al., 2010).

1.2.1 Safety assessment

Medicinal plants are generally regarded as safe based on their long-standing use in various cultures. However, there are case reports of serious adverse events after administration of herbal products. In a lot of cases, the toxicity has been traced to contaminants and adulteration. However, some of the plants used in herbal medicines can also be highly toxic. As a whole, herbal medicines can have a risk of adverse effects and drug-drug and drug-food interactions if not properly assessed. Assessment of the safety of herbal products, therefore, is the first priority in herbal research.

These are various approaches to the evaluation of safety of herbal medicines. The heavy metal toxic effects of medicinal plants are due to environmental pollution. Evaluation of the metal toxic effects of medicinal plant constituents requires detailed phyto-chemical and pharmacological studies. It is, however, safe to assume that, based on human experiences in various cultures, the use of toxic plant ingredients has already been largely eliminated and recent reports of toxicity could largely be due to environmental pollution (ICDRA,1991).

1.2.2 Assessment of toxicity

Toxicity investigation will also be required because the analysis alone is unlikely to reveal the contributions to toxicity itself. In assessing toxicity of an herbal medicine, the dose chosen is very important (TDR, 2005).
Toxicity assessment involves one or more of the following techniques. In vivo techniques, in vitro techniques, cell line techniques, micro-array and other modern technique Standardization techniques to adequately model toxicity.

Standardization of herbal formulation requires implementation of Good Manufacturing Practices (GMP) (Neeraj Choudary., et.al 2011). In addition, study of various parameters such as pharmacodynamics, pharmacokinetics, dosage, stability, shelf-life, toxicity evaluation, chemical profiling of the herbal formulations is considered essential. Other factors such as pesticide residue, aflatoxine content, heavy metals contamination, Good Agricultural Practices (GAP) in herbal drug standardization are equally important (Mosihuzzaman M., et.al 2008).

1.3 HEAVY METALS IN MEDICINAL PLANTS

1.3.1 Sources of contamination

With the unregulated medicinal plant trade in many developing countries, several opportunities for contamination exist. Potentially harmful contaminants in medicinal plants may come from:

- Environments where the medicinal plants are grown and conditions where they are collected,
- Conditions under which they are dried and processed,
- Transport and storage conditions; and/or,
- Manufacturing processes during the final stage of preparation (Chan K., 2003).
The correct documentation and traceability of medicinal plants that enter into regional and international trade need to be maintained and monitored. However, in the absence of regulatory controls, the safety and quality of medicinal plants vary considerably.

**1.3.2 Effect of heavy metals on humans**

Plants are an important link in the transfer of contaminants from the soil to humans (McLaughlin, M.J., et al., 1999). Nearly half of the mean ingestion of Cd, Pb and Hg is as a result of food of plant origin (Islam E., et al., 2007).

Heavy metals differ extensively in their bioavailability or ability to enter organisms and cause toxicity. External bioavailability, also known as bioaccessibility, is mainly determined by the ability of the metal ions to be solubilized and released from environmental media (e.g. soil and food), whilst internal bioavailability determines the ability of the metal ions to be absorbed and reach the target organ, where it has a toxic effect (Caussy D., et al., 2003).

Despite being essential in human nutrition, sustained high dietary intakes of certain trace elements can lead to abnormal accumulation in tissues, or overloading of normal metabolic or transport pathways (Renwick A.G., et al., 2004). Considerable levels of trace elements in humans and their correlation with different diseases, including various types of cancer, have motivated extensive research toward quantitative determination of these elements in biological tissues (Alimonti, A., et al., 2008).

Continual heavy metal ingestion, even at low-levels, has damaging effects on humans and animals as there is no good mechanism for their elimination. Heavy
metals exceeding acceptable physiological levels may be highly toxic, with almost all heavy metals being able to generate free radicals. A large amount of DNA damage appears to be linked to metal-induced free radicals (Desoize B., 2002).

**1.4 ADSORPTION MECHANISM**

To understand the adsorption mechanism many empirical relations have appeared connecting the amount adsorbed with principal variable such as concentration at constant temperature and time are termed adsorption isotherms, which are useful for describing adsorption capacity facilitate evolution of the feasibility for selection of the most appropriate adsorbent; for a specification application. Moreover the isotherms play a crucial role in predicting the modeling procedures for analysis and design of adsorption system.

Adsorption of heavy metals by these materials might be attributed to their protein, carbohydrates and phenolic compounds (Sanchez Polo, et al., 2002) which have metal binding functional groups, such as carbonyl, hydroxyl, sulphate, phosphate and amino groups (Gomez-serrane, V, A et al., 1998). Some of the other adsorbents used for the adsorption of heavy metals are fly ash (Krishanan,K.A et al., 2002), dispersed iron-oxide, activated carbon fibres (Ferror Garcia, M.A., et al., 1998), waste rubber (Raji,C., et al., 1997), polymerized onion skin, peat moss (Nath, S.K., et al., 1997), polymerised sawdust (Siuasamy,P, et al., 1999), treated sawdust, mustard husk (Meena,A.K, et al., 2002), agricultural waste and by products (Marshall, W.E, et al., 1993) coconut shell and peanut hull carbon, ozonized GAC (Orhan,Y, et al., 1993), heat treated and sulphurised GAC, steam sulphurised GAC prepared from biogases pith and activated alumina. Moreover, the removal of metal ions from their solutions in the presence of agricultural materials
may be due to the adsorption on surface and pores and also to complexation by these materials.

1.5 MEDICINAL PLANTS FOR ANTIBACTERIAL ACTIVITY

The discovery and development of antibiotics are among the most powerful and successful achievements of modern science and technology for the control of infectious diseases. However, the rate of resistance of pathogenic microorganisms to conventionally used antibacterial agents is increasing with an alarming frequency (Neogi U, et al., 2008). Isolation of bacterial agents less susceptible to regular antibiotics and recovery of resistant isolates during antibacterial therapy is increasing throughout the world (Cohen M.L., 2002 and Hancock E.W., 2005).

In addition to this problem antibiotics are sometimes associated with adverse side effects on the host, which include hypersensitivity, depletion of beneficial gut and mucosal microorganisms, immunosuppressant and allergic reactions (Al-Jabri AA., 2005). The number of multi-drug resistant bacterial strains and the appearance of strains with reduced susceptibility to antibiotics are continuously increasing. This increase has been attributed to indiscriminate use of broad-spectrum antibiotics, immunosuppressive agent, intravenous catheters, organ transplantation and ongoing epidemics of HIV infection (Ng PC, 1994, Dean DA et al., 1996 and Gonzalez CE et al., 1996). Examples include methicillin-resistant staphylococci, pneumococci resistant to penicillin and macrolides, vancomycin-resistant Enterococci as well as multi-drug resistant gram-negative organisms (Norrby RS et al., 2005).

There is an urgent need to control antibacterial resistance by improved antibiotic usage and reduction of hospital cross-infection (Voravuthikunchai S.P et
However, the development of new antibiotics should be continued as they are of primary importance to maintain the effectiveness of antibacterial treatment (Van der Waaij D, Nord CE 2000 and Marchese A, et al., 2001).

The potential for developing antibacterial from higher plants appears rewarding as it will lead to the development of a phytomedicine to act against microbes; as a result, plants are one of the bedrocks for modern medicine to attain new principles (Marchese A, and Shito G.C 2001). Plant based antibacterial represent a vast untapped source of medicine. Plant based antibacterial have enormous therapeutic potential as they can serve the purpose without any side effects that are often associated with synthetic antibacterial. Further continued exploration of plant derived antibacterial is needed today (Evans CE et al., 2002).

Historically, plants have provided a source of inspiration for novel drug compounds, as plant derived medicines have made large contributions to human health and well-being (Hussain MA, and Gorsi MS 2004). Medicinal plants constitute an effective source of both traditional and modern medicines. Herbal medicine has been shown to have genuine utility and about 80% of rural population depends on it as primary health care (Iwu M.M et al., 1999). Over the years, the World Health Organization advocated that countries should encourage traditional medicine with a view to identifying and exploiting aspects that provide safe and effective remedies for ailments of both bacterial and non-bacterial origins (Farnsworth NR, et al., 1985).

In recent years, pharmaceutical companies have spent a lot of time and money in developing natural products extracted from plants, to produce more cost effective remedies that are affordable to the population (Akinyemi K.O et al., 1985).
Scientific experiments on the antibacterial properties of plant components were first documented in the late 19th century (WHO. 1978). It is estimated that today, plant materials are present in, or have provided the models for 50% Western drugs (Doughari J.H 2006). Many commercially proven drugs used in modern medicine were initially used in crude form in traditional or folk healing practices, or for other purposes that suggested potentially useful biological activity. The primary benefits of using plant derived medicines are that, they are relatively safer than synthetic alternatives, offering profound therapeutic benefits and more affordable treatment.

1.6 ANTIOXIDANT ACTIVITIES OF MEDICINAL PLANTS

Various medicinal properties have been attributed to natural herbs. Medicinal plants constitute the main source of new pharmaceuticals and healthcare products (Ivanova et al. 2005). The history of plants being used for medicinal purpose is probably as old as the history of mankind. Extraction and characterization of several active phytocompounds from these green factories have given birth to some high activity profile drugs (Mandal et al. 2007). A growing body of evidence indicates that secondary plant metabolites play critical roles in human health and may be nutritionally important (Hertog et al.1993).

Phytochemical screening of plants has revealed the presence of numerous chemicals including alkaloids, tannins, flavonoids, steroids, glycosides, saponins etc. Many plant extracts and phytochemicals show antioxidant/free radical scavenging properties (Larson 1988; Nair et al. 2007; Parekh and Chanda 2007).

Secondary metabolites of plants serve as defense mechanisms against predation by many microorganisms, insects and herbivores (Lutterodt et al. 1999; Marjorie 1999).
Normally free radicals of different forms are generated at a low level in cells to help in the modulation of several physiological functions and are quenched by an integrated antioxidant system in the body. However, if free radicals are produced in excess amount they can be destructive leading to inflammation, ischemia, lung damage and other degenerative diseases (Halliwell et al. 1992; Hadi et al. 2000; Cavalcanti et al. 2006). Free radical reactions, especially with participation of oxidative radicals, have been shown to be involved in many biological processes that cause damage to lipids, proteins, membranes and nucleic acids, thus giving rise to a variety of diseases (Lee et al. 2005; Campos et al. 2006).

The phenolic compounds are one of the largest and most ubiquitous groups of plant metabolites that possess an aromatic ring bearing one or more hydroxyl constituents (Singh et al. 2007). Phenolic compounds are widely found in the secondary products of medicinal plants, as well as in many edible plants (Hagerman et al. 1998). A number of studies have focused on the biological activities of phenolic compounds, which are potential antioxidants and free radical-scavengers (Rice-Evans et al. 1995; Kahkonen et al. 1999; Sugihara et al. 1999; Cespedes et al. 2008; Reddy et al. 2008). Several studies have described the antioxidant properties of medicinal plants, foods, and beverages which are rich in phenolic compounds (Brown and Rice-Evans 1998; Krings and Berger 2001). Flavonoids are a broad class of plant phenolics that are known to possess a well established protective ability against membrane lipoperoxidative damages (Sen et al. 2005).

Plant products have been part of phytomedicines since time immemorial. These can be derived from any part of the plant like bark, leaves, flowers, roots, fruits, seeds, etc (Gordon and David 2001) i.e. any part of the plant may contain
active components. Knowledge of the chemical constituents of plants is desirable because such information will be of value for the synthesis of complex chemical substances. Such phytochemical screening of various plants is reported by many workers (Mojab et al. 2003; Parekh and Chanda 2007b; Parekh and Chanda 2008).

The present work evaluated the antioxidant activity of twenty medicinal plants and various parts by determination of DPPH radical scavenging, ferric reducing power and hydrogen peroxide scavenging activities of plant extracts using different solvents.

1.7 SCOPE AND OBJECTIVES
1.7.1 Scope

The research presented in this thesis examined a range of different studies relating to the topic of heavy metals in some Indian medicinal plants. Collectively, they provide insight towards understanding the potential risk of an unmonitored medicinal plant trade, the necessity to investigate potential heavy metal accumulation traits of commonly used medicinal plants and to gauge the effect of these heavy metals on plant growth and development.

Inorganic elements such as Fe, Na, Mg, Zn, K and P are essential for human nutrition; the same elements can cause ill effects when consumed at higher concentration levels. Metals such as As, Cd, Cu, Hg and Pb are found to cause toxicity even at low levels. Such toxic metals cause health problem when consuming the medicinal plants contaminated with heavy metals. The concentration levels (ppm) of essential minerals and heavy metals in selected medicinal plants were quantified.
The adsorption technique is the best, economically viable and efficient method for the treatment of heavy metal ion contaminated in medicinal plants. Removal of heavy metal ions from aquatic environment by the adsorption on the activated carbon, and toxic metals from medicinal plants were removed by adsorption method using commercially available Granulated Activated Carbon (GAC) and Nano Particles of Activated Carbon (NPAC) and Nano particles of activated carbon (NPAC) applying batch-wise technique attracts special attention due to its well-known low expensive nature and high efficiency.

However a comparative study on nano and micro adsorbents has not yet been reported. Hence it is proposed to study the simultaneous removal of heavy metal ions such as $\text{As}^{3+}$, $\text{Cd}^{2+}$, $\text{Cu}^{2+}$, $\text{Hg}^{2+}$ and $\text{Pb}^{2+}$ from medicinal plants by adsorption using adsorbents like Granulated Activated Carbon (GAC) and Nano Particles of Activated Carbon (NPAC) to compare the efficiency of the adsorbents in the simultaneous removal of heavy metal ions.

In order to study the effect of various factors like initial concentration of metal ions, dose rate of the adsorbents, contact time, $\text{pH}$ and stirring speed, etc., on the comparative removal of metal ions by using commercial Granulated Activated Carbon (GAC) and Nano Particles of Activated Carbon (NPAC).

Microbial resistance towards the available antibacterial agents has been a major factor for the development of normal microbial inhibitory agents. Medicinal plants and various parts represent a rich source of antibacterial agents and widely used as traditional treatments for numerous human diseases.
The present study investigated the antibacterial susceptibility of medicinal plants and different parts using different solvents such as chloroform, ethyl acetate and ethanol against the five different standard strains of microorganisms.

The most important secondary plant metabolites are phenolic contents and flavonoids. They have distinctive biological activity as natural antioxidants which are used to preserve food quality mainly because they arrest oxidative deterioration of lipids. Antioxidants are compounds that can inhibit oxidation of lipids or other molecules by inhibiting the initiation or propagation of oxidative chain reaction.

This study evaluate and compare the total antioxidant capacity of medicinal plants by common antioxidant activity methods such as Total Equal Antioxidant Capacity (TEAC), phenolic and flavonoids content of plants extracts using different solvents.

1.7.2 Objectives

The overall aim of this study was to provide some verification for the need to monitor Indian medicinal plants against heavy metal contamination, removal of heavy metals, antibacterial activity and antioxidant activity.

The main objective of this work is to investigate the magnitude of heavy metals (arsenic [As], copper [Cu], cadmium [Cd], mercury [Hg] and [Pb]) contamination in some Indian medicinal plants and to compare the levels with recommended levels by the International Organization. Hence remove the heavy metals by adsorption technique using activated carbons. This was achieved through a number of experiments on different aspects related to the topics,
Thus, the specific objectives of the studies were:

- Quantification of essential minerals and non essential heavy metals (toxic metal) present in the medicinal plants and different parts.
- Removal of heavy metals from medicinal plants by adsorption technique using granular and nano particles of activated carbon as adsorbents.
- To study the removal of heavy metal ions by adsorption on GAC and NPAC under various experimental conditions in order to optimize the process parameters and to apply the various first order kinetic equations.
- Evaluating the antibacterial activity of medicinal plants and different parts against various bacterial strains.
- Estimation of total phenolic and flavonoids content in the plants solvents extract.
- Evaluation of antioxidant activity of medicinal plants by determination of 1,1-diphenyl-2-picryl hydrazyl (DPPH) radical scavenging effect, ferric reducing power and hydrogen peroxide scavenging activities of plant extracts are determined Spectrophotometrically.
- Determine the relationship between antioxidant activity, phenolic compounds and flavanoids of twenty medicinal plants extract to confirm that, the constituents are responsible for antioxidant activity of the medicinal plants.