Chapter 1

1. General Introduction

Plant resources are used as raw material for different purposes with various applications, they not only provide basic needs of life but also they form a valuable source of phytochemicals. Plant derived natural products have hold great promise for the discovery and development of new drugs. Worldwide more than 30,000 plant species have been used for medicinal purposes (Haripriya et al., 2010). India is a home to thousands of potential medicinal plant species; ranking sixth among 12 mega biodiversity countries of the world (Kiruba & Jeeva, 2010; Anpin Raja et al., 2010; Mahesh et al., 2010; Meena et al., 2009; Prakash et al., 2008). Western Ghats of India represents one of the biodiversity hotspots in the world covering an area (1, 80,000 km2) which is just under 6% of the total land area of India. Western Ghats harbor >30% of all plant, birds and mammalian species found in India. A remarkable number of modern drugs have been isolated from medicinal plants which led to sudden increase in the number of herbal medicines. Medicinal plants of Western Ghats reported with therapeutic properties are used for the treatment of many infectious diseases and severe diseases of humans including cancer as they contain many bioactive Phytoconstituents which are of curative effects. Medicinal plants are backbone of Indian traditional system of medicine. Some of the ethno-medicines have been incorporated in the organized system of medicine, however numerous of ethno-medicines have remained untouched especially in western ghat region of Karnataka (Bhat satyanarayana, 2004). Natural products based drugs have been used against various diseases since time immemorial. Plant derived natural products hold great promise for the discovery and development of new drugs. Medicinal plants provided
with bioactive compounds which are considered as natural source of antioxidant, antimicrobial and anti-inflammatory agents which have been shown to reduce the risk and progression of many diseases such as cancer and diabetes (Ali et al., 2008 and Pham-Huy et al., 2008) along with the treatment for parasitic infections in humans and animals (Nadkarni, 1954; Chopra et al., 1954; Said, 1969 and Akhtar et al., 2000). Plants are the major source for discovering new compounds with medicinal value for drug development. Plants are the rich sources of secondary metabolites such as alkaloids, phenols, flavonoids, tannins, saponins, glycosides, terpenoids etc. that possess a wide array of biological properties including antibacterial, antifungal, antioxidant and anticancer (De-Fatima et al., 2006). Different parts of plants and whole plant have varied with active compounds and medicinal properties (Harbone, 2006) and according to an estimate 80% of the population in developing countries completely depend on traditional medicine for their primary healthcare. However, this demands the screening of medicinal plants for bioactive Compounds as a basis for further pharmacological studies (Hasan et al., 2007)

1.1. Antidiabetic

Diabetes mellitus is complex and diverse group of disorders that disturbs the metabolism of the biomolecules such as carbohydrates, fats and proteins. According to WHO a total of 171 million cases of diabetic patients were registered worldwide by 2000. It is estimated that the number will significantly rise up to 366 million by 2030 (Wild et al., 2004). Basically Diabetes mellitus is classified into two types, insulin dependent diabetes (type1) and Non-insulin dependent diabetes (type2). Type1 diabetes is an autoimmune disorder characterized by a local inflammatory reaction in and around islets that is followed by selective destruction of insulin secreting β-cells. Type 2 diabetes is characterized by peripheral insulin resistance and impaired insulin
secretion (Foulis, 1987; Gepts & LeCompte, 1985). The occurrence and consequences associated with diabetes are found to be high in the countries like India (31.7%), China (20.8%) and USA (17.17%). The rate is expected to rise up to 79.4%, 42.3% and 30.3% respectively by 2030 (Trease & Evans, 1996). *Diabetes mellitus* is characterized by hyperglycemia that results from an absolute or relative insulin deficiency and is associated with long term complications affecting eyes, kidneys, hearts and nerves (Gispen & Biessels, 2000). Unfortunately in modern medicine still there is no satisfactory effective drug or therapy to cure diabetes (Piedrola *et al.*, 2001) and relies on synthetic drugs available as oral hypoglycemic agents. The continuous consumption of synthetic drugs causes severe side effects apart from being highly expensive. All the current accessible anti-diabetic agents such as sulfonylureas, thiazolidinedione, α-glycosidase inhibitors such as miglitol and acarbose widely used to control hyperglycemia with fail to cure the disease and instead cause several diabetic complications with side effects such as abdominal pain, diarrhea and soft feces in colon (Ahmed *et al.*, 2004; Davis *et al.*, 2001).

The hypoglycemic agents from natural products especially from plants are gaining more importance due to their lower side effects as they possess bioactive compounds called secondary metabolites which are not involved in the metabolism of plants but possess several biological activities such as antibacterial, antidiabetic, anti-inflammatory, anticancer etc. (Stamp, 2003; Aeschbacher *et al.*, 1982; Reinhold *et al.*, 1999; Knekt *et al.*, 1997). In ancient Indian literature, medicinal properties of several herbal plants have been documented and the preparations have been found to be effective in treatment of many severe diseases. Medicinal plants play an important role in the development of modern herbal medicines in the treatment of many diseases such as cancer, liver diseases, arthritis and diabetes (Prashanth *et al.*, 2006). Many
medicinal plants are reported to be useful in the management and treatment of diabetes too (Joy & Kuttan, 1999). Currently there is a growing interest in herbal remedies due to the toxic effects associated with the oral hypoglycemic agents for the treatment of *Diabetes mellitus* (Bhalodi *et al*., 2008). It is estimated that, more than thousand plant species are being used as folk medicine for curing diabetes (Bhandari *et al*., 2008). Herbal products or plant products are rich in flavonoids, phenolic compounds, terpenoids and other constituents which help to reduce blood glucose levels (Jung *et al*., 2006). Plant families are considered to be a source for the most potent hypoglycemic properties (Patel *et al*., 2012a; Patel *et al*., 2012b). The drugs from plant sources are usually considered to be non-toxic with lesser side effects than synthetic drugs. Traditional medicinal plants having anti-diabetic properties will provide useful sources for the discovery of safer hypoglycemic agents (Sunila *et al*., 2012). The ethnobotanical statistics reports about 1200 odd plants that may possess antidiabetic potential worldwide (Arumugam *et al*., 2013; Bnouham *et al*., 2006; Wadkar *et al*., 2008; Tundis *et al*., 2010). These plants are the major source for discovering new compounds with therapeutic value for drug development against most common and very prevalent disease, *Diabetes mellitus*. Medicinal plants having anti-diabetic properties can provide a useful source for the unearthing of safer economic anti-diabetic drug. In the present study, *Ximenia americana*, *Hopea ponga*, *Kandelia candel*, *Vitex leucoxylon* and *Rhizophora apiculata* plants were screened for antidiabetic activity by using standard *in-vitro* methods.

1.2. Anthelmintic

Helminthes are classified as eukaryotic endoparasites which live inside the body, generally parasites like lice and fleas live outside their host. Most diseases caused by Helminthes are of chronic in nature they probably cause severe morbidity and greater
economic and social deprivation among humans and animals. In India incidence of these diseases is at high rate especially during wet seasons with higher 100% incidence. Helminthiasis is an infection disease caused by nematode worms such as *Ascaris lumbricoides, Trichuris trichiura, Nectator americanus* and *Ancylostoma duodenale*. Infection occurred when ingesting food contaminated eggs or larvae, hands or utensils or through penetration of the skin by infective hookworm larvae in contaminated soil (WHO, 2011). Helminthes infections are also among the most common infections in humans, affecting a large proportion of the world’s population in developing countries and produce global burden of disease and contribute to the prevalence of malnutrition, anemia, eosinophilia and pneumonia (Chartier *et al.*, 2001). Inhabitants of tropical or subtropical, low income countries are at risk; children often get infected with one or more species when they are born and remain infected throughout their lives. In some cases these infection results in discomforts and cause substantial ill health resulting into serious morbidity (Agarwal *et al.*, 1979 and Akhtar *et al.*, 1991). Lack of adequate sanitary facilities and supply of pure water coupled with poverty and illiteracy are some of the factors responsible for wide spread nature of this disease in the developing countries. According to World Health Organization (WHO) estimate, more than 1.5 billion (24%) of world population are infected by parasitic worms. These cases are commonly occurred in tropical and subtropical regions with most cases in Africa, America, China and Southeast Asia (WHO, 2014). Lack of adequate sanitary facilities and supply of pure water coupled with poverty and illiteracy are some of the factors responsible for wide spread nature of this disease in the developing countries. In developing countries these parasitic infections became threat to society by causing severe morbidity, including lymphatic filariasis, onchosorciasis and schistomomiasis (Tripathi, 2008). As per WHO, only few drugs
are frequently used in the treatment of parasitic infections (Aswar et al., 2008). Anthelmintic drugs can be classified according to their chemical structure as well as their specific action towards specific type of the helminthes (Rao et al., 1995). In India many anthelmintic drugs are available in market but these are of high cost and limited effective control over parasitic infections (Asolkar et al., 1992 and Kritikar and Basu, 2000). Currently available drugs like Albendazole are capable of a broad spectrum action against the intraluminal parasites and tissue parasites with limitations for use in pregnancy and in children who are less than 2 years of age (Katzung and Bertram, 2000). Even the most common drugs like Piperazine salt have been shown to have side effects like nausea, intestinal disturbance and giddiness (Kumar et al., 2012). Ideal anthelmintic drug should have broad spectrum of action, high percentage of cure with single therapeutic dose, free from toxicity and should be cost effective. Because of the increasing toxicity and allergic manifestations of anthelmintic drugs the gastrointestinal helminthes became resistant to current available synthetic anthelmintic drugs (Singh et al., 2012; Tuse et al., 2001). From ancient time medicinal plants play important role in the elimination of soil transmitted Helminthiasis. Plant bioactive compounds are frequently considered to be less toxic and significantly free from side effects than synthetic ones. Since many effective drugs have been isolated from traditionally reported plants. Phytochemicals or plant based agents are known to provide a rich source of botanical anhelmintics (Satyavati et al., 1976 and Lewis et al., 1977). In the present study, selected plants were evaluated for anthelmintic activity by using Indian adult earthworms (Pheretima posthuma) as animal model.
1.3. Anti-inflammatory

Inflammation is a very common symptom of many chronic diseases and is normal protective response to tissue injury caused by chemical or microbial agents (Ashley et al., 2012). It is well known fact that, the denaturation of tissue proteins leads to inflammatory and arthritic diseases (Williams et al., 2008). Inflammation is a prominent phenotype of various diseases such as rheumatoid arthritis, atherosclerosis and asthma, although inflammation is primarily a protective response against pathogens, toxins and allergens (Gil, 2002). During an inflammatory response mediator such as cytokines, IL-1, tumour necrosis factor (TNF) and Interferons (INF) are released (Hanada et al., 2002; Makarov, 2000). There are many synthetic drugs available to treat inflammation but they have disadvantages because of their detrimental side effects on the gastrointestinal tract, kidneys and on the cardiovascular system and reappearance of symptoms after discontinuation (Srinivasan et al., 2001; Alexandrina, 2010). Steroidal anti-inflammatory agents are available, but they induce damage to the lymphocytes and causes severe side effects. Hence the anti-inflammatory agents from natural sources like plants bioactive compounds is gaining importance and they are more promising agent with less side effect. In the present market, the non-steroidal anti-inflammatory drugs are commonly used for the treatment of inflammatory diseases but these are associated with many side effects like gastric irritation, ulcer etc. (Sreeram et al., 2005). Since ancient times inflammatory disorders and related diseases have been treated with plant or plant derived formulations, because of their specific action and less side effects (Krishnaswamy, 2008; Marc et al., 2008). An anti-inflammatory activity of several plant extracts and isolated compounds have already been scientifically demonstrated (Krishnaswamy, 2008; Marc et al., 2008). Drugs from natural origin are promising
and high in demand in management of inflammation conditions due to their fewer side effects and cost effective in nature (Supayarg et al., 2004). In the present study, *Ximenia americana, Hopea ponga, Kandelia candel, Vitex leucoxylon and Rhizophora apiculata* plants were screened for *in-vitro* anti-inflammatory activity by using standard method.

1.4. Antioxidant

Reactive Oxygen Species (ROS) are an integral part of normal physiological processes, continuously formed as a consequence of aerobic metabolism in eukaryotic cells. ROS at low-to-moderate concentrations play important role in cell physiology, such as regulation of cell growth, cellular signal transduction pathways, and defense against pathogens (Mittler, 2002; Valko et al., 2007). In addition to their biological importance, overproduction of these extremely reactive and unstable oxygen species is considered to be the main contributor to various metabolic and cellular disturbances. Oxidative stress has been suggested to play a major role in the pathogenesis of many degenerative diseases in humans (Halliwell et al., 2007) i.e. inflammatory, cancer, diabetes, aging, cardiovascular diseases; tumor growth and Alzheimer’s disease are contributed by increased cell oxidation (Finkel & Holbrook, 2000; Radisky et al., 2005; Houstis et al., 2006; Fresquet et al., 2006). Free radicals are the chemical species which contains one or more unpaired electrons. These are highly unstable and attain stability cause damage to other molecules by extracting electrons from them. These free radicals enhance the abnormal uncontrolled oxidation reaction in the body which leads to the failure of antioxidant defense mechanism and causes damage to the cell structures increasing risk factor for many diseases such as Alzheimer’s, Parkinson, cardiovascular disorders, liver disease, inflammation and cancer (Rajkapoor et al., 2010). In modern medicine, maintaining the balance
between antioxidant defense system and ROS formation is believed to be a critical concept for healthy biological systems (Tiwari, 2001). However, in recently published data there is use of synthetic antioxidants like hydroxyl toluene (BHT), butylated hydroxyanisole (BHA), tert-butylhydroquinone (TBHQ) and propyl gallate (PG) in the food industry to prevent oxidative deterioration (Lölliger, 1991). But the synthetic antioxidants appear to have carcinogenic and tumor-promoting action (Botterweck et al., 2000). Therefore, it is of great importance to find new sources of safe and inexpensive antioxidants of natural origin in order to use them in food and pharmaceutical formulations. Several studies have showed that increased dietary intake of natural phenolic antioxidants correlate with decreased coronary heart disease (Zadak et al., 2009). Studies have been conducted to identify antioxidants from natural sources, which are suitable alternatives to synthetic antioxidants (Gharibi et al., 2013; Suppakul et al., 2006). Polyphenolic compounds or Phytochemicals present in plants are important components of the human diet; Phytochemicals can be used to regulate oxidation and stress-related chronic diseases such as diabetes and cardiovascular diseases (Kwon et al., 2008). The protective effects of phenolic compounds and flavonoids are directly related to their ability to scavenge free radicals (Fraga, 2010) by undergoing oxidation, producing toxic compounds, which elicit inhibitory effects on pathogenic microorganisms (Vermerris et al., 2006). In order to protect the human body from free radicals, numbers of studies have been carried out on various plants, vegetables and fruits which they are a rich source of antioxidants, such as vitamin A, vitamin C, polyphenolic compounds and flavonoids (Diplock et al., 1998). Natural antioxidants play important role in the enhancement of antioxidant capacity of the blood plasma and helps in the prevention of many diseases including cancer and diabetes (Barros et al., 2007). Phenols and poly phenols are main
secondary metabolites present in a plant which acts as antioxidant or free radical scavengers (Nitha et al., 2007). Phenols also known to have several biological activities such as, anti-inflammatory, anti-tumor and antioxidant activities (Sulaiman et al., 2011; Schofield et al., 2001) Natural antioxidants derived from plants in the form of phenolic compounds (flavonoids, phenolic acids and alcohols, stilbenes, tocopherols, tocotrienols) ascorbic acid and carotenoids (Ali et al., 2008). Antioxidants are compounds that protect cells against the damaging effect of reactive oxygen species (Deepti et al., 2012). Recently natural antioxidants are in high demand because of their potential in health promotion and disease prevention. It is well known that, the antioxidant properties of the plant extracts cannot be evaluated by single method due to the complex nature of Phytochemicals. In the antioxidant defense system, enzymatic antioxidant such as Superoxide Dismutase (SO), Catalase (CAT), Glutathione Peroxidase (CPx) and non-enzymatic plant derived antioxidants such as carotenoids, ascorbic acid, phenol, flavonoids etc., are having antioxidant capacity acts as scavengers in the living system. Risk of the chronic disease and its progression can be achieved by increasing natural antioxidant defense or supplementing with the proven antioxidants (Rajkumar et al., 2010). Antioxidant mechanisms in biological tissues are extremely complex and by the single method it is difficult to decide the antioxidant capacity of crude extracts (Carocho & Ferreira, 2013). A large number of in-vitro methods are available to evaluate the antioxidant activity of pure compound or extracts. Hence in the present study, four in-vitro assays viz., FRAP, PM, H2O2 and DPPH assay are used to evaluate antioxidant activity of Ximenia americana, Hopea ponga, Kandelia candel, Vitex leucoxylon and Rhizophora apiculata plants.
1.4. **Anticancer**

Cancer is a general term applied for series of malignant diseases that may affect different parts of body. This disease is characterized by rapid and uncontrolled formation of abnormal cells, which may mass together to form a tumor or proliferate throughout the body by the process of metastasis. The main types of cancer treatment in humans were surgery, radiation and drugs (chemotherapeutic agents) can often provide temporary relief of symptoms, prolongation of life and occasionally cures. Cancer continues to represent the largest cause of mortality in the world claiming over 6 million lives every year (Hanahan & Weinberg, 2011). Cancer is the leading cause of death worldwide and overall statistics study proves that compared to other diseases death rate of cancer is getting very much high every year and it is one of the most common devastating disease affecting millions of people each year. Cancer has been a leading cause of global morbidity due to its rapid progression and poor diagnosis (Ferlay *et al*., 2015; Kohler *et al*., 2015; Torre *et al*., 2015; Bello *et al*., 2011; Shibuya *et al*., 2002). Lung cancer is the leading cause of cancer deaths in men and 2\textsuperscript{nd} in women (Parkin, 2000). In developing countries since the following decades, numerous people with cancer will continue to increase may be due to life style, nutrition and environmental conditions (Jemal *et al*., 2011; Marmot *et al*., 2007; Veer & Kampman, 2007). In many countries cancer is the 2\textsuperscript{nd} leading cause of death after heart diseases (Dahab & Afifi, 2007). Lung, colorectal and stomach cancer are among the five most common cancers in the world for both men and women (Shoeb, 2006). Lung cancer is the leading cause of cancer deaths worldwide. According to studies conducted by American cancer society estimated in 2016, about 1 of 4 cancer deaths is from lung cancer. Every year, more people die of lung cancer than of colon, breast and prostate cancers. In case of 5 year survival rate of lung cancer patients’ metastasis
it has dropped to 4% from 54% (Siegel et al., 2016). Smoking is the most important contributory factor in the causation of lung cancer and also certain occupations have shown to increase exposure to lung cancer such as asbestos and textile industries. However, most of the anticancer drugs currently used such as doxorubicin, pacilitaxil give rise to undesirable side effects such as cardio toxicity and tumor drug resistance (Carvalho et al., 2009). Many synthetic drugs are available to treat cancer, but those are provided with severe side effects as well as cost effective. According to World Health Organization (WHO) approximately 65-80 % of developing countries including India depend on traditional medicine for their health care due to difficulties of accessing modern medicines (Calixto, 2005). Medicinal plants play a significant role in the treatment of cancer (Ansil et al., 2014; Nurfariza et al., 2014; Mark, 2004). Natural products or derivatives have been demonstrated to have significant anticancer activities due to their ability to inhibit tumor growth, angiogenesis and metastasis without any side effects (Fridlender et al., 2015; Dall'Acqua, 2014; Biersack and Schobert, 2012; Negi et al., 2015; Vindya et al., 2015). It was reported that, 40 % of anticancer agents between 1940 and 2002 were derived from natural products or their mimics, including vinca alkaloids, Taxus diterpenes, camptotheca alkaloids etc. (David et al., 1999). Since ancient times plant secondary metabolites and their semi synthetic derivatives continue to play an important role in the treatment of cancer as novel drugs (Pan et al., 2010; Indap et al., 2006) and 60% of currently used anticancer agents are derived in one way or another from natural sources (Cragg et al., 2009). Plant derived natural products such as flavonoids, terpenes, alkaloids and phenols are gaining more importance due to their diverse pharmacological properties including cytotoxic and cancer chemo protective effects (Maicon et al., 2008). Phytochemicals and even the whole plant extracts are known to prevent arrest or reverse the cellular
and molecular processes of carcinogenesis due to its multiple intervention strategies (Mehta et al., 2010) Because of these reasons herbal medicines are making an impact on both world health and international trade. Already large number of new drugs derived from plants secondary metabolites have been applied in treatment and prevention of cancer (Conforti et al., 2008). In many countries the use of medicinal plants to treat diseases is quiet common due to two main factors i.e. easy access and low cost with less side effects (Borges et al., 2013; Orlanda and Vale, 2015). Surgical resection, radiation or systemic chemotherapy is the main type of treatment for most cancers, but in case of lung cancer post treatment reoccurrence is quite frequent and although the cessation of smoking is important for lung cancer prevention (King et al., 1979). The preventive mechanisms of tumor promotion by natural Phytochemicals range from the inhibition of genotoxic effects, increased antioxidants and anti-inflammatory activity, inhibition of cell proliferation, protection of intracellular communications to modulate apoptosis and signal transduction pathways (Zhao et al., 2014; Soobrattee et al., 2006). The bioactive compounds from medicinal plants are provided with a wide variety of chemical structures with various biological activities and also bioactive compounds from plants are able to suppress or prevent the initial phases of carcinogenesis (Piccolella et al., 2015) which provides important prototypes for the development of novel drugs (Cragg, 1998; Verpoorte, 1998; Vuorelaa et al., 2004).

In the present study, Ximenia americana, Hopea ponga, Kandelia candel, Vitex leucoxylon and Rhizophora apiculata plants were selected for the study. Leaves of Ximenia americana were collected from Karnatak University Campus, Dharwad, India in the month of June, 2014, whereas Leaves of Hopea ponga and Vitex leucoxylon were collected from Anashi forest range of Western Ghats, Uttar Kannada
District, Karnataka, India during the period of May, 2015 and Leaves of *Kandelia candel* and *Rhizophora apiculata* were collected from Mangrove region, Sadashivghad, Karwar, Uttar Kannada District, Karnataka, India during the period of May, 2015.

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Table.1.1 Taxonomic classification of *Ximenia americana*

![Image](image-url)

Fig.1.1. *Ximenia americana*
Ximenia americana plant belonging to the Olacaceae family was selected for the present study and it has been used in the treatment for a wide variety of ailments by many rural communities in Asia commonly known as “wild olive”. It is extensively used as herbal remedy in treatment of malaria, leproutic ulcer, skin infections (Cristina Voss et al., 2000), as antibacterial activity, in fever, tuberculosis, stiffness, tooth decay and wounds (Ogunnyeleye & Ibitoye, 2003). Many works have reported the use of roots in the treatment of leprosy, syphilis, dysentery, and wounds. The stem bark has been reported to have anti-trypanosomal activity and used in treating headaches and mumps (Maikai et al., 2008). Systemic specific studies on Ximenia americana are still not satisfactory particularly in relation to specific biological activity of their chemical constituents.

![Figure 1.2: Hopea ponga](image)
**Hopea ponga**

**Systematic classification**
- Kingdom: Plantae
- (unranked): Angiosperms
- (unranked): Eudicots
- (unranked): Rosids
- Order: Malvales
- Family: Dipterocarpaceae
- Genus: Hopea
- Species: *H. ponga*

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<th>Table 1.2. Taxonomic classification of <em>Hopea ponga</em></th>
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*Hopea ponga* belonging to Dipterocarpaceae family found in tropical ever green forest of Western India and it is widely distributed along the Western Ghat of Karnataka (Shiddamallayya *et al.*, 2008). *H. ponga* is categorized as an endangered tree species under the International Union for Conversation of Nature Red List of threatened species. This plant was reported to be used as traditional medicine in the treatment of piles and snake bite (Muralikrishnan & Chandrashekar, 1997). Bark of *Hopea ponga* is known to have high content of tannin and acts as astringent (Shivaprasad *et al.*, 1999). Methanolic extract of seed wings of *Hopea ponga* exhibits antioxidant and antibacterial activity (Sukesh *et al.*, 2011). Literature survey indicates that there are only few pharmacological studies reported on this plant, revealing the scope for our venture in unmasking its anti-inflammatory property.
**Kandelia candel**

**Systematic classification**
- Kingdom: Plantae
- (unranked): Angiosperms
- (unranked): Eudicots
- (unranked): Rosids
- Order: Malpighiales
- Family: Rhizophoraceae
- Genus: *Kandelia*
- Species: *K. candel*

| Table 1.3. Taxonomic classification of *Kandelia candel* |
*Kandelia candel* is the mangrove tree belonging to Rhizophoraceae family which is distributed along the western region of India. The whole plant of *K. candel* is reported to have antidiabetic activity (Rollet, 1981; Saxena, 1975). In fact rhizophoraceae species are known to have pharmacological activities. Methanolic extract of *K. candel* is used as antihyperglycemic agent in India (Tiwari *et al.*, 2008) and bark, flowers and leaves were reported to have antiviral and antimicrobial properties (Thangam & Kathiresan, 1997; Williams, 1999).

![Vitex leucoxylon](image)

*Fig.1.4. Vitex leucoxylon*
Vitex leucoxylon is commonly known as five leaved chaste tree and belongs to the verbenaceae family. It is small to large deciduous tree, growing up to 20 m in height. It is widely distributed along the Western Ghats of India. The leaves of *V. leucoxylon* are reported to have medicinal properties like relieving headache, fever and catarrh (Chanda, 1982). Reports indicate that, the aqueous and ethanolic extracts of *V. leucoxylon* leaves possess antipsychotic, antidepressant, analgesic, anti-inflammatory, anti-parkinsonian and antimicrobial activities (Makwana *et al.*, 1994; Sarma *et al.*, 1990). Even the root and bark of *V. leucoxylon* are reported to use as astringent and febrifuge (Meena *et al.*, 2010). Many hepatoprotective agents were isolated from leaves and bark of *V. leucoxylon* which includes β-sitosterol, vitexin, isovitexin and aucubin (Rao, 1997)
Fig. 1.5. *Rhizophora apiculata*

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Table 1.5. Taxonomic classification of *Rhizophora apiculata*
*Rhizophora apiculata* is the tree species of mangrove tree belonging to rhizophoraceae family. In Malaysia, the leaves of *R. apiculata* are assayed as antibrast cancer (Nurhanan *et al.*, 2008). Studies on HPLC investigation of *R. apiculata* have shown the presence of catechin monomer, an antioxidant flavonoid (Rahim *et al.*, 2008). This plant is reported to possess anti-inflammatory and antitumor properties and is also used to regulate the antioxidant enzymes in biological system (Vinod & Guruvayoorappan, 2014). Bark of *R. apiculata* is used as a traditional medicine in the treatment of diarrhoea and wounds (School of Thai Traditional Medicine, 1981; Traditional medicine association, 1980). In Malaysia, pyroligneous acid from *R. apiculata* species have been used as sterilizing agent, deodorizer, fertilizer, antimicrobial agent and growth promoting agent (Loo *et al.*, 2006). Alkaline extract from leaf of *R. apiculata* reported to inhibit the HIV replication and HIV induced cytopathic effects. Some other studies have confirmed the antiviral property of *R. apiculata* extracts, which may be due to presence of antipolysaccharide in the extracts that acts as an antiviral agent (Kirtikar *et al.*, 1935). Keeping in view all the above facts, the present research was taken with following five objectives as follows

1. Phytochemical profiling and Pharmacognostic study on selected plants.
2. Green synthesis and characterization of nanoparticles from the selected plant extracts.
4. Evaluating the Cytotoxic activity of selected plant extracts and Nanoparticles.
5. Isolation and characterization of potent extract among selected plant of Western Ghats.