The coastal plant community has rich bioprospecting potential due to the presence of valuable genes to tolerate salinity and the novel phytochemicals to overcome the stressful coastal environment. Coastal medicinal plants include mangroves, sand dunes and salt marshes play a crucial role in antibiotic production. Another important property of the coastal plants is the production of many natural antioxidants which acts as free radical scavenger and has the potential to prevent or delay many disorders in human body (Sreelatha et al., 2012).

In this view the two coastal plants *Sesuvium portulacastrum* (L.) L. and *Sauropus bacciformis* (L.) Airy Shaw are studied for their pharmacognostic, phytochemical and pharmacological characteristics.

**Macroscopical and Microscopical characters**

To ensure reproducible quality of herbal products, proper control of starting material is very essential. So in recent years emphasis has been given to standardization of medicinal plants of therapeutic potential. The identification and evaluation of plants drugs by pharmacognostical studies is still more reliable, accurate and inexpensive than modern techniques. According to WHO the macroscopic and microscopic description of a medicinal plant is the first step towards establishing its identity and purity (Anonymous, 2002; Amerjothi, 2002).

*Sesuvium portulacastrum* is a sprawling perennial herb, with thick prostrate, smooth reddish to green stem. Leaves opposite, glossy green and fleshy. Flowers bisexual, pink. Leaves isobilateral and amphistomatic. Sand crystals are fairly common in the spongy mesophyll cells. It consists of small, conical, collateral
vascular strand. The stem is circular with fairly even outline. It consists of an epidermal layer, wide cortex, thin hollow vascular cylinder and wide pith. Calcium oxalate crystals are seen filling the lumen of the most of the xylem elements. Crystals are also seen sparsely in the cortical and pith parenchyma cells (Plate I).

*Sauropus bacciformis* is a coastal annual herb with erect stem. Leaves alternate, subfleshy and glabrous. Flowers unisexual, yellow green, monoecious; fruits capsule; seeds yellowish. The leaves dorsiventral, mesomorphic, hypostomatic. The vascular bundle single and quite prominent. Large calcium oxalate druses are fairly abundant in the ground cells of the midrib. The stem is squarish in outline. The surface is smooth and even. Xylem fibres are seen mostly in the outer zone of the xylem cylinder. Secondary phloem occurs as a thin sheath around the xylem cylinder. Crystals are seen in cortex, and large sphaerocrystals are seen in abundance in the peripheral cortex and pith (Plate II).

**PHARMACOCHEMICAL CHARACTERIZATION**

**Physicochemical characteristics:**

The moisture content is determined in reference to air dried sample by loss on drying method. Deterioration time of the plant material depends upon the amount of water present in the crude drug. If the water content is high, the plant can be easily deteriorated. The percentage of loss on drying should be determined and the water content should be controlled because any excess of water in medicinal plant materials will encourage microbial growth or the presence of insects (Adeyeye and Ayejuyo, 2000). The moisture content of aerial parts of *Sesuvium portulacastrum* and *Sauropus bacciformis* are within the accepted range (6-9%), thus implying that the formulation can be stored for a long period without microbial degradation (Anonymous, 1986).
The evaluation of a crude drug is an integral part of establishing the correct identification of plant material. For this, physicochemical parameters must be determined. The ash value determines the earthy matter or inorganic composition and other impurities present along with the drug. The ash values are generally the index of the purity as well as identity of the drug (Anonymous, 1986). The ash values are indicating the purity of drug, since they are constant for a given drug. In the present study, leaf and stem of *Sauropus bacciformis* has high ash value when compared with other investigated drug sample, *Sesuvium portulacastrum*. These values vary within fairly wide limits and is therefore an important parameter for the evaluation of crude drugs. In certain drugs, the percentage variation of ash value from sample to sample is very small and any marked difference indicates the change in quality (Umadevi, 2012).

The extractive value of water is more than in other solvents investigated. The extractive value obtained by exhausting the plant materials with specific solvents are indicative of approximate measure of their chemical constituents extracted. The extractions of any crude drug with a particular solvent yield a solution containing different phytoconstituents. The composition of these phytoconstituents depends upon the nature of the drug and solvent used. Extractive value provides an indication about the extent of polar and non-polar components present in the medicinal plant material. In the present study the percent extractive value increases from non-polar to polar solvents and due to the abundance of polar phytochemicals. High extractive values are found in polar solvents like water and methanol (Table 4). The results of ash value and extractive values may provide a basis to identify the quality and purity of drug (Anonymous, 2002).
The fluorescence analysis is a tool for the determination of constituents in plant and gives a definite idea on chemical structure (Kewatkar, 2012). Many phytocompounds produce fluorescence when they are suitably illuminated. The fluorescent colour is specific for each compound. A non-fluorescent compound may fluoresce if mixed with impurities that are fluorescent. The fluorescent method is adequately sensitive and enables the precise and accurate determination of the analyte over a satisfactory concentration range without several time consuming dilution steps prior to analysis of pharmaceutical samples (Pimenta et al., 2006). Light within short wavelengths is very active in producing fluorescence in many substances which do not visibly fluoresce in day light. The powder from the whole plant of *Sesuvium portulacastrum* produces green colour under long UV light, dark black and green under short UV light and day light. The plant powder of *Sauropus bacciformis* exhibits yellow green colour under long UV light. The plant powder of *Sesuvium portulacastrum* shows the characteristic yellow green colour when treated with benzene and methanol. The *Sesuvium portulacastrum* powder also shows green color treated with Conc.HCl, 1N HCl, petroleum ether, and methanol. This study helps in the identification of drug in powder form (Table 5 and 6).

**Phytochemical Studies**

Plants constitute an important source of active natural products which differ widely in terms of structures, biological properties and mechanisms of actions. Preliminary qualitative phytochemical analysis of all the extracts is carried out by employing standard conventional protocols. Phytochemical evaluation is one of the tools for the quality assessment which includes preliminary phytochemical screening, chemoprofiling and marker compound analysis using modern analytical techniques. In the last decades, HPTLC has emerged as an important tool for the qualitative semi-
quantitative and quantitative phytochemical analysis of herbal drugs and formulations. HPTLC method is fast, precise, sensitive and reproducible with good recoveries for standardization of herbal drugs. In the present study, the preliminary phytochemical study on leaf and stem extracts of Sesuvium portulacastrum and Sauropus bacciformis reveals the presence of alkaloids, flavonoids, coumarins, terpenoids, phenols, saponins, tannins, sugars, steroids, and glycosides. HPTLC investigation also confirms the presence of alkaloids, flavonoids, steroids and phenols which could make the plant useful for treating different ailments as having a potential of providing useful drugs for human use.

Alkaloids are the largest groups of phytochemicals in plants which have amazing effect on humans and this led to the development of powerful pain killer medicines (Johnson et al., 2012). Alkaloids have been associated with medicinal uses for centuries and one of their common biological properties is their cytotoxicity (Nobori et al., 1994). Several workers have reported the analgesic (Antherden, 1969; Harborne, 1998 and Eleazu et al., 2012) antipasmodic and antimicrobial properties of alkaloids (Okwu and Okwu 2004; Nagababu and Umamaheswara, 2012).

Phenols possess biological properties such as antiinflammation, antiatherosclerosis, cardiovascular protection and improvement of endothelial function as well as inhibition of angiogenesis, and cell proliferation activities (Han et al., 2007). Several studies described the antioxidant properties of medicinal plants which are rich in phenolic compounds. Phenolics can enhance the body’s immune system to recognize and destroy cancer cells as well as inhibiting the development of new blood vessels (angiogenesis) that is necessary for tumour growth. They also attenuate adhesiveness and invasiveness of cancer cells there by reducing their metastatic potential. (Lee et al., 2001; Wojdylo et al., 2007; Wahle et al., 2010).
Flavonoids are potent water soluble antioxidants and radical scavengers which prevent oxidative cell damage and have strong anticancer activity and protect against the different levels of carcinogenesis (Okwu and Okwu, 2004; Sousa et al., 2007). The multiple pharmacological properties of flavonoids, such as antiinflammatory, antidiabetic and cardiovascular activities are to a large extent linked to their polyphenolic and radical scavenging nature (Sghaier et al., 2011; Jose et al., 2012; Perumal et al., 2012). Recent studies showed that flavonoids can bind directly to some protein kinases and then alter their phosphorylation state to regulate multiple cell signaling pathways in carcinogenesis processes (Hou and Kumamoto, 2010). As antioxidants, the flavonoids from plants may provide antiinflammatory activity (Eleazu et al., 2012). Flavonoids act as antidiabetic agents by promoting the regeneration of damaged beta cells in the alloxan induced diabetic rats (Chakravarthy et al., 1980) and as an insulin secretagogues (Geetha et al., 1994).

Tannins are plant polyphenolic compounds and have been found to form irreversible complexes with proteins to provide a typical tanning effect which is important in the treatment of inflammed or ulcerated tissues (Parekh et al., 2007). Tannins exert broad cancer chemoprotective activity in a number of animal models (Umadevi et al., 2012). It was also reported that certain tannins are able to inhibit HIV replication selectively and also used as diuretic (Mithraja et al., 2012). Tannins are recognized as health protecting antioxidants (Eleazu et al., 2012) and used as healing agents in inflammation, leucorrhoea, gonorrhoea, burns, piles, and as antidote (Ali, 1994). Tannins has high potential in treating intestinal disorders such as diarrhoea and dysentery (Akinpelu and Onakoya, 2006).

Saponins has been found to be potentially useful for the treatment of hypercholesterolemia which suggested that they might be acting by interfering with
intestinal absorption of cholesterol (Malinow et al., 1977; Olaleye, 2007). Saponins isolated from plants exhibited hypoglycaemic effects (Petit et al., 1993; Kim et al., 1998; Yoshikawa et al., 2001). They also had been shown to specifically inhibit the growth of cancer cells in vitro (Podolak et al., 1998; Francis et al., 2002).

Steroids have been reported to have antibacterial properties (Raquel, 2007) and they are very important compounds especially due to their relationship with compounds such as sex hormones (Okwu, 2001). Plant sterols are known to be important for their cardio tonic activities, possess insecticidal and antimicrobial properties. Steroids are used to suppress inflammation (Karunyadevi et al., 2009). Phytosterol acts as antioxidant, a modest radical scavenger and physically a stabilizer in the membrane (Yasukazu and Etsuo, 2003).

To understand the nature of the fluorescence emission from these crude drug under different conditions, the preliminary phytochemical analysis of these crude preparations are compared. The comparative analysis clearly shows a correlation between the compounds present in it and their fluorescent behaviour under different conditions. The major bioactive compounds present in these crude preparations are the flavonoids, steroids, terpenoids, coumarins and alkaloids. Flavonones which are light yellow in aqueous condition under UV light turns to bright yellow under alkaline conditions. Similarly the phytosterols when treated with 50% H₂SO₄ show green fluorescence under UV light. Coumarin especially hydroxyl amino acid derivatives like coumaric acid appears yellowish green in alkaline condition under short UV radiation. Terpenoids especially sapogenins exhibit yellow green fluorescence under short UV light (Harbone, 1976). Quinine, aconitin, berberin and emetin show specific colour of fluorescence (Aconitin-light blue, berberin-light yellow, emetin-orange). Fixed oils and fats fluoresce least, waxes more strongly and mineral salts most of all.
(Evans, 1996). The crude drugs of leaf and stem powders of *Sesuvium portulacastrum* and *Sauropus bacciformis* exhibit clear fluorescence behaviour at different radiations which can be taken as standard fluorescence pattern of the drug.

Determination of extractive values, ash residues and active components (Phytochemicals) play a significant role for standardization of the indigenous crude drugs. The purpose of standardized extraction procedure for drugs is to attain the therapeutically desired portion and to eliminate the inert portion by treatment with selective solvent known as *menstruum*. The extract formed can directly used as tincture or fluid extract or further processed for incorporation into tablets or capsules, or it may be fractionated to isolate individual active principle (Thomson, 2007). Thus standardization of extraction procedures contributes significantly to the final quality of herbal drug (Handa *et al.*, 2008).

**GC - MS Analysis**

The major phytocomponents identified in the methanolic leaf and stem extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* by GC-MS study and their bioactivities are listed by in Table 35 and 36. Phytol is detected in leaf methanolic extract of *Sesuvium portulacastrum*. Phytol is an acyclic diterpene alcohol used in the fragrance industry and used in cosmetics, shampoos, toilet soaps, household cleaners, and detergents. It can be used as a precursor for the manufacture of synthetic forms of Vitamin E (Netscher, 2007) and Vitamin K, (Daines, 2003). It is a reactive oxygen species promoting substance and constitute a promising novel class of pharmaceuticals for the treatment of rheumatoid arthritis and possibly other chronic inflammatory diseases (Ogunlesi *et al.*, 2009). Phytol derivatives are said to be the excellent immuno stimulants (Chowdhury and Ghosh, 2012) antiplasmodial (Grace...
et al., 2012) antiulcerous (Haider et al., 2012) hepatoprotective and anticancerous (Hema et al., 2011).

Squalene is a poly unsaturated hydrocarbon liquid and it is found in leaf methanolic extracts of Sesuvium portulacastrum and Sauropus bacciformis. It appears to function in the skin, protecting human skin surface from lipid peroxidation due to exposure to UV and other source of ionizing radiation. In humans, squalene may be useful addition to potentiate the effect of some cholesterol lowering drugs. The primary therapeutic use of squalene currently is in adjunctive therapy in a variety of cancers (Smith, 2000). Squalene has the property of antioxidant and possesses chemopreventive activity against colon carcinogenesis. (Rao et al., 1998).

Vitamin E (α tocopherol) is found in leaf of both the selected taxa studied. It acts as an antioxidant (Bell, 1987) and the other functions include the regulation of enzymatic activities, gene expression and neurological functions (Devaraj et al., 2001; Villacorta et al., 2003; Schneider, 2005). Vitamin E also plays a role in inhibition of platelet aggregation (Dowd and Zheng, 1995; Atkinson, 2008; Muller, 2010). It also protects lipids and prevents the oxidation of polyunsaturated fatty acids (Whitney and Sharonrady, 2011).

Tetradecanoic acid (Myristic acid) is a common unsaturated fatty acid identified in the leaf methanolic extracts of Sauropus bacciformis. Myristic acid is used in the food industry as a flavouring agent. Hexadecanoic or Palmitic acid is a novel and specific inhibitor of HIV-1 fusion and entry (Lin et al., 2011) and is found to have antiinflammatory properties which was proved by structural evidence and kinetic assessment (Aparna et al., 2012). It is found in the leaf and stem methanolic extracts of Sesuvium portulacastrum and also in the stem methanolic extract of
Sauropus bacciformis. Rhodopsin is a carotenoid compound found in stem of Sesuvium portulacastrum. It has antioxidant properties (Dr. Duke’s Phytochemical and Ethnobotanical Database). Benzoic acid is an aromatic compound found in stem of Sesuvium portulacastrum. It occurs naturally free and bound as benzoic acid esters in many plant and animal species. It is found to have antimicrobial and antiinflammatory properties (Tomokuni and Ogata, 1972).

GC-MS analysis is the first step towards understanding the nature of active principles in medicinal plants and this type of analysis will be helpful for further detailed study and pharmacological investigations of the two selected coastal taxa. The detailed phytochemical studies also may add new knowledge to the information in the traditional medical system. The results the present study suggest that these plants prove to be a valuable reservoir of bioactive components of substantial medicinal merit.

Both taxa selected for the present study are taken as green vegetable by coastal people. So the nutritional value of the selected plants are evaluated (Table 16). The results indicate that these plants are the important sources of protein, fibre, carbohydrate, minerals and energy. The nutrient and mineral content of Sesuvium portulacastrum is higher than Sauropus bacciformis. GC-MS study also proves the presence of high vitamin E content. The proximate composition, vitamin, mineral constituents and phytochemical composition of the two taxa suggest that they can be included in diet to supplement our daily nutrient needs and to fight against many diseases as nutraceutical.
Pharmacological Studies

Antioxidant activity

Free radicals are the major cause of various chronic and degenerative diseases such as cardiovascular, autoimmune, neurodegenerative, inflammatory, stroke, diabetes, cancer and ageing (Saha et al., 2008; Sopia et al., 2011; Yuan et al., 2012). The generated ROS are detoxified by the antioxidants present in the body. However, over production of ROS and inadequate antioxidant defense can easily affect and persuade oxidative damage to various biomolecules including proteins, lipids, and DNA. Although several synthetic antioxidants, such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are commercially available but are quite unsafe and their toxicity is a problem of concern. Hence, strong restrictions have been placed on their application and there is a trend to substitute them with naturally occurring antioxidants. Recently there has been an upsurge of interest in the therapeutic potentials of plants as antioxidants in reducing free radical induced tissue injury. Plants contain a wide range of radical scavenging molecules such as phenolic compounds, nitrogen compounds, vitamins, terpenoids and other endogenous metabolites which are rich in antioxidant activity which prevent oxidative cell damage (Cai et al., 2003). In the present study in vitro antioxidant activity of the selected plants is investigated by DPPH scavenging activity, hydroxyl radical scavenging activity, ABTS radical cation scavenging activity, superoxide radical scavenging activity and by measuring reducing power. These methods have proved the antioxidant potential of the extracts in comparison with the reference antioxidants, ascorbic acid and trolox.

DPPH radical scavenging assay is the standard method to measure the antioxidant potential of compounds (Roy et al., 2011). DPPH radical scavenging
system is used to evaluate the antioxidant property of methanol extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis*. A dose dependent relationship in the DPPH radical scavenging activity is observed. DPPH solution shows a strong absorption band at 517nm appearing as a deep violet colour, the absorption vanishes and the resulting decolourization is stoichimetric with respect to degree of reduction. The degree of colour change is proportional to concentration and potency of the antioxidant. A large decrease in absorption of reaction mixture indicate significant free radical scavenging activity of extract (Krishnaiah *et al*., 2011). Antioxidant activity of leaf methanolic extracts of *Sesuvium portulacastrum* is higher than that of *Sauropus bacciformis* and stem methanolic extracts of *Sauropus bacciformis* exhibit higher activity than that of *Sesuvium portulacastrum*. The antioxidant activity is correlated with high phenol content (Saeed *et al*., 2012). The results of the present study suggest that the phytocompounds of the extracts of selected plants are capable of donating hydrogen to free radical to scavenge the potential damage.

Hydroxyl radical is one of the potent reactive oxygen species in biological system. It reacts with polyunsaturated fatty acid moieties of cell membrane phospholipids and causes damage to cell (Khan *et al*., 2012). Hydroxyl radical is regarded as a detrimental species in pathophysiological processes and capable of damaging almost every molecule of biological system and it leads to carcinogenesis mutagenesis and cytotoxicity (Babu *et al*., 2001). Hydroxyl radical scavenging capacity of the extract is directly proportional to its antioxidant activity which is depicted by the intensity of red colour (Gulcin *et al*., 2005). The methanolic extracts of the selected plants scavenged hydroxyl radical more actively than other extracts.

ABTS (2, 2’-azinobis (3-ethylbenzthiazoline-6-sulfonic acid) assay is an excellent tool for determining the antioxidant activity of phytochemical products
The reduction capability of ABTS radical is determined by the decrease in its absorbance at 734nm, which is induced by antioxidant. The rate of reduction or decolourization is directly proportional to the increased concentration of the extract. The methanolic extracts of the selected taxa show potent antioxidant activity, which is higher than that of standard ascorbic acid. The stem methanolic extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* exhibit more antioxidative potential than leaf extracts (Fig: 14 and 16).

Superoxide radical is considered as a major biological source of reactive oxygen species (Alves *et al*., 2010). It is a weak oxidant but it gives rise to generation of powerful and dangerous hydroxyl radicals as well as singlet oxygen, both of which contribute to oxidative stress (Meyer and Isaksen, 1995). All solvent extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* exhibit superoxide scavenging activity but the leaf methanolic extract has effective capacity of scavenging for superoxide radical and it may be correlated with flavonoid content and suggesting its antioxidant potential as observed by Saeed *et al*., 2012.

Reducing power has been used as an antioxidant indicator for the medicinal herbs (Hsu *et al*., 2003). Reducing ability of compound generally depends on the presence of reductants, which exhibit antioxidant activity by breaking the free radical chain through donation of a hydrogen atom (Rathee *et al*., 2009). In the reducing power assay, the presence of antioxidants in the sample result in the reduction of Fe$^{3+}$ to Fe$^{2+}$ by donating of an electron. The extract with reducing power reveals that they are electron donors, reduce the oxidized intermediates and act as primary antioxidant substances. Increase in absorbance indicates an increase in reductive ability. Among the solvents treated, methanolic extract exhibits higher reducing activity. Reducing ability of leaf and stem methanolic extracts of *Sauropus bacciformis* is higher than
that of *Sesuvium portulacastrum* at 800 µg/ml concentration. Several reports indicated that reducing power of bioactive compounds was associated with antioxidant activity (Siddaraju and Becker 2007; Rajan *et al.*, 2011; Jenecius *et al.*, 2012; Saeed *et al.*, 2012). The antioxidants present in the extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* cause the reduction of Fe$^{3+}$/ ferricyanide complex to ferrous (Fe$^{2+}$) and thus proved the reducing power.

The results indicate that both the plant samples used have antioxidant properties but *Sesuvium portulacastrum* is more potent as an antioxidant than *Sauropus bacciformis*. Benjapak *et al.* (2008) and Jenecius *et al.* (2012) reported that in *Sauropus androgynus* the antioxidant activity is correlated with the high amount of phenolic compounds, flavonoids, vitamin C, E and carotenoids. The antioxidant ability could be attributed to phenolic compounds especially flavonoids which possess antioxidant action (Anandakumar, 2009). Magwa *et al.* (2006) reported that the phytocomponents of essential oil from *Sesuvium portulacastrum* are associated with the antioxidant activity. The antioxidative activities observed in the present study can be the synergistic effect of the phytocompounds that present in the plant.

**Anticancer activity**

Cancer is one of the most common devastating diseases affecting millions of people every year. Cancer has been estimated as the second leading cause of death in humans. So there has been an intense search on various biological sources to develop a novel anticancer therapy for several years. The antitumour activity of methanol leaf extracts of *Sauropus bacciformis* and *Sesuvium portulacastrum* are evaluated in EAC tumour bearing mice. The methanol extracts of the above said plants treated at the dose of 150mg/kg body weight and 300mg/kg body weight have significantly
increased the life span of EAC tumour bearing mice and reduced tumour volume and tumour (viable) cell count and improved the haematological parameters to more or less normal level (Table 22). A rapid increase in ascitic fluid volume is observed in EAC bearing mice. Ascitic fluid is the direct nutritional source for tumour growth and it meets the nutritional requirement of the tumour cells (Prasad and Giri, 1994). The increase in life span of the animal indicates, reduction in nutritional fluid volume, cessation of tumour growth as a positive result and it further confirms the antitumour effect of whole plant extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis*. The antitumour potential of the extracts are found to be concentration dependent. The reliable criteria of judging the effect any anticancer drug is the prolongation of life span of animals (Rockwell *et al*., 1972). So it may be concluded that the methanolic extracts of the taxa selected decreased the nutritional ascitic fluid volume, arresting the tumour growth and increase the life span of EAC bearing mice.

In cancer chemotherapy, the major problems that are being encountered are myelosuppression and anaemia (Price and Greenfield, 1958; Hoagland, 1982). One main obstacle for a successful anticancer therapy is the development of resistance overtime. Many aggressive tumours become refractory to anticancer therapy with hardly any chemotherapeutic alternatives (Crespo-ortiz and Wei, 2011). The anaemia encountered in tumour bearing mice is mainly due to reduction in RBC or haemoglobin percentage and this may occur either due to iron deficiency or due to haemolytic or myelopathic conditions (Fenninger and Mider, 1954; Rajeshwar *et al*., 2005). Treatment with methanol extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* brought back the haemoglobin content, RBC and WBC counts more or less to normal levels (Table 22). This clearly indicates that the whole plant extracts of the selected plants possess protective action on the haemopoietic system.
From the results of the present study it is concluded that the whole plant extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* increased the life span of tumour bearing mice, reduced tumour volume and improved haematological parameters. The association between flavonoid and reduced cancer risk have been reported in the previous studies that showed a decrease in cancer risk with consumption of fruits and vegetables (Ferguson *et al*., 2004; Park *et al*., 2008). Plant derived compounds have played an important role in the development of several clinically useful anticancer agents (Cragg and Newmann, 2006). The presence of alkaloids with flavonoids in the plants may explain the superior anticancerous potential. (Vijayan *et al*., 2004; Park *et al*., 2011). Several flavonoids had been shown to inhibit cancer development while exhibiting antioxidant activities in various animal models studied (Ingram *et al*., 1997; Lahirichatterjee *et al*., 1999; Olayiwola *et al*., 2004).

Phytol, 9, 12, 15. Octadecatrienoic acid, 2, 3 dihydroxypropyl ester, (Z, Z, Z), Oleic acid, eicosyl ester, squalene, vitamin E and oleic acid are the anticancerous compounds studied in the methanolic extracts of *Sesuvium portulacastrum* and Tetradecane, 1-iodo, squalene, vitamin E acetate Trideca-1, 3, 7, 11- tetraene-1,1-dicarbonitrile, 4, 8, 12- trimethyl- (E, E)- are the anticancerous compounds (Dr. Duke’s Phytochemical and Ethnobotanical Data base) studied in the extracts of *Sauropus bacciformis* which could account for the anticancerous potential of these plants and these make the plants useful as a anticancerous drug. Further steps can be taken to isolate the phytoconstituents responsible for anticancer activity which may result in a modern drug.
Antidiabetic activity

Diabetes mellitus is a chronic disorder in metabolism of carbohydrates, proteins, and fats due to absolute or relative deficiency of insulin secretion and its action or both. This leads to prolonged hyperglycaemia with disturbances in most metabolic processes inside human body (Bastaki, 2005). Diabetes mellitus arises from the irreversible destruction of the pancreatic beta cells of islets of langerhans causing degranulation and reduction of insulin secretion (Junod et al., 1969). This disorder has affected substantial population regardless of sex, age and socioeconomic status (Kannur et al., 2006). According to WHO, the number of diabetes cases in Southern Asia and Western Pacific is currently at 170 million and it is expected to reach 336 million at the end of 2030 (Sunil et al., 2011).

The use of plants for the treatment of patients with diabetes is common throughout the world (Mitra et al., 1996). Detailed investigations of the mechanism of action of herbal biomolecules have revealed that some of them allow the regeneration of β cells and thus causing reversal of diabetes in human. It has been documented that number of β cells and secretory granules increase after the treatment with Beta vulgaris plant extract (Bolkent et al., 2000). Fresh leaf juice of Catharanthus roseus had been reported to reduce blood glucose in normal and alloxan diabetic rabbits (Nammi et al., 2003; Singh et al., 2001). Catharanthus roseus extracts also showed improvement in parameters like body weight and lipid profile as well as regeneration of β cells of pancreas and so might be of value in diabetes treatment (Ahmed et al., 2010). Ethanolic leaf extract of Phyllanthus amarus exhibited antidiabetic or hypoglycaemic activity on alloxan induced diabetic mice may be due to the presence of phyllanthin, hypophyllarnthin, nirulin, flavonoids, terpenes, triterpenes, alkaloids and other constituents present in the leaves which could act synergically or
independently in enhancing activity of glycolytic and gluconeogenic enzymes (Shetti et al., 2012). Oral administration of extracts of Sauropus bacciformis and Sesuvium portulacastrum (300mg/kg body weight) for 14 days to alloxan induced diabetic rat significantly reduced blood glucose level by increased insulin secretion and improvement of body weight. The normoglycaemia achieved by the extracts may be either due to the formation of neoislets rich in β cell granulation or by the replication or expansion of existing residual islets as observed by Verma et al. (2013) in Crotalaria ternatea extract treated diabetic rats.

Urea is the main end product of protein metabolism. Amino acid deamination takes place in the liver, which is also the site of urea cycle, where ammonia is converted into urea and excreted through urine. Creatinine is a waste product formed in muscle by creatinine metabolism. Creatinine is synthesized in the liver, passes into the circulation and is taken up almost entirely by skeletal muscle. Its retention in the blood is evidence of kidney impairment. The diabetic hyperglycaemia by alloxan produces elevation of Urea and Creatinine in the plasma which are considered as significant markers for renal dysfunction (Alarcon et al., 2005). The results of the present study show significant increase in the level of plasma urea and creatinine in the alloxan treated diabetic group compared to control (Table 24). These results indicate that diabetes might lead to kidney dysfunction. Treatment with Sesuvium portulacastrum and Sauropus bacciformis whole plant extracts decrease the level of urea and creatinine significantly compared to the mean value of diabetic group. This further confirms the utility of the selected plants in diabetic associated complications (El-Demerdash et al., 2005; Jarald et al., 2008).

Glycosylated haemoglobin has been found to be increased over a long period of time in diabetes. During diabetes, the excess of glucose present in blood reacts with
haemoglobin to form glycosylated haemoglobin (Alyass and Ibrahim, 1981). The rate of glycation is proportional to the concentration of blood glucose. In the present study in the alloxan induced diabetic rats there is a significant increase (p<0.01) in glycosylated haemoglobin (HbA1c) level compared with normal rats (Table 24). The oral administration of the selected plant extracts shows a significant decrease (p<0.01) in the content of glycosylated haemoglobin that could be due to an improvement in glycaemic status.

A significant reduction in serum protein, albumin and globulin is observed in alloxan induced diabetic rats when compared to control (Group I) and glibenclamide treated rats (Group VII). On the other hand, in the Sesuvium and Sauropus extracts treated diabetic rats protein metabolism never deviated from normal range (Table 25). Hypoalbuminemia is a common problem in diabetic animals and is generally attributed in the presence of nephropathy. The reversal of these changes by methanol extracts of selected plants proved that insulin deficiency has been grossly corrected.

There is an increase in transaminase activities in the serum of diabetic animals. The increased levels of transaminases, which are active in the absence of insulin because of increased availability of amino acids in diabetes are responsible for the increased glucogenesis and ketogenesis observed in diabetes (Felig et al., 1970). There is an improvement noticed in the levels of SGOT. SGPT and ALP are as a consequence of improvement in the carbohydrate, fat and protein metabolism due to the administration of methanol extracts of Sesuvium portulacastrum and Sauropus bacciformis. The results obtained in the present study is in accordance with the previous reports (Wang et al., 1991; Liu et al., 2001; Banu et al., 2009).
The level of serum lipids is usually elevated in diabetes mellitus and such an elevation represents a risk factor for coronary diseases under normal circumstances. Insulin activates the enzyme lipoprotein lipase which hydrolyses triglyceride. However, in diabetic state, this enzyme is not activated due to insulin deficiency resulting in hypertriglyceridaemia and hypercholesterolaemia (Pushparaj et al., 2007). The mechanisms responsible for the development of these two processes of uncontrolled diabetes in human are due to a number of metabolic abnormalities that occur sequentially. Treatment with plant extracts of Sesuvium and Sauropus significantly reduce the total cholesterol, and triglyceride level in the alloxan induced diabetic rats. In alloxan treated rats show significant increase in serum lipid profiles LDL-C and VLDL-C except HDL-C when compared with normal rats. The rats treated with glibenclamide (Group VII) and methanol extracts of Sesuvium portulacastrum and Sauropus bacciformis (Group III, IV, V and VI) show a significant reduction in the elevated level TG, TC, LDL-Cholesterol and VLDL-Cholesterol. Similarly on administration of whole plant methanol extracts of selected plants to the diabetic rats, HDL-C level is found to be restored to normal (Rajalingam et al., 1993). A variety of dearrangements in metabolic and regulatory mechanisms, due to insulin deficiency are responsible for the observed accumulation of lipids. The impairment of insulin secretion results in enhanced metabolism of lipids from the adipose tissue to the plasma. Further it has been reported that diabetic rats treated with insulin shows normalized lipid levels (Pathak et al., 1981). These findings also support the hypothesis that the activity of the plant extracts may be directly attributed to improvement in insulin level upon treatment (Sharma et al., 2003).

In alloxan induced diabetic rats there is an increase in phospholipid. Phospholipids are present in cell membrane and make up vast majority of the surface
lipoprotein forming a lipid bilayer that acts as an interface with polar plasma environment and non-polar lipoprotein core (Cohn and Roth, 1996). Administration of whole plant methanol extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* and glibenclamide decrease the levels of phospholipids. It is concluded that, medicinal plants have been reported to possess antihyperglycaemic activity.

An increase in Lipid peroxidation (LPO), and decrease in SOD, CAT, GSH activity is observed in serum, liver and kidney of alloxan induced diabetic rats (Table 27). Similar result was also reported by earlier studies (Sajeeth *et al.*, 2010). Reddy *et al.* (2005) reported that there was a close relation between increase in free radicals, blood glucose and lipid peroxidation in diabetes progression. Increase LPO impairs membrane function by decreasing membrane fluidity and changing the activity of membrane bound enzymes and receptors (Verma *et al.*, 2013). This also indicates that the inhibition in oxidative damage is due to the antiperoxidative effect of the phytoconstituents present in the whole plant extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis*. Enzymatic antioxidants such as SOD, CAT are considered as primary enzymes since they are involved in the direct elimination of reactive oxygen species (Arulselvan and Subramanian, 2007). SOD is an important defence enzyme it scavenges O$_2^-$ anions from H$_2$O$_2$ and other free radicals derived from secondary reactions and reduces the toxic effect. CAT is a heme protein which catalyses the reduction of H$_2$O$_2$ and known to be involved in detoxication of H$_2$O$_2$ concentration *in vivo*.

Earlier studies reported that treatment with *Posidonia oceanica* leaf extract to alloxan treated mice enhanced the activity of SOD, CAT and GSH and eliminated of ROS generated by alloxan (Gokce and Haznedaroglu, 2008). Treatment with *Sesuvium portulacastrum* and *Sauropus bacciformis* whole plant extracts enhance the
activity of these enzymatic oxidants which might be due to involvement in decreased oxidative stress as evidenced by decrease of LPO. These findings suggest that the whole plant extracts of selected plant extracts induce antioxidant activity by attenuating lipid peroxidation caused by various forms of free radicals and in this way it affects the lipid profile.

The present study has shown that the whole plant methanol extracts of selected plants have antidiabetic, antihyperlipidaemic and antioxidant effects. The possible antidiabetic activity of the extracts might be due to stimulation of residual pancreatic insulin or by increasing peripheral utilization of glucose. These plant extracts at high dose (300mg/kg body weight) are more effective and show similar curative effect as standard that is drug glibenclamide (600mg/kg body weight). The action of Sauropsis bacciformis and Sesuvium portulacastrum extracts on the pancreatic β cells and absence of acute toxicity may offer a new hope to the diabetics in future (Ahmed et al., 2010). It is evident from the present study that the whole plant extracts of both taxa studied are proved relevant for the improvement of parameters like body weight lipid profile and antioxidant system and as a consequence their use might be of value in the treatment of diabetes.

**Hepatoprotective activity**

The liver is a vital organ of the body and plays a major role in metabolism, performing a number of functions including glycogen storage, decomposition of red blood cells, plasma protein synthesis, hormone production and detoxification. (Paliwal et al., 2009; Maruthi et al., 2010). During this detoxification process, the liver suffers from challenges affecting the hepatic architecture and hepatocytes. In general the liver suffers from hepatotoxicity which damages it. Hepatic dysfunction due to
ingestion or inhalation of hepatotoxins is increasing worldwide. Management of liver diseases is still a challenge to modern medicine. In view of severe undesirable side effects of synthetic agents, there is growing focus to follow systemic research methodology and to evaluate scientific basis for the traditional herbal medicines that are claimed to possess hepatoprotective activity. Antihepatotoxic herbs restore the bile flow and reduce total bilirubin, bilivirdin, triglycerides, cholesterol and total lipids in liver (Thakur and Kharya, 2011). The attention of pharmacologists throughout the world has been focused on finding out safer and potent hepatoprotective drug. Recently people are returning to the natural product with the hope of safety and security (Rachehh et al., 2011).

Carbon tetrachloride (CCL₄) is one of the most commonly used hepatotoxin. It produces an experimental damage that histologically resembles viral hepatitis. Toxicity begins with the change in endoplasmic reticulum, which results in the loss of metabolic enzymes located in the intracellular structures (Recknagel, 1983). It is well documented that CCl₄ is biotransformed under the action of Cytochrome P₄₅₀ in the microsomal compartment of the liver to trichloromethyl radical which reacts with oxygen to give trichloromethyl peroxyradical. (Raucy et al., 1993). Both the radicals can bind covalently to the macromolecule and causes peroxidative degradation of membrane lipid of the adipose tissue, which leads to leakage of serum marker enzymes. It is possible that hepatocellular damage occurs when the free radicals generation exceeds the cellular radicals scavenging capacity (Jadhav et al., 2010).

Assessment of liver toxicity is done by measuring the marker enzymes such as SGOT, SGPT and ALP. These enzymes are present in high concentration in the cytoplasm. When there is hepatic injury these enzymes leak into blood stream in conformity with extent of hepatotoxicity. Plant extracts of Sesuvium portulacastrum
and *Sauropus bacciformis* at the dose 300mg/kg body weight significantly restored the elevated levels of these serum marker enzymes. The normalization of serum markers by the extracts of selected plants suggests that they are able to condition the hepatocytes so as to protect the membrane integrity against CCl₄ induced leakages to marker enzymes into the circulation. The above changes can be considered as an expression of the functional improvement of hepatocytes. Animal groups IV, VI and VII (received CCl₄ plus 300 mg/kg b.wt of test extracts and standard drug silymarin) show a significant increase in the body weight and food consumption when compared to CCl₄ group animals. This findings suggest that the extract administered has significantly neutralized the toxic effects of CCl₄ and helped in the regeneration of hepatocytes (Farooq *et al.*, 1997).

Serum bilirubin is one of the most sensitive tests employed in the diagnosis of hepatic diseases. Hyperbilirubinemia was observed due to excessive heme destruction and blockage of biliary tract. As a result of blockage of the biliary tract there is a mass inhibition of the conjugation reaction and release of unconjugated bilirubin from damaged and dead hepatocytes (Wolf *et al.*, 1997). Administration of *Sesuvium portulacastrum* and *Sauropus bacciformis* plant extracts decreases the level of bilirubin and increased the level of protein suggesting that it has offered protection.

Protein metabolism is an important process in liver and a healthy functioning of liver is required for the synthesis of serum protein. Hypoproteinemia is a feature of liver damage due to significant fall in protein synthesis. The reduction in the serum albumin and globulin levels in CCl₄ intoxicated group might be due to liver damage (Venukumar and Latha 2002). Hepatotoxicity impairs the synthetic function of liver (David, 1999). Treatment with *Sesuvium portulacastrum* and *Sauropus bacciformis* extracts ameliorated the imbalance. γ-glutamyl transferase (GGT) is a hepatic
microsomal enzyme, and most useful in the diagnosis of liver diseases. The activity of serum glutamyl transferase is generally elevated as a result of liver disease. Changes in $\gamma$-glutamyl transferase is parallel to those of amino transferases. The acute damage caused by CCl$_4$, elevated the level of the $\gamma$-glutamyl transferase but the treatments with *Sesuvium portulacastrum* and *Sauropus bacciformis* plant extracts brings the level to normal due to its antioxidant activity (Anitha *et al.*, 2012).

The free radical induced damage is prevented and neutralized by radical scavenging molecules. This is also accomplished by a set of antioxidant enzymes such as glutathione peroxidase (GPx), glutathione reductase (GSH), superoxide dismutase (SOD) and catalase (CAT). When the balance between ROS production and antioxidant defense is lost, oxidative stress results which through a series of events deregulates the cellular functions leading to various pathological conditions (Castro *et al.*, 1974). Any compound, natural or synthetic, with antioxidant properties might contribute towards the partial or total alleviation of this type of damage. Vitamin E, a fat-soluble molecule present in the interior of membrane protects against LPO while ascorbate, a water soluble antioxidant reduces oxidized $\alpha$-tocopherol and lipid peroxides (Singh *et al.*, 2005). The extracts of both the taxa studied are rich in vitamin E. In the present study the elevations in the levels of products of lipid peroxidation in the liver of the rat treated with CCl$_4$ is observed. The increase in malondialdehyde (MDA) levels in liver suggests enhanced lipid peroxidation leading to tissue damage and failure of antioxidant defense mechanisms to prevent formation of excessive free radicals. Treatment with extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* significantly reversed these changes. Hence it may be possible that the mechanism of hepatoprotection by the extracts used is due to their antioxidant effects (Sumedha and Miltonprabu, 2014).
Glutathione (GSH) protects cells against electrophilic attacks provided by free radicals and peroxides. GSH deficiency leads to cellular damage in kidney, muscle, lung, jejunum, colon, liver, lymphocytes and brain (Orhan et al., 2007). Superoxide dismutase (SOD) a metallo protein is the most sensitive enzyme index in liver injury and one of the most important enzymes in the enzymatic antioxidant defense system. It scavenges the superoxide anion to form hydrogen peroxide and oxygen, hence diminishing the toxic effects caused by these radical (Cartis et al., 1972). In the present study, it is observed that the methanol extract of *Sesuvium portulacastrum* and *Sauropus bacciformis* plant extracts significantly increased the SOD activity in CCl$_4$ intoxicated rats thereby reduced CCl$_4$ induced oxidative damage and protect the hepatocytes.

Catalase (CAT) is an antioxidant enzyme marker widely distributed in all animal tissues and the highest activity is found to the red cells and in the liver. CAT decomposes hydrogen peroxide and protects the tissue from highly reactive hydroxyl radicals (Chance et al., 1952). Therefore the reduction in the activity of these enzymes may lead to many of deleterious effects due to the accumulation of superoxide radicals and hydrogen peroxide. Administration of methanol extract of *Sesuvium* and *Sauropus* increases the activities of CAT in CCl$_4$ induced liver damage in rats by scavenging the excessive free radical and protecting the liver from CCl$_4$ intoxication. Glutathione peroxide (GPx) is a seleno enzyme, it protects the cells from damage due to accumulation of free radicals like hydrogen and lipid peroxides (Zaltzber et al., 1999). Treatment with the test extracts is normalizing this antioxidant system.

The ethanolic leaves extract of *Trianthema portulacastrum* ameliorates AFB$_1$ (Aflatoxin B$_1$) induced toxicity due to its combined antioxidant potential as well as hepatoprotective action (Banu et al., 2009). The previous studies had shown that the
antioxidant systems and phytochemicals such as flavonoids, terpenoids, alkaloids, steroids etc are proved to have hepatoprotective activity (Baek et al., 1996; Vijyan et al., 2003; Chin et al., 2004; Ekbote et al., 2010). The hepatoprotective activity observed in the present study may be attributed to the phytoconstituents like Vitamin E, 9, 12, 15 - Octadecatrienoic acid, and 2, 3 -dihydroxypropyl ester, (Z,Z,Z) - in Sesuvium portulacastrum leaves and squalene in Sauropus bacciformis (Duke’s Phytochemical and Ethnobotanical Database).

Antiinflammatory activity

Many plants have long been recognized as important sources of therapeutically effective treatment for inflammatory diseases (Jaijoy et al., 2010). The analgesics and antiinflammatory activity may be due to the presence of phytoconstituents like flavonoids, tannins, saponins, triterpenes and coumarins (Patrick et al., 2011; Varsha et al., 2011). The ethanol extract of Sauropus androgynus leaves had significantly reduced the induced elevation of body temperature in rats which suggested that the extract had some influence on the prostaglandin biosynthesis since it is believed to be a regulator of body temperature. Sauropus androgynus leaves could be beneficial in the management of inflammations pains and fever. These activities may be due in part, to the presence of phytochemicals such as flavonoids, alkaloids, steroids or terpenes (Dascombe, 1985). Previous studies had shown that flavonoids and related polyphenols contribute significantly to the antioxidant and antiinflammatory activity (Okoli and Akah, 2004; Senthamarai selvi and Anusha, 2012).

In the present study, the antiinflammatory activity of the extracts of Sesuvium portulacastrum and Sauropus bacciformis has been established. The extracts are
found to be significantly inhibiting the carrageenan induced rat paw oedema, a test which has significant predictive value for antiinflammatory agents acting by inhibiting the mediators of acute inflammation. Carrageenan induced inflammation is useful in detecting orally active antiinflammatory agents (Muhammad et al., 2012). The development of carrageenan induced oedema is believed to be biphasic (Udegbunam et al., 2012). The initial phase is attributed to the release of histamine and serotonin. The second phase of oedema is due to the release of prostaglandins, bradykinin and lysozyme and it is sensitive to most antiinflammatory drugs (Jothimanivannan et al., 2010). The antiinflammatory activity of whole plant methanolic extract of *Sesuvium portulacastrum* and *Sauropus bacciformis* suggest that it may be due to their effect on prostaglandin, bradykinin and lysozyme synthesis.

Treatment with methanol extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* at both 150mg/kg body weight and 300mg/kg body weight exhibit highly significant (p<0.001) activities comparable to control. There are significant difference in their antiinflammatory activity at 150mg/kg body weight and 300mg/kg b.wt hence they are found to be dose dependent. The methanolic leaf extracts of *Sesuvium portulacastrum* and *Sauropus bacciformis* have phytoconstituents with antiinflammatory activity as noted in Table 34. These compounds may have the role in antiinflammatory effect. (Dr.Duke’s Phytochemical and Ethnonotanical Database).

This result provides a scientific basis for the utilization of these herbs in traditional medicine for the treatment of wounds and other conditions that can cause inflammation. Further tests are needed to explore the exact mechanism of action at the molecular level and to know the actual constituents responsible for this activity. The methanolic whole plant extract of *Sesuvium portulacastrum* and *Sauropus bacciformis* could serve as an alternative in antiinflammatory therapy in managing
inflammatory conditions or as complementary therapy thereby minimizing the side effects of these standard drugs.

The present study confirms the therapeutic potential of the two coastal plants Sesuvium portulacastrum and Sauropus bacciformis. These plants are proved to be promising in the management and alleviation of cancer, liver diseases, painful inflammatory conditions, ageing and related disorders to save mankind. As these two taxa are used as green vegetables by the coastal people, these plants are evaluated to ascertain their usefulness as food and in formulation of drug. Because of rich nutrient and mineral content, these plants can be used as a potential source of nutraceutical. In future these taxa can be further exploited for the bioactive compounds.