Allelopathy is a natural biological phenomenon in which an organism produces some biochemical compounds which influence the growth, survival, reproduction and biological processes of other organisms. These biochemical compounds are known as allelochemicals and can have positive allelopathy (beneficial) or negative allelopathy (detrimental) effects on the targeted organisms. The study of influence of various environmental conditions on the process of seedling growth in hostile environments would ultimately result in a great decline in plant cover. With this view, several attempts have been made to study impact of various abiotic stresses. Besides this features allelopathy phenomenon exerts influence on growth and metabolism of the plants.

_Cromolaena odorata_ is fast growing perennial ever green shrub native to south America and central America. It has become an aggressive invasive weed in tropical Asia, Africa and in some parts of Australia. This genus is known as Siam weed belonging to family Asteraceae and have wide range of allelopathic potential. _Chromolaena odorata_ grows in many soil types. It forms dense stands as weed and prevent establishment of other species both due to competition and allelopathic effect. In the coastal sand dunes of Goa occurrence of the _Chromolaena odorata_ has been noticed by Janarthanam and Dessai (2005). However, the allelopathic influence of this plant on various costal species has a not been so far investigated. So to know the possible impact of _Chromolaena odorata_ on the coastal vegetation, the research problem was selected. The significant findings of the present study can be summarized as follows:
1. **Photosynthetic pigments**

   a. **Chlorophyll**

   The leaf extract treatment of *Chromolaena odorata* enhances chlorophyll level among all studied species, while negative impact was found by leaf leachate treatment of same plant species. This *Chromolaena odorata* was toxic to other plant when present in living state or naturally, caused loss in chlorophyll and hence loss of productivity of studied coastal species.

   b. **Carotenoid**

   Carotenoid contents under leaf extract treatment of *Chromolaena odorata* affects positively for some species studied viz. *Sonneratia alba*, *Acanthus ilicifolius*, *Salvadora persica*, *Crotalaria Sp*. while for other studied species viz. *Derris trifoliata* and *Ipomoea pes-caprae* showed negative impact of this treatment as compared to their control one. In case of leaf leachate treatment different kinds of results were observed i.e. plants like *Sonneratia alba*, *Acanthus ilicifolius*, *Crotalaria verrucosa*, *Crotalaria retusa* shown exact opposite result that of leaf extract treatment. Only *Salvadora persica* showed positive response to both treatment of *Chromolaena odorata*. Leaf leachate treatment showed positive impact to enhance carotenoid level in plants like *Derris trifoliata*, *Salvadora persica* and *Ipomoea pes-caprae*. Leaf leachate treatment showed positive impact on carotenoid contents in the studied coastal species.

   According to Koiwa *et al.* (1986) and Cunningham and Gantt (1998) carotenoids act as antioxidant (Free-radical scavengers). Therefore it can be concluded from our result that leaf extract and leaf leachate of *Chromolaena odorata* may play important role in enhancing antioxidative potential of plants. But it may quite depend on plant response or plant species. Elevation in carotenoid under these treatments indicates plant response to protect photooxidative damage of chlorophyll and photosystem.
2. Carbohydrates

Leaf extract treatment of *Chromolaena odorata* found responsible to improve in total sugar level in studied coastal plants. Decline in total sugar level of all studied plants under leaf leachate treatment of *Chromolaena odorata* indicates heavy impact of leaf extract on photosynthetic carbon metabolism. Both treatments were responsible for marked changes in level of various carbohydrate fractions. It was noticed that all studied coastal plants showed similar kinds of response as that of reducing sugar content to total sugar contents except *Crotalaria verrucosa*.

Leaf extract treatment of *Chromolaena odorata* there was enhancement found in amount of starch in all coastal plants however leachate treatment showed reverse condition i.e. decline in starch contents. It can be concluded that leaf extract treatment of *Chromolaena odorata* responsible or helpful for productivity of other plants. While leaf leachate treatment affects adversely to productivity of other plants therefore it will also helpful in preparation of weedicide.

3. Enzymatic Antioxidants
   
a. Enzyme Catalase

The activity of enzyme catalase was stimulated in all the coastal plant species due to the application of leaf extract and leaf leachate extracts of *Chromolaena odorata* and the stimulation was more pronounced in leaf leachate extracts. The enzyme activity exhibits almost three fold stimulation in Mangrove plant *Sonneratia alba* and *Acanthus ilicifolius* followed by a sand dune species *Ipomoea pes-caprae*. Thus the extracts of *C. odorata* may possess some allelochemicals which might have significantly increased the activity antioxidant enzyme catalase in all the coastal plant studied.
b. **Enzyme Peroxidase**

The activity of enzyme peroxidase was stimulated in all the coastal plant species studied except *Derris trifoliata*, due to the application of leaf extract and leaf leachate extracts of *Chromolaena odorata* and the stimulation was more pronounced in leaf leachate extracts. The enzyme activity exhibits almost two fold stimulation due to leaf leachate extract as compared to control.

The application of leaf extract and leaf leachate of *C. odorata* may contribute in the increase in H$_2$O$_2$ that may be further attributed to the resulting reactive oxygen species (ROS) by allelochemical stress. The increase in the activity of peroxidase enzyme can certainly prove the strong antioxidant defense mechanism of coastal species studied. The level of antioxidant enzyme peroxidase either increased or decreased by the application of leaf extracts and leaf leachate. The observed negative impact on the *Derris trifoliata* plant may be due to the presence of large amounts of phenolics in the plant. The increase in the activity of enzyme peroxidase as an antioxidative defense mechanism certainly proves the phytotoxic nature of *C. odorata* leaf extract and leaf leachate extract.

c. **Superoxide Dismutase**

Enzyme superoxide dismutase was stimulated in all the coastal plant species studied except *Derris trifoliata*, due to the application of leaf extract and leaf leachate extracts of *Chromolaena odorata* and the stimulation was more pronounced in leaf leachate extracts. The enzyme activity exhibits almost two fold stimulation in leaf leachate extract as compared to control.

d. **Polyphenol Oxidase**

The activity of enzyme Polyphenol oxidase was stimulated in all the coastal plant species studies, by the application of leaf extract and leaf leachate extracts of *Chromolaena odorata* and the stimulation was more pronounced in
leaf leachate extracts. The enzyme activity exhibits almost two fold stimulation in leaf leachate extract as compared to control.

Increasing in protective enzyme activities ensured that the plants treated can effectively protect the membrane from the active oxygen and led to the stability of the membrane, so that the seedlings were able to acclimate to the allelopathic stress by adjusting the activities of SOD, CAT and PPO as Suggested by Yan et al. (2013).

4. Antioxidant assay
   a. DPPH radical scavenging activity
   DPPH radical scavenging activity of different coastal Mangroves and their associates influences by allelochemicals of Chromolaena odorata through leaf extract and leaf leachate treatment. The allelochemicals released by Chromolaena odorata improve greatly the bleaching action of free radicals in studied plants, which ultimately cause higher development in the antioxidative capacity of these plants.

   b. Ferric Ion Reducing Antioxidant Power
   Allelopathic treatments of Chromolaena odorata were responsible to alter the FRAP activity. In case of leaf leachate treatment also FRAP activity found decreased in most of studied plants except Salvadora persica and Crotolaria retusa. The Chromolaena odorata has allelopathic potential that directly or indirectly affect on antioxidative potential of other plants and helps to Chromolaena odorata to compete with others.

   c. Metal chelating
   Metal chelating ability of studied coastal species was significantly inhibited. Highest inhibition in this activity observed under leaf leachate treatment of Chromolaena odorata than leaf extract treatment. Due to both treatments all studied plants had displayed a mild enhancement in chelating
activity. Hence allelochemicals of *Chromolaena odorata* may helpful to enhance therapeutic potential of influenced plant against various diseases.

d. **Reducing power**

Among all studied plant reducing power potential found elevated under both leaf extract and leaf leachate treatments of *Chromolaena odorata*. It can be concluded that leaf leachate treatment of *Chromolaena odorata* highly alters antioxidative potential of other plants than leaf extract treatment. But both treatments were found responsible to change significantly reducing power potential.

e. **Total Antioxidant Capacity**

It can be concluded that the leaf leachate and leaf extract treatments of *Chromolaena odorata* were responsible to decline in TAC level of all influenced plants. But leaf leachate treatment found highly effective to decline TAC levels. i.e. these treatments responsible to weaken antioxidative strength of other plants.

f. **Polyphenols**

There was a wide variation in the amount of total phenolics in the studied coastal species. The leaf leachate treatment was found more effective as compared with leaf extract treatment. Leaf leachate treatment elevates the total phenolic content. It can be concluded that leaf leachate and leaf extract of *Chromolaena odorata* causing stressful condition on these coastal plants. The allelopathic effect of *C. odorata* leads to oxidative stress in these coastal plants and this stressed environment might force the cell to produce these secondary products as an adaptive mechanism.
g. Ascorbic acid

Leaf extract and leaf leachate treatments of *Chromolaena odorata* on mangrove and their associates showed inconsistent results. The reduction in ascorbic acid content in mangrove associate species may be due to consumption of ascorbic acid in ascorbate glutathione oxidative pathway and in true mangrove species enhanced level of ascorbic acid posses an adaptive feature in response to allelopathic effect of *Chromolaena odorata*.

5. Osmolytes

a. Proline

Proline content was accumulated in all the studied plant and the accumulation was more pronounced in *Derris trifoliate* and *Crotalaria verucosa* due to the treatment of leaf extract and leaf leachate of *Chromolaena odorata*. As proline involved in the stabilization of protein it has a role as a protector of enzymes concerned in plant metabolism. Hence, the increased content of proline indicates the protective role of it under oxidative stress.

b. Glycine betaine

The alteration in glycine betaine contents in all studied plants was observed due to allelopathic treatment of *Chromolaena odorata*. Leaf extract treatment found responsible to decline glycine betaine level in all studied plants. Leaf leachate treatment causes an elevation in glycine betaine level as compare to their control one. The accumulation of glycine betaine under leaf leachate treatments indicates due to this treatment other plants undergoes some kind of metabolic stress and the plant under study (treatments) tried to overcome that stress by increasing glycine betaine content to protect enzymes and cell membrane.
c. Glutathione reduced

Highest content of reduced glutathione was observed in *Ipomoea pes-caprae* (0.76 ug/g) and lowest content in *Salvadora persica* under controlled condition. Both the leaf extract and leaf leachate treatment increases the reduced glutathione (GSH) content in all studied plants. Leaf leachate of *Chromolaena odorata* was comparatively increased GSH than that of leaf extract. It can be concluded that the allelochemicals present in the *Chromolaena odorata* generates oxidative stress in especially in coastal species. The oxidative stress leads to formation of free radicals and toxic substances.

d. Free Amino Acids

*Chromolaena odorata* leaf extract and leaf leachates were stimulating the total amino acid content of the studied plants. The stimulation was more pronounced in *Derris* and *Crotolaria* followed by true mangroves *S. alba* and *A. ilicifolius*. In the present study also the total amino acids were accumulated. The accumulation of amino acids in *Derris* and *Crotalaria* their respiratory pathways have been hampered due to allelochemical stress. There is rapid formation of protein and accumulation of amino acids and amides will occur and the process of amino acid utilization might be inhibited due to presence of phenolic compounds or degradation of protein into amino acids by enhanced protease activity as suggested by Tang *et al.* (1995).

6. GC MS Analysis

The phytotoxicity of *Chromolaena odorata* in this study might be due to the interactions of various groups of fatty acids and phenols. Hence, the presence of some of phenolic compounds in leaf of *Chromolaena odorata* will certainly prove its allelochemical nature having negative effect on growth and metabolism of surrounding habitat.
7. **Nitrogen fractions**

a. **Total nitrogen**

Leaf leachate and leaf extract treatment of *Chromolaena odorata* both adversely affect nitrogen contents of all studied coastal plants. In leaf extract treatment highest loss in nitrogen content was observed in *Salvadora persica*. Leaf leachate treatment cause highest decline in nitrogen content in *Derris trifoliata* (48.61% loss) and lowest loss under same treatment observed in *Acanthus ilicifolius*.

The allelochemicals of *Chromolaena odorata* hampers the net productivity of other plants and the nitrogen metabolism seems to be rather sensitive to allelochemicals of *Chromolaena odorata* in all studied plant species.

b. **Nitrate Reductase**

The activity of enzyme Nitrate reductase was inhibited in all the coastal plant species due to the application of leaf extract and leaf leachate extracts of *Chromolaena odorata* and the stimulation was more pronounced in leaf leachate extracts. The *C. odorata* leachate extract may interferes the aborption and transport of nitrate, which leads into decrease in NR activity in all studied plants.

c. **Nitrate**

Nitrate content was decreased under both leaves extract and leaf leachate treatment of *Chromolaena odorata* as compared to control. Decrease in nitrate-nitrogen was found more prominent in *Derris trifoliata*. Leaf leachate treatment of same *Chromolaena odorata* was found more toxic than other treatments.
8. **Inorganic constituents**

Phosphorous contents get decreased under both these treatment of *Chromolaena odorata* as compared to control. It can be concluded the allelochemical treatment of *Chromolaena odorata* adversely affect phosphorus uptake potential of other plants.

Potassium content was decreased in all studied coastal plants under both leaf extract and leaf leachate treatment. According to Mengel and Krikby (1982), potassium deficiency in plants responsible to fall down in nitrate reductase activity, disturbance of protein metabolism and accumulation of amino acids and soluble organic nitrogenous compounds. Our results are in accordance of Mengel and Krikby (1982) where nitrate reductase enzyme activities were reduced with decline in potassium contents.

Sodium content in all studied plants was reduced under both these allelochemical treatments of *Chromolaena odorata*. It can be concluded that allelochemicals of *Chromolaena odorata* influences sodium contents and show adverse impact on growth and development of studied plants.

*Chromolaena odorata* affects calcium uptake potential adversely which may leads to decline in activation of various enzymes. This directly or indirectly affects metabolic processes in those plants. The decline in calcium under studied treatment showed decline in productivity of those plants via decline in catalyzing rate of nitrate reductase, nitrogenase and other essential enzymes.

Due to allelopathic treatment of leaf extract of *Chromolaena odorata* there was decreased magnesium level observed in all studied plants. Leaf leachate treatment caused higher loss in magnesium level than that of leaf extract treatment among all studied plants.

The treatment of *Chromolaena odorata* declines sulphur contents, due to this inhibition of protein synthesis and ultimately results in reduction of biomass production in influenced plant.
Chromolaena odorata adversely affected micronutrient uptake potential of other plant and created scarcity of nutrient among them to minimize competition. Copper, manganese, iron and zinc contents were found decreased under both leaf extract and leaf leachate treatment among all studied plants. The allelochemicals from Chromolaena odorata may positively or negatively alters stress tolerance capacity of other plant by changing zinc content in them.

Hence it is need to eradicate the Chromolaena odorata an invasive weed from coastal line vegetation. This will help to regenerate the mangrove vegetation across the coastal line and also help to protect them in their natural habitat (in situ conservation).