Biological Control of Indian White Termites with Oriental Foliage

Nidhi Srivastava1* Anju Meshram2

1Department of Bioscience and Biotechnology, Banasthali University, Banasthali, 2Rajasthan1Department of Biotechnology, Kalinga University, Naya Raipur, Chhattisgarh

***Corresponding author: Dr. Nidhi Srivastava, Associate Professor, Department of Bioscience and Biotechnology, Banasthali University, Banasthali-304022, Rajasthan, India**

Introduction

Termites, present in a broad range of terrestrial environment, are the most damaging pests and cause considerable problems in housing, agriculture and forestry. They are eusocial insects belonging to order Isoptera with extremely well structured colonies and division of labour among different castes. Termites are worldwide nuisance; particularly in tropical areas with relatively high humidity. They feed on cellulose-based material i.e. books, wood, furniture boxes, etc. In the sub-humid and semi-arid tropical regions, furniture, buildings, annual and perennial crops are substantially damaged by termites and they continue to be the most harmful pest because of their capability to damage wooden structures. Termites are numerous in number and usually form the diverse component of ecological system predominantly in the forest regions of the humid environment. Termites fit into the order Isoptera, identified by their distinguishing social behavior. A termite colony usually consists of reproductives (a king and a queen) as well as the soldiers and workers. These colonies are subterranean and present within wood above-ground. They are generally present in decomposing wood, timber, plant refuse, or in soil rich in organic or humus substance. The significant damage caused by these invasive termites in terms of both economy and ecology is expected to increase with change in climate, advancement in urbanization and financial globalization. These intruder termites classically spread with swarming timbers and characteristically attack the man-made environments and then spread to more indigenous environment or habitat. Apart from the damage caused by termites, increase in the use of prospective pesticides in urban areas and natural landscapes could lead to negative ecological impacts on food webs and invertebrate species composition.

(a) (b) (c)

Figure 1: Termites (a) Termite mounds at Banasthali University (b) termites on soil (c) wood infected with termites

Termites are well recognized for their economic consequences and the harm they cause to agricultural plants. They comprise huge substantial value to man in the bioconversion as well as degradation of lignocellulose waste materials. Fungus-growing termites are the most difficult termites in the agriculture belonging to Termitidae. They are the main threat of sub-humid and semi-arid regions, resulting in financial losses to the field crops, forests trees, buildings and rangelands.

Previously, termite management was completely dependent on chemical pesticides particularly the constant organochlorine. Their drawbacks include the highest left over effect and the expansion of insecticides resistance in target pests. In the same way, undesirable health effects on human and major concerns for environmental damage resulted in the substitution of chemical or synthetic insecticides with biological products, which is universally practical and acceptable approach. Thus, management of insect pest by wide use of chemical or synthetic pesticides as a basis for environmental pollution, is a global ecological challenge.

In current years, use of locally available plants has attained great significance mostly among the scientific community for their high bioefficacy against termites. Numerous plants possess repellent and antitermite activities such as Cassia leaf, Country borage, lemon grass, Eucalyptus, vetiver oil, clove bud, cedar wood and isoborneol.

The overuse and misuse of chemical pesticides has caused detrimental effects on environment with destruction of valuable organisms. The use of botanicals as microbial agents and biopesticides is thus a new credible approach for the control and management of various insect pests. These biopesticides being eco-friendly, target specific, biodegradable and economically feasible has emerged as better substitutes to synthetics pesticides.

Insecticide

Natural insecticides or botanicals should be derived from locally available plants with little or no processing. These plants should not act as hosts for the crop pests or develop into weeds. Active metabolites derived from plants can act as toxicants, insect growth regulators, synergists as well as repellents. Majority of insect pests are regulated with several plant derived oils. Plants contain several bioactive compounds like terpenoids, alkaloids, glycosides, phenols, tannins, flavonoids, etc. in their leaves, stem, bark, seed and oil. These natural bioactive compounds are reported to have potent anti-termite property.

In numerous ways, phytochemicals toxicity to insects have been studied including growth retardation, suppression of calling behaviour, toxicity, fecundity and fertility reduction, inhibition of feeding property, and deterrence of oviposition. However, only the use of nicotine is widely described as insecticide in comparison to other alkaloids.

The utilization of plants or products of plant's origin for pest management is very familiar and numerous herbal products are employed to manage a broad range of insects e.g., Nicotine from Nicotiana tobacum, Azadirachtin from neem oil and rotenoids from leguminous plants roots, Lonchocarpus species. These plant products serve as feeding deterrents and insect growth regulators

Biological control

The burning issue of present scenario is the biological control of destructive pest termites via green management techniques focusing on minimum undesirable effect on environment. Various constituents and secondary metabolites from plants own toxic or repellent effect on termites. Pretreatment of wooden house building materials yielded good result in India. However the application in soil treatment against subterranean termite attacks needs further research. Plant extracts as new wood preservatives have healthier prospects against termite infestation, non-toxic, safe for environment and biodegradable, but they are less effective than chemicals.

Various termite control techniques used in India are under native conventional knowledge. Termites are used as indicator of different environmental aspects, viz. predictable rainfall, soil productiveness, etc. Since ages in Indian subcontinent, termite control by exploitation of locally available plants is a frequent practice. Since this practice has been emerged in old age time with no advancement in technology, it do not offer harmful effect on environment and absolutely safe for humans. Thus a scientific traditional knowledge of pest management and their implication is the requirement of present condition.

Phytochemicals

Phytochemicals (organic chemicals) on the basis of their function in plant metabolism are categorized as primary or secondary constituents, extracted from plants. Phytochemicals are plant protectants and studies have demonstrated their broad range of natural activities against insects. Phytochemicals serve as growth inhibitors, repellents, antifeedants, chemosterilants, attractants, or insecticides. Antioxidants serve a central role in defending biological systems against numerous diseases.

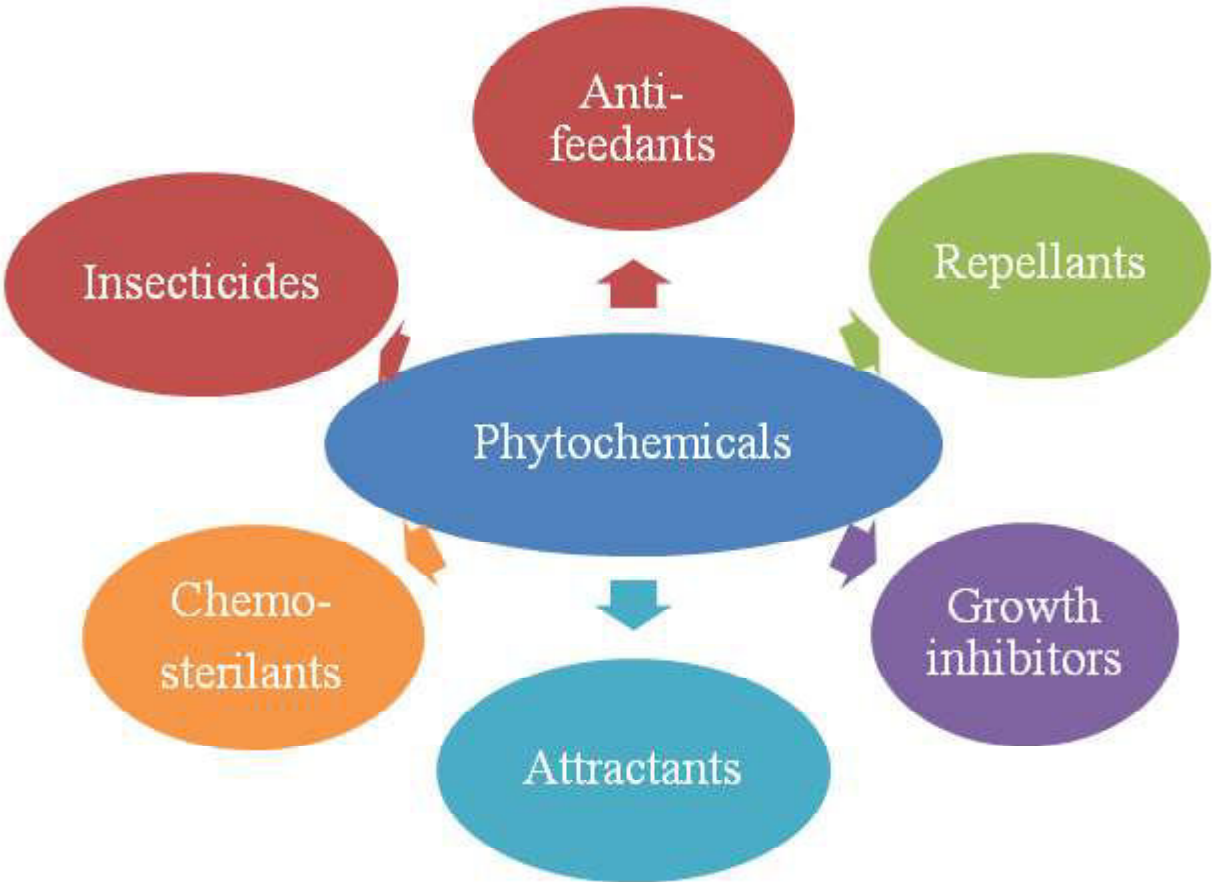

Figure 2: Biological properties of phytochemicals against insects

Secondary Metabolites

Secondary metabolites produced by plants are complex structures with a potential activity against insects. As an alternative for chemical/ synthetic pesticides, numerous plants have been identified so far with insecticidal property that can be utilized for pest management. Aim and management techniques dealing with termites protect constructions and prevent massive economic loss. Accurate recognition of the target termite species, appropriate mapping of their attack with proper treatment will lead environmentally safe, successful, cost effective management of termites. Educational and promotional activities for spread of knowledge will add to the prevention of buildings from termite's attack.

Alkaloids

Alkaloids are groups of basic compounds characterized by the presence of a heterocyclic nitrogen atom. They are naturally present in many plant species and are often toxic to animals and humans. Alkaloids include diverse molecules like strychnine, atropine, cotinine, nicotine, solanidine and pyrrolizidine alkaloids. Weak inhibitory activity against the MCF-7 cell line is exhibited by the piperidine alkaloid isolated from methanol extracts of Arisaema decipiens Schott (Araceae) rhizomes. The alkaloid obtained from Alstonia boonei showed potential insecticidal property against maize stem borer Sesamia calamistis. Alkaloids isolated from Stichoneuron caudatum possess significant insect toxicity, antifeedant and repellant activities. Root extracts of S. caudatum showed significant acetylcholinesterase (AChE) inhibitory activity associated with the insecticidal activity. The alkaloids of Cynanchum mongolicum is reported as potential insect growth inhibitors for Spodoptera litura larvae which effect many crops and causes substantial economic lossess.

Araceae

Araceae family comprises of monocotyledonous plants having flowers on spadix inflorescence. Usually the spadix is accompanied by a leaf like bract called spathe. Araceae is also called the arum family and its members as aroids. The family comprises of 114 genera and 3750 species generally present in tropical and temperate areas of the world. In India, about 25 genera and more than 140 species have been reported, mostly from the southern and

western parts of the country. Colocasia antiquorum and Pothos aureus are two well-known plants of this family.

Aroids are important medicinal plants as well, for instance, Agalonema treubii is a valuable source for glycosidase inhibitors that are antimetastatic, antidiabetic, immunomodulatory and antiviral in nature. Rhaphidophora decursiva is known to exhibit antimalarial activity. The rhizome powder of Homalomena aromatica is used for the treatment of skin disease in India and as an anti-inflammatory agent.

Epipremnum aureum

Epipremnum aureum (Linden and Andre) G.S Bunting commonly known as Rhaphidophora aurea, belonging to Araceae family is an evergreen herbaceous plant indigenous to Solomon Islands and Southeast Asia, and inhabits sheltered and shaded forests like a root climbing foliage. E. aureum is fashioned as an essential decorative flora utilized broadly as hanging baskets, totems or in dish gardens for interiorscaping owing to its ability to grow at low light intensity.

E. aureum (Pothos aurea) is capable of removing indoor pollutants like xylene, benzene and formaldehyde. The phytochemical constituents in the E. aureum aerial roots intertwined over two different trees may vary. This may be accredited to the varying biological composition of the host tree. Aerial roots of P. aurea can be regarded as a promising source for antimicrobial drugs.

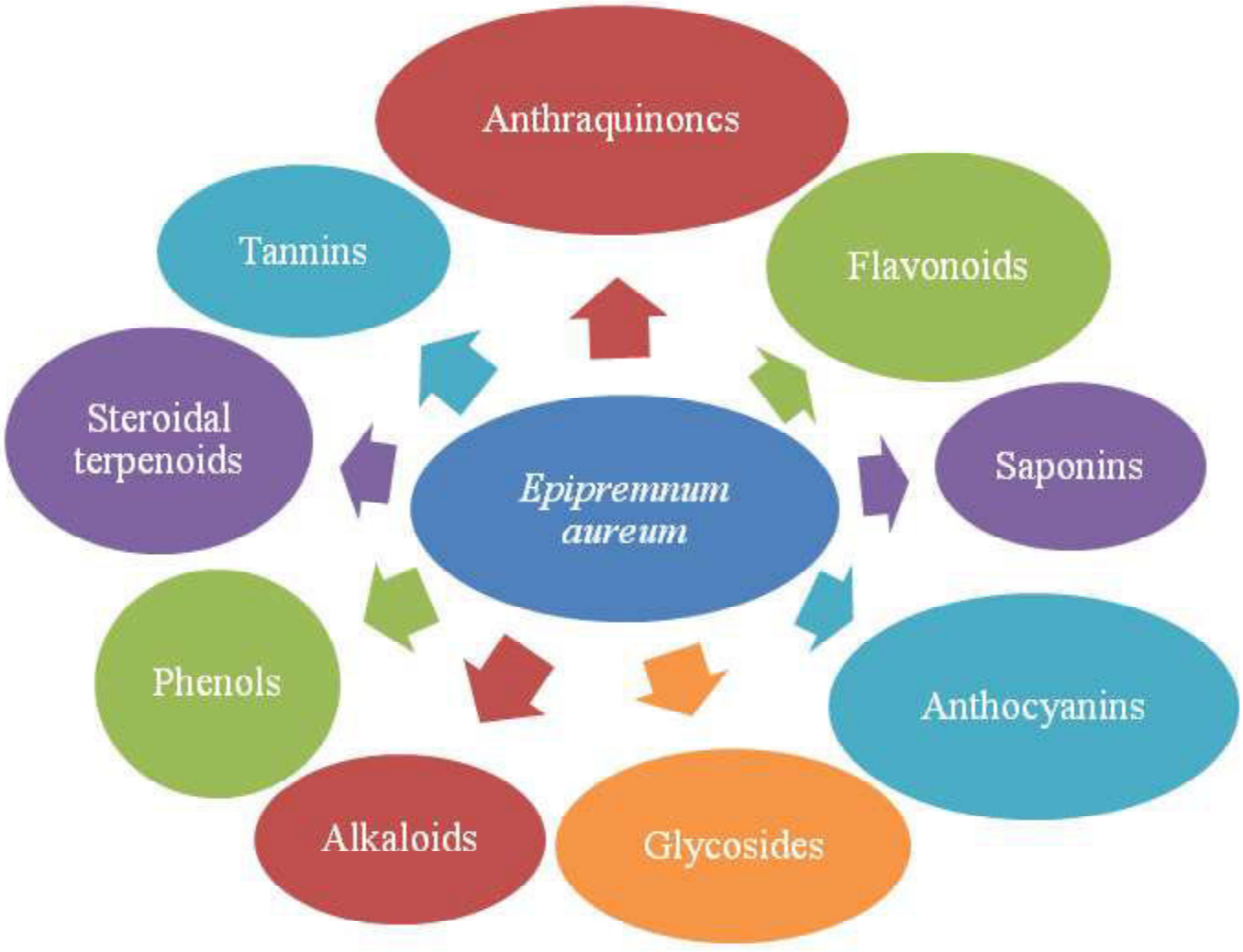

Figure 3: Phytochemicals present in Epipremnum aureum

The antitermite, antibacterial and antioxidant activities of E. aureum ethanolic extract have been reported. The antibacterial efficacy of E. aureum aqueous extract against Escherichia coli and Streptococcus aureus is also proved.

Aerial roots of Pothos aurea can be regarded as a promising source for antimicrobial drugs. Aqueous extract of E. aureum can be used for the discovery of biologically active natural products for the development of new pharmaceuticals as it possesses high antimicrobial activity comparable to standard drugs.

Rhaphidophora aurea is reported to have potent wound healing, antimicrobial, antioxidant activity and contains phytoconstituents like flavonoids, alkaloids, steroids, tannins, terpinoids, saponins, anthocyanin, phenols, anthraquinin and glycosides.

The plant E. aureum is reported as rich source of alkaloids and many alkaloids were reported from the leaves of the plant using GC-MS. In vitro antitermite activity of alkaloids isolated from leaf, root and stem of E. aureum against Odontotermes obesus have also been reported.

Epipremnum pinnatum

Epipremnum pinnatum (Linn.) Engl. (syn. Rhaphidophora pinnatifida Linn.) is another closely related Araceae member. It has potent anti-inflammatory and analgesic property.

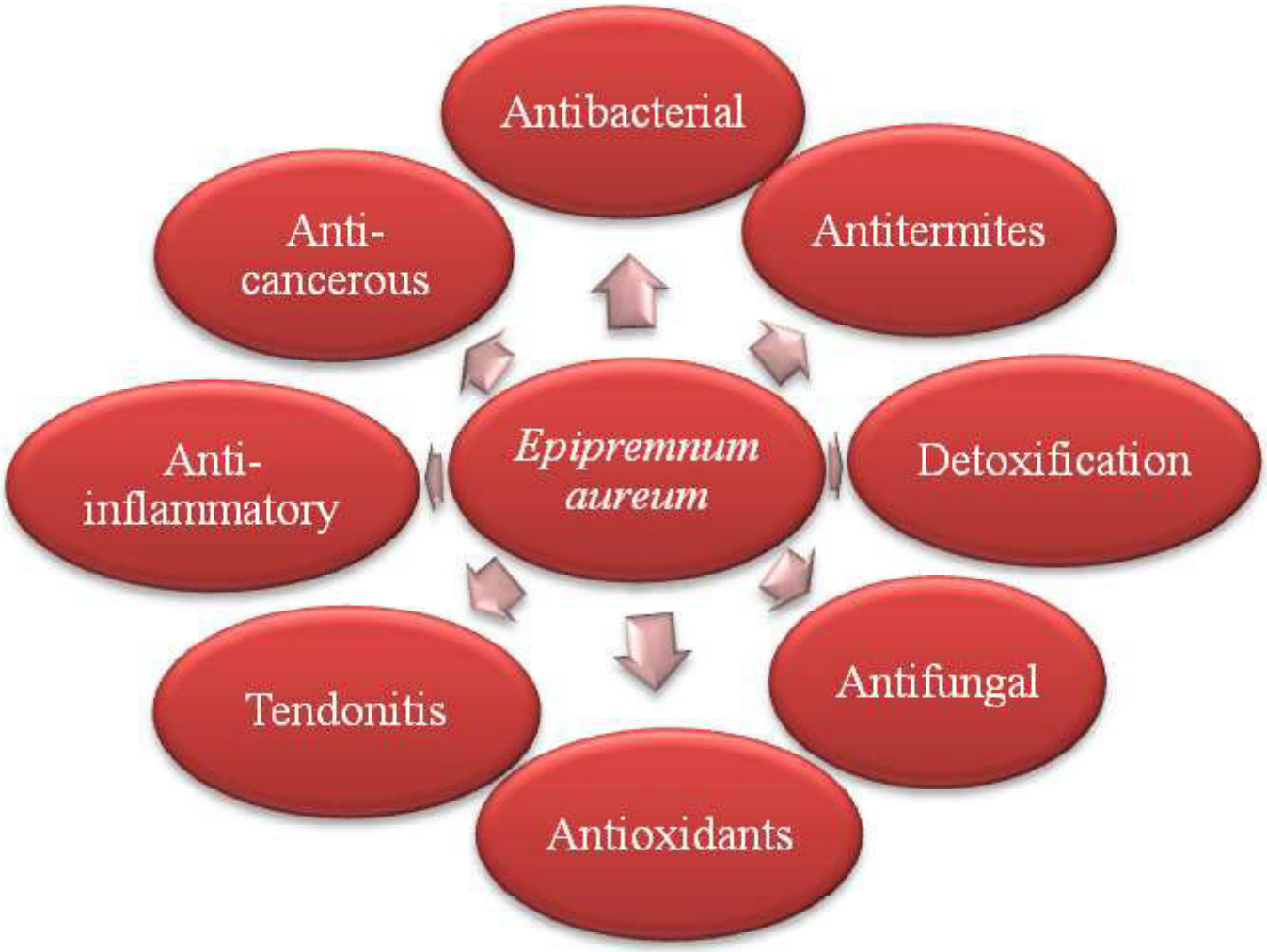

Figure 4: Ethnomedicinal and pharmacological properties of Epipremnum aureum

Epipremnum pinnatum (L.) Engl. is a large root-climber (Araceae) commonly known as Dragon Tail plant or centipede togavine, broadly identified in Singapore and Malaysia. It is traditionally known for the treatment of skin disease and in anticancer preparation. E. pinnatum pose potent anti-inflammatory and analgesic property. It has been exploited as traditional remedies due to its therapeutic properties and ability in enhancing the immune system. It has potent analgesic and anti-inflammatory activity. Its beneficial effects may be from their role in satabilization of lysosomes and free radical scavenging activity.

Epipremnum aureum (Linden and Andre) G.S. Bunting and Epipremnum pinnatum (L.) Engl. belonging to the family Araceae were studied for the isolation and characterization of alkaloids for their antitermite activity against subterranean termites O. obesus. The present research study could be summarized and concluded as follows:

Currents Findings

Presence of phytochemical compounds in the methanol extract of aerial root and leaf explants of E. aureum and E. pinnatum opens new door for the use of these plant in various biological activities including, pharmacological and environmental field. The usage of this ornamental plant should be promoted as an alternative for synthetic chemicals as it is very common well known plant , can grow and maintained easily and also affordable. In earlier studies, many evidences confirmed the identified phytochemicals of this particular species to be bioactive. The high antioxidant potential, free radical scavenging activity and antioxidative enzymes of E. aureum and E. pinnatum should be utilized for the development of new drugs for antioxidant therapy.

Isolation of alkaloids from E. aureum and E. pinnatum leaf explants were done with acid-base procedure and alkaloids were separated by incorporating miscible and immiscible solvent system. Purification of alkaloids was done through silica gel column chromatography with non-polar to polar solvents. The alkaloids were separated on the basis of polarity. Purified alkaloid fractions of E. aureum and E. pinnatum were tested for their in vitro antitermite activity by No-choice and Direct-choice assay on paper and soil. Further identification of alkaloids structure was done using GC-MS on the basis of mass fragmentation pattern. It was observed that the antirepellant activity of alkaloids of E. aureum and E. pinnatum alkaloids was more than the termiticidal activity.

Morphological analysis of images of dead termites through SEM revealed distortion and deformation of whole body cuticle alkaloids treated E. aureum and E. pinnatum in comparison to control termites having normal cuticle distribution on the body surface. The number of mechanical/ chemical sensory system i.e. hairs present on the anterior portion of the termites have been decreased in E. aureum and E. pinnatum alkaloids treated O. obesus in comparison with control worker termites.

After purification of alkaloids with solvent extraction, Epipremnum species promised for a good termiticidal activity. However, to confirm the exact nature of the toxicant, further molecular studies are needed. Nevertheless, the present study clearly indicates that the alkaloids reported from E. aureum and E. pinnatum act as potential agents for controlling the soft bodied termites.

The presence of various bio-active compounds detected after GC-MS analysis using the alkaloid fractions of E. aureum and E. pinnatum justifies the use of whole plant for various elements by traditional practitioner. However, isolation of individual phytochemical constituents and subjecting it to the biological activity will be definitely giving fruitful results and will open a new area of investigation of individual components and their insecticidal activity. Therefore, it is recommended as a plant of environmental importance.

Conclusion

Chemical insecticides have resulted in environmental deterioration and harmful effects on human and consequently resulted in the utilization of biological components. Termite's management based on excess application of pesticides has resulted in severe economic losses and environmental problems like soil and water contamination due to their low biodegradability and high toxicity. Globally, termiticides include a number of active ingredients like chlorfenapyr, cypermethrin, bifenthrin, fipronil, imidacloprid and permethrin. However, social organization and enigmatic lifestyle of termites makes their control difficult. Thus, it is absolutely important to look forward for new methods of termite control to facilitate safe environment and human beings.