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MANGROVES AS HOLISTIC SOURCE OF DHANWANTARI SALUTES THE NATURE

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ABSTRACT:

India has a rich heritage of knowledge on plant-based drugs both for use in preventive and curative medicine. A country like India is very much suited for development of drugs from medicinal plants. A large number of these plants grow wild and exploited especially for use in indigenous pharmaceutical houses. This presentation will review the utilization of mangroves in Southeast Asia (especially Thailand and the Philippines), the importance of the mangrove forests to maintaining the biodiversity of intertidal zones of sheltered coastlines such as is found in Phang Nga Bay, Thailand, the species diversity of the mangrove forests, and the chemical constituents (salts, organic acids, carbohydrates, hydrocarbons, benzoquinone, naphthofurans, sesquiterpenes, triterpenes, alkaloids, flavonoids, polymers, sulfur derivatives, and tannins) that have been isolated from mangrove plants and their potential application to medicine and agriculture. Past and ongoing collaborative work on constituents of Thai and Philippine Mangrove plants including Acanthus illicifolius, Aegiceras corniculatum, Derris trifoliata, Excoecaria agallocha and Heritiera littoralis will be highlighted. Some of these plants produce valuable drugs which have high export potential. The use of plants and plant products as medicines could be traced as far back as the beginning of human civilization. Mangrove plants have been used in folklore medicines and extracts from mangrove species have proven inhibitory activity against human, animal and plant pathogens. The present review deals with the pharmacological activity of mangrove medicinal plants. Several species of mangrove produce bioactive compounds that may control microbial growth. Medicinal-plant extracts, known to produce certain bioactive molecules which react with other organisms in the environment, are known to be less toxic to humans and are environmentally friendly due to the less pollutant released during production Also, preliminary studies have demonstrated that the mangrove plant extracts have antibacterial activity against pathogenic bacterial strains. Mangrove extracts can also be the possible sources of mosquito larvicides, antifungal, antiviral, anti-cancer and anti-diabetic compounds.

KEYWORDS:

MANGROVES, MEDICINAL PLANTS, PATHOGENIC MICROORGANISMS, DRUG RESISTANCE.

INTRODUCTION:

The name “mangrove” originated from a combination of the Portuguese word “Mangue” that means tree and an English word “grove” that means orchard or garden. Mangrove plants include approximately 12 families and more than 50 species. Other synonymous terms suggested include “Mangrove community,” “Mangrove swamp,” “Mangrove ecosystem,” and “coastal woodland.” Mangrove generally refers to a group of salt-tolerant and evergreen woody plants that have morphological adaptations. Mangroves are a type of tropical forest, uniquely positioned at the dynamic interface of land and sea. They are found along coasts and estuaries throughout the tropics and subtropics and are capable of thriving in salt water; prospering in conditions to which only a few species have adapted. Mangroves form the foundation of a highly productive and biologically rich ecosystem which provides a home and feeding ground for a wide range of species, many of which are endangered. Although mangroves make up less than one percent of all tropical forests worldwide, they are highly valuable ecosystems, providing an array of essential goods and services which contribute significantly to the livelihoods, well-being and security of coastal community. Mangrove plant extracts have been used for centuries to treat several health disorders. Plant-derived substances have recently become of great interest owing to their versatile applications.[1] As antibiotics are increasingly used and misused, the bacterial strains become resistant to antibiotics rapidly. Therefore, there is a need to search for new infection-fighting strategies to control microbial infections. The rise of antibiotic resistant microorganisms is one of the severe problems in healthcare systems of the world, and infectious diseases are the second most serious cause of death worldwide. Plants are rich in a wide variety of phytochemicals like tannins, terpenoids, alkaloids, flavonoids, and antimicrobial peptides that have been found to have antimicrobial activities (Panda et al. 2009). In addition, medicinal plants have been used for centuries as remedies for human diseases because they contain components of holistic medicines.

FIGURE-1: SOME MANGROVE FORESTS

Location of Mangroves: Mangroves can be found in over 118 countries and territories in the tropical and subtropical regions of the world. The largest percentage of mangroves is found between the 5° N and 5° S latitudes. Approximately 75% of world's mangroves are found in just 15 countries. Asia has the largest amount (42%) of the world's mangroves, followed by Africa (21%), North/Central America (15%), Oceania (12%) and South America (11%). The latest remotely-sensed global synthesis, estimates global mangrove forest area post-2000 as 141,333 km² ±6%.

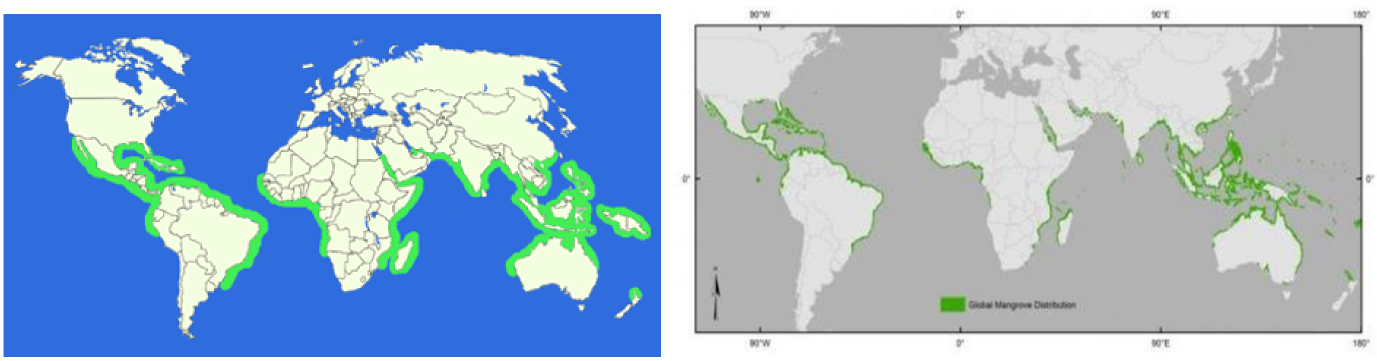


FIGURE-2: GLOBAL LOCATION OF MANGROVES

Classification of Mangroves:

1. True mangroves are mainly restricted to intertidal areas between the high-water levels of neap and spring tides. Plant species from true mangroves belong to at least 20 different families. About 80 species of true mangrove trees/shrubs are recognized, of which 50–60 species make a significant contribution to the structure of mangrove forests.

2. Minor species of mangroves are distinguished by their inability to form conspicuous elements of the vegetation and they rarely form pure communities.

3. The Mangal associates are salinity-tolerant plant species, which are not found exclusively in the proximity of mangroves and may occur only in transitional vegetation. However, they do interact with true mangroves.

Traditional Knowledge: Mangrove Plants also known as Fisher-Folk Medicine. Of the 65 species of mangrove plants, 12 species are found to be widely used by local medical practitioners in many countries like Africa, South East Asia, South America and Australia. These 12 species viz. *Acanthus clicifolius*, *Aegiceras majus*, *Avicennia africana*, *A. marina*, *A. officinalis*, *Ceriops caudolleana*, *Exocoecaria agallocha*, *Kandelia rhecdi*, *Nypa fruticans*, *Rhizophora mangle*, *R. mcronata* and *Sonneatia caseolaris* are used to cure some deeded diseases like leprosy, elephantiasis, tuberculosis, malaria, dysentery, ulcers and some skin diseases. Balsco and Banerjee and Gosh reported that 27 and 65 species of mangrove are present in India respectively. Mangrove forests are distributed in various deltaic regions of the east coast. However, 78% and 12% of the Indian mangrove are found in the east coast and (including Andaman and Nicobar) and west coast respectively. Out of total 65 species, only 18 species are being traditionally used by the people living in the vicinity of mangrove forests.

FIGURE-3: MANGROVES TREES

Mangrove Tree: Mangrove trees grow where no tree has grown before because they are able to survive saltwater conditions and soil which is unstable and poor in oxygen (anaerobic). Mangroves are a group of trees and shrubs that are capable of growing in marine, estuarine, and, to a limited degree, fresh-water. They occupy the fringe of intertidal shallows between the land and the sea. Mangrove trees are not able to grow in freshwater as fast as other freshwater plants and may also be unable to cope with the bacteria and fungi found in freshwater. Most mangrove trees lack a heartwood and instead have narrow vessels that are densely and evenly distributed throughout the wood. Thus, they are able to withstand damage to the bark and outer trunk. About 70 species of trees and shrubs are considered principal or true mangrove forms. These belong to 19 families, but of these only 2 are exclusively mangroves. The highest diversity of mangroves is found in the region from Malaysia to New Guinea. Eighty percent of these are found in the Indo-Pacific (India to Australia), 9 % in East Africa, 6 % in West Africa, 5 % in the Caribbean, and 5 % in South America.[2]

Features of Mangrove Trees:

Flora: Plants of mangroves are generally divided into two groups, namely, (i) true or exclusive mangroves species and (ii) associated mangrove species. True mangrove species grow only in mangrove environment and do not extend into terrestrial plant community and are morphologically, physiologically and reproductively adapted to saline, waterlogged and anaerobic condition. Some of the plants that grow in the terrestrial environment and pure halophytes (plants that grow only in saline environment) are also found within or in the peripheral area of mangrove wetlands. These species are considered as mangrove associates.

Adaptation: Mangrove environment is highly dynamic and harsh and mangrove species are variously adapted to cope with these environmental conditions.

Breathing roots: Underground tissue of any plant requires oxygen for respiration and in mangrove environment, oxygen in soil is very limited or nil. This necessitates mangrove root system to take up oxygen from the atmosphere. For this purpose, mangrove species have specialized above ground roots called breathing roots or pneumatophores. In some species, these roots are pencil sized and peg like whereas in some other species they look like a knee. These roots have numerous pores through which oxygen enters into the underground tissues. In some plants buttress roots function as breathing roots and also provide mechanical support to the tree.

FIGURE-4: BREATHING ROOTS OF MANGROVES

Silt roots: In some mangrove species, roots diverge from stems and branches and penetrate the soil some distance away from the main stem as in the case of banyan trees. Because of their appearance and because they provide the main physical support to these they are called as stilt roots. These roots also have many pores through which atmospheric oxygen enters into the roots.

Vivipary: Saline water, unconsolidated saline soil with little or no oxygen is not a conducive environment for seeds to germinate and establish. To overcome this, mangrove species have unique way of reproduction, which is generally known as vivipary. In this method of reproduction, seeds germinate and develop into seedlings while the seeds are still attached to the parent tree. These seedlings are normally called as propagules and they photosynthesize while still attached to the mother tree. The parent tree supplies water and necessary nutrients. They are buoyant and float in the water for some time before rooting themselves on suitable soil.

FIGURE-5: SOME EXTINCT SPECIES OF MANGROVES

UTILIZATION OF SOME MANGROVES SPECIES:

SPECIES	USE
Acanthus illicifolius and *A. ebracteatus*	leaf juice used as hair preserver, fruit pulp as blood purifier, dressing for boils and snake bite, leaf preparation used for rheumatism.
Aegiceras corniculatum and *A. floridium*	bark and seed used as fish poison.
Avicennia alba	bark and seed used as fish poison, resin used in birth control, seed ointment relieves smallpox ulceration.
Ceriops tagal	source of firewood and tannins, yields high quality dyes, bark stops hemorrhaging (source of anticoagulant)
Excoecaria agallocha	fish and arrowhead poison in Thailand it is known to cause blindness and skin eruptions in the Philippines it is used as medication for toothache, in Malaysia bark extract is taken as a purgative.
Rhizophora species	timber, fishing stakes, piles, firewood, charcoal, and tannins; *R. mucronata* bark used to treat diarrhea, dysentery, and leprosy; fruit sap used as a mosquito repellent; wine is made from fruit and honey from the nectar.
Sonneratia caseolaris	fruit is eatable, sap is used as a skin cosmetic, leaves are used for goat food.
Sonneratia ovata	fruit is eatable and used to treat sprains, fermented juice used as anticoagulant.
Xylocarpus species	firewood, timber, and tannin; bark extract is used to treat cholera

TABLE-1: UTILIZATION OF MANGROVE

Primary Chemical Constitution of Mangroves: Although the chemistry of mangrove plants has still not been studied as extensively as most other plant species, investigation of the chemical constituents has led to the discovery of several novel compounds many of which are useful for medicinal or agricultural purposes. The following indicates the classes of compounds and some of the constituents reported from the plants of the mangrove forest and their reported medicinal or agricultural value, if any.

1. Salt: cations: (Na^+, NH_4^+, K^+, $Ce^{+2,}$ Mg^{+2}), anions: (F^-, Cl^-, Br^- , NO_2^-, NO_3^-, PO_4^{-3}, SO_4^{-2})

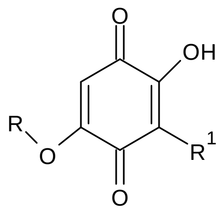
2. Organic Acids: (oxalic, malonic, citric, fumaric, tartaric, and maleic).[3]

3. Carbohydrates: Rhizophora (D-galactose, L-rhamnose, L-arabinose, D-galacturonic, and 4-0-Methyl-Dglururonic acid) *Heritiera littoralis* (fructose, glucose, sucrose trisaccharide, myo-inositol and pinitol).[4,5]

4. Alkanes

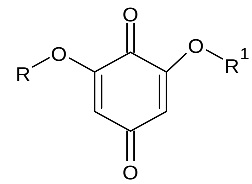
5. Benzoquinones[7-9]

Aegiceras corniculatum



1. R = H, $R^1 = C_{11}H_{23}$, Embelin
2. R = H, R = $C_{13}H_{27}$, Rapanone
3. R = CH_3, $R^1 = C_{11}H_{23}$, 5-O-Methylembelin

Kandelia candel



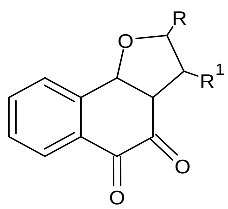
R = H, 2,6-Dihydroxy-p-benzoquinone

R = CH_3, 2,6-Dimethoxy-p-benoquinone

Biological activity of O-methylembelin: toxic to fish, 1 ppm, toxic to the fungi *Pythium ultimo*

6. Napthofurans[10]

Avicennia marina

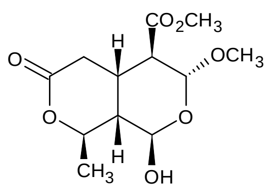


1. R = H, R^1 = H; 2. R = H, R^1 = OH; 3. R = $(H_3C)_2C(OH)$, R^1 = H

Biological activity: phytoalexins

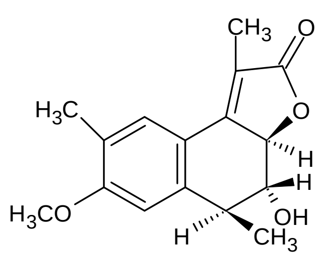
7. Secoiridoids[11]

Xylocarpus moluccensis

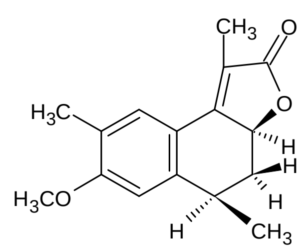


Biological activity: African Army worm (*Spodaptera exemta*) antifeedant

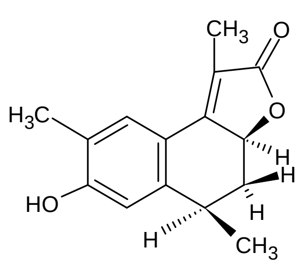
8. Sesquiterpenes[12]



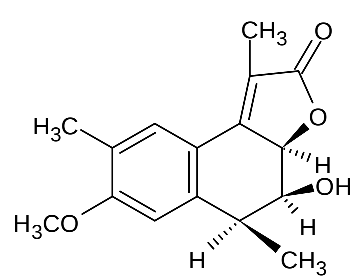
Heritianin



Heritonin



Heritol

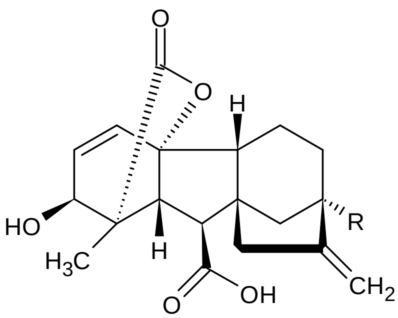


Vallapin

Biological activity: Toxic to Fish

9. Diterpenes[13-16]

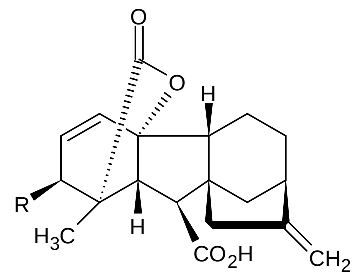
Bruguiera gymnorhiza



Gibberellin A3 (R = OH)

Gibberellin A7 (R = H)

Rhizophora mucronata

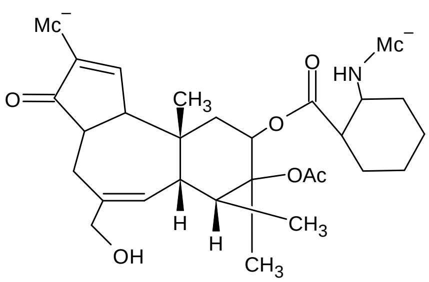


Gibberellin A4 (R = OH)

Gibberellin A9 (R = H)

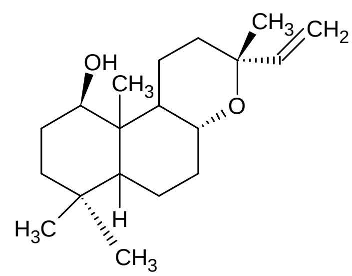
Biological activity: plant growth hormones

Sapium indicum (Euphorbiaceae)



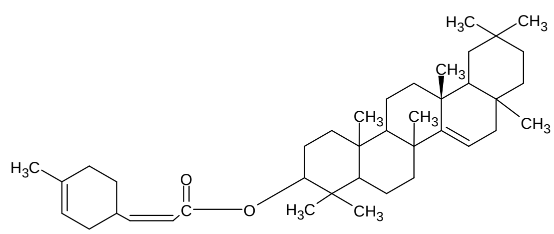
4a-Sapinine

Rizophora apiculata



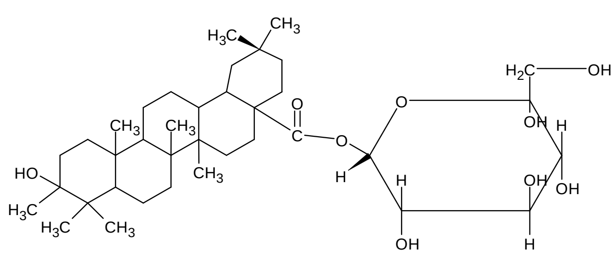
1-hydroxy-epimanoyl oxide

10. Triterpenes[17-19] *Rhizophora apiculata*



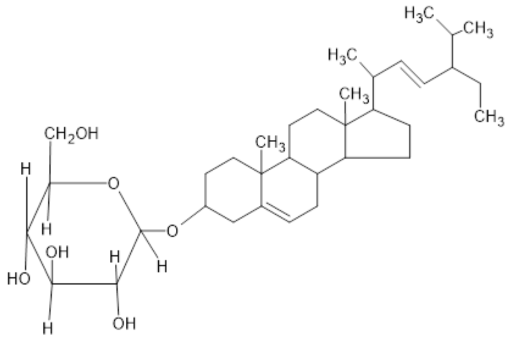
Taraxeryl cis-p-hydroxycinnamate

Acanthus illicitolius



Olean-12-en-28oic acid, -3-hydroxy-ß-D-glucopyranosyl ester

Eritera littoralis

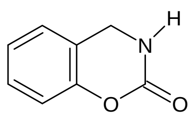


Stigmasteryl-β-D-glucopyranoside

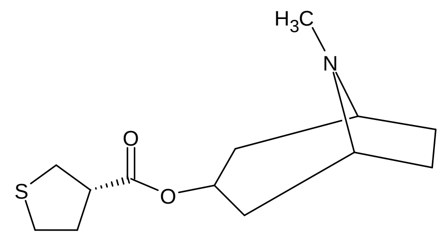
Biological activity: antifungal agent, 60% *Pythium ultimum*, 75% Rhizoctania sol boll weevil antifeedant (100% at 3 mg)

11. Alkaloids[17,20,21]

Acanthus illicifolius, *Bruguiera sexangula*

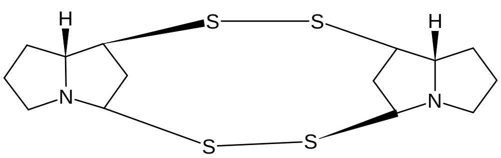


Benzoxazolin-2-one

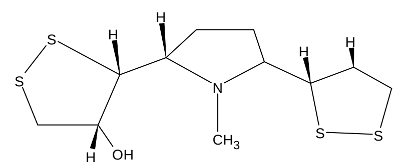


Brugine

Antitumor activity



Cassipourine (*Cassiourea gummiflua*)

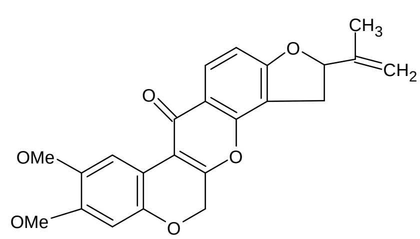


Gerrardine (*Cassipourea gerrardii*)

12. Flavonoids Compounds[22]

Isoflavonoids

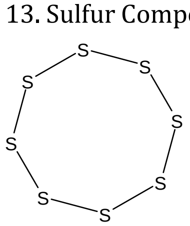
Derris species



Rotenone

Biological activity: fish toxin and pesticide

13. Sulfur Compound[23-25]



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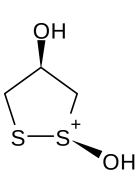
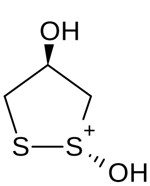
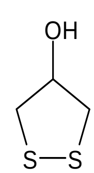


Brugierol (cis)



Isobrugierol (trans)



4-Hydroxy-1,2dithiolane

Biological activity: fish toxin and pesticide

Avicennia illicifolius

Bruguiera cylindrica

THERAPEUTIC USES OF MANGROVES PLANTS:

Anti-Microbial Activity of Mangrove Plants: The antibacterial activity of mature leaves, tender leaves and bark extracts of *Avicennia marina*, *Avicennia officinalis* and *Bruguiera sexangula*. The antibacterial activity was screened using by agar diffusion technique against pathogenic bacteria species of *Staphylococcus* sp., *Proteus* sp., *Escherichia coli*, *Shigella* sp. and *Pseudomonas* sp. Twelve different plant extracts in *A. marina*, *A. officinalis* and *B. sexangula* exhibited different degree of growth inhibition against tested bacterial strains. Mature leaf extracts of *A. marina* and tender leaf extracts of *A. officinalis* in ethyl acetate exhibited promising antibacterial activity than other plant extracts.

FIGURE-6: ***A. FLORIDIUM***

FIGURE: ***ACANTHUS ILLICIFOLIUS***

Plant extracts in ethyl acetate showed strong inhibition compared to other extracts on all tested bacterial strains. Among all bacterial strains, *Pseudomonas* sp. and *E. coli* showed considerable growth inhibition against almost all plant extracts.

Anti-Fungal Properties of Mangrove Plants: The antifungal activity of chloroform extract of leaves of *Acanthus ilicifolius* was evaluated in *Aspergillus fumigatus* infected mice. Swiss albino mice (60) were divided into five groups. All the groups were immunosuppressed with cyclophosphamide and cortisone acetate couple of days prior to intranasal inoculation with *Aspergillus fumigatus* conidia (10^6) in all the groups, except the first. Treatment was initiated at 24 h of fungal inoculation and continued up to day 14, and included amphotericin B (1 mg/kg orally) for group III and extract of *Acanthus ilicifolius* at 250 mg and 500 mg/kg for group IV and V, respectively. Groups I and II received sterile water orally for the same period. From each group, three mice were sacrificed after 1 h and the remaining mice on the 14th day of inoculation. One-hour post-inoculation lung colony forming unit count confirmed the delivery of conidia into the lungs.

Antinociceptive, Anti-Inflammatory, and Antipyretic Activity Mangrove Plants: Different mangrove species reporting one or more of these activities: antinociceptive, anti-inflammatory, and antipyretic activity. Some of the reports coincide for a given species, and, therefore, a total of 17 plants were reported to have such activity. However, only one plant, *Pongamia pinnata* was studied for antipyretic activity. In nine cases, further phytochemical studies were carried out to find out the active constituent(s). One of the studies justified that the activity might be due to betulinic acid since betulinic acid is known for its anti-inflammatory activity and was present in the extract. According to chemical classification, the active compounds, isolated from the mangrove plants, can be classified into diterpenes, flavonoids, isoflavonoids, monoterpenes, phenolics, steroids, triterpenes, xanthones, and a compound with unidentified structure. Plants often produce secondary metabolites under stressful conditions. Therefore, it is not surprising that mangrove plants, facing various ecological and environmental stresses, biosynthesize a wide range secondary metabolite of potential medicinal importance. The present literature survey has revealed that mangrove plants contain a wide range of compounds showing antinociceptive, anti-inflammatory and or antipyretic activity. Pain itself is not any disease. It is manifested in certain disease or pathological conditions. Use of natural products in the management of pain goes back to thousands of years. Use of poppy by various civilizations or the use of willow bark to cure fever led to the isolation of morphine and salicylic acid, respectively. These two drugs are still used extensively in modern medical practice. Present trend of the researchers to focus on mangrove plants has opened up an arena to find bioactive compounds from a source that has long been ignored or less explored. It is expected that research on mangrove plants will continue to rise in the coming days.

FIGURE-7: ***RHIZOPHORA MUCRONATE, XYLOCARPUS GRANATUM, SONNERATIA CASEOLARIS***

Anti-Cancer Activity of Mangrove Plants: Bark extract of *Bruguiera sexangula,* is active against two tumours, Sarcoma 180 and Lewis Lung Carcinoma. This activity is due to tannins, an unidentified alkaloid, tropine and its acetic acid ester (brugine) present in the extract. Ribose derivatives of benzoxazoline extracted from *Acanthus illicifolius* Linn. is reported to be active against cancer. A few other plants found in coastal region are also known for medicinal property. *Pongamia pinnata* is used as source of crude drug for treatment of tumours, piles, skin diseases, wounds, ulcers and these activities are related to flavonoids (chalcone) present in the plant. *Pandanus odoratissimus* Linn. f. is rich in phenols, lignins and a benzofuran derivative; and, these compounds exhibit antioxidant activity. *Morinda citrifolia* Linn. rich in polysaccharides shows anticancer and analgesic activities.

OTHER IMPORTANCE OF MANGROVES:

1. Provide Habitat: Mangroves provide shelter for the juveniles and adults of many fish species, including commercially and recreationally important species such as mullet, bream, whiting, luderick, flathead, and shellfish such as prawns and crabs.

2. Provide Food: Mangrove trees produce large amounts of organic matter. The fallen leaves, seeds, and seedlings enter the waterway and are directly grazed by some small animals. The litter is further broken down by bacteria and fungi. Decaying pieces of debris are eaten by other aquatic animals called detritivores (e.g., crabs). These in turn provide food for larger fish and other animals.

3. Act as a Buffer: Mangroves act as a buffer; reducing erosion and maintaining water quality. A mangrove community also provides a buffer between the terrestrial and nearby marine environments; trapping and stabilizing sediment, nutrients, and contaminants from runoff, thus helping to maintain water quality. Mangroves protect coastal land by absorbing the energy of tidal currents and storm-driven wind and wave action, creating a natural breakwater that helps stop erosion. Evidence from major storm and wave events has shown the importance of mangrove forests in reducing storm damage.

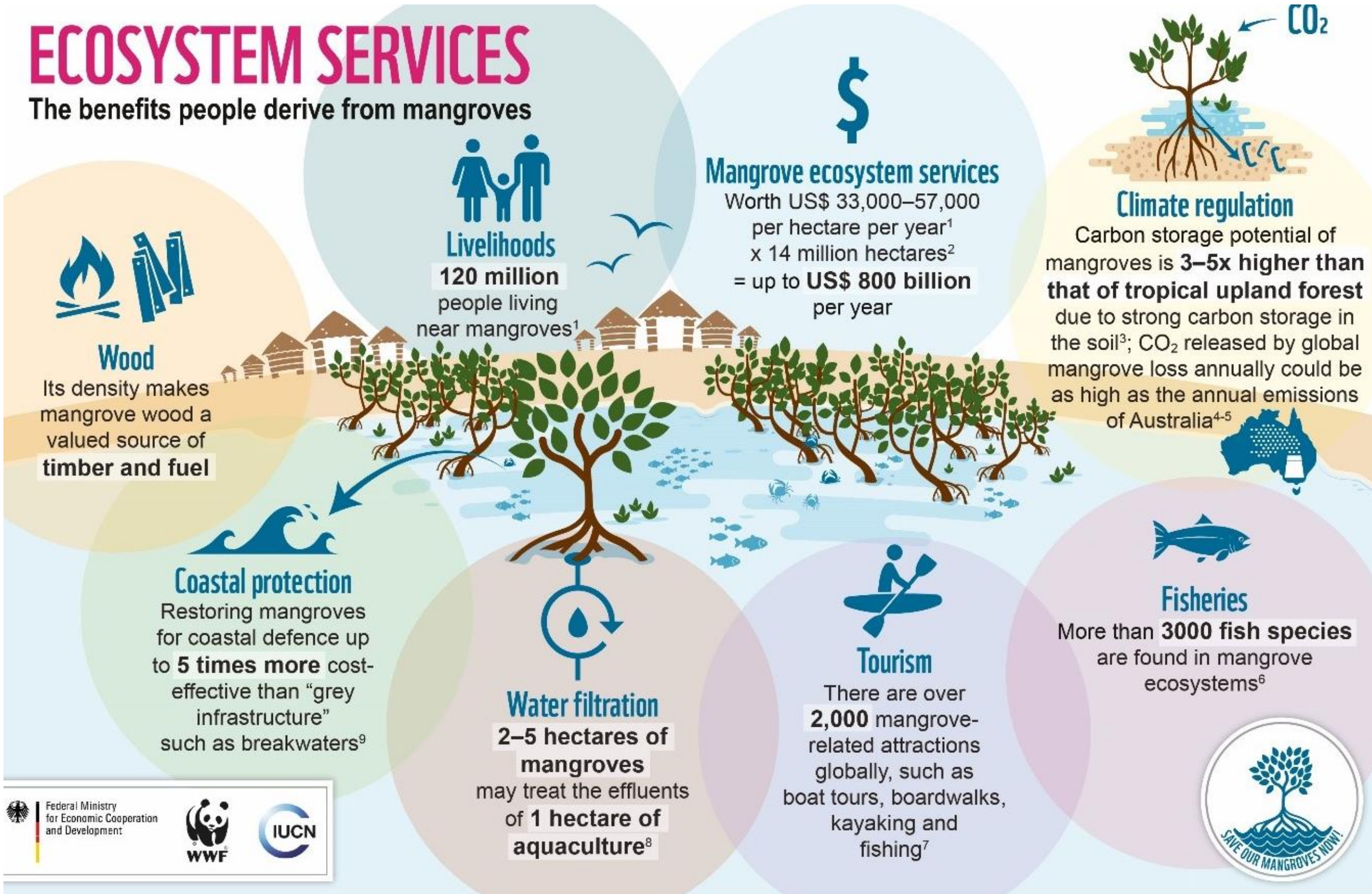


FIGURE-8: IMPORTANCE OF MANGROVES.

Mangrove Tea: Mangrove Tea (*Pelliciera rhizophorae*) belongs to the "true mangroves" and is one of the most attractive, unique, and rarest mangroves ever. *Pelliciera rhizophorae* grows along the coast of Central America (Mangroves: tea mangrove *Pelliciera rhizophorae*).

FIGURE-9: MANGROVE TEA

If the right conditions like nutritious soils, high humidity of 80–90 %, a lot of intense light, as well as air temperature of 25–30 C are provided, *Pelliciera rhizophorae* grows which can reach up to 20 m in height. (Mangroves: tea mangrove *Pelliciera rhizophorae*). The leather-like leaves of *Pelliciera rhizophorae* reach a length of 20 cm and more and the width is up to 5 cm. The surface and the bottom side are smooth, and only on the edges of the leaves are some small hairs. The ripped brown fruit of *Pelliciera rhizophorae* is most of the time about 10 cm in diameter. The fruit of the Mangrove Tea contains exactly one viviparous seed which is just a little bit smaller than the fruit itself (Mangroves: tea mangrove *Pelliciera rhizophorae*). The seed is surrounded by a 3–5 mm thin protection layer. The leaves of this mangrove contain tannins and other substances found in tea. Furthermore, its visual appearance resembles strongly to a leaf of a tea plant (Mangroves: tea mangrove *Pelliciera rhizophorae*). This is why the *Pelliciera rhizophorae* also called Mangrove Tea was considered part of the Tea Plant family for over than a century. Mangrove Tea grows in the intertidal zone in which the oxygen-poor soils offer high salinity and sometimes trace metals or other pollutants. Most of the time, these pollutants as well as the salt are excluded by the roots of the mangrove volume were analyzed. The counts of beneficial and harmful bacteria were determined. Results revealed that the tea extract from *C. decandra* prevents the oral cancer incidences and maintain good health conditions of the animals. Salivary bacterial species of the test animals were detected. The predominant types of bacteria isolated from the saliva, tongue, dorsum, and buccal mucosa were *Streptococcus* spp., *Lactobacillus* spp., and *Bifidobacteria*. Lactic acid bacteria and bifidobacteria are two well-known groups of beneficial bacteria which constitute an integral part of the health condition. They impart nutritional and therapeutic benefits to their host. The vitamins and enzymes produced by the lactic acid bacteria contribute to host metabolism. The antimicrobial substances produced by these bacteria control the proliferation of undesired pathogens. Lactic acid bacteria produce a soluble compound which may interact directly with oral tumor cells in culture and inhibit their growth. Data from epidemiological and experimental studies indicate that ingestion of lactobacilli and bifidobacteria and their fermented products reduce the risk of certain types of cancer and inhibit tumor growth.

CONCLUSION: Consequently, it is evident through the provided report and additional resources that the abiotic and biotic features of the Home bush mangrove ecosystem rely on one another to sustain a functioning environment. Through the adaptations of various organisms, the ecosystem is able to function and thrive as a cohort. Through this report it is evidently clear that the results shown from the experiments conducted support the hypothesis' formed at the beginning of the report. It was shown that the abundance and distribution of the flora and fauna within the Home bush mangroves was determined by the abiotic factors such as wind speed, temperature, humidity, soil moisture, soil pH, water salinity, water pH and the water turbidity etc. Additionally, through the study of the history of Home bush it can be concluded that the introduced species have had a detrimental effect on the original inhabitants of the Home bush mangroves. This hypothesis is supported through the obvious decline of the little tern. Although the study of antibacterial activity of mangrove herbal plant, the antimicrobial activity against bacterial and fungal human pathogens Antinociceptive, Anti-Inflammatory, and Antipyretic Activity Mangrove plants that shows results which indicated that scientific studies carried out on medicinal plants having traditional claims of effectiveness might warrant fruitful results. These plants could serve as useful source of herbal medicine.

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