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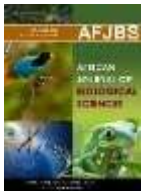

A Review On Potential Bioactive Compounds For Therapeutic Alternatives From Mangrove Species

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Abstract

Emerging drug resistance among pathogens is a growing threat to mankind. The rise of MDR strains of bacteria has generated a great challenge to treat infections caused by bacteria with the available antibiotics. For ages, the vast floral species of the mangrove ecosystem have been used for medicinal importance as they represent a valuable source of novel drug compounds although the chemistry and bioactivity of flora remain partly uninvestigated. Recently plant-derived therapeutic agents have gained an immense importance in the field of medical sciences for treating several health disorders and chronic diseases. An extensive literature is available on phytochemical profiling of mangroves but in this review an attempt was made to focus on latest findings of different mangrove species which have been reported for high phytochemical constituents with other biological activity.

Keywords— Drug resistance, Bioactive potentialities, Mangrove extracts, GC-MS analysis

I. INTRODUCTION

The discovery of antibiotics has created a turning point in medical interventions to treat pathogenic infections, but unfortunately, each discovery was consistently followed by the emergence of drug resistance. Today, research is active in finding alternative therapy for combating multidrug-resistant pathogens. To support and to guide the efforts, the WHO has published a list of the most dangerous bacteria that are resistant to current treatments and requires the development of new antibiotics for combating the resistance. Among them are various Gram-positive bacteria that are responsible for serious healthcare and community-associated infections. Methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus faecium*, and drug-resistant *Streptococcus pneumoniae* are of particular concern. The resistance of bacteria is an evolving phenomenon due to genetic mutations and/or acquired genomes. Thus, antimicrobial resistance demands continuous efforts to create strategies to combat this problem and optimize the over usage of antibiotics. The World Health Organization (WHO) published a global priority pathogens list and categorized them as critical, high, and medium antibiotic-resistant bacteria that need to be addressed urgently through research and development of new alternative drug treatments.

Serious effects like gastrointestinal abscesses, blockages and haemorrhages have been observed with the usage of non-steroidal and synthetic anti-inflammatory drugs (NSAIDs). On the contrary, Indian medicine has many traditional herbal extracts of plants like *Andrographis paniculata* which are being safely used for treating hepatitis. Likewise chronic environmental stress and genetic disorders induced lethal diseases like Parkinson's, cardiovascular, Alzheimer's, cancer, etc are due to hyper-accumulation of free radicals.

Mangroves have always been captured the attention of scientists and still confounds the research community. They are categorised as salt tolerant ecosystem that is found mainly in tropical and subtropical intertidal regions of the world (Bandaranayake, 2002). Due to the unique habitat of mangroves, their ability to grow in the intertidal zone develops different physio-chemical processes to survive and reproduce. Hence they develop a very special ecosystem of microbial flora that trigger the production of novel compounds with variant biological activity that can be used as therapeutic drugs in the future. (Saleh Amer et al., 2020).

Traditional use of mangrove plants in ethno-medicine is continuing till today and extracts from mangrove species have proved to have strong inhibitory activity against the plant, animal, and human pathogens (Saranraj and Sujitha, 2015). Mangrove plants are extensively studied for antimicrobial components for pharmaceutical importance. Traditionally, *R. racemosa* bark is used to treat boils and fungal infections. An infusion of its leaf and bark is used to treat diarrhoea, dysentery, fever, malaria and leprosy (C.N. Duke, J.A. Allen et al., 2006)

New age drug discovery is based on natural product mainly plant products as they are cheaper alternative and mostly effective. Essential phytochemicals present in medicinal plants as secondary metabolites serve as precursors for synthesis of useful therapeutic drug compounds. They include alkaloids, flavonoids, tannins and phenolic compounds and derive the medicinal value to the plant species. These metabolites have been identified from different mangroves and mangrove associates belong to categories like alkaloids, flavonoids, carbohydrates, carotenoids, aliphatic alcohols, amino acids, hydrocarbons, fatty acids, phenolic compounds, tannins, saponins, terpenes, and related compounds (Bandaranayake, 2002). According to Wu et al. 2008, 349 metabolites have been isolated from mangrove species out of which 200 metabolites are exclusively reported from true mangroves. For supporting life processes, biomolecules such as amino acids, carbohydrates, and proteins, that are the product of primary metabolism, are essential for live growth, and products of secondary metabolism like alkaloids, flavonoids, phenolics, steroids, terpenoids, etc., have pharmacological, toxicological and ecological importance (Bandaranayake, 2002). Therefore, DPPH and FRAP assay are very reliable methods to measure anti-oxidative capacity of natural organic molecules.

An extensive literature reported on mangroves for their bioactivities like Latex of *Excoecaria agallocha* has a biocidal effect on marine organisms and phytoplanktons (Reddy et al. 1991; Bandaranayake, 2002). Different plant extracts from Rhizophoraceae mangroves have been shown to be effective against different human pathogens [Sravya et al.,]. A polysaccharide constituent obtained from the leaf of *Rhizophora apiculata* has shown toxicity against HIV-1/HIV-2 or SIV viral strains causing AIDS under controlled conditions [Mariappan Premanathan et al.,].

Over 200 bioactive metabolites have been isolated from true mangroves which contain antibacterial and antifungal properties (Bose and Bose, 2008; Wu et al. 2008 and Chandrasekaran et al. 2009). They contain huge number of phytochemicals that are beneficial for human body acts as natural antioxidants by protecting from free radical damage. Antioxidants control and reduce the damage by inhibiting the oxidation caused by reactive oxygen species (ROS). ROS plays an important role in human physiological processes (D'Autr´eaux and Toledano, 2007). Proper extraction methods play a major role in qualitative and quantitative plant based bioactive compound research. Several research studies and traditional knowledge among the coastal population reveals an effective anti-inflammatory, antiviral, antimicrobial, anticancer, anti-diabetes, antifungal and insecticidal properties of mangrove plants (Habib et al., 2018; Sachithanandam et al., 2021). Study on *A. officinalis* determined that ethyl acetate extract of *A. officinalis* has numerous natural molecules that could be useful for pharmaceutical applications like anticancer, antioxidant, antimicrobial, anti-inflammatory.

Bioactive potentiality of mangroves:

Being ecologically and biochemically unique, mangroves produce a wide array of natural compounds. Khafagi et al. 2003 studied the presence of tannins, flavonoids, sterols, glycosides, and natural acids in the ethanol concentrate of the shoot framework of *Avicennia marina.* The methanolic concentrate of *Avicennia marina* indicated the optimum presence of pentanoic acid, decanoic acid, diethylhydroxylamine, α-amyrin as active compounds in Ceriops decandra. Plant tissues of bark, root and leaves of three different mangrove species were screened qualitatively and quantitatively for total phytochemical analysis. Presence of highly polar bioactive compounds (alkaloids, saponins, tannins, flavonoids and reducing sugar) were reportedin them. *Avicennia africana* showed the highest concentrations of alkaloid and saponin. Leaves showed the highest concentration of alkaloids whereas barks showed the highest concentration of saponins. *Rhizophora racemosa* had the highest mean concentrations of flavonoids and tannins, leaves had the highest concentration of flavonoids whereas the stem contained the highest concentration of tannins. The GC-MS results of active column fraction of *A. officinalis* revealed that the active principals were a mixture of hydroxyl-4 methoxy benzoic acid, di ethyl phthalate, oleic acid. (Valentin Bhimba B et al. 2010) In their study, crude extracts failed to exhibit desired response, where as the fractions had broad spectrum activity against few test organism. Study on Landolphia owerrience has revealed that phytochemical compounds like glycoside, saponin, tannins, flavonoids, terpenoids, alkaloids have antimicrobial activity Nypa fruticans showed the highest mean concentration of reducing sugars (Edu et al. 2015)

Antimicrobial activity:

Throughout the world, comprehensive research studies on mangroves reported for their antimicrobial properties as they possess a strong bactericidal property against numerous microorganisms. As these plants are rich in secondary metabolites, they have been found in vitro to have antimicrobial properties. The antibacterial potential of the methanolic extract of *Excoecaria agallocha* was reported by Chandrasekaran et al. (2009). Abeysinghe et al. (2006) reported the promising antibacterial activity of *Avicennia marina*. Alamgir et al. (2007) studies on methanolic extract of *Xylocarpus granatum* suggested the antimicrobial activity is due to presence of triterpenes. Moderate antibacterial activity by *Suada maritama* is due to presence of phenolic compounds like tannins (Patra et al. 2011b). Presence of glycosides, saponins, tannins, flavonoids, alkaloids, terpenoids may influence the antibacterial activity of *Avicennia officinalis* (Bhimba et al.

2010). Presence of flavonoids as an active constituent in *Lumnitzera racemosa* extract can be attributed for its antibacterial activity (D'Souza et al. 2010). Studies of Kumar et al. (2011) reported best antifungal activity in Chloroform and methanolic extracts of *Avicennia marina, Excoecaria agallocha*, *Lumnitzera racemosa*, *Derris trifoliata, Bruguiera gymnorrhiza, Ceriops decandra* and *Acanthus ilicifolius* against the *Aspergillus niger, Rhizopus oryzae, Candida albicans* and *Saccharomyces cerevisiae*. A study reported by H.Jahnmanchi & Raju et al.(2017) the purified ethyl acetate fraction using the microwave extraction method of Aegiceras corniculatum have shown a very potent inhibition of *Mycobacterium tuberculosis* in the microgram range with negligible cytotoxicity against mammalian cells.

In a similar study, Das et al., (2018), revealed that *A. officinalis* bark and leaves ethanolic extract exhibited antimicrobial activity against *B. subtilis, E. coli* and *P. aeruginosa*. Das (2020) also reported promising antibacterial activity due to the presence of terpenoids, phenolics and alkaloids. Thus, pharmacological screening of natural products can be a source of innumerable bioactive therapeutic agents. The antibacterial activity of crude extract of *A. officinalis* leaves showed strong activity against five different test microorganisms *S. mutans, K. pneumkiae, P. aeruginosa, B. substilis and E. aerogenes*. (P. Lalitha, A. Parthiban 2021)

The antimicrobial effectiveness of plant extracts also depends upon parts of the plant used and the solvent utilized for extraction Okla et al. (2021). The investigation of Muhammad Sohaib, Fahad N.I. et al 2022) in a comparative study on antimicrobial, antioxidant, and cytotoxic activities of A*. marina, P. australis,* and *M. oleifera* based ethanolic plant extracts has depicted that ethanol as a solvent for the extraction of phyto-constituents can play an important role in *Moringa oleifera* antimicrobial and antioxidant properties. *Moringa oleifera* based ethanolic extract was found maximum cytotoxic potential against HepG2 cell lines as indicating that phenolic ingredients playing a major role in cytotoxic activities because Etanol extract contains maximum phenolic contents comparatively. The leaf extracts of *R. apiculata* have exhibited significant antibacterial activity against *P.aeruginosa, A.hydrophila, S. aureus* and *B. subtilis* The highest zone of inhibition was exhibited by the aqueous extract against all the strains, disclosed that the phytocompounds in the aqueous are highly potent to act against the bacterial strains. (Sravya M.V.N., Sampath Kumar 2023**).**

Several research groups screened different species of mangrove plants *Lumnitzera littoral, Avicenia, Rhizophora apiculat, Bruguiera gymnorrhiza, Heritiera littoralis, Suaeda nudiflora*, Lumnitzera *racemosa, Ipomoea tuba, Avicennia alba, Rhizophora mucronata, Sonneratia alba and Exoecaria agallocha, Avicennia Alba Blume, Acanthus ilicifolius* [73 to 80] for their antioxidant and antimicrobial properties in order to identify potent new molecules with therapeutic value against many Gram positive and Gram negative multi drug resistance human pathogens

Antioxidant Property:

Free radicals and oxidative injuries are a consequence of various diseases in humans. Several free radicals like hydroxyl (HO•), per-hydroxyl (HO2 •), superoxide (O2 •−), nitric oxide (NO•) are produced in plants and human body as a result of on-going physiological processes. Environmental stresses like high-light intensity, extreme temperatures, drought condition, floods acts as trigerring factor for the production of ROS in plants inducing oxidative stress (Thatoi et al. 2014; Jithesh et al. 2006). Krishnamoorthy et al. (2011) studied the antioxidant capacities of two

Indian mangrove species *Bruguiera cylindrica* and *Ceriops decandra*. Patra et al. 2009, studies disclosed that *Excoecaria agallocha* possesses tremendous antioxidant properties that are tested for DPPH radical scavenging, reducing power and H2O2 radical scavenging property. Previous Studies also revealed the Bark extract of Rhizophora apiculata have free radical scavenging activity.

Investigations of Banerjee et al. (2008) on leaf, stem, bark and root extracts of six mangroves species and four mangrove associates, have found high phenolic content (GAE), strong reducing ability and anti-radical activity. Another study on Stem and bark extracts of *Ceriops decandra* showed the best possible result. In an another study by Malik et al. (2017) showed that *Bruguiera sexangular* extract with polar solvents showed high flavonoid and highest phenolic contents. Also found that the methanol extract of *Lumnitzera racemosa* exhibit most active radical scavenger activity.

The studies of G. Eswaraiah et al. 2020, reported the maximum scavenger activity, 95.62% was found in the leaf exact of *Lumnitzera racemosa* at concentration of 200 mg/ml and the minimum scavenging activity, and 37.78% was found in the leaf extract of *Suaeda nudiflora* at concentration of 50 mg/ml by DPPH radical scavenging activity

The study of Sachithanandam et al., (2020) extensively studied methanolic crude extract of *Rhizospora mucornata.* Based on UV-visible spectroscopy, FTIR, NMR and HRMS analysis they reported the presence of bioactive compound termed as Quinizarin. This study identified Quinizarin has potential antimicrobial, antioxidant, and cytotoxic activity. Antioxidant activity study on ethyl acetate crude extract of *A. officinalis* leaves by DPPH method (P. Lalitha, A. Parthiban, V. Sachithanandam 2021) confirmed high antioxidant activity associated with low concentrations (23.6 $\pm$0.43 µg/ml). These results correspond to the amount of bioactive compound present in crude extracts of the *A. officinalis* leaves.

A study on *A. marina* leaves showed that ethyl acetate extract has a good antioxidant activity along with substantial potential for preventing and disrupting the biofilm formation, which worsens microbial infection. Furthermore, GS-MS analysis detected the wide range of biological activities, especially acting as antimicrobial, antibiofilm and antioxidant agents with minimal adverse side effects. (Hassan et al, 2022)

A study on *R. racemosa* stem bark demonstrating excellent ability to effectively scavenge free radicals, chelate metal ions and donate hydrogen. The extracts showed promising activity against the tested dermatophytes, with ethyl acetate and ethanol extracts being the most effective. It suggests that it can serve as leads for alternative and renewable source of phyto - based antioxidants with antifungal potential for the treatment of dermatophytic infections in humans (Basil N. Ita, Samuel 2022)
In Silico molecular Docking studies of *Acanthus ilicifolius* leaf extract against four Multidrug-resistant bacteria was evaluated for identifying lead molecules to inhibit cell division. These findings showed that the *Acanthus ilicifolius* leaf extract have a greater affinity for the FtsZ (6YMI) protein, which is responsible for bacterial cell division, and the DPPH free radical scavenging activity of leaf extract was reported to have moderately strong antioxidant activity. Thus it could be employed to fight antibiotic-resistant bacteria [Amrun Naher et al., 2022]. The combination of polysaccharide and selenium has many advantageous properties which may be applied in various

fields of nanobiotechnology due to higher stability, biocompatibility, and biodegradability. In a study on Selinium Nano Particles of *Rhizophora mucronata leaves polysaccharides* (RMLP-SeNPs) showed an excellent scavenging capacity on DPPH, ABTS, and reducing power when compared to other forms of selenium. Moreover, selenium nano particles showed good antimicrobial and antibiofilm activity against tested strains of *Aeromonas hydrophila, Escherichia coli, Staphylococcus aureus*, and *Pseudomonas aeruginosa*. Results suggested that these findings may also provide an opportunity to use SeNPs in food industries, biomedical, cosmetics, and pharmaceutical applications, especially to develop novel antioxidant and antimicrobial compounds (Natwar Jha et al. 2022).

Anticancer property:

As reported by WHO 2020, Cancer accounts for the death of 10 million people worldwide. It is brought about by dynamic abnormalities in the expression of tumour suppressor proteins, growth factors and transcription factors which leads to malignant growth of the cell called Cancer. The need to search for complementary and alternative medicines is the need of the hour because of the side effects related with the traditional cancer chemotherapies and the supposed advantages of more natural treatment alternatives. Anti-inflammatory and anticancer properties of several medicinal plants have been studied extensively. Cytotoxic acitivities of *Xylocarpus granatum* against various cell lines found to be the presence of Xylogranatins A-D compounds. (Yin et al. 2006; and Das et al. 2015). Several studies on mangrove plant extracts have been revealed the anticancer properties. in an in vitro cytotoxic assay studies of Tian et al. (2009), has found that 3′ ,4′ ,5,7- Tetrahydroxy flavone isolated from *Sonneratia caseolaris* have potential inhibition activity against cell proliferation of SMMC-7721 human hepatoma cells. The methanol extract of the leaves *Sonneratia apetala* against EAC cell line showed positive response giving 34% inhibition against EAC cells in swiss albino mice model (Patra et al. 2015). Studies on methanolic extract of *Rhizophora apiculata* have found good anti-inflammatory and anti-tumor activity against B16F10 melanoma cells in mice model of Prabhu and Guruvayoorappan (2012a). Sari et al. (2018), revealed the anti-cancer potentials of *Nypa fruticans* is due to polyisoprenoids.

Earlier studies by Huang et al. (2016) suggested that Ethanol extracts of *Avicennia marina* are rich in phenolic and flavonoid content and can be used to induce apoptosis in human breast and liver cancer cells. The Cytotoxicity studies against pancreatic cell lines by Patil et al. (2011) confirmed that the stem extracts of *Excoecaria agallocha* has promising cytotoxicity. Batsa and Periyasami (2013) extensively studied the anticancer activity of *Excoecaria agallocha* leaf extracts in cell line model. A detailed study and thorough clinical trials on extracts of *Excoecaria agallocha, Bruguiera sexangular*, and *Avicennia africana* have been carried out by Kathiresan 2000; Subhan et al. 2008a, b; Kathiresan et al. 2006; Patra et al. 2011b and it is been observed that they are potential anti-viral, anti-cancer, anti-HIV, and anti-tumor agents.

In a comparative study on *Avicenina marina, Phragmites australis, Moringa oleifera* the cytotoxic effects of ethanolic plant extracts in HepG2 cell lines were investigated and confirmed that all the tested extracts have cytotoxicity up to some extent. Among them *Moringa oleifera* contains maximum phenolic contents as compared to extracts of *Avicenina marina* and *Phragmites australis*, which might be the major contributor to its anticancer activities. (Muhammad Sohaib, Fahad et al. 2022). GC-MS Studies of Eswaraiah et al., 2020 disclosed that the Avicennia marina has anti-cancer properties against various cancer cells. Momtazi-borojeni studies reported the crude

extract of *Avicennia marina* exhibited with excellent anti-cancer properties at 250 µg /ml. Later studies by Shan Tian, Kandasamy Saravanan et al., revealed that *Avecinnia marina* mediated Ag NPs was excellent anti-cancer agent against A549 lung cancer cells. The result was proved that the Ag NPs was concentration dependent inhibitor agent and 54% of inhibition was observed at 50 µg/mL and it was comparatively low than previous reports.

Anti-inflammatory

The evaluative anti-inflammatory study of *R. apiculata* extract on carrageenan-induced paw edema in BALB/c mice evinced anti-inflammatory properties. the extract (at 10 mg/kg BW, for 10 consecutive days) exhibited reduction in paw size at 4 h post-carageenan injection (0.39 [± 0.04] mm) relative to that seen in control (no extract) mice (0.47 [± 0.03] mm) group animals on the same hour. The total white blood cell count and hemoglobin levels were also remarkably increased in extract-treated hosts. Analysis of this methanolic extract revealed the presence of a high content of 4-pyrrolidinyl, pyrazole, and ketone derivatives. These studies suggest that *R. apiculata* extract could be used as a (natural) anti-inflammatory and anti-tumor agent. (V. Vinod Prabhu and C. Guruvayoorappan, 2012)

The results of anti-inflammatory and α-glucosidase inhibitory activities of *Brugueria parviflora* leaves showed that the crude extract significantly increased the percentage inhibitory activity against α-glucosidase and decreased NO production in LPS-stimulated RAW 264.7 cells in a dose-dependent manner. The purified fractions were further evaluated for the anti-inflammatory and α-glucosidase inhibitory effects. The results indicated that flavonoid quercetin showed the most potent inhibitory effect against α-glucosidase activity with an IC50 value of 3:4±0:5 µg/mL and the LPS-induced NO production of 11.8 µM at the concentration of 100 µg/mL. These findings suggest that flavonoids from *B. parviflora* leaves may be useful as anti-inflammatory agent. (Tung Thanh Bui,1 Khanh Phuong, 2022) *In vitro* anti-inflammatory activity of four different extracts of *A. corniculatum* was revealed through protein denaturation assay. Diclofenac sodium was used as a standard reference Among all the 4 extracts, methanol extract showed significant anti-inflammatory activity with 85.32 ± 1.63 percentage inhibition of protein degradation which was comparable with standard. The aqueous extract also showed potential anti-inflammatory activity (71.9167 ± 1.12970) when compared to other remaining extracts. (Kulkarni BD et.al., 2019)

An *in vitro* anti-inflammation activity of *Rhizophora mucronata* Lam. from Pichavaram Mangrove Forest, Tamil Nadu, India showed whole plant can be the potent source. Protein denaturation (bovine albumin) findings showed that the *R. mucronata* leaf, bark and stilt root extract could serve as an important anti-inflammatory agent, as maximum inhibition (296.26%) was observed from root extract followed by bark (259.48%) and leaf (237.62%). Moreover, among the three extracts, the maximum inhibition 284.17% was observed from bark extract followed by root (265.05%) and leaf (232.61%). These results provide evidence from membrane stabilization as an additional mechanism of their anti-inflammatory effect. (KAUR, S.; SYED ALI et al.2018)
In the evaluation of anti-inflammatory activity of hydro alcoholic extract of *L. racemosa* leaves (EHA-Lr) revealed that the 200 mg/kg dose was most effective in reducing leukocyte migration in the paw edema model in mice and showed superior inhibition compared to indomethacin and in the LPS-induced acute lung inflammation model the 50 mg/kg dose was most effective in reducing plantar volume and was able to prevent acute lung inflammation with low toxicity (Jhonatta

Alexandre Brito *Dias et al.2022).* One new neolignan compound, racelactone A (1), together with seven known compounds were isolated from the methanolic extract of the leaves and twigs of *Lumnitzera racemosa*. Mass and NMR spectroscopic data interpretation determined compounds 1 (racelactone A), 4 (methyl gallate), and 5 (myricitrin) showed significant anti-inflammatory effects with IC50 values of 4.95 ± 0.89, 1.95 ± 0.40, and 2.57 ±0.23 μM, respectively with anti-inflammatory assays on superoxide anion generation and elastase release in fMLF/CB-induced human neutrophils. (Yu, Szu-Yin, Shih-Wei Wang et al.2018)

Bio active compound and drug discovery:

Traditional techniques such as TLC and column chromatography using silica gel as stationary phase have been opted by several researchers for the separation of bioactive constituents from plant extracts. Apart from this some of the highly sensitive techniques used were HPLC-MS, GC-MS, LC-MS. Proper identification and structure elucidation of the extracted compounds have been performed mostly using UV, FTIR, NMR, and MS by several research studies. A detailed review of literature (Sayantani Mitra, Nabanita Naskar et al., 2021) lists different phytochemicals that have been qualitatively identified from mangrove species. Qualitative phytochemical screening studies of mangroves identified various classes of alkaloids, terpenoids, flavonoids, fatty acids, sugars, carbohydrates, tannins, lipids, phenolic compounds, proteins, etc., Different bioactive compound classes have been majorly reported from *Avicennia sp.*, *Bruguiera sp.*, *Acanthus sp.*, *Rhizophora sp.*, *Ceriops sp., Sonneratia sp.,* and *Xylocarpus sp*. Further studies (isolation, extraction) using these species may provide new leads in the field of natural product research.

GC-MS/ LC-MS analysis:

Earlier reports by researchers documented by GC-MS analysis of crude extract of *A. officinalis* leaves revealed the presence of different bioactive compounds such as organic aliphatic and aromatic acids, phenols, esters, alcohol, steroids and terpenoids. The GC-MS chromatogram of ethyle acetate extract of the *A. Officinalis* leaves components corresponding to the eight peaks were determined as Trans-cinnamic acid (27.7%), 2,4-Di-tert-butylphenol (3.33%), Phenol, 3-(2-phenylethyl (3.31%), n-hexadecanoic acid (18.79%), Dibutyl phthalate (100%), Phytol (2.47), b _ Sitosterol (5.9%), Androst-7-ene-6 and 17- dione, 2,3,14-trihydroxy (6.69%). The Structures of identified bioactive compounds were illucidated. Among these Dibutyl phthalate (aromatic organic ester) had the highest percentage composition (100%) and the chemical compound phenol, 3-(2-phenylethyl) (3.31%) the lowest percentage composition. Their study determined that ethyl acetate extract of *A. Officinalis* composed of numerous natural molecules which could be attributed to pharmacetical applications like anticancer, antioxidant, antimicrobial, anti-inflammatory. (Lalitha Parthiban). The GC-MS analysis of *A.officinalis* active column fraction (F13) identified the active principals as hydroxyl - 4 methoxybenzoic acid, diethyl phthalate and Oleic acid. (Bhimba et al. 2010). GC-MS along with FTIR analysis of the methanolic extracts *Bruguiera gymnorrhiza* and *Excoecaria agallocha* revealed the presence of various phytoconstituents namely alkaloids, terpenoids, phenols and quinones that may contribute to the antimicrobial activity against *Staphylococcus aureus* and *Klebsiella pneumonia*, and antioxidant potential and have great promise in treating various diseases *(*Khadeeja S, Ragunathan R, Johney J, Muthusamy K (2022)

The GC-MS profile of crude methanolic extract of *A. marina* on the basis of spectral data analytical studies revealed the presence of a mixture of volatile compounds. In a study, (Aseer Manilal et al., 2016) a total of nine prominent peaks were observed with retention times Benzaldehyde,3-methyle

(6.811), 2-Methoxy-4-vinylphenol (9.211), Cyclobuta (1,2:3,4) dicyclooctene,hexadec (11.669), Benzeneethanol,4-hydroxy (12.173), 4-(2,6,6-Trimethylcyclohexa-1,3-dienyl)b (13.709), Lycorenan-7-one,9,10dimethoxy-1-methyl (14.531), 1,2-Dicarboxy-3-(4,chlorophenyl)2,3(1H) (23.249), Phenol,2-(1,1-dimethylethyl)-4-(1-methyl (23.350), Methyl p-(2-phenyl-1-benzimidazolyl)benz (26.490). Among them the major constituents identified were benzeneethanol,4-hydroxy- (RT = 12.173), followed by benzaldehyde,3-methyle- (RT = 6.811). Their findings attributed the antibiotic potency displayed by the *Avicenia marina* could be associated with the high percentage of benzene ethanol, 4-hydroxy and benzaldehyde,3-methyle.

Another study on *Avicennia marina* GC-MS analysis, 5 bioactive compounds was identified from the partially purified leaf extract of mangrove plant. The identification was performed based on the peak areas, molecular weight and molecular formula. The n-hexadecanoic acid was recorded maximum at the retention time of 30.94 with 10.7026 % of peak value followed by 2-cyclohexen-1-one, 4-hydroxy-3,5,5-trimethyl-4- (3-oxo-1-butenyl) (8.6%), phytol (8.4 %), hexadecanoic acid, ethyl ester (6.2 %) and 3,7,11,15-tetramethyl-2-hexadecen- 1-ol (4.9 %) at the retention time of 27.89, 33.27, 31.23 and 28.27 respectively (Fig-3). These five compounds were found active molecules responsible for the inhibition of multi-drug resistant Staphylococcus aureus agents. (Dayanidhi, Ajith kumar 2012)

Study on the extracts of mangrove plants: *Acanthus ilicifolius, Excoecaria agallocha, Rhizophora apiculata* and *Rhizophora mucronata* had been reported for the presence of a wide range of bioactive compounds. A total of 135 chemical constituents were identified and compared with their retention time in the NIST library 2011. The chemical constituent's characterization analysis reported as essential oils, higher alkanes, acid, alcohol and esters. The major peaks obtained indicated the presence of 8-pentadecane, 1, 2, 5-trimethylphyrrole, Di-(2-ethylhexyl) phthalate, diethyl phthalate, epoxyhexobarbital and cyclooctacosane (Satyavani et al 2015). The NMR and mass spectrometric analysis Raola and Chakraborty (2017) reported that the extracts of Rhizophora mucronata showed the presence of terpenoids, Olean-12- en-3-yl acetate which has the antimicrobial, antidiabetic, antiinflammatory, antidepressant and anticancer activities.

Vundru Anil Kumar, Kandru Ammani et al. (2013) investigated and identified bioactive phytochemical constituents of the methanol, chloroform and ethanol extracts of leaves of *C. decandra* by GC-MS analysis (Table 1). The methanol extract of *C. decandra* is found to contain fatty acids, esters, steroids, triterpenes, alcohols, the chloroform extract is found to contain esters, alkanes, alkenes, steroids, diterpenes, triterpenes, and the ethanolic extract is found to contain esters, alkanes, alkenes, steroids, alkaloids and alcohols. Among three organic solvent extracts, it is observed that chloroform extracts were comparatively more effective against the third and forth instar larvae at very low concentrations. This investigation illustrates the potency of organic solvent extracts of leaves of *C. decandra* in controlling the wide spread of fungal diseases and larvae and thus contributes as an affordable way to control phyto pathogenic fungi, S. Litura and A. aegypti. This is explained by the different solvents properties, such as polarity which enables them to extract different type of compound(s) that results in different larvicidal properties.

The qualitative investigation of phytochemical analysis carried out on the leaves from the methanol extracts of *Acanthus ilicifolius* revealed the presence of medicinally important constituents such as alkaloids, saponins, phenolics, flavonoids, steroids, cardiac glycosides, tannins and terpenoids,

which may account for antioxidant effects of these plants tested. Similarly, *H. curassavicum* methanol extracts showed the presence of all phytochemicals except cardiac glyco-sides (Chinnathambi et al.2021). A detailed study on *A. marina* leaves ethyl acetate extract (MEE) was analyzed by GC-MS, and a total of 22 (88.5%) constituents were identified and quantified in the extract (Table 1). The chemical composition of mangrove ethyl acetate extract mostly constituted of alcohol (33.97%), fatty acids and their derivatives (18.13%). The major components in MEE were found to be 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl) (31.13%), b-Sitosterol (11.58%), 1,2-Benzenedicarboxylic acid (5.26%), and Bergamotol (4.43%) (Hassan et al., 2022)

GC-MS analysis:

Gas chromatography-Mass spectroscopy of *Lumnitzera racemosa* methanol leaf extract revealed the peaks that indicated the occurrence of different compounds. The mass spectral finger print of compounds identified using the data library, the compound names are listed in (Table 1). This study revealed the presence of different bioactive compounds mainly: furfurals and fatty acids. In vitro anticancer activity on MCF 7 and HeLa cancer cells using MTT assay of bioactive compounds present in *L. racemosa* revealed significant cytotoxic activity against MCF 7 with IC50 value, 46.098 mg/mL and HeLa cells with IC50 value of 59.497 mg/mL, indicating leaf extracts has high anticancer activity on MCF 7 cells in comparison with HeLa cell lines (G. Eswaraiah, K. Abraham Peele et al., 2020).

Species	Compounds	References
A. Officinalis leaves	Trans-cinnamic acid (27.7%), 2,4-Di-tert-butylphenol (3.33%), Phenol, 3-(2-phenylethyl (3.31%), n-hexadecanoic acid (18.79%), Dibutyl phthalate (100%) Phytol (2.47), b _ Sitosterol (5.9%), Androst-7-ene-6 and 17- dione, 2,3,14-trihydroxy (6.69%)	Lalitha Parthiban et al.
A. Officinalis	hydroxyl - 4 methoxybenzoic acid diethyl phthalate Oleic acid	Bhimba et al. 2010
A. marina	Benzaldehyde,3-methyle (6.811), 2-Methoxy-4-vinylphenol (9.211), Cyclobuta (1,2:3,4)dicyclooctene,hexadec (11.669), Benzeneethanol,4-hydroxy (12.173), 4-(2,6,6-Trimethylcyclohexa-1,3-dienyl)b (13.709), Lycorenan-7-one,9,10dimethoxy-1-methyl (14.531), 1,2-Dicarboxy-3-(4,chlorophenyl)2,3(1H) (23.249), Phenol,2-(1,1-dimethylethyl)-4-(1-methyl (23.350), Methyl p-(2-phenyl-1-benzimidazolyl)benz (26.490)	Aseer Manilal et al. 2016
A. marina	2-cyclohexen-1-one, 4-hydroxy-3,5,5-trimethyl-4- (3-oxo-1-butenyl) (8.6%), phytol (8.4 %), hexadecanoic acid, ethyl ester (6.2 %) 3,7,11,15-tetramethyl-2-hexadecen- 1-ol (4.9 %)	Dayanidhi, Ajith kumar et al. 2012
C. decandra leaves		Vundru Anil Kumar, Kandru Ammani et al. (2013
Methanol extract	1,3-Diolein (triterpene) RT 21.557 Lupeol (triterpene) RT28.708 Stigmast-5- en-3-ol, oleate (steroid) RT 26.011 Glycidol stearate (esters) RT 20.067 Methyl linolenate (ester) RT 21.518 Clionasterol (triterpene) RT 27.760	
Chloroform extract	Phthalic acid dioctyl ester (ester) RT22.030 squalene (triterpene) RT24.022 Stigmast-5-en-3-ol, (3.beta.) (steroid)RT27.783	

	α-amyrin (triterpene) RT28.250
	Lupeol (triterpene) RT28.855
Ethanol extract	1H-Purin-6-amine, [(2-fluorophenyl)methyl] (purines or alkaloids) RT21.151
	A-Neooleana-3(5),12-diene (alkene) RT24.941
	9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-,acetate,(3. β,4. α.,5. α.) (steroid) RT25.942
	Stigmast-5-en-3-ol, (3.beta.) (steroid) RT26.016
	9,19-Cycloergost-24(28)-en-3-ol, 4,14-dimethyl-, acetate (steroid) RT26.405
	Cycloartenol (alcohol) RT26.450
	Methyl commate B RT28.710
	Fumaric acid, tetradec-3-enyl tridecyl ester (ester) RT28.979
A. marina leaves	Hassan, Ibrahim, Hala et al.
(Ethyl acetate extract)	4.06 12,15-Octadecadiynoic acid, methyl ester 0.63 %
	7.00 Cyclohexanol,1-methyl-4-(1-methylethenyl)-, acetate 3.12%
	8.87 Undecane 2.36 %
	12.82 2-Cyclohexen-1-one, 2-methyl-5-(1-methylethen yl) 1.13%
	19.76 Bergamotol, Z-à-trans 4.43 %
	21.76 Diethyl phthalate 2.58 %
	23.15 2-Furanmethanol, tetrahydro-à,à,5-trimethyl-5-(4-meth yl-3-cyclohexen-1-yl)
	23.79 5,8,11,14-Eicosatetraenoic acid, methyl ester, (all-Z)- 2.90 %
	25.182H-Pyran-3-ol,tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-,[3S-
[3à,6à(R*)]]- 31.13%	27.27 E-8-Methyl-9-tetradecen-1-ol acetate 0.91 %
	27.74 1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester 5.26 %
	28.01 (E)-Tonghaosu 1.45 %
	28.94 Pentadecanoic acid, 14-methyl-, methyl ester 1.03 %
	29.71 Hexadecanoic acid 2.59 %
	32.15 Ethyl (9z,12z)-9,12-octadecadienoate 1.09%
	32.28 9-Octadecenoic acid (z)- 2.05 %
	32.51 Phytol 2.33 %
	33.04 12-Methyl-e,e-2,13-octadecadien-1-ol 1.93 %
	39.81 1,2-Benzenedicarboxylic acid 4.36 %
	42.53 Campesterol 1.90 %
	43.24 Stigmasterol 3.89 %
	44.08 á-Sitosterol
Lumnitzera racemosa leaf	G. Eswaraiah et al. 2020
(Methanol extract)	5.568 Furfural
	9.041 2-Furan Carboxaldehyde, 5-methyl
	14.227 2-FuranCarboxaldehyde-5-(hydroxyl methyl)
	19.496 Benzyle chloride
	22.407 Hexa decanoic acid – methyl ester
Avicennia alba leaf	G. Eswaraiah et al. 2020
(Methanol extract)	14.202 Catechol borane
	15.344 2-Methoxy -4- vinyl phenol
	17.465 Cyclohepta Siloxane, Tetra deca methyl 9.317%
	18.042 Neophytadiene (7,11,15 Trimethyle -3- methylene -1- hexadecene 16.989%
	18.234 Hexadecanoic acid 29.499%
	19.496 Docosanoic acid (Behenic acid) 4.079%
	21.249 3,7,11,15 Tetra methyl -2-hexadecene-1-ol 1.481%
	21.343 3- (3-Fluoro anilino)- 1- (3-nitrophenyl) -1- Propanone 7.954%
	22.406 Hexa decanoic acid – methyl ester 2.386%
	24.265 Phytol 2.337%
	27.404 Alpha amyrin 8.219%
	27.645 Docosanoic acid, Methyl ester 2.277%
Bruguiera gymnorrhiza	Khadeeja S, Ragunathan et.al. (2022)
(Methanol extract)	23.4844 Butanoic acid
	23.9434 Succinic acid, pent-4-enyl propyl ester
	24.0194 2-Pentenoic acid, 4-oxo-, methyl ester
	24.3651 Thiazolidine, 3-methyl-
	7.6253 6,7,8-Trimethoxy-3,4-dimethyl-1-methylsulfanyl-3,4-dihydroisoquinoline
	23.8980 L-Leucine, methyl ester
	7.1880 2-Furancarbonitrile
	16.6974 Glutaric acid, di(4-cyanophenyl) ester
	24.0022 1-Dodecanamine, N-dodecyl
	28.6250 9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)
	37.8775 Coumarine, 4-methyl-7-hydroxy-8-benzoyl-
Excoecaria agallocha	Khadeeja S, Ragunathan et.al. (2022)

(Methanol extract)	4.1048 Acetylacetone
	6.8916 Trifluoroguanidine
	8.1685 Picolinamide
	8.5621 p-Aminotoluene
	16.7231 Phthalic acid, hexyl 2-propylphenyl ester
	20.3128 Enanthamide
	20.3916 Cyclopentanecarboxaldehyde
	21.2097 Benzamide, 4-fluoro-N-allyl-
	22.0511 L-Leucine, ethyl ester
	23.5800 1,3-Dioxolane
	26.5490 Octanamide, N-(2-butyl)-N-heptyl-
	31.7868 2H-1-Benzopyran-2-one, 3,4-dihydro-6-hydroxy-
	37.7123 Glutaric acid, 2-methylpent-3-yl 2,2,3,4,4,4- hexafluorobutyl ester

Table1: Bioactive compounds identified from different mangroves and their percent composition with retention times in minutes

GC-MS analytical studies proved that the leaf extract of *Avicennia alba* contain a high content of phenolic compounds. GC-MS chromatogram of methanolic leaf extract of *Avicennia alba* have showed 12 peaks indicating presence of 12 compounds (G. Eswaraiah, K. Abraham Peele et al., 2020) The spectral fingerprint of each compound can be identified from the data library. From the chromatogram peaks, found different bioactive leads which includes: terpenoids, silicones, phenolic compounds and fatty substances (Table 1). Among all, one unknown compound was found i.e., 3- (3-Fluoroanilino)-1-(3-nitrophenyl)- 1-propanone (7.954%), which was not reported previously and it is first time reported from mangrove plant *Avicenia alba*. In MTT assay, cell line viability of treated cells decreased gradually with increase of the sample concentration. The methanol extract showed potent cytotoxicity against Human breast adeno carcinoma (MCF7) and HeLa cell lines, the viability of cancerous cells is reduced to 44.68% for MCF 7 and 35.89% for HeLa cells.

Conclusion:

Emergence of multidrug-resistant bacteria has become a major source of concern around the world, and pharmaceutical waste is a major reservoir of these bacteria. Pharmaceutical waste, which consists of unwanted or expired medicines that are thrown into the environment without being properly treated and disposed, is responsible for the emergence of multidrug-resistant bacteria in the environment. According to research findings, the four isolated strains of *Staphylococcus aureus*, *Staphylococcus* sp., *Staphylococcus saprophyticus*, and *Aeromonas jandaei* were resistant to practically all antibiotics available as they acquired antibiotic resistance through gene transfer. Before being dumped, pharmaceutical waste should be processed and make them non hazardous (Amrun Naher et al., 2022). The developing enthusiasm for the complementary and alternative medicines is principally due to disadvantages related with the traditional chemotherapies and the supposed advantages of more natural treatment alternatives.

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References:

1. Bandaranayake, W.M., 2002. Bioactivities, bioactive compounds and chemical constituents of mangrove plants. Wetl. Ecol. Manag. 10 (6), 421–452.
2. C.N. Duke, J.A. Allen, (2006) *Rhizophora mangle, R. samoensis, R. racemosa, R. harrisonii* (Atlantic–East Pacific Red Mangrove). Species Profiles for Pacific Island Agroforestry, 10, 1–18
3. Wu, J., Xiao, Q., Xu, J., Li, M. Y., Pan, J. Y., Yang, M. H., 2008. Natural products from true mangrove flora: source, chemistry and bioactivities. Nat. Prod. Rep. 25(5), 955– 981.
4. Reddy, T., Rajasekhar, A., Jayasunderamma, B., Ramamurthi, R., 1991. Studies on marine bioactive substances from the Bay of Bengal: Bioactive substances from the latex of the mangrove plant Excoecaria agallocha L.: Antimicrobial activity and degradation. In: Thompson, M.F., Sarojini, R., Nagabhushanam, R. (Eds.), Bioactive Compounds from Marine Organisms with Emphasis on the Indian Ocean. Oxford & IBH Publishers Co. Pvt. Ltd, New Delhi, pp. 75–78.
5. Bose, S., Bose, A., 2008. Antimicrobial activity of Acanthus ilicifolius (L.). Indian J. Pharm. Sci. 70 (6), 821–823.
6. D'Autr´eaux, B., Toledano, M.B., 2007. ROS as signaling molecules: mechanisms that generate specificity in ROS homeostasis. Nat. Rev. Mol. Cell Biol. 8 (10), 813–824.
7. Premanathan, M., Arakaki, R., Izumi, H., Kathiresan, K., Nakano, M., Yamamoto, N., Nakashima, H., 1999a. Antiviral properties of a mangrove plant, Rhizophora apiculata Blume, against human immunodeficiency virus. Antivir. Res. 44 (2), 113–122.
8. Khafagi, I., Gab-Alla, A., Salama, W., Fouda, M., 2003. Biological activities and phytochemical constituents of the gray mangrove Avicennia marina (Forssk.) Vierh. Egypt. J. Exp. Biol. 5 (1), 62–69.
9. Edu, E.A.B., Edwin-Wosu, N.L., Udensi, O.U., 2015. Evaluation of bioactive compounds in mangroves: a panacea towards exploiting and optimizing mangrove resources. J. Nat. Sci. Res. 5 (23), 1–9.
10. Chandrasekaran, M., Kannathasan, K., Venkatesalu, V., Prabhakar, K., 2009. Antibacterial activity of some salt marsh halophytes and mangrove plants against methicillin resistant Staphylococcus aureus. World J. Microbiol. Biotechnol. 25 (1), 155–160.
11. Abeysinghe, P.D., Pathirana, R.P., Wanigatunge, R.N., 2006. Evaluation of antibacterial activity of different mangrove plant extracts. Ruhuna J. Sci. 1, 104–112.
12. Abeysinghe, P.D., 2010. Antibacterial activity of some medicinal mangroves against
13. Alamgir, M., Rob, M., Kundu, D., Joy, J., Sarder, M., 2007. Bioactivity of two medicinal plant Xylocarpus granatum Koen. (Meliaceae) and Sarcolobus globosus Wall. (Asclepiadaceae) of Sundarbans mangrove forest. Orient. Pharm. Exp. Med. 7 (4), 379–384.
14. Patra, J.K., Thatoi, H.N., 2011b. Metabolic diversity and bioactivity screening of mangrove plants: a review. Acta Physiol. Plant. 33 (4), 1051–1061.
15. Bhimba, B.V., Meenupriya, J., Joel, E.L., Naveena, D.E., Kumar, S., Thangaraj, M., 2010. Antibacterial activity and characterization of secondary metabolites isolated from mangrove plant Avicennia officinalis. Asian Pac. J. Trop. 3 (7), 544–546.
16. D' Souza, L., Wahidullah, S., Devi, P., 2010. Antibacterial phenolics from the mangrove Lumnitzera racemosa. Indian J. Mar. Sci. 39 (2), 294–298.
17. Kumar, V.A., Ammani, K., Siddhardha, B., 2011. In vitro antimicrobial activity of leaf extracts of certain mangrove plants collected from Godavari estuarine of Konaseema delta. India. Int. J. Med. Arom. Plants 1 (2), 132–136.

18. Saranraj, P., Sujitha, D., 2015. Mangrove medicinal plants: a review. Am. Eur. J. Tox. 7 (3), 146-156.
19. H. Janmanchi, A. Raju, M.S. Degani, M.K. Ray, M.G.R. Rajan, Antituberculosis, antibacterial and antioxidant activities of Aegiceras corniculatum, a mangrove plant and effect of various extraction processes on its phytoconstituents and bioactivity, South African Journal of Botany, Volume 113, 2017, Pages 421-427, ISSN 0254-6299, https://doi.org/ 10.1016/j. sajb.2017. 09.019.
20. Thatoi, H., Patra, J., Das, S., 2014. Free radical scavenging and antioxidant potential of mangrove plants: a review. Acta Physiol. Plant. 36(3), 561-579.
21. Jithesh, M., Prashanth, S., Sivaprakash, K., Parida, A.K., 2006. Antioxidative response mechanisms in halophytes: their role in stress defence. J. Genet. 85 (3), 237-254.
22. Krishnamoorthy, M., Sasikumar, J., Shamna, R., Pandiarajan, C., Sofia, P., Nagarajan, B., 2011. Antioxidant activities of bark extract from mangroves, Bruguiera cylindrica (L.) Blume and Ceriops decandra Perr. Indian J. Pharmacol. 43 (5), 557-562.
23. Patra, J.K., Panigrahi, T.K., Rath, S., Dhal, N.K., Thatoi, H., 2009. Phytochemical screening and antimicrobial assessment of leaf extracts of Excoecaria agallocha L.: a mangal species of Bhitarkanika, Orissa, India. Adv. Nat. Appl. Sci. 3 (2), 241-246.
24. Banerjee, D., Chakrabarti, S., Hazra, A.K., Banerjee, S., Ray, J., Mukherjee, B., 2008. Antioxidant activity and total phenolics of some mangroves in Sundarbans. Afr. J. Biotechnol. 7 (6).
25. Malik, N., Zin, Z.M., Razak, S., Ibrahim, K., Zainol, M.K., 2017. Antioxidative activities and flavonoids contents in leaves of selected Mangrove species in Setiu Wetlands extracted using different solvents. J. Sustain. Sci. Manag. 3, 14-22.
26. Yin, S., Fan, C. Q., Wang, X. N., Lin, L. P., Ding, J., Yue, J. M., 2006. Xylogranatins A□ D: novel Tetranortriterpenoids with an unusual 9, 10-s eco scaffold from Marine mangrove xylocarpus granatum. Org. Lett. 8(21), 4935-4938.
27. Kathiresan, K., 2000. A review of studies on Pichavaram mangrove, Southeast India. Hydrobiologia 430 (1-3), 185-205.
28. Kathiresan, K., Boopathy, N.S., Kavitha, S., 2006. Coastal vegetation- an underexplored source of anticancer drugs. Nat. Prod. Radiance 5 (2), 115-119.
29. Subhan, N., Alam, A., Ahmed, F., Shahid, I.Z., 2008a. Antinociceptive and gastroprotective effect of the crude ethanolic extracts of Excoecaria agallocha Linn. Turk. J. Pharm. Sci. 5, 143-154.
30. Tian, M., Dai, H., Li, X., & Wang, B., 2009. Chemical constituents of marine medicinal mangrove plant Sonneratia caseolaris. *Chin. J. Oceanol. Limnol.*, 27(2), 288.
31. Das, G., Gouda, S., Mohanta, Y.K., Patra, J.K., 2015. Mangrove plants: A potential source for anticancer drugs. Indian J. Geo-Mar. Sci. 44 (5), 666-672.
32. Das, S.S., 2020. Qualitative determination of phytochemical constituents and antimicrobial activity of the mangrove plant Avicennia alba Blume. Int. J. Res. Anal. Rev. 7 (1), 627-633.
33. Patra, J.K., Das, S.K., Thatoi, H., 2015. Phytochemical profiling and bioactivity of a mangrove plant, Sonneratia apetala, from Odisha Coast of India. Chin. J. Integr. Med. 21 (4), 274-285.
34. Prabhu, V.V., Guruvayoorappan, C., 2012a. Anti-inflammatory and anti-tumor activity of the marine mangrove Rhizophora apiculata. J. Immunotoxicol. 9 (4), 341-352.
35. Sari, D.P., Basyuni, M., Hasibuan, P.A., Sumardi, S., Nuryawan, A., Wati, R., 2018. Cytotoxic and antiproliferative activity of polyisoprenoids in seventeen mangroves species against WiDr colon cancer cells. Asian Pac. J. Cancer Prev. 19 (12), 3393-3400.

36. Huang, C., Lu, C.K., Tu, M.C., Chang, J.H., Chen, Y.J., Tu, Y.H., Huang, H.C., 2016. Polyphenol-rich Avicennia marina leaf extracts induce apoptosis in human breast and liver cancer cells and in a nude mouse xenograft model. Oncotarget 7 (24), 35874–35893.
37. Patil, R., Manohar, S.M., Upadhye, M.V., Katchi, V., Rao, A.J., Mule, A., Moghe, A.S., 2011. Antireverse transcriptase and anticancer activity of stem ethanol extracts of Excoecaria agallocha (Euphorbiaceae). Ceylon J. Sci. (Biol. Sci.) 40 (2), 147–155.
38. Batsa, A., Periyasamy, K., 2013. Anticancer activity of Excoecaria agallocha leaf extract in cell line model. Int. J. Pharm. Biol. Sci. 3, 392–398.
39. Habib MA, Khatun F, khatun Ruma M, Kabir AH, Chowdhury AR S, Rahman A, and Hossain MI. A Review On Phytochemical Constituents of Pharmaceutically Important Mangrove Plants, Their Medicinal Uses and Pharmacological Activities. VRI Phytomedicine 2018; 6:1-6.
40. V. Sachithanandam, N. Saravanane, K. Chandrasekar, P. Karthick, P. Lalitha, S. Sai Elangovan, M. Sudhakar, Microbial diversity from the continental shelf regions of the Eastern Arabian Sea: A metagenomic approach, Saudi Journal of Biological Sciences, Volume 27, Issue 8, 2020, Pages 2065-2075, ISSN 1319-562X,
41. Hassan A.H. Ibrahim, Hala H. Abdel-Latif, Eman H. Zaghloul, Phytochemical composition of Avicennia marina leaf extract, its antioxidant, antimicrobial potentials and inhibitory properties on Pseudomonas fluorescens biofilm, Egyptian Journal of Aquatic Research, Volume 48, Issue 1, 2022, Pages 29-35, ISSN 1687-4285, https://doi.org/10.1016/j.ejar.2021.10.007.
42. P. Lalitha, A. Parthiban, V. Sachithanandam, R. Purvaja, R. Ramesh, Antibacterial and antioxidant potential of GC-MS analysis of crude ethyl acetate extract from the tropical mangrove plant Avicennia officinalis L., South African Journal of Botany, Volume 142, 2021, Pages 149-155, ISSN 0254-6299,
43. N.B. Dhayanithi, T.T. Ajith Kumar, R. Ganesha Murthy, K. Kathiresan, Isolation of antibacterials from the mangrove, Avicennia marina and their activity against multi drug resistant Staphylococcus aureus, Asian Pacific Journal of Tropical Biomedicine, Volume 2, Issue 3, Supplement, 2012, Pages S1892-S1895, ISSN 2221-1691, https://doi.org/10.1016/S2221-1691(12)60516-4.
44. Das, S.K., Samantaray, D., Mahapatra, A., Pal, N., Munda, R., Thatoi, H., 2018. Pharmacological activities of leaves and bark extracts of a medicinal mangrove plant *Avicennia officinalis* L. Clin. Phytosci. 4, 13.
45. P. Lalitha, A. Parthiban, V. Sachithanandam, R. Purvaja, R. Ramesh, Antibacterial and antioxidant potential of GC-MS analysis of crude ethyl acetate extract from the tropical mangrove plant *Avicennia officinalis* L., South African Journal of Botany, Volume 142, 2021, Pages 149-155, ISSN 0254-6299,
46. Okla, M.K., Alatar, A.A., Al-Amri, S.S., Soufan, W.H., Ahmad, A., Abdel-Maksoud, M.A., 2021. Antibacterial and antifungal activity of the extracts of different parts of *Avicennia marina* (Forssk.). Vierh. Plants 10 (2), 252.
47. Muhammad Sohaib, Fahad N.I. Al-Barakah, Hussein M. Migdadi, Fohad Mabood Husain, Comparative study among *Avicennia marina, Phragmites australis, and Moringa oleifera* based ethanolic-extracts for their antimicrobial, antioxidant, and cytotoxic activities, Saudi Journal of Biological Sciences, Volume 29, Issue 1, 2022, Pages 111-122, ISSN 1319-562X,
48. In vitro Assessment of Antibacterial and Antioxidant Activity of *Rhizophora apiculata* leaf extracts Sravya M.V.N., Sampath Kumar N.S., Dirisala Vijaya R., Sai Kiran G.V.S.D. and

Simhachalam G. *Res. J. Biotech.;* Vol. 18(6); 58-65; doi: https://doi.org/10.25303/1806rjbt058065; (2023)

49. Hassan A.H. Ibrahim, Hala H. Abdel-Latif, Eman H. Zaghloul, Phytochemical composition of *Avicennia marina* leaf extract, its antioxidant, antimicrobial potentials and inhibitory properties on Pseudomonas fluorescens biofilm, Egyptian Journal of Aquatic Research, Volume 48, Issue 1, 2022, Pages 29-35, ISSN 1687-4285,
50. Basil N. Ita, Samuel I. Eduok, In vitro antioxidant and antifungal activities of *Rhizophora racemosa* G.F.W. Mey. stem bark extracts, Scientific African, Volume 15, 2022, e01091, ISSN 2468-2276,
51. Saleh Amer, M., Zaghloul, E.H., Ibrahim, M.I.A., 2020. Characterization of exopolysaccharide produced from marine-derived *Aspergillus terreus* SEI with prominent biological activities. Egyptian Journal of Aquatic Research 46 (4), 363-369.
52. Natwar Jha, Palanichamy Esakkiraj, Asaikkutti Annamalai, Avinash Kant Lakra, Sanjay Naik, Venkatesan Arul, Synthesis, optimization, and physicochemical characterization of selenium nanoparticles from polysaccharide of mangrove *Rhizophora mucronata* with potential bioactivities, Journal of Trace Elements and Minerals, Volume 2, 2022, 100019, ISSN 2773-0506,
53. Momtazi-Borojeni AA, Behbahani M, Sadeghi-Aliabadi H. Antiproliferative activity and apoptosis induction of crude extract and fractions of *Avicennia marina*. Iran J Basic Med Sci. 2013 Nov;16(11):1203-8. PMID: 24494074; PMCID: PMC3909633.
54. Shan Tian, Kandasamy Saravanan, Ramzi A. Mothana, Govindan Ramachandran, Govindan Rajivgandhi, Natesan Manoharan, Anti-cancer activity of biosynthesized silver nanoparticles using *Avicennia marina* against A549 lung cancer cells through ROS/mitochondrial damages, Saudi Journal of Biological Sciences, Volume 27, Issue 11, 2020, Pages 3018-3024, ISSN 1319-562X,
55. V. Vinod Prabhu and C. Guruvayoorappan Journal of Immunotoxicology, 2012; 9(4): 341-352 Informa Healthcare USA, Inc.ISSN 1547-691X DOI: 10.3109/1547691X.2012.660997 Journal of Immuno toxicology 21 January 2012 1547-691X1547-6901© Informa Healthcare USA, Inc.10.3109/1547691X.2012.6609972012 Anti-inflammatory and anti-tumor activities of R. apiculata
56. Tung Thanh Bui,1 Khanh Phuong Thi Nguyen,1 Phung Phi Kim Nguyen,2 Dung Tien Le , 1,3 and Thuy Le Thi Nguyen, Anti-Inflammatory and α-Glucosidase Inhibitory Activities of Chemical Constituents from Bruguiera parviflora Leaves Journal of Chemistry Volume 2022, Article ID 3049994, 9 pages https://doi.org/10.1155/2022/3049994
57. Pharmacognosy Research, Volume 11, Issue 3, July-September, 2019 BADARINATH KULKARNI, et al.: Neuroprotective and Anti-inflammatory Activities of Aegiceras corniculatum (L.) Blanco
58. KAUR, S.; SYED ALI, M.; ANURADHA, V.; SUGANYA, V.; ASHASHALINI, A.; BHUVANA, P. *In vitro* anti-inflammatory activity of mangrove plant *Rhizophora mucronata* Lam. (Malpighiales: Rhizophoraceae). Braz. J. Biol. Sci. [online]. 2018, vol. 5, No. 10, p. 417-426. ISSN 2358-2731. DOI: 10.21472/bjbs.051018
59. Jhonatta Alexandre Brito Dias, Antonio Carlos Vital Júnior, Fábio Miguel Santos Costa, Priscilla Yevellin Barros de Melo Lima, Helimarcos Nunes Pereira, Iranildo José da Cruz Filho, Cristiane Moutinho Lagos de Melo, Teresinha Gonçalves da Silva, Ivone Antônia de SouzaAntioxidant, anti-inflammatory and antimicrobial activities promoted by hydroalcoholic extract of *Laguncularia racemosa* (l) c.f. leaves Gaert, *International Journal of Advanced Engineering*

Research and Science (IJAERS) ISSN: 2349-6495(P) | 2456-1908(O)Vol-9, Issue-9; Sep, 2022 Article DOI: https://dx.doi.org/10.22161/ijaers.99.15

60. Yu, Szu-Yin, Shih-Wei Wang, Tsong-Long Hwang, Bai-Luh Wei, Chien-Jung Su, Fang-Rong Chang, and Yuan-Bin Cheng. 2018. "Components from the Leaves and Twigs of Mangrove *Lumnitzera racemosa* with Anti-Angiogenic and Anti-Inflammatory Effects" *Marine Drugs* 16, no. 11: 404. https://doi.org/10.3390/md16110404
61. Sayantani Mitra, Nabanita Naskar, Punarbasu Chaudhuri, A review on potential bioactive phytochemicals for novel therapeutic applications with special emphasis on mangrove species, Phytomedicine Plus, Volume 1, Issue 4, 2021, 100107, ISSN 2667-0313,
62. Bhimba, Valentin & Jaganathan, Priya & Joel, Elsa Lycias & Naveena, D & Kumar, Suman & Thangaraj, Muthusamy. (2010). Antibacterial activity and characterization of secondary metabolites isolated from mangrove plant *Avicennia officinalis*. Asian Pacific Journal of Tropical Medicine. 3. 412-420. 10.1016/S1995-7645(10)60131-9.
63. Khadeeja S, Ragunathan R, Johney J, Muthusamy K (2022) Phytochemical Analysis, Antimicrobial and Antioxidant Activity of Mangrove Plants *Bruguiera gymnorrhiza* (L.) Lam. And *Excoecaria agallocha* L.. Indian Journal of Science and Technology 15(47): 2594-2604. https://doi.org/ 10.17485/IJST/v15i47.1633
64. Aseer Manilal, Tsegaye Tsalla, Zerihun Zerdo, Gemechu Ameya, Behailu Merdekios, Shiju Easo John, Evaluating the antibacterial and anticandidal potency of mangrove, *Avicennia marina*, Asian Pacific Journal of Tropical Disease, Volume 6, Issue 2, 2016, Pages 136-140, ISSN 2222-1808
65. Satyavani, K., Gurudeeban, S., Manigandan, V., Rajamanickam, E., Ramanathan, T., 2015. Chemical compositions of medicinal mangrove species *Acanthus ilicifolius, Excoecaria agallocha, Rhizophora apiculata* and *Rhizophora mucronata*. Curr. Res. Chem. 7, 1-8.
66. Raola, V.K., Chakraborty, K., 2017. Two rare antioxidative prenylated terpenoids from loop-root Asiatic mangrove *Rhizophora mucronata* (Family Rhizophoraceae) and their activity against pro-inflammatory cyclooxygenases and lipoxidase. Nat. Product Res. 31, 418-427.
67. Vundru Anil Kumar, Kandru Ammani, Busi Siddhardha, Uppalapati Sreedhar, Gudapati Aravind Kumar, Differential biological activities of the solvent extracts of *Ceriops decandra* (Griff.) and their phytochemical investigations, Journal of Pharmacy Research, Volume 7, Issue 7, 2013, Pages 654-660, ISSN 0974-6943,
68. Chinnathambi Pothiraj, Paulraj Balaji, Ramkumar Shanthi, Muthukrishnan Gobinath, Rangasamy Suresh Babu, Abdullah Al-Dosary Munirah, Atef Hatamleh Ashraf, Kamatchi Ramesh Kumar, Veeramani Veeramanikandan, Ramasubramanian Arumugam, Evaluating antimicrobial activities of *Acanthus ilicifolius L. and Heliotropium curassavicum* L against bacterial pathogens: an in-vitro study, Journal of Infection and Public Health, Volume 14, Issue 12, 2021, Pages 1927-1934, ISSN 1876-0341,
69. G. Eswaraiah, K. Abraham Peele, S. Krupanidhi, M. Indira, R. Bharath Kumar, T.C. Venkateswarulu, GC-MS analysis for compound identification in leaf extract of Lumnitzera racemosa and evaluation of its in vitro anticancer effect against MCF7 and HeLa cell lines, Journal of King Saud University - Science, Volume 32, Issue 1,

2020, Pages 780-783, ISSN 1018-3647,

70. G. Eswaraiah, K. Abraham Peele, S. Krupanidhi, R. Bharath Kumar, T.C. Venkateswarulu,Studies on phytochemical, antioxidant, antimicrobial analysis and separation of bioactive leads of leaf extract from the selected mangroves, Journal of King Saud University - Science, Volume 32,

Issue 1,2020, Pages 842-847, ISSN 1018-3647, https://doi.org/10.1016/ j.jksus. 2019. 03.002.

71. G. Eswaraiah, K. Abraham Peele, S. Krupanidhi, R. Bharath Kumar, T.C. Venkateswarulu, Identification of bioactive compounds in leaf extract of *Avicennia alba* by GC-MS analysis and evaluation of its in-vitro anticancer potential against MCF7 and HeLa cell lines, Journal of King Saud University - Science, Volume 32, Issue 1, 2020, Pages 740-744, ISSN 1018-3647,
72. Antimicrobial activity of mangrove plant (*Lumnitzera littorea*) Shahbudin Saad1*, Muhammad Taher2, Deny Susanti3, Haitham Qaralleh3, Nurul Afifah Binti Abdul Rahim3, Asian Pacific Journal of Tropical Medicine (2011)523-525
73. N.B. Dhayanithi, T.T. Ajith Kumar, R. Ganesha Murthy, K. Kathiresan, Isolation of antibacterials from the mangrove, *Avicennia marina* and their activity against multi drug resistant *Staphylococcus aureus*, Asian Pacific Journal of Tropical Biomedicine, Volume 2, Issue 3, Supplement, 2012, Pages S1892-S1895, ISSN 2221-1691,
74. Rajendra, Seepana & Karthick, Perumal & Kada, Narayana Murthy & CH, Ramesh & Mohanraju, Raju & Annamalai, Vijayakumar. (2016). Evaluation of antimicrobial properties from the mangrove *Rhizophora apiculata* and *Bruguiera gymnorrhiza* of Burmanallah coast, South Andaman, India. Journal of Coastal Life Medicine. 4. 475-478. 10.12980/jclm.4.2016J6-52.
75. G. Eswaraiah, K. Abraham Peele, S. Krupanidhi, R. Bharath Kumar, T.C. Venkateswarulu, Studies on phytochemical, antioxidant, antimicrobial analysis and separation of bioactive leads of leaf extract from the selected mangroves, Journal of King Saud University - Science, Volume 32, Issue 1, 2020, Pages 842-847, ISSN 1018-3647,
76. Sahoo G, Mulla NS, Ansari ZA, Mohandass C. Antibacterial Activity of Mangrove Leaf Extracts against Human Pathogens. Indian J Pharm Sci. 2012 Jul;74(4):348-51. doi: 10.4103/0250-474X.107068. PMID: 23626390; PMCID: PMC3630730.
77. Dr. Surya shekhar das, "Qualitative Determination Of Phytochemical Constituents And Antimicrobial Activity Of The Mangrove Plant *Avicennia Alba* Blume", IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348-1269, P- ISSN 2349-5138, Volume.7, Issue 1, Page No pp.627-633, February 2020,
78. Souza, Lisette D., Solimabi Wahidulla, and Prabha Devi. "Antibacterial phenolics from the mangrove *Lumnitzera racemosa*." (2010). Indian Journal of Marine Sciences, vol. 39(2), pp. 294-298
79. Amrun Naher, Md Moniruzzaman, Shirmin Islam, Abdullah Hasan, Gobindo Kumar Paul, Tabassum Jabin, Suvro Biswas, Shahriar Zaman, Md Abu Saleh, Md Salah Uddin, Evaluation of biological activity and in silico molecular docking studies of *Acanthus ilicifolius* leaf extract against four multidrug-resistant bacteria, Informatics in Medicine Unlocked, Volume 33, 2022, 101092, ISSN 2352-9148.