

# VEDIC RESEARCH INTERNATIONAL Phytomedicine

eISSN 2330-0280

JOURNAL HOME PAGE AT [WWW.VRIPRESS.COM](http://WWW.VRIPRESS.COM)

## MINI REVIEW

DOI: <http://dx.doi.org/10.14259/pm.v6i1.220>

## A Review On Phytochemical Constituents of Pharmaceutically Important Mangrove Plants, Their Medicinal Uses and Pharmacological Activities.

**MD AHASUN HABIB<sup>1</sup>, FAHMIDA KHATUN<sup>1\*</sup>, MASTURA KHATUN RUMA<sup>2</sup>, ASM HOMAUN KABIR CHOWDHURY<sup>1</sup>, AL RUMANAN SILVE<sup>3</sup>, ARRAYF RAHMAN<sup>4</sup>, MD IMRAN HOSSAIN<sup>4</sup>**

<sup>1</sup>Department of Biotechnology, Bangladesh Agricultural University, Mymensingh-2202. <sup>2</sup>Department of Biotechnology and Genetic Engineering, Jahangirnagar University, Dhaka-1342. <sup>3</sup>Northern International Medical College and Hospital, Dhaka-1205. <sup>4</sup>Department of Biotechnology and Genetic Engineering, Khulna University, Khulna 9208

**Article Info:** Received: November 3rd, 2017; Accepted: March 21st, 2018

## ABSTRACT

Mangrove plants are salt tolerant, distributed in tropical and subtropical zones around the globe. Nowadays, these mangrove plants have become a major topic of discussion in aspect of bioprospecting of pharmaceutically important bioactive compounds. Moreover, different parts of mangrove plants are used in folklore medicines for having some curative and protective properties against different diseases. This review discusses about different phytochemicals derived from leaves, barks, stems, roots, flowers, fruits and seeds of mangrove plants. The most valuable bioactive compounds obtained from these plants are polyphenols, flavonoids, alkaloids, carotenoids, tannins, saponins, steroids, aminoacids, carbohydrates, proteins, vitamins etc. This review also shows pharmacological activities of mangrove plants including antimicrobial (such as antibacterial, antiviral and antifungal), antiinflammatory, anti-ulcer, antidiarrhoeal, anticancer, antidiabetic, anti-HIV, antinociceptive, hepato-protective, anti-arthritis, analgesic, antioxidant and cytotoxic activities.

**Keywords:** mangrove plants, phytochemicals, antioxidants, medicinal uses, pharmacological activities.

## Introduction

Mangroves are the halophytic and salt resistant oceanic tidal forests consisting of epiphytes, shrubs, palms, ground ferns, grasses and trees which are connected in groves or stands [1]. According to living environment of the mangrove flora, it is usually classified into two subgroups such as true mangrove and semi-mangrove [2]. From the very beginning of human civilization, people have been using different parts of these mangrove plants in different types of clinical conditions either consciously or subconsciously. Mangroves plants are mainly valuable in aspect of their bioactive compounds like antioxidants.

Antioxidant can inhibit a specific oxidizing enzyme or reacts with oxidizing agents prior to causing damage to other molecules [3]. Recently, scientists replace synthetic antioxidants with natural antioxidants from plant materials because of the carcinogenic properties of the synthetic antioxidants [4]. *Rhizophora mucronata*, *Thespesia populneoides*, *Sonneratia apetala* and *Avicennia marina* are good sources of natural antioxidants among selected mangrove plants [5]. More than 200 bioactive metabolites are isolated from true mangroves of tropical and subtropical populations [2]. By their chemical structure, alkaloids, flavonoids, saponins, tannins, steroids, triterpenes and phenolics are the most important isolated compounds which have a vast range of therapeutic possibilities [6].

Mangroves are traditionally used for feed, food (fruits and nectar) and medicinal purposes in all over the world. Several

\*Corresponding Author

**Dr. Fahmida Khatun**

Department of Biotechnology, Bangladesh Agricultural University, Mymensingh 2202

Email: [fahmida.meem@bau.edu.bd](mailto:fahmida.meem@bau.edu.bd)



mangrove plants viz. *Avicennia africana*, *A. officinalis*, *A. marina*, *Sonneratia caseolaris*, *Acanthus ilicifolius*, *Aegiceras majus*, *Ceriops candolleana*, *Excoecaria agallocha*, *Kandelia rhecdi*, *Nypa fruticans*, *Rhizophora mucronata* and *R. mangle* are widely used by local medical practitioners in many countries like South America, Australia, Africa, South East Asia and India. These mangrove plants are used for the treatment of several skin diseases, leprosy, ulcers, tuberculosis, elephantiasis, malaria and dysentery [7]. The mangrove plants have also been traditionally used for the remedy of asthma, painful arthritis, rheumatism, inflammation and diabetes [8]. They can produce natural metabolites with different biological activities such as antioxidant, hepatoprotective, mosquito larvicidal, antibacterial, antifungal, antiviral, antidiarrhoeal, antifeedant, insecticidal and cytotoxic activity [9,10].

This review focuses on phytochemicals and antioxidant potentials, traditional and medicinal uses, biological and pharmacological activities exhibited by diverse mangrove plants of the world.

## Phytochemical Constitutes of Mangrove Plants

The common phytochemical constituents of mangrove plants are alkaloids, carotenoids, aliphatic alcohols, amino acids, free fatty acids, carbohydrates, hydrocarbons, pheromones, lipids, steroids, triterpenes, tannins and phenols [11]. Antioxidant activity and flavonoid contents are reported in leaves of mangrove species (*Avicennia alba*, *Bruguiera cylindrica*, *Bruguiera sexangula*, *Rhizophora apiculata* and *Lumnitzera racemosa*) in Setiu Wetlands. The species are selected according to their popularities, benefits, most studied and uses on antioxidant activity and flavonoid contents [12]. *Rhizophora* species (such as *Rhizophora apiculata*, *Rhizophora mucronata* and *Rhizophora mangle*) are sources of well known and medically useful secondary products such as alkaloids, glycosides, essential oils and other organic compounds [13]. Primarily, plant phenolics are sources of natural antioxidants which may occur in all parts of the plants such as leaves, roots, barks, fruits, vegetables, nuts and seeds [14]. *R. apiculata* is widely used in charcoal industry in Malaysia and its bark is able to produce high yields of tannins [15]. Tannins are often determined by reducing power and scavenging activities [16].

*Excoecaria agallocha* indicates the presence of polyphenols, saponins, alkaloids, tannins, carotenoids, chalcones, cyclitol, excoecaria toxins, fluratoxin, glycerides of fatty acids, lipids, phorbol esters, polysaccharides, proteins, sugars, steroids, diterpenes, triterpenes, cytosporon B and C and phomopsin A, B, C [17]. Leaves and stems of *Sesuvium portulacastrum*

indicate the presence of phytochemicals including alkaloids, tannins and terpenoids. Its major phytoconstituents are 3, 5, 4- trihydroxy-6, 7-dimethoxyflavone 3-glucoside; trans-4-hydroxyprolinebetaine and praline [18]. Fruit of *Sonneratia apetala* contains polyphenols, flavonoids, anthocyanins, vitamin C contents and antioxidants [19]. Steroids, fatty acids, hydrocarbons, sugars and pectins are isolated from *Sonneratia caseolaris* [20]. Both the plant *Sonneratia alba* and *Bruguiera cylindrical* reveal presence of phytochemicals such as alkaloids, flavonoids, tannins, saponins, triterpenes and anthraquinones [21]. Flavonoids (rutin, isovitexin, vitexin, isoorientin), triterpinoids (ursolic acid and 2a, 3a, 23-trihydroxyurs-12-en-28-oic acid) and tannins (punicalagin, punicalin, terflavins A and B, tergallagin, tercatatin, chebulagic acid, geranin, granatin B, corilagin) are the phytochemicals of *Terminalia catappa* [22].

Mansonone-D, mansonone-H, thespone and thespesone have been extracted from heart wood of *Thespesia populnea*. Its bark reveals the presence of phytochemicals such as quercetin, gossypol, tannin, acacetin and leaf extract is the source of  $\beta$ -sitosterol, lupeol and lupenone [23]. The flowers of *T. populnea* contain kaempferol, kaemperol-7-glucoside and gossypetin. Its fruit kernels also contain  $\beta$ -sitosterol, ceryl alcohol and thespesin [24]. Flavonoids, alkaloids, phenolic acids, steroids, monoterpenes, triterpenoids, tetraterpenoids and limonoids are isolated from the leaves, stems, barks and fruits of *Xylocarpus* species [25]. Numerous alkaloids have been reported in the fruits, roots and barks extracts of *Xylocarpus granatum* [26]. Four alkaloids such as acetonyl dihydrochelerythrine, N-methyl flindersine, chelerythrine and dihydrochelerythrine were isolated from the root barks of *X. granatum* [27]. Flavonoids like catechin and epicatechin have been reported in the bark of *Xylocarpus moluccensis* [28]. Different phytochemical constituents present in different mangrove plants have been shown in Table 1.

## Medicinal Uses of Mangrove Plants

Depending on WHO (World Health Organization) data, more than 80% of world resident rely on using plant for their medicine and mangroves have been widely used for that purpose. Mangrove plants play an important role in the remedy of fever, kidney stone, toothache, sore throat, dysentery, malaria, constipation, fungal infections, rheumatism etc. [6]. *Acanthus ilicifolius* is a mangrove plant used against asthma, rheumatism, snake bite and paralysis, while its root, leaf, bark and stem have been used for prevention of tumor growth and cancer progression [29,30]. Recently, Rege *et al.* found that *Avicennia* species have diverse medicinal properties against HIV, cancer, diarrhoea,

**Table1: Phytochemical Constituents of Mangrove Plants**

Botanical name	Used plant parts	Phytochemicals	References
<i>Acanthus ilicifolius</i>	Leaves, flowers and roots	Steroids, terpenoids, triterpenoids, lignans, phenolics, saponins, flavonoids, alkaloids, tannins and anthraquinones.	[11,54-56]
<i>Acrostichum aureum</i>	Aerial parts and leaves	Alkaloids, glycosides, saponins, tannins, steroids, phenols, polyphenols, flavonoids, terpenoids and reducing sugars.	[57-59]
<i>Aegiceras corniculatum</i>	Barks, stems, leaves and roots	Flavonoids, hydroquinones, benzoquinones, polyphenols, lignans, tannins, sterols, sitosterols, stigmasterols, pentacyclics, triterpenes, saponins, gallic acids and syringic acids.	[11,60-62]
<i>Alstonia macrophylla</i>	All organs, leaves, stems, barks and roots	Alkaloids, flavonoids, iridoids, triterpenoids, pytosterols, saponins, tannins and simple phenolics.	[63-65]
<i>Avicennia alba</i>	Leaves, barks and stems	Saponins, flavonoids, alkaloids, tannins, triterpenes, steroids and carbohydrates.	[66]
<i>Avicennia marina</i>	Leaves, barks, stems and seeds	Polyphenols, flavonoids, alkaloids, tannins, betulinic acids, lupeols, carboxylic acids, phytoalexins, steroids, phytosterols, tocopherols, terpenes, fatty acids, proteins, xanthoproteins, sugars, resins, coumarins and glycosides.	[67-70]
<i>Avicennia officinalis</i>	Whole plant, leaves, barks and stems	Alkaloids, flavanoids, terpenoids, phenolics, tannins, sterols, glycosides, amino acids, proteins, resins, reducing sugars, saponins, carbohydrates, steroids, phenols, cardiac glycosides and catechols.	[71-73]
<i>Bruguiera cylindrica</i>	Leaves, stems, barks and fruits	Tannins, triterpenes, flavonoids, saponins and alkaloids.	[21,74,75]
<i>Bruguiera gymnorhiza</i>	Leaves and barks	Steroids, flavonoids, phenols, hydroquinones, tannins, saponins, terpenoids, gums and reducing sugars.	[32,76-78]
<i>Bruguiera parviflora</i>	Fruits and leaves	Triterpenoids, lupenones, ascorbic acids, carotenoids, proteins, sugars, tannins and phenolics.	[11,79,80]
<i>Bruguiera sexangula</i>	Stems and barks	Triterpenoids, bruguines, benzoquinones, phenolics, phenolic glycosides, flavonoids, lignans, alkaloids, tropines and acetic acid esters.	[81,82]
<i>Ceriops decandra</i>	Leaves, barks and roots	Sugars, proteins, phenolics, alkaloids, anthraquinones, triterpenoids, flavonoids, catechins, tannins, carbohydrates, lipids, monosaccharides, steroids, cardiac glycosides and saponins.	[11,83-86]
<i>Derris trifoliata</i>	Seeds, stems, leaves and roots	Flavanones, alkaloids, flavonoids, saponins, tannins, steroids and triterpenoids.	[87,88]
<i>Excoecaria agallocha</i>	Leaves, stems, barks and roots	Alkaloids, saponins, phenols, steroids, glycosides, tannins, flavonoids, amino acids, proteins, carbohydrates, lipids, ascorbic acids, diterpenoids, triterpenoids, fats and gums.	[89-92]
<i>Heritiera littoralis</i>	Fruits, leaves, stems and barks	Alkaloids, polyphenols, carotenoids, tannins, amino acids, carbohydrates, fatty acids, flavonoids, lipids, polysaccharides, proteins, saponins, sesquiterpenes, aliphatic carboxylic acids, sugars, triterpene esters, tribulosides and pentacyclic triterpenoids.	[2,11,93,94]
<i>Ipomoea pes-caprae</i>	Aerial parts, leaves, stems and roots	Alkaloids, steroids, flavonoids, phenols, tannins, glycosides, sugars, proteins, saponins, quinines, amino acids, terpenoids, carbohydrates, monosaccharides, oligosaccharides, free anthraquinones, polyphenols and soluble starches.	[95-98]
<i>Melaleuca leucadendron</i>	Leaves, fruits and barks	Flavonoids, alkaloids, steroids, phenolhydroquinones, phenolics, triterpenoids, tanins, saponins, monoterpenes and sesquiterpenes.	[99-101]
<i>Morinda citrifolia</i>	Leaves, fruits and roots	Phenolic compounds, flavonoids, organic acids, caproic acids, caprylic acids, ursolic acids, alkaloids, proteins, anthraquinones, sugars, soluble solids, dietary fibers, vitamins, proxeronines, alcohols, esters, ketones, lactones, scopoletins, glycosides, polysaccharides, iridoids, lignans, trisaccharides and triterpenoids.	[102-105]
<i>Pongamia pinnata</i>	Leaves, seeds, barks and flowers	Phenolics, fatty acids, amino acids, alkaloids, glycosides, flavonoids, fixed oils, carbohydrates, saponins, $\beta$ -sitosterols, tannins, resins, sugars, phytosterols and triterpenes.	[106-108]

**Table2: Medicinal Uses of Mangrove Plants**

Botanical name	Plant parts	Medicinal uses	References
<i>Derris trifoliata</i>	Aerial parts, leaves, roots and stems	Cure for calculus, asthma, fever, sores, rheumatism, chronic paralysis, dysmenorrheal, diarrhea, dysentery, cuts and wounds. Used as carminative, laxative and anti-arthritis agent.	[109,110]
<i>Heritiera fomes</i>	Seeds, leaves, roots, barks and stems	Treatment of hepatitis, jaundice, abscess, eczema, acne, boils, scabies, itch, infections, dermatitis, rash, sores, scar, warts, diarrhea, dysentery, indigestion, colic, acidity, constipation, bloating, stomachache, goiter and diabetes.	[35,111,112]
<i>Rhizophora mucronata</i>	Leaves, roots, fruits and flowers	Treatment of constipation, elephantiasis, haematoma, hepatitis, febrifuge, diarrhea or gastric motility disorder, diabetes, inflammation, wounds, ulcers, fertility related and menstruation disorders.	[6,113,114]
<i>Sesuvium portulacastrum</i>	Leaves	Remedy for fever, kidney disorders, scurvy, various infections, epilepsy, conjunctivitis, dermatitis, haematuria, leprosy, purgative, toothache, dysentery and diarrhea.	[115,116]
<i>Sonneratia Alba</i>	Fruits	To expel intestinal parasites, to treat coughs, skin injuries, swellings and sprains.	[6,50]
<i>Sonneratia apetala</i>	Fruits and leaves	To treat gastrointestinal disorders (such as diarrhea, dysentery, indigestion, colic, acidity and stomachache).	[111]
<i>Sonneratia caseolaris</i>	Fruits	To treat sprain poultices, bleeding, hemorrhages, piles and toxicity against mosquito larvae. Used as an astringent and antiseptic.	[6,117]
<i>Terminalia catappa</i>	Leaves, fruits and barks	Cure for dysentery, headache, scabies, leprosy, colic, liver diseases, internal parasites, eye problems and rheumatism.	[118-120]
<i>Thespesia populnea</i>	Leaves, fruits and barks	Remedy for swollen joints, hepatitis, jaundice, ulcers, wounds, scabies, guinea worm infections, urinary tract infections, diabetes, cholera, cough, asthma, dysentery, hemorrhoids and various skin diseases including psoriasis.	[121,122]
<i>Xylocarpus moluccensis</i>	Barks, leaves and fruits	Cure for fever, gastrointestinal disturbances (such as cholera, dysentery, diarrhea), headaches, fatigue, chest pains joint pains, buccal pains, stomach pains, swelling of the breast, aphrodisiac, elephantiasis, scabies, constipation and candidacies.	[28,123,124]

hepatitis, diabetes, inflammation, oxidative stress-related diseases etc. [31]. Resin of *Avicennia alba* is used in birth control, ulcers treatment, remedy of skin diseases and also used to cure tumors. The bark and seed of *A. alba* are used as a fish poison [6]. The bark of *Bruguiera gymnorrhiza* is used to cure malaria and diarrhea in the Solomon Islands and its leaf is used to treat burns. Its stem is also used to cure viral fever, while its root and bark are used in the treatment of diabetes [32].

*Ceriops decandra* is used as a traditional medicine for diabetes, diarrhea, dysentery, angina, wounds and boils [33]. *Excoecaria agallocha* has traditional medicinal values against sores, stings, ulcers, epilepsy, leprosy, paralysis, rheumatism, dermatitis and conjunctivitis [34]. The decoction of stem and seed of *Heritiera littoralis* is traditionally used to cure dysentery, diarrhoea, stomach aches and also used in the control of mosquitoes [35]. *Ipomoea pes-caprae* is commonly used to treat jelly-fish bite and in ritual baths to alleviate evil spirits [36]. *I. pes-caprae* is used against various

diseases such as, dysentery, constipation, diabetes, hypertension, arthritis, meningitis, kidney ailments, hydrocephaly and fatigue in different parts of the world [37]. Its leaf is used for the treatment of rheumatism pain and inflammation [38].

Leaves and barks of *Melaleuca leucadendron* are used in folk medicine as sedating, tranquilizing, evil-dispelling and pain-relieving agents [39]. Noni juice extracted from Noni fruit (*Morinda citrifolia* L.) is the most effective product that is helpful to cure arthritis, high blood pressure, headache, muscle pain, heart failure, cancer and diabetes etc. [40]. Decoction expressed from *Pluchea indica* leaf is used to treat fever. The sap derived from its leaf is used to cure dysentery. A poultice of its leaf is applied externally to treat soothe sores and ulcers [41]. Whole parts of *Pongamia pinnata* are used as a crude medicine for the remedy of diarrhea, tumours, piles, abscess, ulcers and skin diseases etc. [42].

Mangrove plants including *Derris trifoliata*, *Heritiera fomes*,

*Rhizophora mucronata*, *Sesuvium portulacastrum*, *Sonneratia alba*, *Sonneratia apetala*, *Terminalia catappa*, *Thespesia populnea* and *Xylocarpus moluccensis* are reported to have been widely used against treatment of various diseases which are presented in Table 2.

## Biological and Pharmacological Activities of Mangrove Plants

Different mangrove species (such as *Sonneratia apetatala*, *Salvadora persica*, *Rhizophora mucrunata*, *Avicennia alba*, *A. officinalis*, *Bruguiera cylindrica* and *Excoecaria agallocha*) have been found for antimicrobial activity [43]. Significant pharmacological activities like antioxidant, anti-inflammatory, anticarcinogenic, antiosteoporotic and hepatoprotective activities have been demonstrated in extracts of *Acanthus ilicifolius* [44,45]. *Alstonia macrophylla* has showed different pharmacological and biological activities such as antioxidant, antimicrobial, antiprotozoal, antimalarial, antidiabetic, anti-inflammatory, antidiabetic, antipyretic, CNS depressant,

antifertility and antidiarrhoeal activities [46]. The leaf, pneumatophore and bark of *Ceriops decandra* are used for antidiabetic, antinociceptive, anti-inflammatory and antioxidant activities [47]. *Derris* species have antiviral, antibacterial ichthyotoxic, insecticidal, pesticidal, analgesic, antipyretic, antidiysenteric, antidiuretic and antispasmodic activity [48]. Root and stem of *Derris indica*, *D. elliptica* and *D. trifoliata* showed antimicrobial and antifungal properties [49]. Anti-HIV, anticancer, antiviral and antibacterial agent properties have been presented with clinical trials from *Excoecaria agallocha* [50]. Noni (*Morinda citrifolia* L.) has different therapeutic effects such as anthelmintic, analgesic, hypotensive, anti-inflammatory, antibacterial, antiviral, antifungal, antitumor, antimutagenic, anticarcinoma and anticlastogenic effects [40,51]. *Pongamia pinnata* possess antioxidant, antiinflammatory, antiplasmodial, antidiarrhoeal, antiulcer, antinociceptive, antihyperglycemic, antilipidperoxidative and antihyperammonic activity [52]. *Xylocarpus* species have a broad range of biological activities include antimicrobial, antimalarial, antifilarial, antifeedant, antidiarrhoeal, anticancer, antidyslipidemic and

**Table 3: Biological and Pharmacological Activities of Mangrove Plants**

Botanical name	Plant parts	Bioactivity test	References
<i>Avicennia marina</i>	Fruits and leaves	Antibacterial, antiplasmodial, antiviral, antimicrobial, antifungal, hepatoprotective, antioxidant, anti-arthritis, antinociceptive, anticancer and cytotoxic activity.	[125-127]
<i>Heritiera fomes</i>	Leaves, stems and barks	Antioxidant, anticancer, anti-inflammatory, antinociceptive, antihyperglycemic, antimicrobial, spermicidal, molluscicidal and cytotoxic activity.	[112,128,129]
<i>Melaleuca leucadendron</i>	Leaves	Antioxidant, antifungal, anti-hyaluronidase and anti-inflammatory activity.	[100,130]
<i>Pluchea indica</i>	Roots and leaves	Antioxidant, anti-amoebic, anti-inflammatory, antinociceptive, antidiabetic, antiulcer, anticancer, antituberculosis and antiophidian activity.	[131-133]
<i>Rhizophora apiculata</i>	Leaves, stems, barks, roots, fruits and flowers	Antibacterial, antiviral, antifungal, anti inflammatory, antidiarrheal, anti-diabetic, antiemetic, larvicidal, antioxidant, anti-ulcer, anti-HIV activity, analgesic, cytotoxic and hepatoprotective activity.	[134-137]
<i>Rhizophora mucronata</i>	Barks, leaves and fruits	Antidiabetic, anti diarrheal, antibacterial, antiviral, antifungal, anti inflammatory, anti-HIV, anti-septic, anti-ulcerogenic, mosquito larvicidal, antioxidant, hepatoprotective and antiplasmodial activity.	[9,136,138]
<i>Sesuvium portulacastrum</i>	Leaves, barks, stems, flowers and fruits	Antibacterial, antifungal, anti-inflammatory, antioxidant, antidiabetic, anticancer, antitumor, nematocidal and analgesic activity.	[116,139]
<i>Sonneratia apetala</i>	Leaves, seeds, barks and fruits	Antibacterial, antioxidant, antidiabetic, anticancer, anti-inflammatory, antihepatitis, analgesic, antidiarrhoeal, anthelmintic and cytotoxic activity.	[6,111,140]
<i>Terminalia catappa</i>	Seeds, leaves and barks	Antioxidant, antibacterial, antifungal, analgesic, anticolic, antihyperalgesic, anti-inflammatory, anticancer, anti-HIV reverse transcripts and hepatoprotective activity.	[141,142]
<i>Xylocarpus granatum</i>	Barks, seeds and stems	Tyrosinase and antioxidant activities, antidiarrhoeal, antibacterial, cytotoxicity, antifeedant, cardiotonic, antihyperglycemic and antidyslipidemic activity.	[143-145]

gastroprotective activity [53].

Biological and pharmacological activities of *Avicennia marina*, *Heritiera fomes*, *Melaleuca leucadendron*, *Pluchea indica*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Sesuvium portulacastrum*, *Sonneratia apetala*, *Terminalia catappa* and *Xylocarpus granatum* are summarised in Table 3.

## Conclusion

In this study, we have focused on different phytochemicals and antioxidants (including polyphenols, flavonoids, alkaloids, tannins, saponins, lignans, proteins, carbohydrates, steroids, resins etc.) derived from the extracts of mangrove plants which are used in medicinal purposes for human beings. Now-a-days, *Avicennia*, *Bruguiera*, *Excoecaria*, *Heritiera*, *Rhizophora*, *Sonneratia* and *Xylocarpus* species are the most important mangrove plants that can cure skin diseases, hepatic and gastrointestinal disorders, fungal infections etc. They also have different pharmacological activities such as antibacterial, antiviral, antifungal, anti-inflammatory, antidiarrhoeal and cytotoxic activities.

This review article may be valuable for different pharmaceutical companies in all over the world for the new drug discovery.

## References

1. Premanathan M, Kathiresan K, Nakashima H: **Mangrove halophytes: a source of antiviral substances.** *S Pac Study* 1999, **19**:49-57.
2. Wu J, Xiao Q, Xu J, Li MY, Pan JY, Yang M: **Natural products from true mangrove flora: source, chemistry and bioactivities.** *Nat Prod Rep* 2008, **25**:955-981.
3. Brewer MS: **Natural antioxidants: sources, compounds, mechanisms of action and potential applications.** *Comp Rev Food Food Saf* 2011, **10**:221-246.
4. Sasaki Y, Kawaguchi S, Kamaya A, Ohshita M, Kabasawa K, Iwama K, Taniguchi K, Tsuda S: **The comet assay with 8 mouse organs: results with 39 currently used food additives.** *Mutat Res* 2002, **519**:103-119.
5. Vadlapudi V, Naidu KC: **Evaluation of Antioxidant potential of selected mangrove plants.** *J Pharm Res* 2009, **2**(11): 1742-1745.
6. Bandaranayake WM: **Traditional and medicinal uses of mangroves.** *Mangroves and Salt Marshes* 1998, **2**:133-148.
7. Prabhakaran J, Kavitha D: **Ethnomedicinal importance of mangrove species of Pitchavaram.** *Int J Res Pharm Biomed Sci* 2012, **3**:611-614.
8. Roome T, Dar A, Naqvi S, Choudhary MI: **Evaluation of antinociceptive effect of *Aegiceras corniculatum* stems extracts and its possible mechanism of action in rodents.** *J Ethnopharmacol* 2011, **135**(2):351-358.
9. Babu BH, Shylesh BS, Padikkala J: **Antioxidant and hepatoprotective effect of *Acanthus ilicifolius*.** *Fitoterapia* 2001, **72**:272-277.
10. Rouf R, Uddin SJ, Shilpi JA, Alamgir M: **Assessment of antidiarrhoeal activity of the methanol extract of *Xylocarpus granatum* bark in mice model.** *J Ethnopharmacol* 2007, **109**:539.
11. Bandaranayake WM: **Bioactivities, bioactive compounds and chemical constituents of mangrove plants.** *Wet Ecol Manag* 2002, **10**:421-452.
12. Malik NH, Zin ZM, Razak SBA, Ibrahim K, Zainol MK: **Antioxidative activities and flavonoids contents in leaves of selected mangrove species in setiu wetland extracted using different solvents.** *J Sustain Sci Manag* 2017, **3**:24-34.
13. Afidah AR, Emmanuel R, Jein S, Jain MK, Sani MI, Hasnah O: **Antioxidant activities of mangrove *Rhizophora apiculata* bark extracts.** *Food Chem* 2008, **107**:200-207.
14. Loo AY, Jain K, Darah I: **Antioxidant and radical scavenging activities of the pyroligneous acid from a mangrove plant, *Rhizophora apiculata*.** *Food Chem* 2007, **104**:300-307.
15. Jain K, Afidah AR, Azman IM: **Anti-corrosive performance of wash primer based on mangrove tannin.** Proceedings of the 15<sup>th</sup> Symposium of Malaysian chemical Engineering, September 11-12, UTM, Malaysia, 2002: pp: 323-327.
16. Gulcin I, Oktay M, Kirecci E, Kufrevioglu OI: **Screening of antioxidant and antimicrobial activities of anise (*Pimpinella anisum* L.) seed extracts.** *Food Chem* 2003, **83**:371-382.
17. Huang Z, Cai X, Shao C, She Z, Xia X, Chen Y, Yang J, Zhou S, Lin Y: **Chemistry and weak antimicrobial activities of phomopsins produced by mangrove endophytic fungus *Phomopsis* sp. ZSU-H76.** *Phytochem* 2008, **69**:1604-1608.
18. Khajuria RK, Sun KA, Suri OP, Atal CK: **3, 5, 4-Trihydroxy 6, 7-dimethoxyflavone 3-glucoside from *Sesuvium Portulacastrum*.** *Phytochem* 1982, **21**:1179-1180.
19. Hossain SJ, Basar MH, Rokeya B, Arif KMT, Sultana MS, Rahman MH: **Evaluation of antioxidant, antidiabetic and antibacterial activities of the fruit of *Sonneratia apetala* (Buch.-Ham.).** *Orient Pharm Exp Med* 2013, **13**:95-102.
20. Hogg RW, Gillan FT: **Fatty acids, sterols and hydrocarbons in the leaves of eleven species of mangrove.** *Phytochem* 1984, **23**:93-97.
21. Gawali P, Jadhav BL: **Antioxidant activity and antioxidant phytochemical analysis of mangrove species *Sonneratia alba* and *Bruguiera cylindrica*.** *Asian J Microbiol Biotech Environ Sci* 2011, **13**(2):257-261.
22. Ahmed SA, Swamy BMV, Gopkumar P, Dhanapal R, Chandrashekar VM: **Anti-diabetic activity of *Terminalia catappa* Linn. leaf extracts in alloxan-induced diabetic rats.** *Iran J Pharmacol Therapeutic* 2005, **4**:36-39.
23. Parthasarathy R, Ilavarsan R, Karrunakaran CM: **Antidiabetic activity of *Thespesia populnea* bark and leaf extract against streptozotocin induced diabetic rats.** *Int J PharmTech Res* 2009, **1**:106-109.
24. Ghosh K, Bhattacharya TK: **Preliminary study on the anti-implantation activity of compounds from the extracts of seeds of *Thespesia populnea*.** *Indian J Pharmacol* 2004, **36**:288-291.
25. Edreva A, Velikova V, Tsonev T, Dagnon S, Gurel A: **Stressprotective role of secondary metabolites: diversity of functions and mechanisms.** *Gen Appl Plant Physiol* 2008, **34**:67-78.
26. Shen LR, Guo D, Yu YM, Yin BW, Zhao L: **Chemical constituents of plants from the genus *Xylocarpus*.** *Chem Biodivers* 2009, **6**:1293-1308.
27. Chou FY, Hostettmann K, Kubo I, Nakanishi K, Taniguchi M: **Isolation of an insect antifeedant N Methylflindersine and several benz (C) phenanthridine alkaloids from east African plants; a comment on chelerythrine.** *Heterocycles* 1977, **7**:969-977.
28. Wangenstein H, Alamgir M, Duong GM, Gronhaug TE, Samuelsen AB: **Chemical and biological studies of medicinal plants from the Sundarbans mangrove forest.** *Adv Phytother Res* 2009, **1**:59-78.
29. Subudhi HN, Choudhary BP, Acharya BS: **Some medicinal plants of Mahanadi Delta in state of Orissa.** *J Econ Taxon Bot* 1992, **16**:479-487.

30. Graham JG, Quinn ML, Fabricant DS, Farnsworth NR: **Plants used against cancer.** *J Ethnopharmacol* 2000, **73**:347-377.
31. Rege AA, Ambaye RY, Deshmukh RA: **In vitro testing of anti-HIV activity of some medicinal plants.** *Indian J Nat Prod Resour* 2010, **1**:193-199.
32. Haq M, Sani W, Hossain ABMS, Taha RM, Monneruzzaman KM: **Total phenolic contents, antioxidant and antimicrobial activities of *Bruguiera gymnorrhiza*.** *J Med Plants Res* 2011, **5**(17):4112-4118.
33. Duke JA, Wain KK: *Medicinal Plants of the World.* Longman Group Ltd, UK; 1981.
34. Prakash S, Khan M, Khan H, Zaman A: **A piperidine alkaloid from *Excoecaria agallocha*.** *Phytochem* 1993, **22**:1836-1837.
35. Patra JK, Thatoi HN: **Metabolic diversity and bioactivity screening of mangrove plants: a review.** *Acta Physiol Plant* 2011, **33**(4):1051-1061.
36. Pongprayoon U, Bohlin L, Sandberg F, Wasuwat S: **Inhibitory effect of *Ipomoea pes-caprae* on guinea ileum smooth muscle.** *Acta pharm Nordice* 1989, **1**(1):41-44.
37. Nair KV, Gopakumar K, Yaganarasimhan SN, Santha TR, Kesashavamurthy KR: **Medicco-botany of Andaman and Nicobar Island-IV (Ayurvedic Drugs-2).** *Anc Sci Life* 1986, **5**(3):191-196.
38. Naskar K, Bakshi DNG: **Vegetation pattern of the Sundarbans.** In mangrove swamps of the sundarbans- An ecological perspective, (NayaPrakash: Calcutta, India); 1995: 27-174.
39. Tsuruga T, Chun YT, Ebizuka Y, Sankawa U: **Biologically active constituents of *Melaleuca lecadendron*: inhibitors of induced histamine release from rat mast cells.** *Chem Pharm Bull* 1991, **39**:3276-3278.
40. Peter PI: **Clinical research on *Morinda citrifolia* L. -Noni.** *Noni Clin Res J* 2007, **1**(1,2):1-4.
41. Wiart C: **Medicinal plants of the Asia-Pacific: Drugs for the future?** World Science Publishing Co. Pte. Ltd, Singapore; 2006: 629-630.
42. Shoba GF, Thomas M: **Study of antidiarrhoeal activity of four medicinal plants in castor-oil induced diarrhoea.** *J Ethnopharmacol* 2001, **76**(1):73-76.
43. Mane S, Jadhav BL: **Pharmacognosical investigations of *Bruguiera cylindrica*.** In: Proceedings of National Symposium, Biosciences, Biotechnology and Bioenterprises 2004; 236-240.
44. Mani senthil kumar KT, Gorain B, Roy DK, Zothanpuia, Samanta SK, Pal M, Biswas P, Roy A, Adhikari D, Karmakar, Sen T: **Antiinflammatory activity of *Acanthus ilicifolius*.** *J Ethnopharmacol* 2008, **120**(1):7-12.
45. Singh A, Duggal S, Suttie A: ***Acanthus ilicifolius* Linn.- Lesser known medicinal plants with significant pharmacological activities.** *Ethnobot Leaf* 2009, **13**:431-436.
46. Khyade MS, Kasote DM, Vaikos NP: ***Alstonia scholaris* (L.) R. Br. and *Alstonia macrophylla* Wall. ex G. Don: a comparative review on traditional uses, phytochemistry and pharmacology.** *J Ethnopharmacol* 2014, **153**:1-18.
47. Uddin SJ, Shilpi JA, Barua J, Rouf R: **Antinociceptive activity of *Cerriops decandra* leaf and pneumatophore.** *Fitoterapia* 2005, **76**(2):261-263.
48. Telekone RS, Khan M: **Antiinflammatory and antioxidant activity of extracts and isolated compounds from *Derris brevipes* Benth (Baker).** *J Phytopharmacol* 2014, **3**(3):180-192.
49. Khan MR, Omoloso AD, Borevai Y: **Antimicrobial activity of *Derris elliptica*, *D. indica* and *D. trifoliata* extracts.** *Fitoterapia* 2006, **11**(4):327-330.
50. Peter KLN, Sivasothi N: **A guide to the mangroves of Singapore I: the ecosystem and plant diversity.** Singapore Science Centre; 1999: 136-137.
51. Furusawa E, Hirazumi A, Story S, Jensen J: **Antitumor potential of a polysaccharide-rich substance from the fruit juice of *Morinda citrifolia* (noni) on sarcoma 180 ascites tumour in mice.** *Phytother Res* 2003, **17**:1158-1164.
52. Sangwan, Savita, Rao DV, Sharma RA: **A review on *Pongamia pinnata* (L.) Pierre: a great versatile Leguminous plant.** *Nat Sci* 2010, **8**(11):130-139.
53. Ruscoe CNE: **Growth disruption effects of an insect antifeedant.** *Nat New Biol* 1992, **236**:159-160.
54. Firdaus M, Prihanto AA, Nurdiani R: **Antioxidant and cytotoxic activity of *Acanthus ilicifolius* flower.** *Asian Pac J Trop Med* 2013, **3**(1):17-21.
55. Li MY, Xiao Q, Pan JY, Wu J: **Natural products from semi-mangrove flora: source, chemistry and bioactivities.** *Nat Prod Res* 2009, **26**:281-298.
56. Rao PV, Sujana P, Vijayakanth T, Naidu MD: ***Rhinacanthus nasutus*-its protective role in oxidative stress and antioxidant status in streptozotocin induced diabetic rats.** *Asian Pac J Trop Dis* 2012, **2**(4):327-330.
57. Khan SA, Hossain MA, Panthi S, Asadujjaman M, Hossain A: **Assessment of antioxidant and analgesic activity of *Acrostichum aureum* Linn. (Family- Pteridaceae).** *Pharmacologyonline* 2013, **1**:166 - 171.
58. Thomas A, Peter KJP, Chandramohanakumar N: **A profiling of anti-tumour potential of sterols in the mangrove fern *Acrostichum aureum*.** *Int J Pharmacogn Phytochem Res* 2016, **8**:1828-1832.
59. Uddin SJ, Jason TL, Beattie KD, Grice D, Tiralongo E: **(2S, 3S)-Sulfated pterisin C, a cytotoxic sesquiterpene from the Bangladeshi mangrove fern *Acrostichum aureum*.** *J Nat Prod* 2011, **74**:2010-2013.
60. Zhang D, Wu J, Zhang S, Huang J: **Oleanane triterpenes from *Aegiceras corniculatum*.** *Fitoterapia* 2005, **76**:131-133.
61. Gomez E, Cruz-Giron O, Cruz AA, Joshi BS, Chittawong V, Miles DH: **Toxicants from mangrove plants, V. Isolation of the piscicide, 2-hydroxy-5-methoxy-3-undecyl-1, 4-benzoquinone (5-O-methylembelin) from *Aegiceras corniculatum*.** *J Nat Prod* 1989, **52**:649-651.
62. Xu M, Deng Z, Li M, Li J, Fu H, Proksch P, Lin W: **Chemical constituents from the mangrove plant, *Aegiceras corniculatum*.** *J Nat Prod* 2004, **67**:762-766.
63. Khyade MS, Vaikos NP: **Phytochemical and antibacterial properties of leaves of *Alstonia scholaris* R. Br.** *Afr J Biotechnol* 2009, **8**:6434-6436.
64. Parveen M, Khanam Z, Akhtar A, Ahmad SM: **A novel antimicrobial flavonoid glycoside from the leaves of *Alstonia macrophylla* Wall ex A. DC (Apocynaceae).** *Chin Chem Lett* 2010, **21**:593-595.
65. Kam TS, Choo YM: **New indole alkaloids from *Alstonia macrophylla*.** *J Nat Prod* 2004, **67**:547-552.
66. Nagababu P, Rao VU: **Antibacterial activity and phytochemical screening of leaves and stem extracts of *Avicennia alba* blume.** *Int J Appl Biol Pharm* 2012, **3**(4): 399-405.
67. Mehera SA, Ahmad VU, Saifullah SM, Mohammad FV, Ambreen K: **Steroids and triterpenoids from gray mangrove *Avicennia marina*.** *Pak J Bot* 2011, **43**(2): 1417-1422.
68. Ravikumar S, Gnanadesigan M, Suganthi P, Ramalakshmi A: **Antibacterial potential of chosen mangrove plants against isolated urinary tract infectious bacterial pathogens.** *Int J Med Med Sci* 2010, **2**(3):94-99.
69. Sharaf M, El-Ansari MA, Saleh NAM: **New flavonoids from *Aicennia marina*.** *Fitoterapia* 2000, **71**:274-277.
70. Poompozil S, Kumarasamy D: **Studies on some phytochemical constituents of some selected mangroves.** *J Artif Intell Res* 2014, **2**:590-592.
71. Shanmugapriya R, Ramanathan T, Renugadevi G: **Phytochemical characterization and antimicrobial efficiency of mangrove plants *Avicennia marina* and *Avicennia officinalis*.** *Int J Pharm Biol Arch* 2012, **3**:348-351.
72. Thirunavukkarasu P, Ramkumar L, Ramanathan T, Silambarasan G: **Antioxidant activity of selected coastal medicinal plants.** *World J Fish Mari Sci* 2010, **2**(2): 134-137.
73. Ganesh S, Vennila JJ: **Phytochemical analysis of *Acanthus ilicifolius* and *Avicennia officinalis* by GC-MS.** *Res J Phytochem* 2011, **5**:60-65.
74. Mahadevan B, Luch A, Bravo CF, Atkin J, Steppan LB, Pereira C, Kerkvliet NI, Baird WM: **Dibenzo [a,l] pyrene induced DNA adduct formation in lung tissue in vivo.** *Cancer Lett* 2005, **227**:25-32.

75. Takahashi KA: **Brugine from *Bruguiera cylindrica*. *Phytochem* 1975, **14**:1458.**
76. Homhual S, Bunyapraphatsara N, Kondratyuk T, Herunsalee A, Chaukul W, Puzzuto JM, Fong HHS, Zhang HJ: **Bioactive dammarane triterpenes from the mangrove plant *Bruguiera gymnorrhiza*. *J Nat Prod* 2006, **69**(3): 421-424.**
77. Rahman MA, Ahmed A, Shahid IZ: **Phytochemical and pharmacological properties of *Bruguiera gymnorrhiza* roots extract. *Int J Pharm Res* 2011, **3**(3):63-67.**
78. Sur TK, Hazra A, Hazra AK, Bhattacharyya D: **Antioxidant and hepatoprotective properties of Indian Sunderban mangrove *Bruguiera gymnorrhiza* L. leaf. *J Basic Clin Pharm* 2016, **7**(3):75-79.**
79. Chumkaew P, Kato S, Chantrapromma K: **A new triterpenoid ester from the fruits of *Bruguiera parviflora*. *Chem Pharm Bull* 2005, **53**(1):95-96.**
80. Basak UC, Singh S, Rout P: **Nutritional and antioxidant properties of some edible mangrove fruits used by rural communities. *J Agric Food Tech* 2016, **6**(1):1-6.**
81. Li L, Huang CG, Wang CY, Guoa YW: **Sexangulic acid, a new cytotoxic triterpenoid from the Chinese mangrove *Bruguiera sexangula*. *Nat Prod Res* 2010, **24**(11):1044-1049.**
82. Bao S, Deng Z, Fu H, Proksch P, Lin WH: **Diterpenes and disulfides from the marine mangrove plant *Bruguiera sexangula* var. *rhynchopetala*. *Helv Chim Acta* 2005, **88**:2757-2763.**
83. Rao VU, Nagababu P: **Pharmacological evaluation of *Ceriops decandra* (Griff.) Ding Hou stem extracts. *Int J Recent Sci Res* 2015, **6**(2):2783-2789.**
84. Banerjee D, Chakrabarti S, Hazra AK, Banerjee S, Ray J, Mukherjee B: **Antioxidant activity and total phenolics of some mangroves in Sundarbans. *Afr J Biotechnol* 2008, **7**(6):805-810.**
85. Anjaneyulu AS, Rao VL, Lobkovsky E, Clardy J: ***Ceriopsin E*: a new epoxy ent-kaurene diterpenoid from *Ceriops decandra*. *J Nat Prod* 2002, **65**(4):592-594.**
86. Ghosh A, Misra S, Dutta AK, Choudhury A: **Pentacyclic triterpenoids and sterols from seven species of mangrove. *Phytochem* 1985, **24**:1725-1727.**
87. Yenesew A, Twinomuhwezi H, Kabaru JM, Akala HM, Kiremire BT, Heydenreich M, Peter MG, Eyase FL, Waters NC, Walsh DS: **Antiplasmodial and larvicidal flavonoids from *Derris trifoliata*. *Bull Chem Soc Ethiop* 2009, **23**:409-414.**
88. Shamsuddin AA, Najiah M, Suvik A, Azariyah MN, Kamaruzzaman BY, Effency AW, John BA: **Antibacterial properties of selected mangrove plants against *Vibrio* species and its cytotoxicity against *Artemia salina*. *World Appl Sci J* 2013, **25**(2):333-340.**
89. Sofia S, Teresa MVM: **Investigation of bioactive compounds and antioxidant activity of *Excoecaria agallocha*, L. *Int J Pharm Sci Res* 2016, **7**(12):5062-5066.**
90. Patra JK, Mohapatra AD, Rath SK, Dhal NK, Thatoi H: **Screening of antioxidant and antifilarial activity of leaf extracts of *Excoecaria agallocha*, L. *Int J Integr Biol* 2009, **7**(1):9-15.**
91. Kang J, Chen RY, Yu DO: **A new isopimarane-type diterpene and a new natural atisane-type diterpene from *Excoecaria agallocha*. *J Asian Nat Prod Res* 2005, **7**:729-734.**
92. Singh CR, Kathiresan K, Anandhan S, Suganthi K: **Antioxidant and antibacterial activity of field grown and tissue cultured root callus of mangrove species. *European J Med Plants* 2014, **4**(6):723-742.**
93. Christopher R, Nyandoro SS, Chacha M, de Koning CB: **A new cinnamoyl-glycoflavonoid, antimycobacterial and antioxidant constituents from *Heritiera littoralis* leaf extracts. *Nat Prod Res* 2014, **28**(6):351-358.**
94. Yoshio T, Kanako M, Hidako S, Toshiya M, Eiji H, Anki T, Takakazu, Hideaki O: **A new phenylpropanoidglycerol conjugate from *Heritiera littoralis*. *Nat Med* 2000, **54**:22-25.**
95. Retna AM, Ethalsha P: **Phytochemical tests, antioxidant potential and TLC analysis of *Ipomoea pes caprae* and *Catharanthus roseus*. *Int J Nat Prod Res* 2014, **4**(2): 58-64.**
96. Rogelio PM, Edgar ES, Carolina EM: **Characterization of lipophilic pentasaccharides from beach morning glory (*Ipomoea pes-caprae*). *J Nat Prod* 2005, **68**(2):226-230.**
97. Huang D, Ou B, Prior RL: **The chemistry behind antioxidant capacity assays. *J Agric Food Chem* 2005, **53**:1841-1856.**
98. Ethalsha P, Retna AM: ***In vitro* studies of antibacterial and antioxidant activity of *Ipomoea pes-caprae* root extracts. *World J Pharm Sci* 2015, **3**(3):622-627.**
99. Kissinger, Yamani A, Thamrin GA, Muhayah NR: **Bioprospecting of kerangas forest as natural medicine material sources: screening phytochemistry compound of kerangas forest tree species. *J Wetlands Environ Manag* 2016, **4**(2):13-19.**
100. Surh J, Yun JM: **Antioxidant and anti-inflammatory activities of butanol extract of *Melaleuca leucadendron* L. *Prev Nutr Food Sci* 2012, **17**:22-28.**
101. Fu L, Xu BT, Xu XR, Qin XS, Gan RY, Li HB: **Antioxidant capacities and total phenolic contents of 56 wild fruits from South China. *Molecules* 2010, **15**:8602-8617.**
102. Shovic AC, Whistler WA: **Food sources of provitamin A and vitamin C in the American Pacific. *Trop Sci* 2001, **41**:199-202.**
103. Sang S, Cheng X, Zhu N, Stark RE, Badmaev V, Ghai G, Rosen R, Ho CT: **Flavonol glycosides and novel iridoid glycoside from the leaves of *Morinda citrifolia*. *J Agric Food Chem* 2001, **49**:4478-4481.**
104. Satwadhkar PN, Deshpande HW, Hashmi SI, Syed KA: **Nutritional composition and identification of some of the bioactive components in *Morinda citrifolia* juice. *Int J Pharm Pharm Sci* 2011, **3**(1):58-59.**
105. Su BN, Pawlus AD, Jung HA, Keller WJ, McLaughlin JL, Kinghorn AD: **Chemical constituents of the fruits of *Morinda citrifolia* (noni) and their antioxidant activity. *J Nat Prod* 2005, **68**:592-595.**
106. Mahendra, Giri, Rasika, Bhalke, Pal S: **Gastroprotective effect of hydroalcoholic leaves extract of *Pongamia pinnata*. *Int J Pharm Bio Sci* 2010, **1**(3):1-6.**
107. Yadav PP, Ahmad GA, Maurya R: **Furanoflavonoids from *Pongamia pinnata* fruits. *Phytochem* 2004, **65**:439-443.**
108. Li L, Li X, Shi C, Deng Z, Fu H, Proksch P, Lin W: **Pongamone A-E, five flavonoids from the stems of a mangrove plant, *Pongamia pinnata*. *Phytochem* 2006, **67**:1347-1352.**
109. Kambaska KB, Purandra M, Dyanidhi M: **Green leaves for diarrhoeal diseases used by the tribals of Kenojhar and Mayurbhanj district of Orissa, India. *Ethanobot Leaflet* 2006, **10**:305-328.**
110. Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A: **Agroforestry Database: a tree reference and selection guide version 4: 2009, 1-5.**
111. Mollik MAH, Hossan MSH, Paul AK, Taufiq-Ur-Rahman M, Jahan R, Rahmatullah M: **A comparative analysis of medicinal plants used by folk medicinal healers in three districts of Bangladesh and inquiry as to mode of selection of medicinal plants. *Ethanobot Res Appl* 2010, **8**:195-218.**
112. Ali M, Nahar K, Sintaha M: **An evaluation of antihyperglycemic and antinociceptive effects of methanol extract of *Heritiera fomes* Buch- Ham. (Sterculiaceae) barks in Swiss albino mice. *Adv Nat Appl Sci* 2011, **5**(2):116-121.**
113. Ravikumar S, Nazar S, Nuralshiefa A, Abideen S: **Antibacterial activity of traditional therapeutic coastal medicinal plants against some pathogens. *J Environ Biol* 2005, **26**(2):383-386.**
114. Liebezeit G, Rau MT: **New Guinean mangroves –traditional usage and chemistry of natural products. *Mar Biodivers* 2006, **36**:1-10.**
115. Rojas A, Hernandez L, Rogeho PM, Mata R: **Screening for antimicrobial activity of crude drug extracts and pure natural products from Mexican medicinal plants. *J Ethnopharmacol* 1992, **35**:127-149.**
116. Chandrasekaran M, Senthilkumar A, Venkatesalu V: **Antibacterial and antifungal efficacy of fatty acid methyl esters from the leaves of *Sesuvium portulacastrum* L. *Eur Rev Med Pharmacol Sci* 2011, **15**(7):775-780.**

117. Ghani A: *Medicinal plants of Bangladesh with chemical constituents and uses*. edn 2nd: Asiatic Society of Bangladesh, Dhaka; 2003; 228-229.
118. Fan YM, Xu LZ, Gao J, Wang Y, Tang XH, Zhao XN, Zhang ZX: **Phytochemical and anti-inflammatory studies on *Terminalia catappa***. *Fitoterapia* 2004, **75**:253-260.
119. Asiah O, Nurhanan YM, Ilham AM: **Determination of bioactive peptide (4.3 kda) as an aphrodisiac marker in six Malaysian plants**. *J Trop Forest Sci* 2007, **19**(1): 61-63.
120. Lex AJT, Barry E: *Terminalia catappa (Tropical almond) species profiles for Pacific Island*. *Agroforestry* 2006, **2**(2):1-20.
121. Sathyanarayana T, Sarita T, Balaji M, Ramesh A, Boini MK: **Antihyperglycemic and hypoglycemic effect of *Thespesia populnea* fruit in normal and alloxan-induced diabetes in rabbits**. *J Saudi Pharm* 2004, **12**:107-111.
122. Ilavarasan R, Vasudevan M, Anbazhagan S, Venkataraman S: **Antioxidant activity of *Thespesia populnea* bark extracts against carbon tetrachloride-induced liver injury in rats**. *J Ethnopharmacol* 2003, **87**:227-230.
123. Uddin SJ, Shilpi JA, Alam SM, Alamgir M, Rahman MT, Sarker SD: **Antidiarrhoeal activity of the methanol extract of the barks of *Xylocarpus moluccensis* in castor oil and magnesium sulphate-induced diarrhoea models in mice**. *J Ethnopharmacol* 2005, **101**(1-3):139-143.
124. Chong KY, Tan HTW, Corlett RT: **A checklist of the total vascular plant flora of Singapore: native, naturalised and cultivated species**. Raffles Museum of Biodiversity Research, National University of Singapore, Singapore; 2009:273.
125. Mahasneh AM: **Screening of some indigenous Qatari medicinal plants for antimicrobial activity**. *Phytother Res* 2002, **16**:751-753.
126. Gandomani MZ, Malatib EF: **Evaluation of protective efficacy of *Avicennia marina* (Forssk.) Vierh. leaves against complete Freund's adjuvant-induced arthritis in Wistar rats**. *Iran J Pharm Res* 2014, **13**(3):945-951.
127. Han L, Huang X, Dahse HM, Moellmann U, Fu HZ, Grabley S: **Unusual naphthoquinone derivatives from the twigs of *Avicennia marina***. *J Nat Prod* 2007, **70**(6):923-927.
128. Wangenstein H, Dang HCT, Uddin SJ, Alamgir M, Malterud KE: **Antioxidant and antimicrobial effects of the mangrove tree *Heritiera fomes***. *Nat Prod Commun* 2009, **4**(3):371-376.
129. Patra JK, Thatoi H: **Anticancer activity and chromatography characterization of methanol extract of *Heritiera fomes* Buch. Ham., a mangrove plant from Bhitarkanika, India**. *Orient Pharm Exp Med* 2013, **13**(2):133-142.
130. Rini P, Ohtani Y, Ichiura H: **Antioxidant, anti-hyaluronidase and antifungal activities of *Melaleuca leucadendron* Linn. leaf oils**. *J Wood Sci* 2012, **58**:429-436.
131. Biswas R, Dutta PK, Achari B, Bandyopadhyay D, Mishra M, Pramanik KC, Chatterjee TK: **Isolation of pure compound R/J/3 from *Pluchea indica* (L.) Less. and its anti-amoebic activities against *Entamoeba histolytica***. *Phytomedicine* 2007, **14**:534-537.
132. Roslida A, Erazuliana A, Zuraini A: **Anti-inflammatory and antinociceptive activities of the ethanolic extract of *Pluchea indica* (L.) Less leaf**. *Pharmacologyonline* 2008, **2**:349-360.
133. Widiawati PS, Budianta TDW, Gunawan DI, Wongso RS: **Evaluation antidiabetic activity of various leaf extracts of *Pluchea indica* Less**. *Int J Pharmacogn Phytochem Res* 2015, **7**(3):597-603.
134. Melchor G, Armenteros M, Fernandez O, Linares E, Fragas I: **Antibacterial activity of *Rhizophora mangle* bark**. *Fitoterapia* 2001, **72**:689-691.
135. Perera LMS, Ruedas D, Gómez BC: **Gastric antiulcer effect of *Rhizophora mangle* L.** *J Ethnopharmacol* 2001, **77**:1-3.
136. Rohini RM, Das AK: **A comparative evaluation of analgesic and anti-inflammatory activities of *Rhizophora mucronata* bark extracts**. *Pharmacologyonline* 2009, **1**:780-791.
137. Ramanathan T, Hariharan B, Ganesan K: **Antidiabetic activity of a coastal mangrove leaves of *Rhizophora mucronata***. *Plant Arch* 2008, **8**(2):931-933.
138. Chandrasekaran M, Kannathasan K, Venkatesalu V, Prabhakar K: **Antibacterial activity of some salt marsh halophytes and mangrove plants against methicillin resistant *Staphylococcus aureus***. *World J Microbiol Biotech* 2009, **25**:155-160.
139. Sheela D, Uthayakumari F: **GC-MS analysis of bioactive constituents from coastal sand Dune taxon – *Sesuvium portulacastrum* (L.)**. *Biosci Discov* 2013, **4**(1):47-53.
140. Patra JK, Das SK, Thatoi H: **Phytochemical profiling and bioactivity of a mangrove plant, *Sonneratia apetala*, from Odisha coast of India**. *Chin J Integr Med* 2015, **21**:274-285.
141. Federspil P, Wulkuw R, Zimmerman T: **Effect of standardized Myrtol in therapy of acute sinusitis**. *J Biol Sci* 2007, **76**(6):23-26.
142. Tan GT, Pezzuto JM, Kinghorn AD, Hughes SH: **Evaluation of natural products as inhibitors of human immunodeficiency virus type 1 (HIV-1) reverse transcriptase**. *J Nat Prod* 1991, **54**:143-154.
143. Alam MA, Sarder M, Awal MA, Sikder MMH, Daulla KA: **Antibacterial activity of the crude ethanolic extract of *Xylocarpus granatum* stem bark**. *Bangladesh J vet Med* 2006, **4**:69-72.
144. Vijai L, Mahendra S, Raghubir R: **Antidiarrhoeal activity in seed kernels of *Xylocarpus granatum***. *Asian J Pharm Boil Res* 2011, **1**:62-66.
145. Srivastava AK, Srivastava S, Srivastava SP, Raina D, Ahmad R: **Antihyperglycemic and antidyslipidemic activity in ethanolic extract of a marine mangrove *Xylocarpus granatum***. *J Pharm Biomed Sci* 2011, **9**:22.

**Note:** VRI Press, Vedic Research Inc. is not responsible for any data in the present article including, but not limited to, writeup, figures, tables. If you have any questions, directly contact authors.

Visit us @ [www.VRIPress.com](http://www.VRIPress.com) : DOI: <http://dx.doi.org/10.14259/pm.v6i1.220>

Copyright © 2013-2018 VRI Press, USA. All rights reserved.