PHARMACOLOGICAL ACTIVITY OF MANGROVE MEDICINAL PLANTS AGAINST PATHOGENIC BACTERIA AND FUNGI

K. KOLANJINATHAN
Division of Microbiology, Faculty of Science,
Annamalai University,
Annamalai Nagar, Chidambaram-608 002
Tamil Nadu,
India.

And

P. SARANRAJ
Assistant Professor of Microbiology,
Department of Biochemistry,
Sacred Heart College (Autonomous),
Tirupattu-635 601,
Tamil Nadu,
India.

Abstract

Mangrove plant extracts have been used for centuries as a popular method for treating several health disorders. Plant-derived substances have recently become of great interest owing to their versatile applications. In the present study, healthy leaves of Avicennia officinalis, Ceriops decandra and Acanthus ilicifolius were collected from the mangrove forest, Parangipet, Cuddalore District, Tamil Nadu, India. The leaves were shade dried and powdered by hand crushing. The preparations of different leaves extract was done through modified method. Three different solvents viz., methanol, chloroform and ethyl acetate were used to study the antimicrobial activity of herbal plants. Disc diffusion method was adopted for evaluation of antimicrobial activity of three different mangrove medicinal plant leaves. The antimicrobial activity of methanol, chloroform and ethyl acetate leaf extract of Avicennia officinalis, Ceriops decandra and Acanthus ilicifolius were studied in different concentrations (100 mg/ml, 200 mg/ml, 300 mg/ml). Among the three concentrations (100 mg/ml, 200, 300 mg/ml) used, maximum inhibitory zone was observed at 300 mg/ml followed by 200 mg/ml and 100 mg/ml. No zone of inhibition was observed in the negative DMSO control. Among the three plants, maximum inhibition activity was exhibited by Acanthus ilicifolius followed by Ceriops decandra and Avicennia officinalis.

Key words: Mangrove plants, *Avicennia officinalis*, *Ceriops decandra*, *Acanthus ilicifolius*, Pathogenic microorganisms and Antimicrobial activity.

Mangroves are woody trees or shrubs and the salt marsh halophytes are herbs and sledges. The mangrove plants are distributed in 121 countries and Pichavaram mangrove forest is one of the coastal ecosystems of Tamilnadu, India with rich vegetation. Mangroves are used in traditional medicine for the treatment of many diseases (Kirtikar and Basu, 1991). Mangrove forests are among one of the world's most productive tropical ecosystems and are highly potential because the ecosystem is always under stress which leads to the production of certain compounds for their survival. India harbors some of the best mangrove forests of the world which are located in the alluvial deltas of the major rivers such as the Ganga, Mahanadi, Godavari, Krishna, Cauvery and also on the bay of Andaman and Nicobar Islands (Mishra *et al*., 2005; Kathiresan and Rajendra, 2005; Thatoi and Biswal, 2008; Upadhyay *et al*., 2008; Upadhyay and Mishra, 2008; Mandal and Naskar, 2008). It covers about 6,749 sq km along the 7,516.6 km long coast line, including Island territories (Mandal and Naskar, 2008).

Mangrove plants have been used in folklore medicines and extracts from mangrove species have proven inhibitory activity against human, animal and plant pathogens. Several species of mangrove produce bioactive compounds that may control microbial growth (Miki *et al*., 1994). Also, preliminary studies have demonstrated that the mangrove plant extracts have antibacterial activity against pathogenic bacterial strains; *Staphylococcus* sp., *Escherichia coli* and *Pseudomonas* sp. and antibiotic resistant bacterial strains; *Staphylococcus* sp. and *Proteus* sp. (Ishibashi *et al*., 1993). Mangrove extracts can also be the possible sources of mosquito larvicides, antifungal, antiviral, anti-cancer and anti-diabetic compounds (Wu *et al*., 1997). Secondary metabolites like alkaloids, phenolics, steroids and terpenoids have been characterized from mangroves and have toxicological, pharmacological and ecological importance. However, these studies are restricted to the mangroves of muddy region. Only few species like *Pemphis acidula* are growing only in coral sand substrates (Philip *et al*., 2009).

Mangrove plant extracts have been used for centuries as a popular method for treating several health disorders. Plant-derived substances have recently become of great interest owing to their versatile applications. Mangroves are biochemically unique, producing a wide array of novel natural products. Mangrove and mangrove associates contain biologically active antiviral, antibacterial and antifungal compounds (Vadlapudi and Naidu, 2009). The effects of Mangrove extracts on some microorganisms including *Shigella* sp., *Staphylococcus* sp., *Pseudomonas* sp. has been reported in some studies in the area of pharmacology (Abeysinghe *et al*., 2006). Also different type of solvents

including ethanol, chloroform, ethyl acetate have been used for extraction (Ravikumar *et al*., 2010).

Mangrove forests not only play an essential role as the source of food for marine organisms but are also a good source of food for human consumption based on their nutrient potential (Carvalho, 2007; Lim *et al*., 2006). Several mangrove plants are consumed as medicinal plants in traditional medicine for many years (Bandaranayake, 2002). Some recent studies confirmed the medicinal properties in some mangrove plants which were consumed in folkloric medicine. For example, 3′,4′,5,7- Tetrahydroxy flavone isolated from *Sonneratia caseolaris*, a mangrove plant showed a significant inhibition activity against cell proliferation of SMMC-7721 human hepatoma cells in an *in vitro* cytotoxic assay carried out by Minqing *et al*. (2009).

At present, there is a need to search for new antimicrobial agents because infectious diseases are still a global problem because of the development and spread of drug-resistant pathogens. Encouraged by the idea of "Drugs from the Sea", the chemists have identified lots of bioactive compounds with novel structures from the rich marine bioresource in the recent fifty years. Among them, marine derived microbes have contributed an important proportion. Microbes have been known to be a major source of active compounds used in medicine. In the present study, three different mangrove medicinal plants were evaluated for its antimicrobial activity against human pathogens. The present study was aimed to assess the antimicrobial activity of methanol, chloroform and ethyl acetate extract of *Avicennia officinalis*, *Ceriops decandra* and *Acanthus ilicifolius* against human clinical pathogens.

Materials and Methods

Collection of Mangrove Plant Materials

Healthy leaves of mangrove plants *viz*., *Avicennia officinalis*, *Ceriops decandra* and *Acanthus ilicifolius* were collected from the mangrove forest, Parangipet, Cuddalore District, Tamil Nadu, India. The plant materials like leaves were washed thoroughly with tap water and then with sterilized distilled water for the removal of dust and sand particles. The leaves were shade dried and powdered by hand crushing. The powdered samples were hermetically sealed in separate polythene bags until the time of the extraction. This was used as the raw material for the extraction of antimicrobial compounds against the microbes used.

Test Microorganisms

Microorganisms chosen were obtained from the laboratory of Department of Microbiology, Annamalai University. The organisms used for this study were; *Staphylococcus aureus*, *Streptococcus* pyogenes, *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Aspergillus niger* and *Penicillium* sp. The bacterial isolates were confirmed

using Gram staining, motility test, platting on selective medium, catalase test, oxidase test and other biochemical test and also inoculating them on specific media. The fungal isolates were identified by Lactophenol cotton blue staining (LPCB) and plating of Sabouraud's Dextrose agar (SDA).

Evaluation of Mangrove Plant Leaf Extracts for Its Antimicrobial Activity

Preparation of Leaf Extract

The preparations of different leaves extract was done through modified method (Saranraj et al., 2012).

Methanol Extraction Method

The shade dried leaf materials were used for the methanol extraction procedure; about 5 gm of leaf powder were weighed and mixed with methanol (1:3 w/v) which was incubated for two days. After the incubation period, the slurry was filtered through Whattman No.1 filter paper in a beaker and allowed it for evaporation. The residue was dissolved with Dimethyl sulfoxide (DMSO) with different concentrations and checked it for its Antimicrobial activity.

Ethyl Acetate Extraction Method

The shade dried leaf materials were used for the ethyl acetate extraction procedure; about 5 gm of leaf powder were weighed and mixed with ethyl acetate (1:3 w/v) which was incubated for two days. After the incubation period, the slurry was filtered through Whattman No.1 filter paper in a beaker and allowed it for evaporation. The residue was dissolved with Dimethyl sulfoxide (DMSO) with different concentrations and checked it for its antimicrobial activity.

Chloroform Extraction Method

The shade dried leaf materials were used for the chloroform extraction procedure; about 5 gm of leaf powder were weighed and mixed with chloroform (1:3 w/v) which was incubated for two days. After the incubation period, the slurry was filtered through Whattman No.1 filter paper in a beaker and allowed it for evaporation. The residue was dissolved with Dimethyl sulfoxide (DMSO) with different concentrations and checked it for its antimicrobial activity.

Antimicrobial Activity

Antimicrobial activity of medicinal plant was tested through several methods like Tube dilution method, well plate method and Disc diffusion method. Disc diffusion method is most commonly employed method to evaluate the antimicrobial activity. In the present study, Disc diffusion method was used to test the antimicrobial activity of leaves of *Avicennia officinalis*, *Ceriops decandra* and *Acanthus ilicifolius*. The Disc diffusion technique was introduced by Kirby – Bauer.

Inoculum Preparation

Bacterial inoculum was prepared by inoculating a loopful of test organisms in 5 ml of Nutrient broth and incubated at 37°C for 3-5 hours till a moderate turbidity was developed. The fungal inoculum was prepared by inoculating a loopful of test organisms in 5 ml of Sabouraud's dextrose broth and incubated at room temperature for 3-5 hours till a moderate turbidity was developed. The turbidity was matched with 0.5 Mc Farland standards.

Preparation of Paper Disc

Disc of 5 mm diameter were pretreated using Whatman filter paper No.1. These were sterilized in the hot air oven at 160°C for 1 hour. The discs were impregnated with 20 µl of different solvent extracts (Methanol, Ethyl acetate and Chloroform) at different concentration ranging from 100 - 300 mg/ml for the five different seeds to check their antimicrobial activity. Control paper discs were also prepared by using 1% DMSO.

Antimicrobial Susceptibility Test

Disc diffusion method was adopted for the evaluation of antimicrobial activity of five different medicinal leaves. Muller Hinton agar was prepared and autoclaved at 15 lbs pressure for 20 minutes and cooled at 45°C. The cooled media was poured on to sterile petriplates and allowed for solidification. The plates with media were seeded with the respective microbial suspension using sterile swab. The disc impregnated with respective leaf extracts at different concentration (100 - 300 mg/ml) individually were placed on the four corners of each petridishes, control disc was also placed. The petridishes were then incubated at 37°C for 24 hours. After incubation period, the diameter of the zone formed around the paper disc were measured and expressed in mm.

Results and Discussion

Healthy leaves of *Avicennia officinalis*, *Ceriops decandra* and *Acanthus ilicifolius* were collected from the mangrove forest, Parangipet, Cuddalore District, Tamil Nadu, India. The plant leaves were washed thoroughly with tap water and then with sterilized distilled water for the removal of dust and sand particles. The leaves were shade dried and powdered by hand crushing. The preparations of different leaves extract was done through modified method. Three different solvents *viz*., methanol, chloroform and ethyl acetate were used to study the antimicrobial activity of herbal plants.

In the present research, the antimicrobial activity of methanol extract of *Avicennia officinalis* was analyzed in the present study and the results were furnished in Table - 1. Maximum antibacterial activity was observed in the bacteria *Bacillus subtilis* (27 mm, 31 mm and 37 mm) followed by *Pseudomonas aeruginosa* (28 mm, 33 mm and 34 mm), *Staphylococcus aureus* (24 mm, 26 mm and 28 mm) and *Streptococcus*

pyogenes (11 mm, 16 mm and 18 mm). The fungi *Penicillium* sp. (16 mm, 18 mm and 19 mm) showed more inhibitory activity when compared to *Aspergillus niger* (9 mm, 13 mm and 15 mm). The results of the present study coincide with the findings of Saranraj *et al*. (2012) and Sekar *et al*. (2012).

The antimicrobial activity of chloroform extract of *Avicennia officinalis* was determined in the present investigation and the results were given in Table - 2. Maximum antibacterial activity was observed in the bacteria *Bacillus subtilis* (22 mm, 26 mm and 32 mm) followed by *Pseudomonas aeruginosa* (23 mm, 28 mm and 29 mm), *Staphylococcus aureus* (19 mm, 21 mm and 23 mm) and *Streptococcus pyogenes* (No zone, 11 mm and 13 mm). The fungi *Penicillium* sp. (11 mm, 13 mm and 14 mm) showed more inhibitory activity than *Aspergillus niger*.

The antimicrobial activity of ethyl acetate extract of *Avicennia officinalis* was evaluated in the present research and the results were presented in Table - 3. Maximum antibacterial activity was observed in the bacteria *Bacillus subtilis* (19 mm, 23 mm and 29 mm) followed by *Pseudomonas aeruginosa* (20 mm, 25 mm and 26 mm), *Staphylococcus aureus* (16 mm, 18 mm and 20 mm) and *Streptococcus pyogenes* (No zone, 8 mm and 11 mm). The ethyl acetate extract of *Avicennia officinalis* showed resistance against *Penicillium* sp. and *Aspergillus niger*. No zone of inhibition was observed against *Penicillium* sp., *Aspergillus niger* and negative DMSO control.

Saranraj *et al*. (2010) evaluated the antibacterial potentiality of ethanol and ethyl acetate solvent extracts of mature leaves of *Acalypha indica* against nine pathogenic bacterial isolates *viz*., *Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Escherichia coli, Salmonella typhi, Shigella flexneri, Klebsiella pneumoniae, Vibrio cholerae* and *Pseudomonas aeruginosa*. The turbidity of the bacterial inoculums was compared with 0.5 Mc Farland standards and the antibacterial potential of *Acalypha indica* ethanol extract was tested by using Agar well diffusion method. The ethanol extract of *Acalypha indica* (100 mg/ml) showed maximum zone of inhibition (30 mm) against *Pseudomonas aeruginosa*, *Escherichia coli* and *Bacillus subtilis*. *Staphylococcus aureus* showed less zone of inhibition (12 mm). The ethyl acetate extract of *Acalypha indica* (100 mg/ml) showed maximum zone of inhibition (23 mm) against *Escherichia coli*.

Sivasakthi *et al*. (2011) evaluated the antibacterial potentiality of ethanol and ethyl acetate solvent extracts of mature leaves of *Datura metel* against nine pathogenic bacterial isolates *viz*., *Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Escherichia coli, Salmonella typhi, Shigella flexneri, Klebsiella pneumoniae, Vibrio cholerae* and *Pseudomonas aeruginosa*. The turbidity of the bacterial inoculums was compared with 0.5 Mc Farland standards and the antibacterial potential of *Datura metel*

ethanol extract was tested by using Agar well diffusion method. The ethanol extract of *Datura metel* (100 mg/ml) showed maximum zone of inhibition (26 mm) against *Pseudomonas aeruginosa*, *Escherichia coli* and *Bacillus subtilis*. *Staphylococcus aureus* showed less zone of inhibition (8 mm). The ethyl acetate extract of *Datura metel* (100 mg/ml) showed maximum zone of inhibition (19 mm) against *Escherichia coli*. There was no zone of inhibition against *Pseudomonas aeruginosa*.

The antimicrobial activity of methanol extract of *Ceriops decandra* was studied and the results were showed in Table - 4. Maximum antibacterial activity was observed in the bacteria *Bacillus subtilis* (31 mm, 35 mm and 38 mm) followed by *Staphylococcus aureus* (28 mm, 29 mm and 31 mm), *Pseudomonas aeruginosa* (22 mm, 25 mm and 28 mm) and *Streptococcus pyogenes* (20 mm, 23 mm and 26 mm). The fungi *Penicillium* sp. (18 mm, 20 mm and 23 mm) showed more inhibitory activity when compared to *Aspergillus niger* (15 mm, 17 mm and 21 mm).

The antimicrobial activity of chloroform extract of *Ceriops decandra* was tested and the results were furnished in Table - 5. Maximum antibacterial activity was noticed in the bacteria *Bacillus subtilis* (26 mm, 30 mm and 36 mm) followed by *Staphylococcus aureus* (23 mm, 24 mm and 26 mm), *Pseudomonas aeruginosa* (17 mm, 20 mm and 23 mm) and *Streptococcus pyogenes* (15 mm, 18 mm and 21 mm). The fungi *Penicillium* sp. (13 mm, 15 mm and 18 mm) showed more inhibitory activity when compared to *Aspergillus niger* (10 mm, 11 mm and 14 mm).

The antimicrobial activity of ethyl acetate extract of *Ceriops decandra* was investigated (Table – 6). Maximum antibacterial activity was recorded in the bacteria *Bacillus subtilis* (23 mm, 27 mm and 33 mm) followed by *Staphylococcus aureus* (20 mm, 21 mm and 23 mm), *Pseudomonas aeruginosa* (14 mm, 17 mm and 20 mm) and *Streptococcus pyogenes* (12 mm, 15 mm and 18 mm). The fungi *Penicillium* sp. (9 mm, 12 mm and 15 mm) showed more inhibitory activity when compared to *Aspergillus niger* (No zone, 8 mm and 11 mm).

Saranraj *et al*. (2011) screened the pharmacological activity of the ethanol and ethyl acetate extract of *Datura metel* and *Acalypha indica* for its antifungal activity against pathogenic fungi. Six different fungal isolates *viz*., *Candida albicans*, *Candida glabrata*, *Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus niger* and *Penicillium chrysogenum* were tested for its antifungal activity. The collected leaf samples were powdered and the bioactive compounds were extracted by using ethanol and ethyl acetate in a Soxhelet extractor. The antifungal activity was determined by using Well diffusion method. Ethanol and ethyl acetate extracts with different concentrations (100mg/ml, 200mg/ml and 300mg/ml) were mixed with 1 ml of Dimethyl sulfoxide (DMSO) and added into the well. The inhibitory effect of ethanol extract was relatively

high when compared to ethyl acetate extract. The extract of *Datura metel* showed maximum zone of inhibition against fungal pathogens when compared to *Acalypha indica*.

Acanthus ilicifolius (family of Acanthaceae) is a valuable medicinal plant that is widespread in tropical Asia and Africa, through Malaya to Polynesia (Xie *et al.*, 2005). *Acanthus ilicifolius* extracts have been used in various folk medicines as remedies against rheumatism, neuralgia, poison arrow wounds, coughs, asthma and bacterial infections with subsequent scientific supports to these claims (Mastaller, 1997). These created an interest to test the possible antimicrobial activity of different parts of this plant, which has not been reported; hence, the present study was undertaken. The phytochemical literature reveals the presence of 2-benzoxazolinone, lignan glucosides, benzoxazinoide glucosides, flavone glycosides and phenylethanoid glycosides in this plant (Kanchanapoom *et al*., 2001).

The antimicrobial activity of methanol extract of *Acanthus ilicifolius* was determined in the present study (Table – 7). Maximum antibacterial activity was noticed in the bacteria *Bacillus subtilis* (30 mm, 33 mm and 38 mm) followed by *Pseudomonas aeruginosa* (28 mm, 32 mm and 35 mm), *Staphylococcus aureus* (25 mm, 31 mm and 34 mm) and *Streptococcus pyogenes* (20 mm, 23 mm and 27 mm). The fungi *Penicillium* sp. (18 mm, 21 mm and 24 mm) showed more inhibitory activity when compared to *Aspergillus niger* (15 mm, 18 mm and 22 mm). The finding of the present study was supported by Saranraj and Sivasakthivelan (2012) and Saranraj *et al*. (2012).
The antimicrobial activity of chloroform extract of *Acanthus ilicifolius* was evaluated (Table – 8). Maximum antibacterial activity was observed in the bacteria *Bacillus subtilis* (25 mm, 30 mm and 34 mm) followed by *Pseudomonas aeruginosa* (23 mm, 28 mm and 31 mm), *Staphylococcus aureus* (20 mm, 26 mm and 29 mm) and *Streptococcus pyogenes* (15 mm, 18 mm and 22 mm). The fungi *Penicillium* sp. (13 mm, 16 mm and 19 mm) showed more inhibitory activity when compared to *Aspergillus niger* (10 mm, 13 mm and 17 mm).

The antimicrobial activity of ethyl acetate extract of *Acanthus ilicifolius* was investigated (Table – 9). Maximum antibacterial activity was observed in the bacteria *Bacillus subtilis* (22 mm, 27 mm and 31 mm) followed by *Pseudomonas aeruginosa* (20 mm, 25 mm and 28 mm), *Staphylococcus aureus* (17 mm, 23 mm and 26 mm) and *Streptococcus pyogenes* (12 mm, 15 mm and 19 mm). The fungi *Penicillium* sp. (10 mm, 12 mm and 14 mm) showed more inhibitory activity when compared to *Aspergillus niger* (9 mm, 13 mm and 16 mm). No zone of inhibition was observed in the negative DMSO control.

Saranraj and Sivasakthivelan (2012) tested the antibacterial activity of *Phyllanthus amarus* was tested against Urinary tract infection causing bacterial isolates *viz*., *Staphylococcus aureus*, *Serratia marcescens*, *Escherichia coli*, *Enterobacter* sp., *Streptococcus faecalis*, *Klebsiella pneumoniae*, *Proteus mirabilis* and *Pseudomonas aeruginosa*. The *Phyllanthus amarus* was shade dried and the antimicrobial principles were extracted with methanol, acetone, chloroform, petroleum ether and hexane. The antibacterial activity of *Phyllanthus amarus* was determined by Agar Well Diffusion Method. It was found that methanol extract of *Phyllanthus amarus* showed more inhibitory activity against UTI causing bacterial pathogens when compared to other solvent extracts.

Sekar *et al*. (2012) screened the pharmacological activity of the ethanol and acetone extract of *Phyllanthus amarus*, *Acalypha* and *indica Datura metel* for its antimicrobial activity against selected pathogen. The antimicrobial activity was determined by using Disc diffusion method. Ethanol and acetone extracts with different concentrations (100mg/ml, 200mg/ml and 300mg/ml) were mixed with 1 ml of Dimethyl sulfoxide (DMSO). The inhibitory effect of ethanol extract was relatively high when compared to acetone extract. The study of antimicrobial activity of herbal plant extract of *Datura metel*, *Acalypha indica* and *Phyllanthus amarus* showed that the ethanol extract shows promising antimicrobial activity against bacterial and fungal human pathogens when compared to acetone extract

Table - 1: Antimicrobial Activity of Methanol Extract of *Avicennia Officinalis*

S.No	**Bacteria**	**Concentration of the extract (mg/ml) and zone of inhibition (mm in dm)**			
		DMSO Control	**100 mg/ml**	**200 mg/ml**	**300 mg/ml**
1	*Staphylococcus aureus*	NZ	24 mm	26 mm	28 mm
2	*Streptococcus pyogenes*	NZ	11 mm	16 mm	18 mm
3	*Pseudomonas aeruginosa*	NZ	28 mm	33 mm	34 mm
4	*Bacillus subtilis*	NZ	27 mm	31 mm	37 mm
5	*Aspergillus niger*	NZ	9 mm	13 mm	15 mm
6	*Penicillium* sp.	NZ	16 mm	18 mm	19 mm

NZ – No Zone

Table - 2: Antimicrobial Activity of Chloroform Extract of *Avicennia Officinalis*

S. No	Bacteria	Concentration of the extract (mg/ml) and zone of inhibition (mm in dm)			
		DMSO Control	100 mg/ml	200 mg/ml	300 mg/ml
1	*Staphylococcus aureus*	NZ	19 mm	21 mm	23 mm
2	*Streptococcus pyogenes*	NZ	NZ	11 mm	13 mm
3	*Pseudomonas aeruginosa*	NZ	23 mm	28 mm	29 mm
4	*Bacillus subtilis*	NZ	22 mm	26 mm	32 mm
5	*Aspergillus niger*	NZ	NZ	NZ	NZ
6	*Penicillium* sp.	NZ	11 mm	13 mm	14 mm

NZ – No Zone

Table - 3: Antimicrobial Activity of Ethyl Acetate Extract of *Avicennia Officinalis*

S. No	Bacteria	Concentration of the extract (mg/ml) and zone of inhibition (mm)			
		DMSO Control	100 mg/ml	200 mg/ml	300 mg/ml
1	*Staphylococcus aureus*	NZ	16 mm	18 mm	20 mm
2	*Streptococcus pyogenes*	NZ	NZ	8 mm	11 mm
3	*Pseudomonas aeruginosa*	NZ	20 mm	25 mm	26 mm
4	*Bacillus subtilis*	NZ	19 mm	23 mm	29 mm
5	*Aspergillus niger*	NZ	NZ	NZ	NZ
6	*Penicillium* sp.	NZ	NZ	NZ	NZ

NZ – No Zone

Table - 4: Antimicrobial Activity of Methanol Extract of *Ceriops Decandra*

S. No	Bacteria	Concentration of the extract (mg/ml) and zone of inhibition (mm)			
		DMSO Control	100 mg/ml	200 mg/ml	300 mg/ml
1	*Staphylococcus aureus*	NZ	28 mm	29 mm	31 mm
2	*Streptococcus pyogenes*	NZ	20 mm	23 mm	26 mm
3	*Pseudomonas aeruginosa*	NZ	22 mm	25 mm	28 mm
4	*Bacillus subtilis*	NZ	31 mm	35 mm	38 mm
5	*Aspergillus niger*	NZ	18 mm	20 mm	23 mm
6	*Penicillium* sp.	NZ	15 mm	17 mm	21 mm

NZ – No Zone

Table - 5: Antimicrobial Activity of Chloroform Extract of *Ceriops Decandra*

S. No	Bacteria	Concentration of the extract (mg/ml) and zone of inhibition (mm)			
		DMSO Control	100 mg/ml	200 mg/ml	300 mg/ml
1	*Staphylococcus aureus*	NZ	23 mm	24 mm	26 mm
2	*Streptococcus pyogenes*	NZ	15 mm	18 mm	21 mm
3	*Pseudomonas aeruginosa*	NZ	17 mm	20 mm	23 mm
4	*Bacillus subtilis*	NZ	26 mm	30 mm	36 mm
5	*Aspergillus niger*	NZ	13 mm	15 mm	18 mm
6	*Penicillium* sp.	NZ	10 mm	12 mm	13 mm

NZ – No Zone

Table - 6: Antimicrobial Activity of Ethyl Acetate Extract of *Ceriops Decandra*

S. No	Bacteria	Concentration of the extract (mg/ml) and zone of inhibition (mm)			
		DMSO Control	100 mg/ml	200 mg/ml	300 mg/ml
1	*Staphylococcus aureus*	NZ	20 mm	21 mm	23 mm
2	*Streptococcus pyogenes*	NZ	12 mm	15 mm	18 mm
3	*Pseudomonas aeruginosa*	NZ	14 mm	17 mm	20 mm
4	*Bacillus subtilis*	NZ	23 mm	27 mm	33 mm
5	*Aspergillus niger*	NZ	9 mm	12 mm	15 mm
6	*Penicillium* sp.	NZ	NZ	8 mm	11 mm

NZ – No Zone

Table - 7: Antimicrobial Activities of Methanol Extract of *Acanthus Ilicifolius*

S. No	Bacteria	Concentration of the extract (mg/ml) and zone of inhibition (mm)			
		DMSO Control	100 mg/ml	200 mg/ml	300 mg/ml
1	*Staphylococcus aureus*	NZ	25 mm	31 mm	34 mm
2	*Streptococcus pyogenes*	NZ	20 mm	23 mm	27 mm
3	*Pseudomonas aeruginosa*	NZ	28 mm	32 mm	35 mm
4	*Bacillus subtilis*	NZ	30 mm	33 mm	38 mm
5	*Aspergillus niger*	NZ	15 mm	18 mm	22 mm
6	*Penicillium* sp.	NZ	18 mm	21 mm	24 mm

NZ – No Zone

Table - 8: Antimicrobial Activities of Chloroform Extract of *Acanthus Ilicifolius*

S. No	Bacteria	Concentration of the extract (mg/ml) and zone of inhibition (mm)			
		DMSO Control	100 mg/ml	200 mg/ml	300 mg/ml
1	*Staphylococcus aureus*	NZ	20 mm	26 mm	29 mm
2	*Streptococcus pyogenes*	NZ	15 mm	18 mm	22 mm
3	*Pseudomonas aeruginosa*	NZ	23 mm	28 mm	31 mm
4	*Bacillus subtilis*	NZ	25 mm	30 mm	34 mm
5	*Aspergillus niger*	NZ	10 mm	13 mm	17 mm
6	*Penicillium* sp.	NZ	13 mm	16 mm	19 mm

NZ – No Zone

Table - 9: Antimicrobial Activity of Ethyl Acetate Extract of *Acanthus Ilicifolius*

S. No	Bacteria	Concentration of the extract (mg/ml) and zone of inhibition (mm)			
		DMSO Control	100 mg/ml	200 mg/ml	300 mg/ml
1	*Staphylococcus aureus*	NZ	17 mm	23 mm	27 mm
2	*Streptococcus pyogenes*	NZ	12 mm	15 mm	19 mm
3	*Pseudomonas aeruginosa*	NZ	20 mm	25 mm	28 mm
4	*Bacillus subtilis*	NZ	22 mm	27 mm	31 mm
5	*Aspergillus niger*	NZ	9 mm	12 mm	14 mm
6	*Penicillium* sp.	NZ	10 mm	13 mm	17 mm

NZ – No Zone

Conclusion

The study of antibacterial activity of mangrove herbal plant extract of *Avicennia officinalis*, *Ceriops decandra* and *Acanthus ilicifolius* showed that the methanol extract showed promising antimicrobial activity against bacterial and fungal human pathogens followed by chloroform extract and ethyl acetate extract. Among the three plants, maximum inhibition activity was exhibited by *Acanthus ilicifolius* followed by *Ceriops decandra* and *Avicennia officinalis*. The results also indicated that scientific studies carried out on medicinal plants having traditional claims of effectiveness might warrant fruitful results. These plants could serve as useful source of new antimicrobial agents.

References

Abeysinghe PD, Pathirana RN (2006). Evaluation of antibacterial activity of different mangrove plant extracts. *Ruhuna Journal of Science*. 1: 104 - 112.

Bandaranayake WM (2002). Bioactivities, bioactive compounds and chemical constituents of mangrove plants. *Wetland Ecology Management.* 10: 421 – 452.

Carvalho AFU (2007). Nutritive value of three organisms from mangrove ecosystem: *Ucides cordatus* (Linnaeus, 1763), *Mytella* sp. (Soot-Ryen, 1955) and *Crassostrea rhizophorae* (Guilding, 1828). *Bra. J. Bio.,* 67(4): 787 – 788.

Ishibashi F, Satasook C, Isman MB, Neil Towers GH (1993). Insecticidal 1H Cyclopentatetrahydro Benzofurans from *Aglaia odorata*. Phytochemistry. 32: 307 – 310.

Kanchanapoom T, Kamel MS, Kasai R, Yamasaki K, Picheansoonthon C, Hiraga Y (2001). Lignan glucosides from Acanthus ilicifolius. *Phytochemistry*. 56: 369 - 372.

Kathiresan K , Rajendra N (2005). Mangrove ecosystems of the Indian ocean region. *Indian J Mar Sci.,* 34(1): 104 – 113.

Kirtikar KR, Basu BD (1991). Indian medicinal plants. Lalit Mohan Basu Publishers, *Allahabad, India,* pp 1 – 2793 I – IV.

Lim SH, Darah I, Jain K (2006). Antimicrobial activities of tannins extracted from Rhizophora apiculata barks. *J. Trop. Forest Sci.,* 81(1): 59 – 65.

Mandal RN, Naskar KR (2008). Diversity and classification of Indian mangroves: a review. *Trop Ecol*. 49(2): 131 – 146.

Miki T, Sakaki T, Shibata M, Inukai Y, Hirosue H, Ikema Y, Yaga S (1994). Soxhlet extraction of mangrove and biological activities of extracts. Kyushu Kogyo Gijutsu Kenkyusho Hokoku. 53: 3347 - 3352.

Minqing T, Haofu D, Xiaoming K, Bingui W (2009). Chemical constituents of marine medicinal mangrove plant Sonneratia caseolaris. *Chin. J. Ocean Limn*. 27(2): 288 – 296.

Mishra PK, Sahu JR, Upadhyay VP (2005). Species diversity in Bhitarkanika mangrove ecosystem in Orissa, India. *Lyonia.* 8(1): 73 – 87.

Philip K, Sinniah SK, Muniandy S (2009). Antimicrobial peptides in aqueous and ethanolic extracts from microbial, plant and fermented sources. *Biotech.,* 8(2): 248 – 253.

Ravikumar S, Gnanadesigan M, Suganthi P, Ramalakshmi A (2010). Antibacterial potential of chosen mangrove plants against isolated urinary tract infectious bacterial pathogens. *International Journal of Medicine and Medical Sciences*. 2(3): 94 - 99.

Saranraj P, Sivasakthivelan P (2012). Screening of antibacterial activity of medicinal plant *Phyllanthus amarus* against Urinary tract infection (UTI) causing bacterial pathogens. *Applied Journal of Hygiene*. 1(3): 19 – 24.

Saranraj P, Stella D, Reetha D (2012). Bioactivity of *Mangifera indica* ethanol extract against human pathogenic microorganisms. *Novus International Journal of Pharmaceutical Technology.* 1(1): 11 – 18.

Saranraj P, Stella D, Sathiyaseelan K, Sajani Samuel (2010). Antibacterial potentiality of Ethanol and Ethyl acetate extract of *Acalypha indica* against human pathogenic bacteria. *Journal of Ecobiotechnology* 2 (7): 23 – 27.

Sekar D, Kolanjinathan K, Saranraj P, Gajendiran K (2012). Screening of *Phyllanthus amarus, Acalypha indica* and *Datura metel* for its antimicrobial activity against selected pathogens. *International Journal of Pharmaceutical and Biological Archives.* 3(5): 1231 - 1236.

Siva Sakthi S, Saranraj P, Geetha M (2011). Antibacterial evaluation and phytochemical screening of *Datura metel* leaf extracts against bacterial pathogens. *International Journal of Pharmacology and Biological Archives.* 2 (4): 1130-1136.

Thatoi HN, Biswal AK (2008). Mangroves of Orissa coast: floral diversity and conservation status. Special habitats and threatened plants of India. *ENVIS Wild Prot. Area.* 11(1): 201 –207.

Upadhyay VP, Mishra PK, Sahu JR (2008). Distribution of mangrove species within Bhitarkanika National Park in Orissa, India. *Trees Life J.* 3(4): 001 – 005.

Vadlapudi V, Naidu KC (2009). Bioefficiency of mangrove plants Lumintzera racemosa and Bruguiera gymnorhiza. *Journal of Pharmacy Research*. 2(9): 1591 - 1592.

Wu TS, Liou MJ, Kuon CS, Teng CM, Nagao T, Lee KW (1997). Cytotoxic and antiplateletaggregation principles from Aglaia elliptifolia. *J. Natural Products.* 60: 606 - 608.