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ANTIMICROBIAL ACTIVITY OF INDIAN HERBS

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ABSTRACT

In today's world there is an immediate and urgent need of anti microbial compounds as there is an increase in the emerging of infectious diseases day by day.[4] Plants produce wide range of bioactive molecules which is suitable in the treatment of such infectious diseases. Present study gives the information about some medicinal plants which act against microorganism in infectious diseases. The zone of inhibition and minimum inhibitory concentration determines the potency of the plant extract against respective microorganism. This study shows antibacterial and antifungal activity of 94 medicinal plants available in India. Bacterial is divided in two large forms gram positive and gram negative which differentiates bacteria based on their physical and chemical properties of cell walls. The present work gives the tabular information about the scientific and common name of the plant, family active constituents, part of plant used, type of extract, microorganism which it is active against and the zone of inhibition ranges.

INTRODUCTION

Human beings have used about 80,000 species of plants for treating various diseases in different system of medicine.[1] Since 1990s the use of medicinal plants start as an important resource to combat serious diseases in the world. The medicinal value of this plants lies on certain bioactive molecules that produce definite physiological action on the human body. The most important chemically active substance include alkaloid, tannins, flavonoids and phenolic compounds.[3] India has the most oldest, richest and diverse cultural traditions associated with the use of medicinal plants and their extracts for treating many number of diseases.[11] Currently available pharmaceuticals such as opium, quinine, digoxin and aspirin are derived from plants.[24]

The worldwide emergence of microorganism has become a major therapeutic problem.[6] As infectious diseases have increased to a great extent along with that antimicrobial resistance has also become a serious issue. Plants and plant extract stand as a new source of antimicrobial agent with a novel mechanism of action.[3] The antimicrobial efficacy featured to some plants in treating diseases infectious disease has been beyond belief.[6] The wide variety of secondary metabolites produced by plants has been proven in acting against certain type of microorganisms including bacteria, fungi, protozoa and viruses. Based on the growth condition required for the microorganisms it is classified into aerobic (can survive and grow in an oxygenated environment), anaerobic (does not require oxygen for growth) and facultative anaerobic (makes

ATP by aerobic respiration if oxygen is present, but is can switch to fermentation if oxygen is absent). To validate the activity and to determine the parameters associated with it, plants with potential antimicrobial activity should be checked against an appropriate microbial model. A very large number of researches in different parts of the world have studied the impact of plant extract on bacteria and fungi.A lot of research has been performed in India on the ethno medicinal plants. Therefore present study gives information about medicinal plants which is active against microorganisms and their inhibitory zone.

Zone of inhibition: There are different analytical approaches for the reliable evaluation of antimicrobial activity ascribed to medicinal plants against selected pathogenic microorganisms.[2] The antimicrobial activity of herbal extracts or plant isolates has usually been evaluated in India using different antimicrobial susceptibility testing methods generally based on diffusion and dilution.[4]One of the way to test the antimicrobial resistance is measuring zone of inhibition. Zone appears on a agar plate in which the sterile swab of stain is given and an antimicrobial agent is applied on to the centre of the agar plate. The plate is then incubated and the zone is measured. The ZOI is measured in millimetre.

Table no.1 provides proven information about 94 Indian medicinal plants which is active against different strains of microorganisms. The aim of the study is to evaluate Indian herbs which are active against pathogenic microorganism and the zone of inhibition of each plant against specific microorganism.

Table. No. 1- Antimicrobial activity of 94 Indian herbs

Scientific name	Common name	Family	Plant part	Type of solvent	Chemical constituents	Microorganism			Ref.
						Aerobic	Anaerobic	Facultative anaerobic	
Abutilon indicum	Indian mallow	Malvaceae	Leaf	Methanol Ethanol Water	Carbohydrates,steroids, glycosides, alkaloids, tannins, phenolics	*Bacillus subtilis*(**)		*S. aureus* (***) *E. coli* (**)	26
Acacia nilotica	Gum Arabic Babul	Fabaceae	Leaf	Methanol	Tannins, flavonoidspolyphenolics glycosides, coumarins	*B. subtilis* (**) *P.fluorescence* (*)		*E. coli* (**) *S. aureus* (**)	22
			Leaf	Ethanol		*P. aeruginosa* (***)	*K. pneumonia* (**)	*S. mutans* (***) *S. aureus* (***) *E. faecalis* (**) *S. bovis* (**) *S. typhimurium* (***) *E. coli* (***) *C. albicans* (***)	20

Achyranthes aspera	Apamarga	Amaranthaceae	Leaf Seeds	Water Ethanol	Oleonic acid, saponins, alkaloids, dihydroxy ketones			*E. coli* (** W L) (** E L) (** E S) *S. aureus* (** E L) (** E S) *C. albicans* (** E L) (** E L)	15
			Whole plant	Water Ethanol			*K. pneumonia* (** E)	*A. faecalis*(* E) *B. cereus* (* E) (* W) *B. subtilis* (* E) *P. mirabilis*(*E) (* W) *S. aureus* (*W) *S. epidermis* (** W)	21
Adhatoda vasica	Vasaka Adhatoda	Acanthaceae	Leaf	Acetone Ethanol		*P. aeruginosa* (** E)		*B. subtilis* (*A) *S. aureus* (*A) (* E)	13
Aegle marmelos	Bael	Rutaceae	Leaf Fruit	Water Ethanol	Alkaloids, terpenoidssaponins, tannins, flavonoids steroids		*K. pneumonia* (* E) (* W)	*S. aureus* (* W) *Streptococcus pyogenes* (* W)	13
Agava sisalana	Sisal	Asparagaceae	Leaf	Water	Flavonoids, Tannins Alkaloids			*Shigella flexneri* (**)	10
Amomum subulatum	Black cardamom	Zingiberaceae	Seeds Fruits	Water	1,8- cineole α- terpinyl acetate	*P. aeruginosa* (**)		*S. aureus* (**) *S. flexneri* (*)	19
Andrographis paniculata	Khalmerg	Acanthaceae	Stem Leaf	Water Methanol	Andrographolide Phenols	*P. aeruginosa* (** S) (* L)		*S. aureus* (* S) *S. flexneri*(* S) *V. cholera* (* S) (* L) *B. subtilis* (*S) (* L)	10
			Leaves	Methanol		*P. aeruginosa* (*)	*K pneumonia* (*)		16
Anethum graveolens	Dill	Umbelliferae	Seeds Leaf	Ethanol	Phellandrene, p-cymene, terpinene, limonene, germacrene D, dill ether, β-	*M. luteus* (* E S)		*E. coli* (** E S) (* E L) *B. cereus* (* E S) (* E L) *B. subtilis* (* E S)	9

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			Seeds	Water		*P. aeruginosa* (**)		*E. coli* (*) *S. typhimurium* (**) *S. flexneri* (*) *S. aureus* (**)	19
Annona reticulata	Wild sweetsop	Annonaceae	Leaf	Methanol Water	Glycosides, alkaloids, saponins, , phenolic compounds, phytosterols	*P. aeruginosa* (** M)	*K. pneumonia* (* M) (*W)	*S. aureus* (*M) (* W) *S. typhi* (* M) *Proteus vulgaris* (**M)	27
Aristolochia bracteolata	Worm killer	Aristolochiaaceae	Leaf	Acetone	Coumarins, steroids, flavonoids, glycosides, terpenoids		*K. pneumonia* (*)		13
Artocarpus heterophyllus	Jack fruit tree	Moraceae	Root Leaf Fruit Seeds	Water Ethanol	ellagic acid, Jacalin amino acid, betullic acid	*P. aeruginosa* (**)	*K. pneumonia* (**)	*S. aureus* (**) *P. mirabilis*(*)	4
Azadirachta indica	Neem	Meliaceae	Leaves	Methanol Water Ethyl acetate	Quercetine βsitosterol Polyphenolic flavonoids			*E. coli* (*M) (* W) (* EA) *S. aureus* (*W)	7
			Leaves	Methanol		*B. subtilis* (**) *P. fluorescens* (**) *A. flavus* (**)		*E. coli* (**) *S. aureus* (**) *Dreschlera turcica* (**) *Fusarium verticillioides* (**)	22
Berberis aristata	Indian barberry	Berberidaceae	Root Bark	Water Ethanol	Berberine , glycosides, tannins, flavonoids, aminoacids, mucilage, terpenoid	*B. subtilis* (*)	*K. pneumonia* (*)	*S. aureus* (***) *E. coli* (*)	4
Buchnania lanzan	Chironji	Anacardiaceae	Leaf Bark	Water	Tannins, flavonoid, phenols, steroids, glycosides			*B. licheniformis* (* B) (* L)	10
Calotropis gigantea	Giant calotrope	Apocynaceae	Leaf	Water Ethanol	Alkaloids, glycosides, tannins, saponins, flavonoids, terpenoids	*P. aeruginosa* (* E)	*K. pneumonia* (* E)	*B. cereus* (* E) *B. subtilis* (*E) *S. subfava* (* E) *A. faecalis*(* E) *P. mirabilis* (* E) (* W) *C. tropicalis* (*E)	21

Cardiospermum halicacabum	Balloon vine	Sapindaceae	Leaf	Acetone Ethanol Water	Phenols Flavonoids	*P. aeruginosa* (* E)		*Streptococcus pyogenes* (* W) *S. aureus* (* A) (*E)	13
Carissa congesta	Bengal currant	Apocynaceae	Leaf	Water Ethanol	Alkaloids, flavonoids, saponins, cardiac glycosides, triterpenoids, phenolic compounds, tannins	*P. aeruginosa* (* E)	*K. pneumonia* (* E)	*S. aureus* (* E) *B. cereus* (*W) (** E) *B. subtilis* (* E) *S. epidermis* (* E) *S. subfava* (* E) *P. mirabilis* (**E) *C. tropicalis* (* E)	21
Cassia auriculata	Senna auriculata	Fabaceae	Flowers	Methanol	Coumarin, Phenols Flavanoids, Glycosides	*P. aeruginosa* (*)	*K. pneumonia* (*)	*E. coli* (*) *S. aureus* (**)	16
Cassia fistula	Golden shower	Fabaceae	Leaf	Water	Butanoic acid, isopropyl acetate, 2- methyl-penthiophane			*Bacillus subtilis* (*)	10
Centella asiatica	Jalbrahmi mandukparni	Apiaceae	Whole plant	Acetone Methanol Ethanol	Saponins Asiaticosides Brahminoside centelloside	*A.flavus* (** M) (*** E)		*B. cereus* (** A) (***M) (*** E) *Serratia spp.* (** M) (* E) *R.mucilaqinosa* (** M) (**E) *P.citrinum*(** M) (** E)	14
			Leaf root	Water		*P. aeruginosa* (** L)		*S. aureus* (* L) *S. flexneri* (* R) (** L) *Candida krusei* (** L) *Bacillus subtilis* (* R) (** L) *E. coli* (**L)	10
Chromolaenaodorata	Eupatorium Siam weed	Asteraceae	Leaf	Ethanol	Tannin, saponin, essential oils	*P. aeruginosa* (*) *B. subtilis* (**)	*K. pneumonia* (**)	*S. aureus* (**) *E. coli* (*)	4
			Leaf	Methanol		*X.*		*E. coli* (* M)	7

				Chloroform		*vesicatoria* (* M) (*C) *R. solanacearum* (* M) (* C)		(* C) *S. aureus* (* M) (* C)	
Cinnamomum zeylanicum	cinnamon	Lauraceae	Bark	Ethanol	Cinnamic aldehyde, turmerone, cis-p-Menth-2-en-1-ol	*P. aeruginosa* (***)	*K. pneumoniae* (**)	*E. coli* (**) *S. aureus* (***) *S. typhimurium* (***) *S. mutans* (***) *E. faecalis* (***) *S. bovis* (***) *C. albicans* (***)	20
				Water		*P. aeruginosa* (*)		*S. aureus* (*)	19
				Ethanol Methanol Water			*Klebsiella* (* E)	*E. coli* (** E) (*M) (*W) *Staphylococcus* (* E) (* M) (* W) *Salmonella* (* W)	17
Clausena excavate	Clausena	Rutaceae	Leaf Root	Water	Prenylated coumarins, carbazole, alkaloids, limonoid, sterol, depside, xanthone	*Bacillus brevis* (** L) (* R)		*S. aureus* (* R) *S.flexneri* (* R) *B. licheniformis* (* R) *Vibrio cholera* (** R)	10
Cordia myxa	Assyrian plum	Boraginaceae	Leaf	Acetone Ethanol Water		*P. aeruginosa* (* E)	*K. pneumonia* (* A) (* W)	*Streptococcus pyogenes* (* A) (* E) *B. subtilis* (* E) *S. aureus* (* E)	13
Croton roxburghii	Rushfoli	Euphorbiaceae	Leaf Bark	Water	Clerodane type diterpenoids	*Bacillus brevis* (* L) (* B) *P. aeruginosa* (** B)		*S. aureus* (* B) *S. flexneri* (**B) *B. licheniformis* (** B)	10
Curcuma longa	Haldi	Zingiberaceae	Rhizome	Ethanol Methanol Acetone	Curcumin, α phellandrene sabinene,borneol, zingiberene sesquiterpenes			*B.cereus* (** A) (** M) (** E) *Serratiaspp.* (* A)	14
				Methanol		*Pseudomon*	*Klebsiella*	*E.coli* (***	17

			Rhizome	Ethanol Water		*as* (*M) (**W) *Alcaligenes* (* M) (* E) (* W)	(* M) (*E) (*W)	E) (* W) *Staphylococcus* (*M) (*E) (*W) *Proteus* (* M) (* E) (* W) *Salmonella* (* M) (* E) (** W)	
			Rhizome	Methanol		B. subtilis (**) P. fluorescens (**) A. flavus (*)		*E. coli* (**) *S. aureus* (**) *D.turcica* (*) *Fusariumverticillioides* (**)	22
Datura stramonium	Thorn apple	Solanaceae	Leaf	Methanol Ethanol Water	Alkaloids, tannin, flavonoids, saponins, glycosides			*S. aureus* (***) *E. coli* (**) *Bacillussubtilis* (**)	26
Diospyros melanoxylon	Coromandel ebony	Ebenaceae	Leaf Bark	Water	Flavones, triterpenes	*B. brevis* (** B) *P. aeruginosa* (** B) (** L)		*S. aureus* (* L) *S. flexneri* (* L) (** B) *B. licheniformis* (* L) (** B) *S. epidermidis* (* L)	10
Eclipta alba	False daisy	Compositae	Leaf	Acetone Ethanol Water	Wedelolactone	*P. aeruginosa* (*A) (* W)	*K. pneumonia* (* A) (* E)	*S.pyrogenes* (*A) (* W) *S. aureus* (* E)	13
Elettaria cardamomum	Cardamom	Zingiberaceae	Fruits Seeds	Water	Alkaloids, flavonoids, saponins, α-ionone, eucalyptol, santolina alcohol	*P. aeruginosa* (***)		*S. aureus* (***) *E. coli* (*) *S. typhi* (*) *S. typhimurium* (*) *S. flexneri* (**)	19
Embelia ribes	False black pepper	Primulaceae	Fruit Root Bark	Water Ethanol	Embelin , resin, tannin	*P. aeruginosa* (*)	*K. pneumonia* (**) *P. mirabilis* (**)	*S. aureus* (**) *E. coli*(**)	4
Emblica officinalis	Amla	Euphorbiaceae	Fruit Root Bark Leaf	Ethanol Acetone Methanol Hot Aqueous Cold Aqueous	Alkaloids, tannins, saponins, cardiac glycosides, steroids, phenols	*A. flavus* (**A) (**M) (*E)		*B. cereus* (**A) (** M) (** E) (* CA) (* HA) *Serratia spp.* (**A) (**E) (*M) *R.mucilagino*	14

								sa (** A) (** M) (* E) *P.citrinum* (**A) (**M) (*E)	
Enhydra fluctuans	Water spinach	Asteraceae	Leaf	Water	β- carotene, saponins, myricyl alcohol, kaurol	*P. aeruginosa* (**)		*S. aureus* (**) *B. licheniformis* (**) *V. cholera* (*) *C. krusei* (*) *S. epidermidis* (*) *B. subtilis* (*)	10
Eryngium foetidum	Mexican coriander	Apiaceae	Stem Leaf	Water	Carotol, β-farnesene, anethole, α-pinene	*P. aeruginosa* (** L) (* S)		*S. aureus* (* S)(* L) *S. flexneri* (* L) (* S) Vibrio cholera (** S) (* L) *Bacillus subtilis* (* S) (* L) *E. coli* (*S) (**L)	10
Eucalyptus globulus	Tasmanian blue gum	Myrtaceae	Leaf	Ethanol	citronellal, citronellol, citronellyl acetate, p-cymene, eucamalol, limonene, linalool			*S. mutans* (**) *E. faecalis* (*) *S. aureus* (**) *Streptococcus bovis* (*)	20
Eugenia jambolana	Java plum	Myrtaceae	Kernel	Methanol	Coumarin, Phenols Flavanoids, Glycosides	*P. aeruginosa* (**)	*K. pneumonia* (*)	*E. coli* (**) *S. aureus* (**)	16
Fagonia cretica	Virgin's mantle	Zygophyllaceae	Whole plant	Water Ethanol	Tannins, phenolic compounds, lignins, saponins, lignans, vitamins	*P. aeruginosa* (*E)	*K. pneumonia* (** E)	*E. coli* (* E) *B. cereus* (*E) *B. subtilis* (*E) *S. epidermis* (*W) *S. subfava* (*E) *A. faecalis* (**E) *P. mirabilis* (*W) (**E)	21
Flemingia nana	Flemingia	Fabaceae	Root	Water	Flavonoids, genistein, isoflavones	*Bacillus brevis* (**) *P. aeruginosa* (**)		*S. aureus* (***) *B. licheniformis* (**) *V. cholera*	10

								(**) *Candida krusei* (**) *S. epidermidis* (**)	
Foeniculum vulgar	Fennel	Umbelliferae	Seeds	Water	α- pinene, α-thujene, limonene, 1,8-cineole, fenchone, thymol, trans-anethole	*P. aeruginosa* (**)		*S. aureus* (**) *E. coli* (*) *S. typhi* (*) *S. typhimurium* (*) *S. flexneri* (**)	19
Glycyrrhiza glabra	Liquorice	Fabaceae	Bark Fruit Root	Water	Saponin-glycyrrhizin, liquiritic acid and glycyrretol Flavonoids Isoflavonoids, stilbenoids coumarins	*B. brevis* (** F) *P. aeruginosa* (* R)		*V. cholera* (** B) (*** R) *S. aureus* (** F) (* F) *S. flexneri* (** F) (* R) *B. licheniformis* (** F) *B. subtilis*(* F)	19
Gnaphalium polycaulon	Many-stemmed cudweed	Asteraceae	Leaf Stem Flower	Methanol	Flavonoids, sesquiterpenes, diterpenes, triterpenes, phytosteroles, anthraquinones	*P. aeruginosa* (*L) (*S) (*F) *A. flavus* (**L) (*S) (*F) *A.fumigates* (*L) (*F) *A. oryzae* (*L) (*S) (*F)		*E. coli* (*L) (*S) (*F) *S. aureus* (*L) (*S) (*F) *S. typhimurium* (*L) (*S) (*F) *B. cereus* (*L) (*S) (*F) *A. hydrophila* (*L) (*S) (*F) *Flavobacterium sp.* (*L) (*S) (**F) *Y. enterocolitica* (*L) (*S) (*F) *L. monocytogenes* (**L) (*S) (*F) *C. albicans* (*L) (*S) (*F) *P. notatum*(*L) (*S) (*F)	11

Gnetum gnemon	Melinjo	Gnetaceae	Fruit	Water	Melinjo resveratrol, gnetin c, gnetin L, gnemonosides A,C and D	*P. aeruginosa* (*)		*S. aureus* (*)	19
Grewia elastica	Dhaman	Malvaceae	Leaf Root	Water	Triterpenoids, flavonoids, steroids, saponins, tannins	*B. brevis* (* L) (** R)		*B. licheniformis* (** R) *V. cholera* (***R) *Candida krusei* (** L) (** R)	10
Hemidesmus indicus	Indian sarsaparilla	Apocynaceae	Stem Leaf	Water	Phenol, alkaloids, tannins, saponins, flavonoids	*P. aeruginosa* (** L)		*S. aureus*(*L) *V. cholerae* (*L) *Candida krusei* (** L) *S. epidermidis* (* L) *Bacillus subtilis* (* S) (** L) *E. coli* (** L)	10
Jasminum angustifolia	Wild jasmine	Oleaceae	Leaf Root	Water Ethanol	Benzyl acetate Benzyl benzoate Phytol, linalool Isophytol Geranyl linalool Methyl linoleate	*Bacillus subtilis* (**)	*K. pneumonia* (**) *P. mirabilis* (**)	*S. aureus* (***) *E. coli* (**)	4
Kaempferia rotunda	Peacock ginger	Zingiberaceae	Root Leaf	Water	Pentadecane, bornyl acetate, benzyl benzoate, camphor	*B. brevis* (**R)		*S. flexneri* (* R) (* L)	10
Lagerstroemia indica	Crape Myrtle	Lythraceae	Leaf	Methanol Water	Alkaloids, cardiac glycosides, tannins, saponins, sterols, triterpenes, anthraquinones, flavonoids	*P. aeruginosa* (**M)	*K. pneumonia* (*M) (*W)	*S. aureus* (*M) (*W) *S. typhi* (*M) *P. vulgaris* (**M)	27
Lanata camara	Big sage Wild sage Red sage Tickberry	Verbenaceae	Leaf Flower	Methanol Ethanol Water	B-caryophyllene, thymol, citral, 1,8- cineole, carvone, limonene			*E. coli* (**) *S. aureus* (***) *B. subtilis* (***)	26
Litsea mohopetala	Meda	Lauraceae	Bark	Water	α- caryophyllene alcohol, pentacosane, caryophyllene oxide, tricosane, aldehydes, alcohol, acids	*B. brevis* (**)		*S. aureus* (*)	10

Mahonia leschenaultii	Mahonia	Berberidaceae	Root	Water Ethanol	Alkaloids- berberine, neprotine, oxyacanthine, palmatine, jatrorrhizine	*B. subtilis* (*)			4
Mangifera indica	Mango	Anacardiaceae	Leaf Root	Water Ethanol	steroids, alkaloids, anthracenocides, coumarins, flavonones, catechol, gallic tannins,	*P. aeruginosa* (*E)	*K. pneumonia* (*W) (***E)	*S. aureus* (*W) (**E) *B. cereus* (*W) (**E) *P. vulgaris*(*E) *E. coli* (**E) *B. subtilis* (* E) *S. epidermis* (*W) (**E) *S. subfava* (*W) (**E) *A. faecalis* (**E) *E. aerogenes* (**E) *P. mirabilis* (*W) (**E)	21
Melastoma malabathricum	Indian rhododendron	Melastomataceae	Leaf Bark	Water	Kaempferol-3-o-β-D- glucoside, kaempferol, naringenin Ellagic acid Anthocyanin β- sitosterol	*B. brevis* (** L) (**B)		*S. aureus* (** B) *Vibrio cholera* (** L) (** B) *Candida krusei* (* L) *Bacillus subtilis* (** L)	10
Mentha arvensis	Pudina	Lamiaceae	Leaf	Acetone Methanol Ethanol Hot Aq Cold Aq	Tannins, phenols, steroids, flavonoids, volatile oils	*A. flavus* (**A) (**M) (**E)		*Bacillus cereus* (**A) (**M) (**E) (**HA) (**CA) *Serratia spp* (**A) (**E) (*M) (*CA) *P.citrinum* (**A) (**M) (*E)	14
Mukia maderaspatana	Cucumis maderaspatanus	Curcurbitaceae	Leaf	Acetone Ethanol			*K. pneumonia* (*A) (*E)	*S. pyogenes* (*A) (*E) *B. subtilis* (*E) *S. aureus*(*A)	13
Murrya koenigii	Curry leaf tree	Rutaceae	Leaves	Methanol	Flavonoids, linalool, elemol, geranyl acetate, myrcene, allo-ocimene			*S. aureus* (*)	16
Nyctanthes arbor-tristis	Night flowering	Oleaceae	Leaf Bark	Water	Arbortristosides A, B, glycerides of palmitic,	*P. aeruginosa* (*L) (** B)		*S. aureus* (** L) (* B) *S. flexneri*	10

	jasmine				linoleic, oleic, stearic and myristic acids, polysaccharide			(** L) (* B) *V. cholerae* (* L) (** B) *S. epidermidis* (** L) (**B) *B. subtilis* (** L) (**B) *E. coli* (** L) (**B)	
Ocimum basilicum	Basil	Labiatae	Leaf	Acetone Ethanol		*P. aeruginosa* (*A)	*K. pneumonia* (*E)	*S. pyogenes* (*E) *B. subtilis* (*A) *S. aureus* (*A) (*E)	13
Oroxylum indicum	Midnight horror	bignoniaceae	Bark	Water	Phlobatannin, flavonoids, phenols, tannins			*S. flexneri* (** B)	10
Paris polyphylla	RhizomaParidis	Melanthiaceae	Rhizomes	Methanol	Steroidal saponins	*A.niger* (***)		*S. aureus* (***) *E. coli* (***) *T. reesei* (***)	24
Partheniu m hysteroph orus	Whiteto p weed Asterac eae	Leaf Leaf	Methanol	Parthenolid , Parthenin, Terpenoids, Flavonoids Volatile oils, Sugars Amino acids			*E. coli* (*M)	7	
			Pet ether Methanol Chloroform Acetone Ethyl acetate		*P. aeruginosa* (***EA) (**C) (**A) (*M)		*B. subtilis* (***C) (***A) (***EA) (*M) *S. aureus* (***C)(***EA) (**A) (**M) (*PE) *E. coli* (*A) (*EA) *C. albicans* (*EA) *S. cerevisiae* (*M) (*C) (**EA) (**A)	8	
Piper nigrum	Black pepper	Piperaceae	Fruit	Ethanol Methanol Water	Tartaric acid, acetic acid, citric acid, succinic acid, gums, pectin, piperine,	*Pseudomonas* (*E) (**W) *Alcaligenes* (*E) (**W)	*Klebsiella* (*E) (*M) (*W)	*E. coli* (**E) (*M) (**W) *Staphylococcus* (**E) (*M) (**W) *Proteus* (*E) (*M) (*W) *Salmonella* (**E) (*M)	17

								(**W)	
Plectranthus ambionicus	Mexican mint	Lamiaceae	Leaf	Acetone Ethanol Water			*K. pneumonia* (*E)	*S. pyogenes* (*A) *B. subtilis* (*E) *S. aureus* (*A) (*W)	13
Pluchea lanceolata	Rasna	Asteraceae	Stem Root	Ethanol	Phenols, flavonoids proanthocyanidins, carotenoids, alkaloids,	*P. aeruginosa* (**)	*K. pneumonia* (**)	*S. aureus* (***) *E. coli* (**)	4
Plumbago indica	Fire plant	Plumbaginaceae	Root	Water Ethanol	Plumbagin plumbagic acid	*P. aeruginosa* (*)	*K. pneumonia* (*)	*S. aureus* (**) *E. coli* (*)	4
Pterospermum acerifolium	Kanak champa	Malvaceae	Leaf	Water	Methyl protocatechuate, vanillic acid, protocatechuic acid			*S. aureus* (*) *S. flexneri* (**) *B. licheniformis* (**)	10
Rauvolfia serpentine	Sarpagandha	Apocynaceae	Leaf	Acetone Methanol Ethanol Cold aqueous Hot aqueous	Indole alkaloid-reserpine, ajmaline, ajmalicine, serpentine	*A. flavus* (**A) (**M)		*B. cereus* (***M) (***E) (**A) (**CA) (**HA) *Serratia spp*(**A) (**M) (**E) (*HA) (*CA) *P.citrinum* (**A) (*M)	14
Solanum xanthocarpum	Yellow-fruit nightshade	Solanaceae	Leaf Whole plant	Acetone ethanol Water				*S. pyogenes* (*A) (*W) *S. aureus* (*E)	13
Syzygium aromaticum	Clove	Myrtaceae	Flower bud	Ethanol	Eugenol Flavonoids, hydroxybenzoic acids, hydroxycinamic acids, hydroxyphenylpropens	*P. aeruginosa* (***)	*K. pneumonia* (*)	*E. coli* (**) *S. typhimurium* (***) *S. mutans* (***) *E. faecalis* (**) *S. bovis* (***) *C. albicans* (***) *S. aureus* (***)	20

			Flower	Ethanol Methanol Water		*Pseudomonas* (**E)(* M) (**W) *Alcaligenes* (** W) (** E) (** M)	*Klebsiella* (* E) (* M) (** W)	*E. coli* (** E) (** M) (** W) *Staphylococcus* (** E) (* M) (** W) *Proteus* (** W) (* E) (** M) *Salmonella* (* E) (* M) (*** W)	17
Terminalia arjuna	Arjun tree	Combretaceae	Leaf	Ethanol	Flavonoid, tannins, phenols, phytosterols, saponins, alkaloids			*S. mutans* (***) *E. faecalis* (**) *S. aureus* (***)	20
			Leaf	Acetone Methanol Ethanol Cold aqueous Hot aqueous		*A. flavus* (**A) (** M) (** E) (* CA)		*B. cereus* (** A) (** M) (** E) (** CA) (* HA) *Serratia spp.* (** A) (** M) (** E) (* CA) *R.mucilaginosa* (** A) (**E) (** M) (* CA) *P.citrinum* (** A) (** M) (** E) (* CA)	14
Terminalia chebula	Black myrobalan	Combretaceae	Fruit	Water Ethanol	Alkaloid, saponins, tannins, steroid, flavonoid, cardiac glycosides, poly-uronolides	*P. aeruginosa* (**) *Bacillus subtilis* (**)	*K. pneumonia* (*) *Proteus mirabilis* (**)	*S. aureus* (***) *E. coli* (***)	4
Tinospora cardifolia	Heart-leafed moonseed	Menispermaceae	leaf	Methanol	Alkaloids, dirterpenoid lactones, glycosides, steroids, sesqui terpenoid, phenolics, aliphatic compounds, polysaccharides	*P. fluorescens* (**) *A. flavus* (*)		*E. coli* (*) *S. aureus* (**) *Dreschlera turcica* (*) *Fusarium verticillioides* (*) *B. subtilis* (**)	22
Trachyspermum ammi	Ajwain	Apiaceae	Fruits Seeds	Water	Thymol, carvacrol, ϒ-terpinene, ρ-cymene	*P. aeruginosa* (**)		*S. aureus* (**) *E. coli* (**) *S. typhimurium* (*)	19

								S. flexneri (*)	
Tridax procumbens	Coatbuttons	Asteraceae	Leaf	Methanol Ethanol Water	Alkaloids, tannins	*B. subtilis* (**)		*S. aureus* (**) *E. coli* (**)	26
Urqinea indica	Jungle pyaz	Asparagaceae	Bulb	Water	Alkyl resorcinols, bufadienolides, phytosterols, flavonoids	*B. brevis* (**) *P. aeruginosa* (**)		*S. aureus* (**) *S. flexneri* (**) *B. licheniformis* (***) *V. cholera* (**) *Candida krusei* (**) *B. subtilis* (***)	10
Viola odorata	Sweet violet	Violaceae	Flowers Twigs	Water	Cyclotides, alkaloids, methyl salicylate, mucilage, vitamin c	*P. aeruginosa* (**)		*S. aureus* (**) *S. typhimurium* (*) *S. flexneri* (**)	19
Vitex negundo	Chaste tree	Lamiaceae	Root	Ethanol Water	Iridoid negundoside, nishindaside vitexicarpinebetulinic acid,	*P. aeruginosa* (**)	*K. pneumonia* (**) *P. mirabilis* (**)	*S. aureus* (**)	4
			Leaf Bark	Water		*B. brevis* (** B) *P. aeruginosa* (** L)		*S. aureus* (**L) (*B) *S. flexneri* (** L) (* B) *B. licheniformis* (** B) *V. cholera* (* L) (**B) *Candida krusei* (** L) *S. epidermidis* (** L) *B. subtilis* (** L) (* B) *E. coli* (** L) (** B)	10
Vitex negundo	Chaste tree	Lamiaceae	Root	Ethanol Water	Iridoid negundoside, nishindaside vitexicarpinebetulinic acid,	*P. aeruginosa* (**)	*K. pneumonia* (**) *P. mirabilis* (**)	*S. aureus* (**)	4
			Leaf Bark	Water		*B. brevis* (** B) *P. aeruginosa* (** L)		*S. aureus* (**L) (*B) *S. flexneri* (** L) (* B) *B. licheniformis*	10

								(** B) *V. cholera* (* L) (**B) *Candida krusei* (** L) *S. epidermidis* (** L) *B. subtilis* (** L) (* B) *E. coli* (** L) (** B)	

Zone of inhibition in mm- * (8-15mm), ** (16-25mm), *** (> 25)

A- acetone, W- water, E- ethanol, M- methanol, EA- ethyl acetate, CA- cold aqueous, HA- hot aqueous, L- leaf, B- bark, S- stem, R- root

B. cereus- Bacillus cereus, B. subtilis- Bacillus subtilis, B. licheniformis, B. brevis- Bacillus brevis, Bacillus licheniformis, P.citrinum- Penicillium citrinum, A. flavus, Aspergillus flavus, E. coli- Escherichia coli, S. aureus- Staphylococcus aureus, K. pneumonia- Klebsiella pneumonia, P. fluorescens- Pseudomonas fluorescens, C. albicans- Candida albicans, A. flavus, Aspergillus flavus, P. aeruginosa- Pseudomonas aeruginosa, V. cholerae- Vibrio cholera, S. flexneri- Shigella flexneri, S. pneumoniae- Staphylococcus pneumoniae, K. aerogenes- Klebsiella aerogenes, P. vulgaris, Proteus vulgaris, P. mirabilis- Proteus mirabilis, S. pyrogenes- Streptococcus pyrogenes, S. mutans- Streptococcus mutans, E. faecalis- Enterococcus faecalis, S. bovis- Streptococcus bovis, A. fumigates- Aspergillus fumigates, A. niger- Aspergillus niger, A. oryzae- Aspergillus oryzae, S. typhi- Salmomella typhi, S. typhimurium, Salmonella typhimurium, S. cerevisiae, Saccharomyces cerevisiae, R. muciloginosa, Rhodotorula muciloginosa, Y. enterocolitica- Yersinia enterocolitica, L. monocytogenes- Listeria monocytogenes, A. hydrophilia- Aeromonas hydrophilia, D. turcica- Dreschlera turcica, A. faecalis- Alcaligenes faecalis, E. aerogenes- Enterobacter aerogenes, T. reesei- Trichoderma reesei, X. vesicatoria- Xanthomonas vesicatoria, R. solanacearum- Ralstonia solanacerum, S. subfava- Staphylococcus subfava, P. notatum- Penicillium notatum, M. luteus- Micrococcus luteus

DISCUSSION AND CONCLUSION

This study discussed about the antibacterial activity of some medicinal plants. Some plants are active against bacteria and some others are active against fungi. The activity against each microorganism depends of variety of factors such as chemical constituents, solvent used for extraction and plant part used for extraction. Antimicrobial activity of Indian herbs depicted in this review can be concluded as follows:

Based on chemical constituents

Every plant are rich in wide variety of secondary metabolites and there are specific chemical constituents which are active against bacteria or fungi. Mostly the antimicrobial activity of plants is due to tannins, saponins, phenolic compounds, essential oils and flavonoids. Example for this is *Centella asiatica*(highly active against fungus and gram +ve bacteria), *Terminalia arjuna* (highly active against gram +ve stain), *Cassia auriculata, Paris polyphylla, Annona reticulate, Lagerstroemia indica, Abutilon indicum* (high activity against gram +ve S.mutans), *Acacia nilotica* (high ZoI against gram +ve, gram –ve and fungus), *Achyranthes aspera, Adhatoda vasica, Aegle marmelos, Aristolochia braceolata, Buchnanania lanza, Calotropis gigantean, Cardiospermum halicacabum, Datura stramonium, Embelica officinalis and Hemidesmus indicus*. The secondary metabolites including glycosides, carbohydrates, terpenoids and coumarins present in this plant are also responsible for antimicrobial activity. In case of *Zingiber officinale* the essential oils such as gingerol, paradol, shogaols and zingerone are responsible

for antibacterial activity.[29]*Ocimum basilicum* contains estragole and methylenecyclohex- 1-ene and *Glycyrrhiza glabra* contains saponins such as glycyrrhizin, liquiritic acid and glycyrretol, flavonoids, isoflavonoids, stilbenoids and coumarine which is responsible for antibacterial and antifungal activity (chemical constituents are highly active against gram –ve bacteria).[30, 31]*Eucalyptus globules* contains many essential oils responsible for antimicrobial activity this includes 1, 8-cineole, citronellol, citronellyl acetate, p-cymene, eucamalol, limonene, linaool, β-pinene, α- terpinol and alloocinine.[32]*Cassia fistula* possess antimicrobial activity because of the presence of butanoic acid, 2- methyl-penthiophane and isopropyl acetate and *Croton roxburghii* contains diterpenoids such as labolane, clerodane, phorbol esters and kaurane as active constituents.[33, 34]

The spices such as clove (highly active against gram +ve, -ve and candida species fungi) and cinnamon contain eugenol as active constituent act against microbe. Black pepper contains piperine and turmeric contains curcumin and turmerone for antibacterial activity.[17] The antimicrobial activity of *Anethum graveolens* is due to carvone, limonene, dill- apiole, linoleic acid and anethole and *Azadirachta indica* is due to triterpenoids, carotenoids, valavinoids, ketones and azadirachtin.[9, 7]The essential oils in Elettaria cardamomum possess antimicrobial activity highly against gram –ve P. aeruginosa and gram +ve S. aureus [35]. *Parthenium hysterophorus* contains 5 terpenoids, volatile oils, flavonoids, amino acids and phenolic derivatives which is responsible for antimicrobial activity (highly against gram +ve and gram –ve stains).[36]

Based on antibacterial and antifungal activity

There are active constituents in plants which act against fungus and bacteria, most of the above mentioned Indian herbs are active against bacteria and some of them are also active against fungi. *Aspergillus* species bears asexual spores which is named as aspergillum [28] and is a fungus; there are many plants which shows antifungal properties which can be summarized as *Paris polyphylla* which shows high ZOI against *Aspergillus niger* and *Centillaasiatica* shows high activity against *Aspergillus flavus*. Plants which show antifungal properties against *Dreschlera turcica* and *Fusarium verticillioides* are *Azadirachta indica, Acacia nilotica, and Tinospora cardifolia*. *Candida albicans* are pathogenic yeast which can live inside and outside the body and plants such as *Acacia nilotica, Syzygium aromaticum and Cinnamomum zeylanicum* shows a high range of activity against fungi *Candida albicans*. *Saccharomyces cerevisiae* common fungi which is using to make nutritional supplements and products such as beer, wine and baked goods. It is also seen in plants and fruits.[25]*Parthenium hysterophorus* is the medicinal plant which is active against *Saccharomyces cerevisiae*. Yeast infections are very rare in humans but the fungi such are *Rhodotorulamucilaginosa* and *Penicillum citrinum* are responsible for most of the fungal infections in humans, the medicinal plants such as *Centella asiatica, Emblica officinalis, Mentha arvensis* which is showing good activity against both the fungi. *Paris polyphylla* showed activity against *Trichoderma reesei* a filamentous fungi.[5]

Based on gram +ve and gram –ve bacteria

All of the medicinal plants listed above are active against bacterias where as some are active against gram -ve and some are active against gram positive. *Syzygium aromaticum, Parthenium hysterophorus, Paris polyphylla, Lanata camara, Jasminium angustifolium, Flemingia nana, Elettaria cardamomum, Datura stramonium, Cinnamomum zeylanicum, Acacia nilotica and Abutilon indicum* are favourably active against gram +ve*Staphylococcus aureus*. *Urginea indica* a herbaceous flowering plant has shown a remarkable activity against the gram +ve stains of *Bacillus subtilis* and *Bacillus licheniformis* whereas *Parthenium hysterophorus, Lanata camara, Centella asiatica and Rauvolfia serpentine are active against gram positive bacillus strains*. *Syzygium aromaticum* and *Cinnamomum zeylanicum* are the medicinal plants which are active against the gram negative stains of both *Pseudomonasaerugiosa* and *Salmonella typhimurium*. *Glycerrhiza glabra* showed a greater activity against gram positive *Vibrio cholera* and *Mangifera indica*

showed high degree of activity against gram positive *Klebsiella pneumonia*.

Based on plant part

As there are many number of active constituents are present in medicinal plants in different parts of the plant that can be a particular part which shows the activity other than whole plant. It can be root, leaves, fruits or rhizomes which can be responsible for the antibacterial or antifungal activity respectively. The extracts of the specific plant part is using for the test of antimicrobial activity to test zone of inhibition or minimum inhibitory concentration. Out of 94 plants more plants showed activity on their leaves extract. 54 plants showed activity for their leaf extract, 16 plants showed activity using their root extract, bark was used form 13 plants, fruits was used form 11 plants, seeds the embryonic part of the plant was used from 7 plants, main reproductive organ of a plant which is a flower is used from 5 plants, stem extract was used from 5 plants, rhizomes of 3 plants showed activity against microorganism and the kernel and bulb was used from 1 plant.

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