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PHARMACOLOGICAL ANALYSIS OF OBNOXIOUS WATER WEED: *EICHHORNIA CRASSIPES* (MART.) SOLMS

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ABSTRACT

Eichhornia crassipes (Mart.) Solms, commonly known as water hyacinth, an aquatic plant coined to diverse activities including its role as an obnoxious weed with tremendous economic and aesthetic implications. The aim of the current experiment was to explore antimicrobial, antioxidant and phytochemical properties of this weed while using different non-polar solvents *viz*., petroleum ether, chloroform and polar solvents i.e., methanol and aqueous (distilled water) solvent extracts of root, stem and leaf of *E. crassipes*. Disc diffusion method was employed to analyse the antifungal activity against two fungi (*Penicillium italicum* and *Botrytis cinerea*) and antibacterial activities against two bacteria *viz*. *Xanthomonas axonopodis* and *Bordetella pertussis*. The extracts of weed showed significant activity against these two fungi and two bacteria when compared to standard. Maximum antifungal and antibacterial potential was recorded in leaf chloroform extract against *B. cinerea* (29 mm) and in leaf methanol extract against *B. pertussis* (17 mm) respectively among other extracts. Moreover, antioxidant potential of weed also showed the presence of significant secondary metabolites. Phytochemical analysis indicate presence of alkaloids, coumarins, terpenoids, tannins and flavonoides and absence of saponins, anthrax-quinones, phlobatanins and cardiac glycosides by standard procedures. These results also depict the significance of the plant in pharmaceutical industry.

Key words: *Eichhornia crassipes*, antibacterial activity, antioxidant activity, phytochemical analysis.

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INTRODUCTION

Water hyacinth (*Eichhornia crassipes* Mart. Solms) has been acknowledged as world's most pervasive, most productive, free floating and self-compatible, allowing selfed seed to be produced in abundance in populations monomorphic for style morph (Center *et al*., 1999; Barrett, 2015). Numerous studies, however, has been carried out to explore its beneficial role in nature e.g. by evaluation of antimicrobial, antioxidant and phytochemical properties in a similar vein as in medicinal or aromatic plants to outweigh its negative role and reported that this weed has a myriad of metabolites. Classic work of Edwards *et al*. (1985) and recent reports claim use of this weed for feed formulations and extensive role in phyto remediation and in removing greenhouse gases (Agunbiade *et al*., 2009; Jafari, 2010; Li *et al*., 2015; Pandey, 2015; Attermeyer *et al*., 2016). Recently, it has been documented that aqueous extracts of leaves of *E. crassipes* has active constituents which significantly enhanced resistance against pathogen *Lactococcus garvieae* in prawn (Chang and Chen, 2016). Extracts of different parts of *E. crassipes* plant in different organic or inorganic solvents were tested on mice models which were reported to have antitumor, anti-ulcerogenic and anti-inflammatory effects (Sanitha, 2005; Ali *et al*., 2009). Besides, scientists have emphasized how little was known about the antioxidant activity of this weed and opined that evaluation of its antioxidant potential and radical scavenging activity is of current interest; subsequently, it can be used to retard the peroxidation of lipid, which ultimately deteriorate the food, decreases its nutritional value as well as functional properties, ultimately leads to the cancer and other chronic diseases by damaging the human tissues (Yagi, 1987; Yen and Chen, 1995; Surendraraj *et al*., 2013). Extensive use of synthetic antioxidants to control the peroxidation of lipid in foods, have increased the health risks due to toxicity (Linderschmidt *et al*., 1986; Sobedio *et al*., 1991; Olukemi *et al*., 2005). Consumers, however, over the time avoiding such foods subsumed with chemicals and stipulate the replacement of synthetic antioxidants with natural one. Therefore, exploitation of new sources of natural antioxidants with these dangerous preservative has attracted increasing attention and plants have always been recommended as best source because they produce antioxidants (nutrients in food) motivated by oxygen and sun light, and slow the oxidative damage to our body by controlling it.

Arguably, oxidative damage induced by free radicals (singlet oxygen, superoxide anion radicals and hydroxyl radicals) has been reported to imbalance the prooxidants and antioxidants ultimately leading to the destruction or modification of macromolecules (DNA, proteins, lipids, carbohydrates etc.) in biological systems. Furthermore, secondary metabolites in plants (alkaloids, terpenoids and phenolics), also known as phytochemical (bioactive compounds) have different metabolic activities, which have been reported to have defence action against damage caused by free radicals by mitigating harmful effects of free radicals hence act as antioxidants. For example, various biochemical and antimicrobial activities, in plants, has been listed for flavonoids (group of polyphenolic substances) which exert antioxidant activity through radical scavenging, protects membranes and metal ion chelation (Kumar *et al*., 2013; Kumar and Pandey, 2013; Liu *et al*., 2010; Rajeshwari *et al*., 2014). Similarly, Kumar *et al*. (2014) also opined that leaf aqueous extracts of *E. crassipes* have potent antioxidant, antimicrobial, cytotoxic and hepatoprotective activity *in vitro* and *in vivo*. Phytochemicals though considered as large and diverse group of compounds of natural origin, yet they have been reported to have no role in nutrition beside work together with other fibre and active compounds of food to protect the body from diseases. Many research reports gathered for importance of medicinal plants are in confirmatory with this view that these plants lack nutrition (Pramila *et al*., 2014). Therefore, attempt was made for preliminary antimicrobial, antioxidant and phytochemical assessment of different parts of *E. crassipes* which may be used in drugs manufacturing and may prove beneficial for humanity by employing in drugs manufacturing.

MATERIALS AND METHODS

Sample collection and extraction: *E. crassipes* whole plant samples were collected from the pond of Jinnah Garden Lahore, Pakistan and different parts of plant were dried after thorough washing and saved in labelled amber colored bottles. The dried powdered plant material was extracted in different non-polar solvents *viz*., (i) petroleum ether, (ii) chloroform and polar solvents i.e., (iii) methanol (iv) distilled water extracts by following maceration method (Fig. 1).

Antimicrobial Activity: Above mentioned solvents were used for extraction of different parts of *E. crassipes* (root, stem and leaf) were also employed to explore their antimicrobial feature and different readings of inhibitory zones against two fungal pathogen and two-gram negative bacteria (Fig. 2). These observations were recorded and compared with reference to standard disc zones.

Antifungal and antibacterial activity: Antifungal and antibacterial activity of the free floating *E. crassipes*, in which all crude extracts were tested, was performed by adopting the methodology of Ferreria *et al*. (1996). Test microorganism employed in the study were two fungal pathogens *viz*., *Penicillium italicum* and *Botrytis cinerea* and two bacterial strains *viz*., *Xanthomonas axonopodis* and *Bordetella pertussis*. After preparation of slants for bacteria and fungus (Qadeer *et al*., 1990) their respective inoculums were prepared. Thereafter, the respective growth media petri-plates were prepared for the measurement of antimicrobial efficacy of extract of specified plant. The petri plate was divided into two sections. In each section the crude extract of different plant parts was poured with the help of sterilized dropper into their respective uniform hole of 0.5 mm. Whereof, in the second and third series of experiments pure solvent and commercially available standard antibiotic disc was placed in the hole as follows (1) Ampicillin disc (10 µg) against *Xanthomonas axonopodis* (2) Amikacin disc (30 µg) against *Bordetella pertussis* (3) Fucanazole (23.75 µg) against *Penicillium italicum and* (4) Kanamycin disc against *Botrytis cinerea* under aspect conditions respectively. The inhibited zone (measured with the aid of vernier calliper, mm in diameter) became prominent after the required incubation time of bacteria and fungi i.e., 24 and 48 hours respectively.

Antioxidant activity: The total antioxidant capacity was assayed for all the extracts by adopting the method devised by Prieto *et al*. (1999).The reaction mixture (100 µl of each solution + 1900µl of reagent solution) was incubated at 95°C for 60 min. Readings were recorded at A_{695} nm, after cooling the samples at room temperature. The antioxidant activity of Beta hydroxyl toluene (BHT; 0.5 mg mL^{-1}) was also assayed for comparison. The scavenging activity was calculated by the following formula:

$$\text{Total antioxidant capacity} = 1 - \frac{A1}{A0}$$

Where A1 was the noted for absorbance of the sample in the presence of scavenger and A0 was recorded for the absorbance of control. The prepared extract of plant fractions in different solvent was used to evaluate the free radical scavenging activity that react with the stable radical DPPH (2,2-diphenyl-1-picrylhydrazyl radical) by following the method established by Erasto *et al*. (2004) at A_{517} nm. Control devoid of plant extracts and contained only reagents.

$$\text{DPPH radical scavenging activity (\%)} = \frac{\text{A control} - \text{A extract}}{\text{A control}} \times 100$$

Where:

- 'A control' was noted as absorbance of DPPH solution with no plant extract

- 'A extract' was noted as absorbance of tested extract.

Readings were taken in triplicate.

Phytochemical tests: Furthermore, plant parts extracts were subjected to phytochemical analysis for the assessment of secondary metabolites *viz*., alkaloids, saponins, anthraquinones, coumarins, terpenoids, flavonoids, tannins, phlobatannins and cardiac glycosides for their presence or absence in the particular extract (Jamil *et al*., 2012). Data was collected in triplicate and results were noted down as an average of three replicates (Snedecor and Corchan, 1980).

RESULTS AND DISCUSSION

Antifungal Activity: Data presented in Table 1 depicted that antifungal activity against *P. italicum* and *B. cinerea* with various non-polar and polar solvents extracts of *E. crassipes* (Figs. 3&4). For the *P. italicum* root extracts in petroleum ether (24 ± 1.00^{a} mm), aqueous extracts of stem (20.3 ± 1.52^{a} mm) and chloroform extracts of leaf (23 ± 1.00^{a} mm) showed maximum value for inhibitory zone. Whereof, chloroform extract of both root and leaf depicted minimum inhibitory zone i.e., 11 ± 1.00^{d} mm and 11 ± 1.00^{b} mm respectively. In contrast, chloroform extracts of leaf and stem showed maximum zone of inhibition (29 ± 1.00^{a}) and (15 ± 1.00 ^{a}) respectively, against the fungus *B. cinerea*. Furthermore, root aqueous extracts showed maximum zone of inhibition (24 ± 1.00 mm) closely followed by leaf extracts in distilled water (24.3 ± 1.52^{b}) whilst, petroleum ether extracts of both leaf and stem showed similar and minimum inhibitory zone i.e., 6 ± 1.00^{c} mm. However, petroleum ether and chloroform extracts of root showed transitional values of zone of inhibition i.e., 10 ± 1.00^{b} mm and 8 ± 1.00^{c} mm respectively for *B. cinerea*.

Antibacterial Activity: In this study antibacterial activity against two gram negative strains *viz*., *X. axonopodis* (Fig. 5) and *B. pertussis* (Fig. 6) have been tested with different solvent (non-polar and polar) extracts of *E. crassipes* (Table 2). Maximum antibacterial activity against *X. axonopodis* was recorded for methanolic extracts of stem (12 ± 1.00^{a} mm) by contrast against pathogenic strain *B. pertussis* maximum activity was recorded leaf methanolic extracts (17 ± 1.00^{a} mm). Similar ability of aqueous extracts of root and stem was recorded against *B. pertussis* (7 ± 2.00 mm) but against *X. axonopodis* maximum inhibition of zone was showed by leaf aqueous extracts (9 ± 1.00^{a} mm). In the current antibacterial assay, the ability of petroleum ether (root) and aqueous distilled water (leaf) extracts of this weed to inhibit the activity of *X. axonopodis* was determined (9 ± 1.00^{a} mm) and (9 ± 1.00^{a} mm) respectively. Transitional values of zone of inhibition i.e., 6.66 ± 1.52^{c} mm and 8 ± 1.00^{bc} mm respectively were showed by extract of leaf in distilled water and petroleum ether.

Research reports demonstrated that plants including aquatic plants produce a range of naturally occurring known therapeutic compounds having anticancer and antimicrobial properties, which are toxic to microbes. Cytotoxic and antimicrobial activities of different parts of *E. crassipes* plant extracts have also been validated in different literature. Several of such annotations have helped in categorization and classification of these active constituents, which helped in production of new antimicrobial drugs, whereas such compounds have also been reported to use as food and feed (Vasu *et al*., 2009; Lata *et al*., 2010; Kurup *et al*., 2013; Kumar *et al*., 2014; Zohra *et al*., 2016; Chang and Chen, 2016). Current study supports the arguments of many researchers that various extracts of this weed have antimicrobial potential like methanolic, crude and aqueous extracts of parts of plant. Our results are in accordance with Baral and Vaidya (2011) reported the better efficacy of methanolic extracts against bacteria while aqueous extracts showed relatively better results against different fungi. Similarly results documented by Jayanthi and Lalitha (2013) strong antimicrobial activity in solvent extracts of *E. crassipes* which also strongly supports our current results. Previously, such results were also reported by Fareed *et al*. (2008) where different solvents were employed like ethanol, methanol and aqueous extracts for different parts of the *E. crassipes* (roots and leaves) to exploit its efficacy against different bacterial and fungal pathogen and aqueous extracts performed well as compared to other. Such difference against the pathogen by a similar extract might be due to their reliance against the pathogen by a similar extract might be due to their reliance on pH, concentration of extract and time duration (Kurup *et al*., 2013; Zohra *et al*., 2016).

Antioxidant activity: Data presented in Table 2 depict the antioxidant and radical scavenging activity with DPPH assay of different extracts of *E. crassipes* by using non-polar-solvents like petroleum ether, chloroform and polar like methanol and dist. water. Antioxidants perform as free radical scavengers that foil and healing the damage done by the free radicals. The total antioxidant assay was accomplished with various plant extracts to analyse them qualitatively. The standards were used to compare the results of plant extracts. Hence they can be used as standards. *E. crassipes* root in petroleum ether extract showed value equal to the standard chemical α-Tocopherol its value is 0.513 and hence can be used as standard. While *E. crassipes* stem in petroleum ether and chloroform extract showed lowest antioxidant values i.e., 0.33 ± 0.12^{a} and 0.44 ± 0.09^{a} respectively and stem in methanol extract showed value 0.45 ± 0.12^{a} which is close to the standard chemical BHT whose value is 0.476.

The distilled water extract of *E. crassipes* leaves showed highest antioxidant value 0.58 ± 0.09[a]. Being stable nitrogen-cantered free radical, DPPH is used for estimation of radical scavenging activity of different parts of plant extracts. The obtained results of plant extracts were being matched with standard antioxidant available. *E. crassipes* root in chloroform extract showed highest value i.e., 0.53±0.08[a] and in methanol extract root showed lowest value i.e., 0.34 ± 0.08[a] while stem in petroleum ether extract showed lowest value i.e., 0.33 ± 0.12[a]. The leaves in distilled water and petroleum ether extract showed highest antioxidant value 0.58 ± 0.09[a] and 0.54 ± 0.07[ab] respectively and overall all extracts showed higher values than standards so cannot be taken as standard because it do not resemble to the standard α-Tocopherol and BHT as presented in Table 2. While, flavonoids have sturdy anti-cancerous activity and its free radical scavengers avert oxidative cell damage, have sturdy anticancer activity (Salah *et al*., 1995; Lata and Dubey, 2010_a, 2010_b). Our results depict that this aquatic weed had strong antioxidants potential which is in line with the previous findings that *E. crassipes* (Mart.) Solms possess many antioxidants like ascorbic acid, glutathione etc (Kurup *et al*., 2013; Lalitha and Jayanthi, 2014). Whereof, similar results were also reported by Subedi *et al*. (2012) that antioxidant helps in treatment of disorders like cardiovascular disease, ageing, cancer, rheumatoid arthritis and diabetes.

Phytochemical Analysis: The present research paper illustrates qualitative analysis of the *E. crassipes* parts *viz*., root, stem and leaf extracts with different non-polar and polar solvents which revealed the presence of many important constituents by using standard procedures are summarized in (Table3). Phytochemical screening of extracts revealed the indication of alkaloids, coumarins, terpenoids, tannins and flavonoides, in contrast to saponins, anthrax-quinones, phlobatanins and cardiac glycosides which were found absent. Considerable research efforts have been headed to evaluate and exploit the presence of such secondary metabolites in other aquatic weeds including *E. crassipes* (Rio *et al*., 1997; Okwu and Josiah, 2006; Vasu *et al*., 2009; Pepsi *et al*., 2012; Rajeshwari *et al*., 2014). Similar results were documented by many researchers for the presence of flavonoids, terpenoids, alkaloids and tannins and these are reported as a source of antioxidants in the weed water hyacinth (Nyananyo and Ogamba, 2005; Jayanthi *et al*., 2011; Lalitha *et al*., 2012, 2013; Kurup *et al*., 2013; Tulika and Mala, 2015). In contrast to Lalitha *et al*. (2012) our results showed absence of cardiac glycosides. Beside Vasu *et al*. (2009) reported the existence of saponins and absence of flavonoids likewise, Vasu *et al*. (2009) also reported the absence of flavonoids whereof, presence of phenols, alkaloids, steroids, triterpenoids and tannins in the methanol extract of *E. crassipes* which is contradiction to our results where saponins were absent but flavonoids and terpenoids were present. Our results are also in line with Lata *et al*. (2010) who assessed the absence of saponins but presence of few secondary metabolites in aqueous extracts of this weed. Such contradictions may be due to variations in geographical regions like minerals in soil and environmental factors which have significant influence on phytochemical contents of the water weed (Chakrabarthy, 2009: Lata and Dubey, 2010_a, 2010_b; Jayanthi *et al*., 2011; Borokini and Ayodele, 2012). The analysis of this study evidenced that *E. crassipes* shows potential for different phytochemical which act as secondary metabolites and are bioactive constituents hence this aquatic weed is a valuable reservoir of secondary metabolites which have active role in scavenging the deleterious effects of reactive oxygen species and also have compounds of substantial medicinal merit.

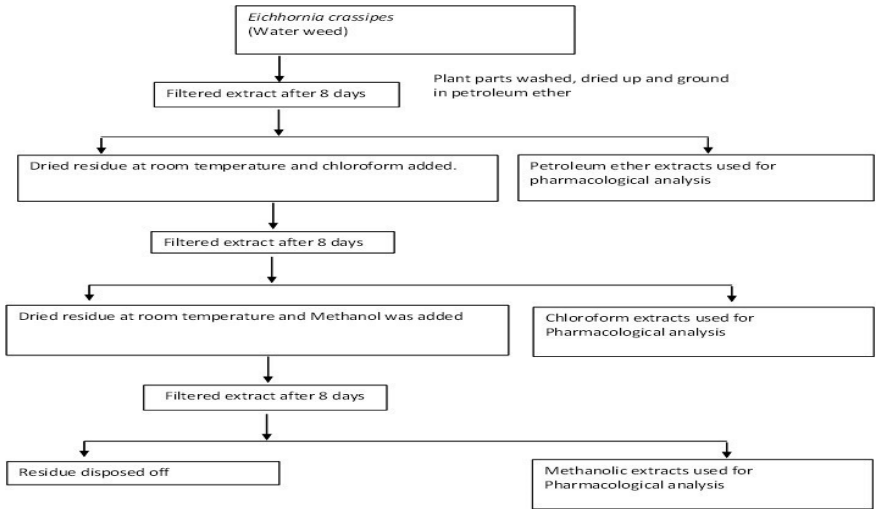
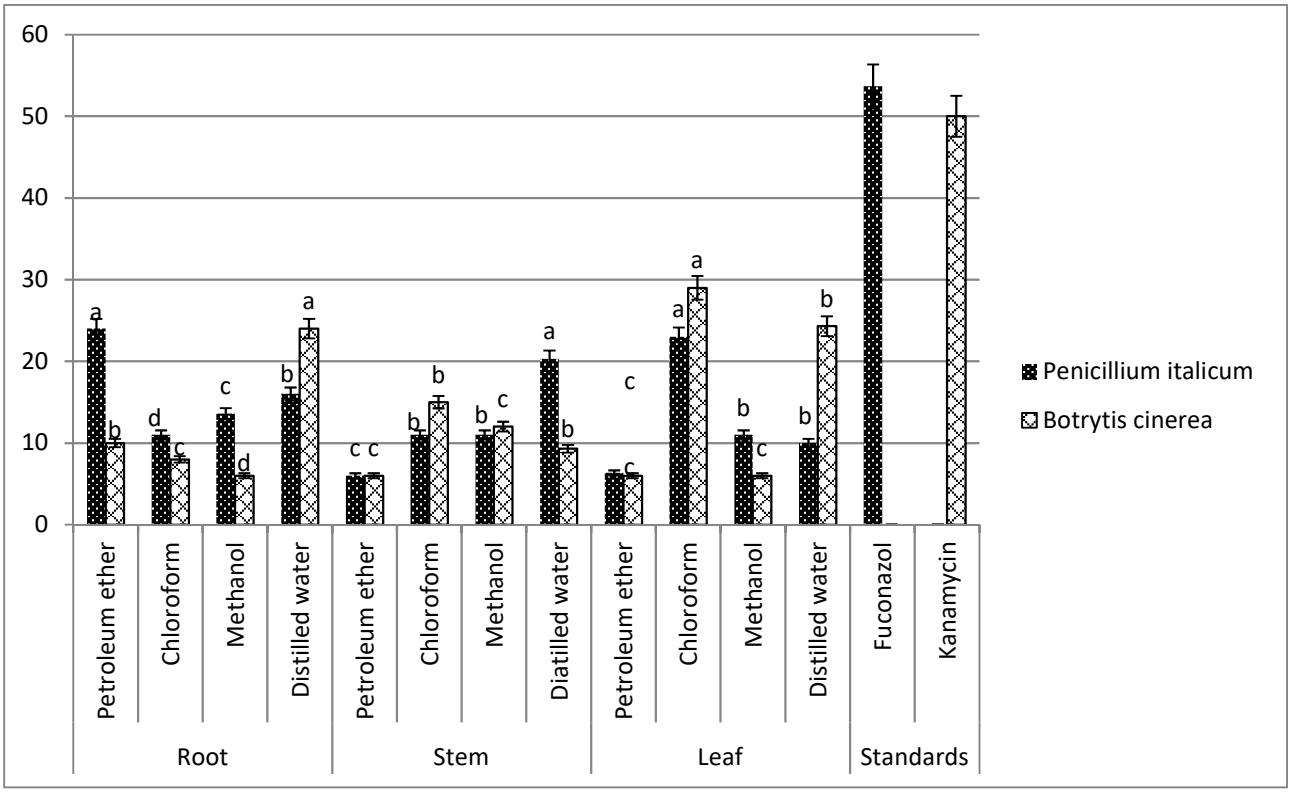


Fig.1. Overall flow diagram showing non-polar and polar solvents extraction method.

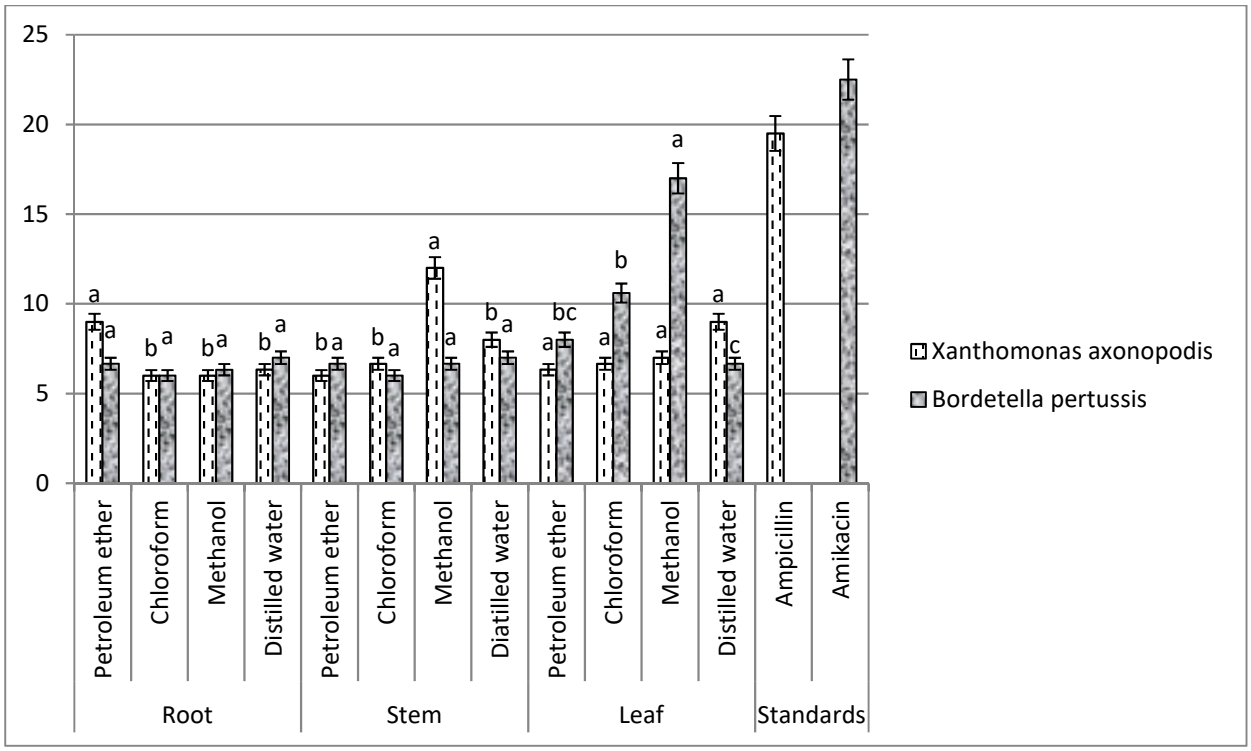
Table 1. Zone of inhibition (diameter in mm) formed by root, stem and leaf of *E. crassipes* extracts against fungal (*Penicillium italicum* and *Botrytis cinerea*) and bacterial (*Xanthomonas axonopodis* and *Bordetella pertussis*) pathogens in various non-polar (petroleum ether, chloroform) and polar (methanol and distilled water) solvents.

Solvents (non-polar and polar)	Plant parts	Diameter of inhibition zone (mm)according to microorganism			
		Fungal strains		Bacterial strains	
		P. italicum	*B. cinerea*	*X. axonopodis* (Gram-negative)	*B. pertussis* (Gram-negative)
Petroleum ether	Root	24 ± 1.00 [a]	10 ± 1.00 [b]	9 ± 1.00 [a]	6.66 ± 1.52[a]
Chloroform		11 ± 1.00 [d]	8 ± 1.00 [c]	6 ± 1.00 [b]	6 ± 1.00 [a]
Methanol		13.6 ± 1.52 [c]	6 ± 1.00 [d]	6 ± 1.00 [b]	6.33 ± 1.52 [a]
Distilled Water		16 ± 1.00 [b]	24 ± 1.00 [a]	6.33 ± 1.52[b]	7 ± 2.00 [a]
Petroleum ether	Stem	6 ± 1.00[c]	6 ± 1.00 [c]	6 ± 1.00 [b]	6.66 ± 1.52 [a]
Chloroform		11 ± 1.00 [b]	15 ± 1.00 [b]	6.66 ± 1.52[b]	6 ± 1.00 [a]
Methanol		11 ± 1.00 [b]	12 ± 1.00 [c]	12 ± 1.00 [a]	6.66 ± 1.52 [a]
Distilled Water		20.3 ± 1.52[a]	9.3 ± 1.52[b]	8 ± 1.00[b]	7 ± 2.00[a]
Petroleum ether	Leaf	6.33 ± 1.52 [c]	6 ± 1.00 [c]	6.66 ± 1.52[a]	8 ± 1.00 [b c]
Chloroform		23 ± 1.00 [a]	29 ± 1.00 [a]	6.66 ± 2.08 [a]	10.6 ± 2.08 [b]
Methanol		11 ± 1.00 [b]	6 ± 1.00 [c]	7 ± 2.00 [a]	17 ± 1.00 [a]
Distilled Water		10 ± 1.00 [b]	24.3 ± 1.52[b]	9 ± 1.00[a]	6.66 ± 1.52 [c]
		Standard discs employed		Standard discs employed	
		Fuconazole	Kanamycin	Ampicillin	Amikacin
		53.66 ± 1.50	50 ±1.20	19.5 ± 2.12	22.5 ± 3.21

LSD = 1.28 each value is an average of three replicates ± followed by standard deviation of each row and column.



(a)



(b)

Fig. 2. Comparison of zone of inhibition (mm) between two (a) fungal pathogen *viz. P. italicum* and *B. cinerea* and (b) bacterial strains *viz. X. axonopodis* and *B. pertussis.*

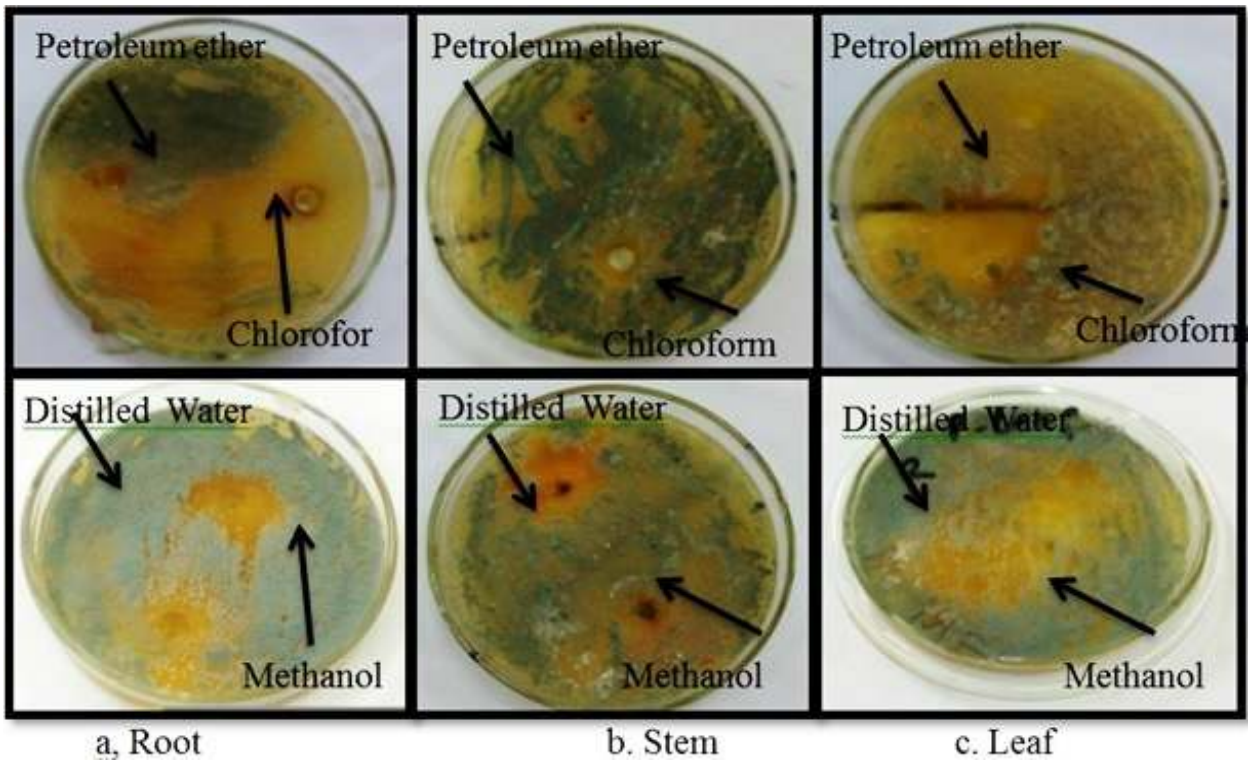


Fig. 3. Antifungal activity of *Eichhornia crassipes* (Mart.) Solms various parts (a) root, (b) stem and (c) leaf extracts in various non-polar i.e., petroleum ether, chloroform and polar methanol and distilled water solvents against *Penicillium italicum.*

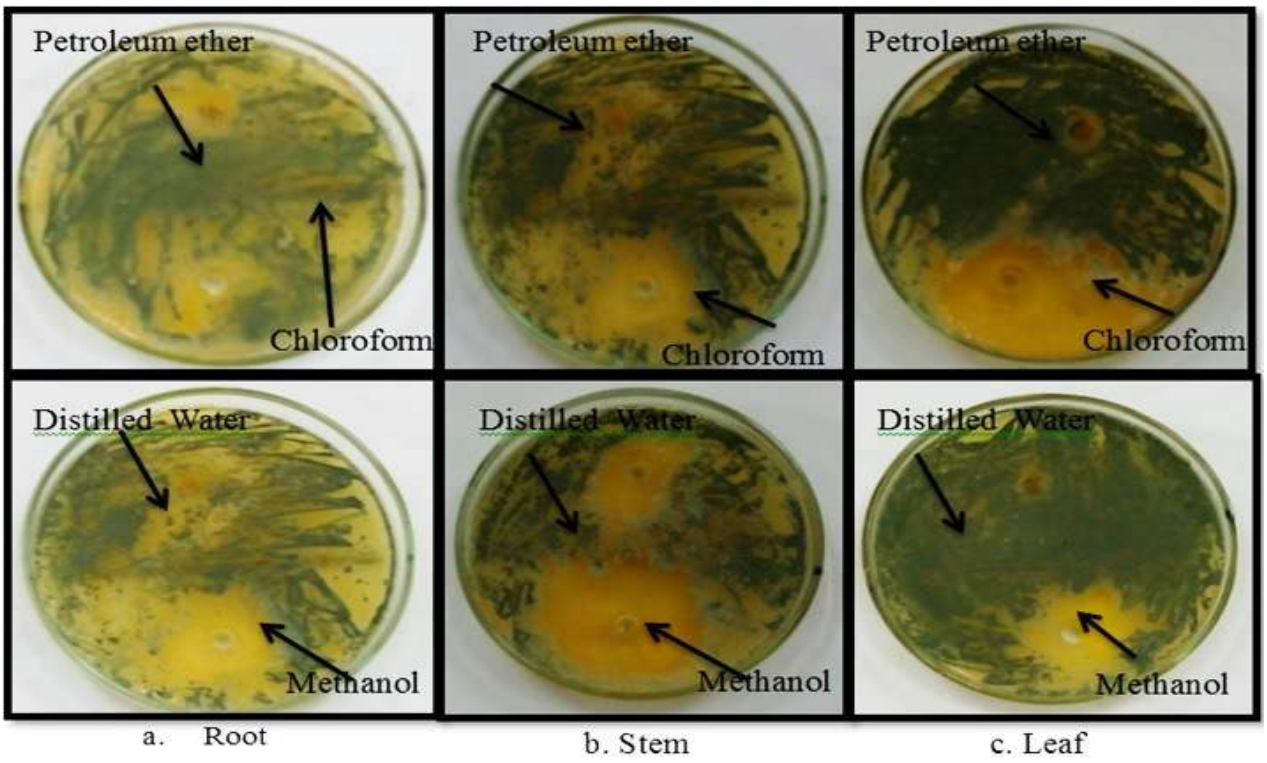


Fig. 4. Antifungal activity of *Eichhornia crassipes* (Mart.) Solms various parts (a) root, (b) stem and (c) leaf extracts in various non-polar i.e., petroleum ether, chloroform and polar methanol and distilled water solvents against against *Botrytis cinerea.*

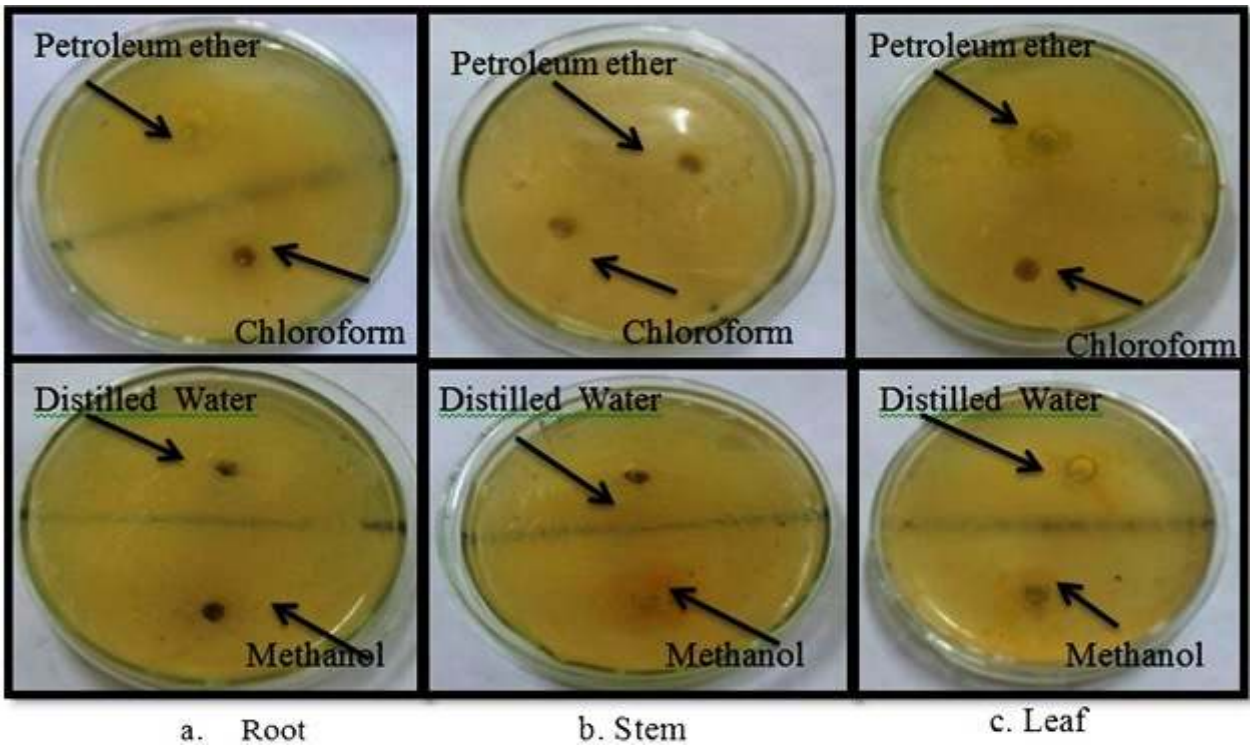


Fig. 5. Antibacterial activity of *Eichhornia crassipes* (Mart.) Solms various parts (a) root, (b) stem and (c) leaf extracts in various non-polar i.e., petroleum ether, chloroform and polar methanol and distilled water solvents against against *Xanthomonas axonopodis.*

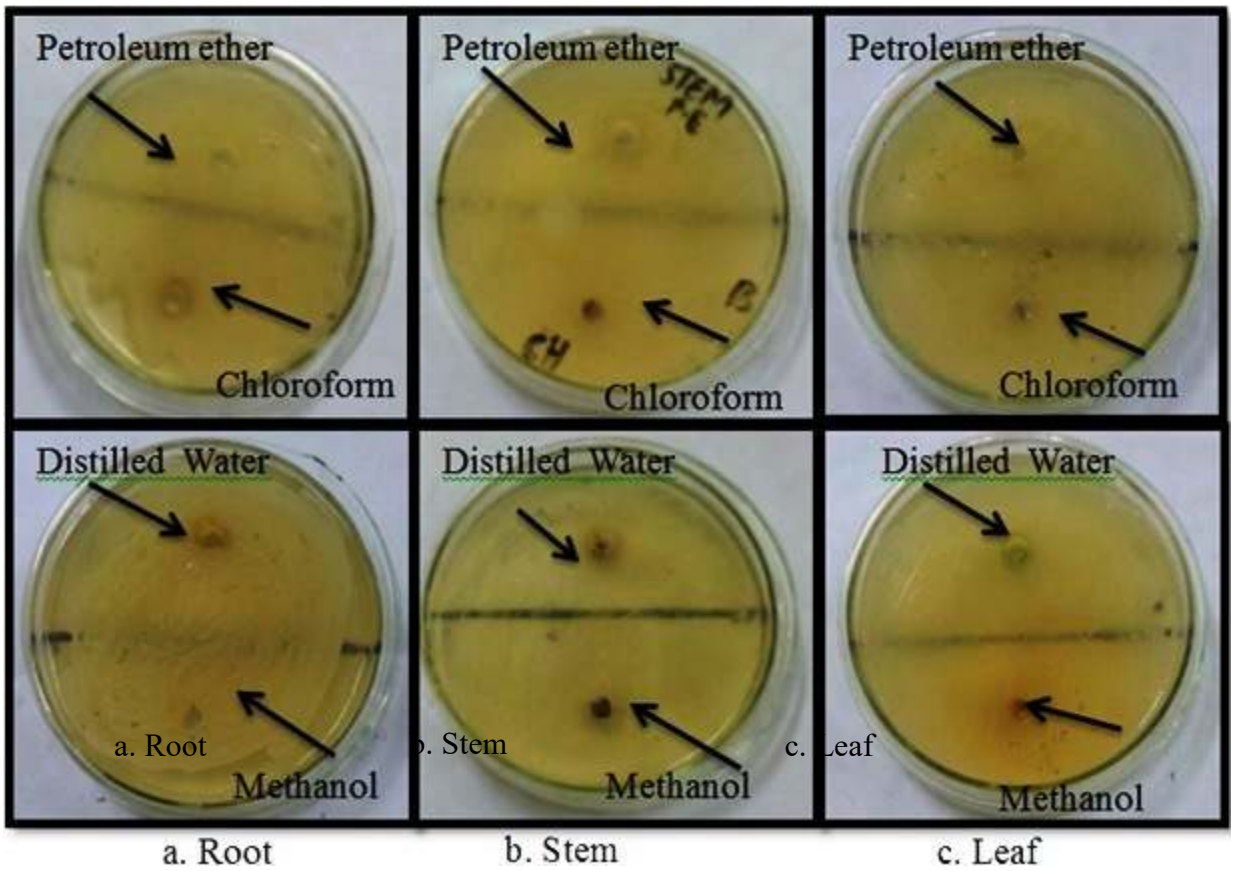


Fig. 6. Antibacterial activity of *Eichhornia crassipes* (Mart.) Solms various parts (a) root, (b) stem and (c) leaf extracts in various non-polar i.e., petroleum ether, chloroform and polar like methanol and distilled water solvents against *Bordetella pertussis.*

Table 2. Antioxidant activity of *E. crassipes* (root, stem and leaf) in different non-polar and polar solvents (petroleum ether, chloroform, methanol and aqueous distilled water extracts) by using (i) total antioxidant assay and (ii) DPPH assay.

Solvents (non-polar and polar)	Plant parts	Antioxidant activity	
		(i) Total Antioxidant assay	(ii) DPPH assay
		Absorption at 695 (nm)	Absorption at 517 (nm)
Petroleum Ether	**Root**	0.51 ± 0.09^{a}	0.51 ± 0.09^{a}
Chloroform		0.53 ± 0.08^{b}	0.53 ± 0.08^{a}
Methanol		0.33 ± 0.09^{b}	0.34 ± 0.08^{a}
Distilled Water		0.53 ± 0.10^{a}	0.52 ± 0.09^{a}
Petroleum Ether	**Stem**	0.33 ± 0.12^{a}	0.33 ± 0.12^{a}
Chloroform		0.44 ± 0.09^{a}	0.46 ± 0.07^{a}
Methanol		0.45 ± 0.12^{a}	0.46 ± 0.10^{a}
Distilled Water		0.46 ± 0.09^{a}	0.46 ± 0.09^{a}
Petroleum Ether	**Leaf**	0.54 ± 0.07^{ab}	0.54 ± 0.07^{ab}
Chloroform		0.33 ± 0.13^{ab}	0.33 ± 0.13^{ab}
Methanol		0.42 ± 0.11^{b}	0.42 ± 0.12^{b}
Distilled Water		0.58 ± 0.09^{a}	0.58 ± 0.09^{a}
Standards		α- Tocopherol = 0.513 Butyl hydroxytouline = 0.476 Blank = 0.026	α- Tocopherol = 0.095 Butyl hydroxytouline = 0.190 Blank = 0.0035

Note: Each value is an average of three replicates ± followed by standard deviation of each row and column.

Table 3. Screening of phytochemicals of *E. crassipes* parts *viz*. root, stem and leaf..

S. #	Phytochemical (indications)	Root	Stem	Leaf
1	Alkaloids (Creamish ppt.)	++	++	++
2	Saponins (Persistent froth)	-	-	-
3	Anthraquinones (Pink froth)	-	-	-
4	Coumarins (Yellow flouresence)	+	+++	+++
5	Terpenoids (Blue-green ring)	++	+++	+++
6	Flavonoids (Dark yellow colour)	++	+++	++
7	Tannins (Brownish colour)	+++	+++	+++
8	Phlobatannins (Red ppt.)	-	-	-
9	Cardiac glycosides (Blue green color)	-	-	-

Indicators: + + + = very high quantities; ++ = high quantities; + = low quantities; - = not detectable.

Conclusion: From the current study it is being concluded that selected water weed showed significant antimicrobial and antioxidant activity along with beneficial phytochemical whilst, results were being compared with the commercially available standards. The statistical analysis performed depicts that both stem and leaf extracts are more potent antimicrobial agent as compared to root extracts. Thus, comprehensive pharmacokinetic research is warranted to determine the dose and efficacy of biologically active compounds and its pattern of disposition. Nonetheless, presence of phytochemical in this worst aquatic weed and appreciable antioxidant and antimicrobial activity makes it a valuable plant because there is call for isolation and purification of active constituents of the plant extracts which show significant antimicrobial activity in order to develop future pharmaceuticals.

Conflict of interest: Authors have no conflict of interest with any other.

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