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Parthenium hysterophorus. L. (Asteraceae): A Boon or Curse? (A Review)

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ABSTRACT

Parthenium hysterophorus (Linn.) is violent every where annual, herbivorous weed, commonly found in America but presently invaded in four continents. It shows hazardous effect on human health, livestock as well as it reduces the crop production due to its allelopathic effect. Partheniun with other constituents discussed are the cause behind the intimidating role of this weed. Inspite of these drawbacks the weed is traditionally known for the treatment of wounds, fever, ulcerated sores and malaria. It can also be used to increase the agricultural productivity and for the elimination of heavy metals from soil as well as from water to reduce pollution. The main aim of this review article is to summarise the main positive and negative effects of the *Parthenium hysterophorus*.

Keywords: *Parthenium hysterophorus,* Allelopathic effect, weeds**.**

INTRODUCTION

From the ancient time human being depends on plants species for their different needs. Various reports are available on utilization of various parts of the plants including weeds[1,2,3]. *Parthenium hysterophorus* (Linn.) (Asteraceae) is a herbaceous annual of Asteraceae family. At present *P. hysterophorus* (Linn.) has captured urban and agriculture zones and become obnoxious weed out of seven one of the seven most intolerable weeds of the world[4] It is commonly called congress weed, carrot weed, star weed, feverweed, white top, chatak chandani, bitter weed, ramphool, gajar ghass etc.

The weed is highly flexible to adverse environmental conditions, and also a successful invader in any open land. It easily establishes its own colony at the cost of other vegetation. The plant is very creative seed producer, with up to 25,000 seeds per plant[5] and with an enormous seed bank, estimated at 2,00,000 seeds m^{-1} in abandoned fields[6] Furthermore, germination of seeds can take place anytime if appropriate moisture level given.

The seeds of the plant remain feasible for a long period of time and can even survive under harsh environmental conditions[7]. Non dormancy and extreme light weight seeds help its extensive spread and establishment. It is an annual with fast maturity level. Generally, flowering takes place when they are 4 to 8 weeks old and flower for several months. The weed can germinate grow mature & set seeds, complete its life cycle in 4 weeks even in under unfavourable conditions such as drought. The weed also has a very high instructive potential[8].

Geographical Distribution

Parthenium weed is naturally found in tropical and subtropical America, from southern United State of America, through southern Brazil and northern Argentina[9]. The weed was accidentally introduced to Asia, Africa and Australia. It is widely known that the weed in India for the first time was recorded by Rao from Puna, (Maharashtra) and blame goes to the USA PL 480 scheme wheat seeds with which the seeds of the *P. hysterophorus* came to India accidently[10]. Since then the weed spread to most part of the Indian sub-continent, including Pakistan. It has also spread to southern China, Taiwan and Vietnam in Asia[11]. It has invaded several African countries; the weed was first introduced accidentally into Ethiopia in 1970s and further spread to Kenya, Mozambique and South Africa[12,13].

Phytochemistry

The phytochemistry of *P. hysterophorus* has attracted considerable interest mainly due to the presence of toxic compounds. Chemical investigation has shown the presence of parthenin (**1**), coronopilin (**2**), 2β-hydroxycoronopilin (**3**), tetraneurin-A (**4**), hysterophorin, hysterin, dihydroisoparthenin, hymenin[15]. One study shows that, isolated 8α-Epoxymethacryloxyparthenin, 8α-epoxymethacryloxy-11,13-dihydroparthenin, and 8α-epoxymethacryloxyambrosin from its air dried leaves[16]. Another study shows that, isolated three pseudoguaianolides 11β-H, 13-dihydroparthenin (R_1 = OH, R_2 = H, **5**), 13-methoxy-11, 13-dihydroambrosin (R_1 = H, R_2 = OMe, **6**) and 13-methoxy-11,13-dihydroparthenin (R_1 = OH, R_2 = OMe, **7**)[17].

Another study shows that, isolated 8β-acetoxyparthenin from the aerial part, a new epoxy-sesquiterpenoid parthoxynol[18] and a highly oxygenated pseudoguaianolide 8β-acetoxyhysterone C,[19] from flower, two minor pseudoguaianolides parthenin-8β-isopentanoate and parthenin-8β-isopentenoate from whole plant of *P. hysterophorus*[20] Two new pseudoguaianolide type sesquiterpene lactones, named deacetyltetraneurin A (8) and hysterone E (9), along with scopoletin (10), 8β-hydroxycoronopilin, and conchasin A (11) were also isolated from flower[21,22]. One report shows that leaves of *P. hysterophorus* contained dihydroparthenin and 13-methoxydihydrocoronopilin[23]. A study shows that isolated stigmasterol, *b*-sitosterol, isoparthenin, coronopilin and 11, 13-dihydroparthenin and chemical investigation[24] afforded a new aliphatic ester hentriacontanyl eicosanoate from aerial parts of *P. hysterophorous*. Four new pseudoguaianolides, hysterones A-D (12-15)[25] and four acetylated pseudoguaianolides were recently obtained from the flowers. Sesquiterpenoid, charminarone (16), the first *seco*-pseudoguaianolide, was isolated along with other well-known compounds from the whole plant of *P. hysterophorus*[26]. Along with above mentioned compounds ambrosin, flavonoids (quercelagetin 3, 7-dimethylether; 6 hydroxyl kaempferol 3-0) fumaric acid (17), *p*-hydroxybenzoin (18), vanillic acid (19), caffeic acid (20), *p*-courmaric acid (21), *p*-anisic acid (22), chlorogenic acid (23), ferulic acid (24), sitosterol and some unidentified alcohols were also isolated. The chemical compound of the oil of *P. hysterophorus.* L. was investigated by GC-MS and 78% of the oil was characterized. The oil contains 63 constituents. The major constituents identified were bornyl acetate (9.15%), geraniol (7.53%) and Phenyl acetonitrile (7.85%) and *b*-myrcene (3.23%) with other known sesquiterpene lactones[27]. The main phenolic acids obtained are caffeic acid, anisic acid, ferulic acid, Borneol, camphor and n-hydroxybenzoic acid[28].

Effects of *Parthenium hysterophorus*:
On living organisms

Earlier investigations had revealed that livestock was facing a serious health problems livestock in Parthenium invaded areas. Incorporation of *P. hysterophorus* into the diet of live stock was found to cause chronic or acute toxicity depending upon the quantum of the weed ingested[29]. In artificial feeding tests buffalo, bull calves accepted the weed alone or in mixture with green fodder; majority of animals under test developed severe dermatitis as well as toxic symptoms and died within 8-30 days. Lesions were found subsequently in the gastrointestinal tract, liver and kidney[30]. One report shows that the weed taints the milk and meat of animals[31]. When parthenium one of the major sesquiterpene of *P. hysterophorus* was tested against *Rattus norvegicus*, it showed symptoms like laboured breathing and dizziness. Its Median lethal dose (LD_{50}) in *R. norvegicus* was found to be 47.79 mg/kg[32]. The pharmacological effects of 10% cold aqueous extract of *P. hysterophorus* flowers was investigated on dog blood pressure and respiration, perfused frog heart, and isolated rabbit duodenum. The extract exhibited hypotensive response, cardiac depressant effect, and mild spasmogenic action on intestinal smooth muscles. Due to the release of histamine in the animal body the flower extract potentiated the hypotensive action of histamine[33]. Parthenium reduces production from livestock by causing various health problems and also by causing scarcity of animal fodder by invading pasture lands. Parthenium can also affect the psychological behavior of animals[34]. It is also responsible to cause human health problems like dermatitis, hay fever, asthma, rhinitis, irritation to eyes, stomach pain, stretching and cracking of skin and breathing problem[35]. Continuous exposure to the pollen grains of *P. hysterophorus* causes allergic bronchitis in human beings[36,37,38,39,40].

Parthenium indirectly effects human health by their interactions with disease-transmitting vectors. One report shows that the toxic impact present on P. hysterophorus positively impact on the survival & energy reserves of malaria vector *Anopheles gambiae*. Females *Anopheles gambiae* survived better & accumulated energy reserves when fed on P. hysterophorus[41].

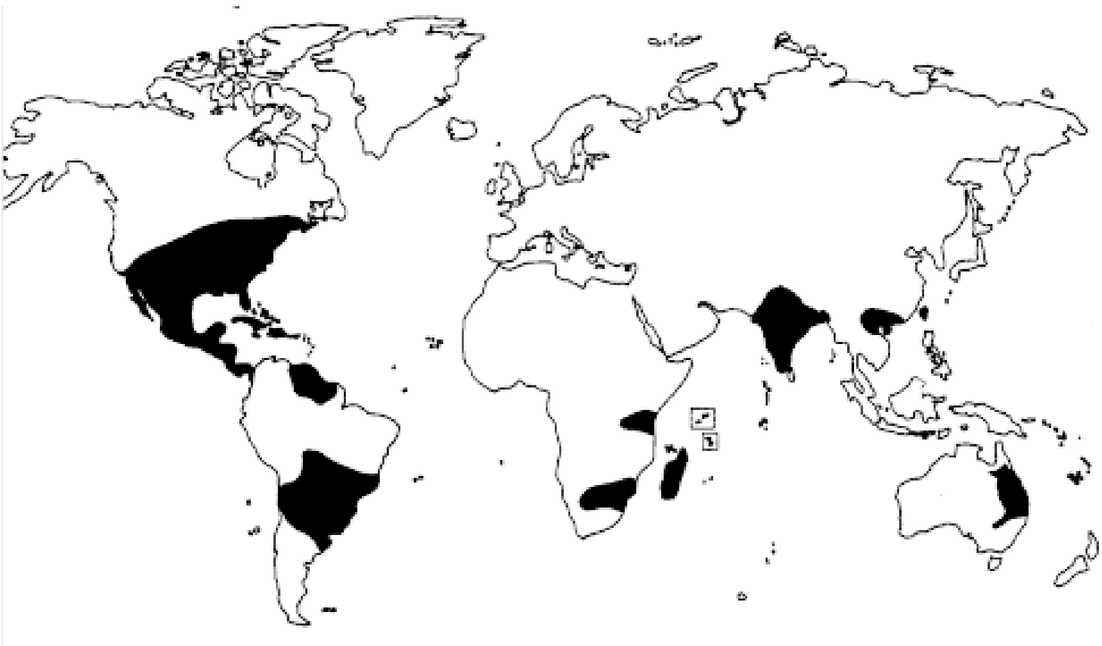
On Agriculture Productivity

It inhibits the germination and growth of other plants due to allelopathy effect. Allelopathy is the phenomenon in which living or dead plant material including decaying litter releases chemicals that inhibit the growth of associated plants. Aqueous extracts of leaves and inflorescence inhibit the germination and growth of barley, corn, wheat and peas as reported by various authors[42,43]. If parthenium is not controlled, Sorghum reduces its yield in Ethiopia[44]. Parthenin, oleanolic acid and embelin are the components which are responsible for reduced germination[45,46,47]. When parthenium extracts were directly sprayed on crop plants, survival of the cell and chlorophyll content were clearly reduced. The allelopathic effect of *P. hysterophorus* extract on the meristametic cell of onion exerts mitotic depression causing chromosomal abnormalities such as fragments, stickiness nuclear vacuolation, bridge, laggards & micronuclei. The suppression of DNA content due to Parthenium causes deviation of normal metabolic activity which is a potential threat to genomic balance[48]. Similar adverse effect of parthenium residue have been reported on growth of *Brassica compestris*, *B. oleracea*, *B. rapa*, *Cicer arietinum* and *Raphanus sativus*[49]. Allelotoxic effect of parthenin on *Vicia faba L*[50].

Residues of parthenium leaf and flower were reported to have toxic effect to aquatic plants like salvinia[51]. The weed has capacity to extract nutrients even from nutrient deficient soil and in crop land can be reduce up to 40% in yield[52]. Various reports have declared it as toxic weed due to its potential to decrease the crop productivity, fodder scarcity, biodiversity depletion and health problems for livestock and human causing hay fever, skin problems and asthma[53]. It reduces agricultural production by suppressing agricultural yield from crops and animals[54].

On Biodiversity

The weed has the potential to disturb the natural ecosystem, as it can grow throughout the year in almost all drastic conditions suppressing native vegetation. Owning the absence of effective natural enemies, its alleopathic effect as well as photo and thermo insensitivity, it is a threat for natural diversity[55,56]. The weed is attributed to be mainly responsible for total habitat change in native Australian grasslands, open wood-lands, river banks and flood plains due to its invasion[57]. The successful progress of biological control depends upon suitable policy, legislative, funding and infrastructure frameworks. Australia has advantages such as being a nation-continent, having achieved early biocontrol successes known to the public, having a unique native flora and enjoying political enthusiasm for biological control[58]. Similarly Parthenium invaded in national wildlife parks have also been reported in

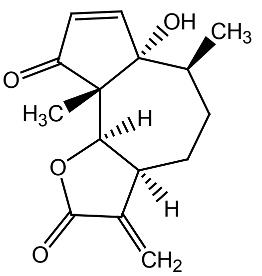


Geographical Distribution of Parthenium hysterophorus in 1994[14]

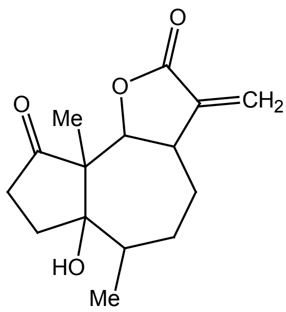
southern India[59]. Parthenium spread over agricultural land, grazing land and highways. It competes with crops cultivated in land at a rapid rate as well as also deplete the nutrient content of soil. Number of seeds in parthenium is very high and it can be disperse by air, water, animal etc. So able to colonize new areas. Moreover, the weed spread all over India such as Punjab, J&K and it replaces the local flora of those places[60,61]. Some of the allelochemicals are washed away by water and enter the aquatic ecosystem which shows adverse effect on aquatic plants[62]. The biological control agents and suppressive plants can be combined successfully to improve the management of parthenium weed to a level that is better than either management option alone[63]. Allelochemicals released from parthenium is capable of changing the physicochemical characteristics of the soil. It affects the moisture content, temperature, pH, organic matter, carbon, nitrogen and phosphorus content and soil microbial activity[64,65,66]. The change in property of the soil due to introduction of allelochemicals affects the reproduction, growth and survival of other nearby plant[67,68,69,70]. Generally parthenium is intended to pose a serious threat to the biodiversity by invading new surroundings and by reducing or totally replacing the indigenous species where it causes total habitat change[71].

Biological activity of parthenium

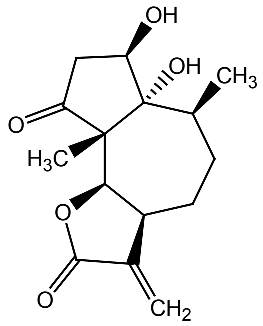
Parthenium is used as traditional medicine in the Caribbean and Central America[5]. It is used for the treatment of wounds, ulcerated sores, fever, anaemia, heart problems and malaria[72]. One study shows that sublethal doses of *P. hysterophorus* major reduction in glucose level in the blood of diabetic ($P<0.01$) rats[73]. It reveals that the active fraction of *P. hysterophorus.* L flower extract is very capable for developing standardized phytomedicine for diabetes mellitus. A study shows that the antitumor activity in the weed. It was found that the methanolic extract of *P. hysterophorous* show antitumor effect in host mice bearing transplantable lymphocytic leukaemia[74]. The extract could either cure mice completely or increase their survival time after they had been injected with cancer cells[75]. Parthenium has shown capable antidote against hepatic amoebiasis[76]. One study shows that allelopathic prospective of *P. hysterophorus* L against pathogenic fungal species (*Drechslera hawaiiensis* (M.B.Ellis), *Alternaria alternata* (Fr.) *Keissl* and *Fusarium monilifrome*)[4]. Aqueous extracts prepared from the aerial parts of *P. hysterophorus* in liquid malt extract medium showed the inhibited growth of all the test pathogenic species by lower concentrations, while aqueous extracts of higher concentrations stimulated biomass production of test fungal species. The ethnobotanical efficacy of various solvent extract of Parthenium against both human and plant pathogenic bacteria showed varied level of inhibition[77]. A pseudoguaianolide isolated from aerial parts of *P. hysterophorus* (Linn) was shows the antibacterial activity against three Gram negative, one Gram positive and some human pathogenic bacteria[78]. Hentriacontanyl eicosanoate an aliphatic ester isolated from *P. hysterphorus* has been evaluated for its antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and antifungal activity against *Aspergillus niger*, *Candida albicans* and *Fusarium oxysporum*[24]. Parthenolide a constituent isolated from *P. hysterophorous* showed significant inhibition on Tobacca mosaic virus in vitro[79]. Various fractions obtained from *P. hysterophorous* showed anti-inflammatory activities[80].



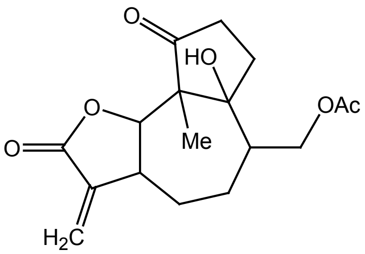
Parthenin (1)



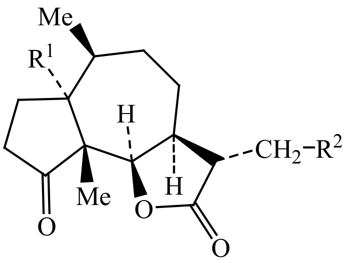
Coronopilin (2)



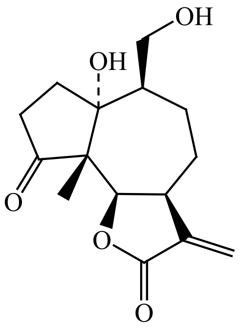
2 -Hydroxycoronopilin (3)



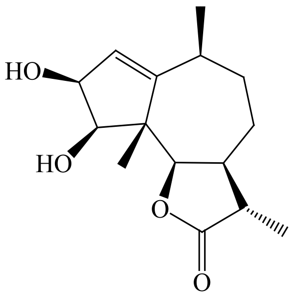
Tetraneurin (4)



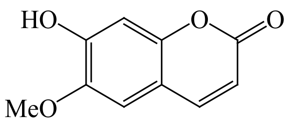
R^1= OH, R^2 = H (5)
R^1= H, R^2 = OMe (6)
R^1= OH, R^2 = OMe (7)



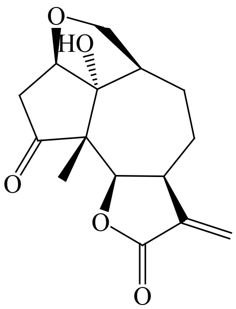
Deacetyltetraneurin A (8)



Hysterone E (9)



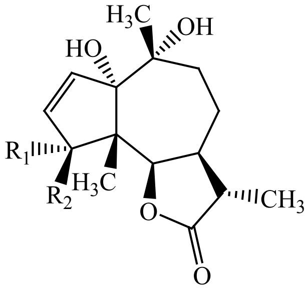
Scopoletin (10)



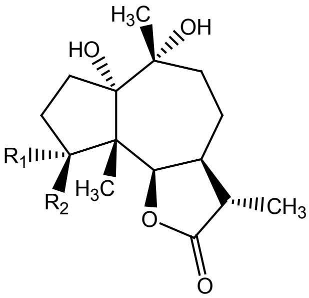
Conchasin A (11)

Potential Use of Parthenium in Agriculture

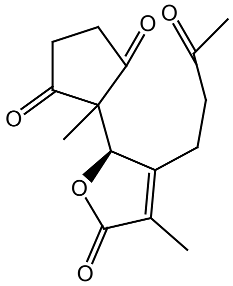
Parthenium can be used as a green manure. In the ratoon rice crop parthenium green leaf manure was superior in influencing the plant height. Similarly, it produces the highest number of filled grains in comparison to main crop. Among the green leaf manure tried, the residual effect for dry matter production was the highest[81] 3% parthenium green manure produces the highest root and shoot biomass in maize, which was significantly greater



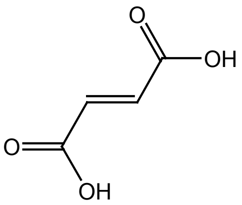
R_1, R_2 = O (12)
R_1 = H, R_2 = OH (13)



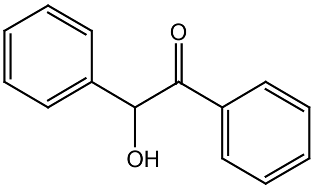
R_1, R_2 = O (14)
R_1 = H, R_2 = OH (15)



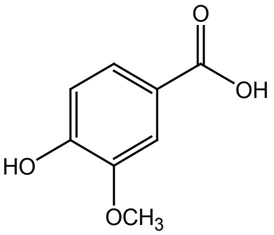
Charminarone (16)



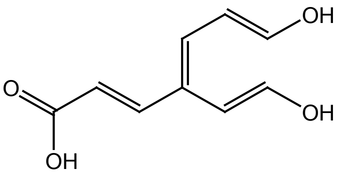
Fumaric acid (17)



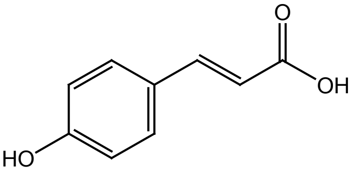
***p*-Hydroxybenzoin (18)**



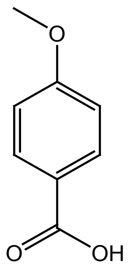
Vanillic acid (19)



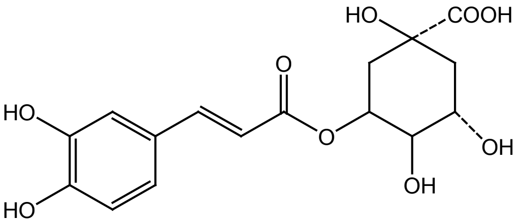
Caffeic acid (20)



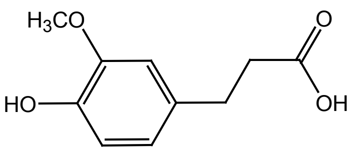
***p*-Coumaric acid (21)**



***p*-Anisic acid (22)**



Chlorogenic acid (23)



Ferullic acid (24)

than that obtained in the control and equivalent to that obtained in the NPK fertilizer treatments[82]. Parthenium can be used as an insecticide and biopesticide. Isolated compounds from various species of Parthenium were found to inhibit larval growth. It was observed that sesquiterpene lactones from Parthenium inhibit the growth of *Heliothis zea* insects. In comparision to unsubstituted ambrosanolide analogues, those oxygenated at C-14 and/or C-15 (parthenolides) was better inhibitory[83]. Roots and stems of *P. hysterophorous* cause the mortality of mosquito larvae but mechanism still not known[84].

One report shows that parthenium contain high nitrogen, phosphorus and potassium (N, P and K)[85]. One report shows that Parthenium composted pre-flowering has higher nitrogen content (2.95%) compared to poultry manure (2.02%), vermi compost (1.21%) and farm yard manure (0.54%)[86]. Similar study has shown that Parthenium compost has higher phosphorus content (0.82%) compared to FYM (0.26%) but lower in comparision to poultry manure (1.6%) and vermi compost (0.86%). Its potassium content is also higher (1.39%) compared to vermi compost (0.55%) and FYM (0.34%) but lower in comparison to poultry manure (1.42%). With increasing decomposition period the toxicity of Parthenium reduces. Parthenium composite with other plant materials reduces its allelopathic inhibition potential on seed germination and seedling growth of the model plant lettuce. This fact explained that composting Parthenium with other less or no allelopathic potential plant materials reduces the amount of allelochemicals released into the soil and the corresponding allelopathic inhibition potential[10]. One report shows that 25% parthenium and 75% cow dung containing waste mixtures for optimum growth and reproduction of *Eisenia fetida* and hence *P. hysterophorous* can be used as feedstock for vermicomposting[56]. Parthenium is among other inhibitors relevant for residue allelopathy as simulated under laboratory condition by delaying germination and reducing plant growth[87, 43]. The use of *P. hysterophorous* compost and green leaf lower the weed population in rice field due to allelopathic effect of compounds present in it. Report also available which shows that *P. hysterophorous* is rich in potash[88].

Parthenium hysterophorus for removal of heavy metals

The soil and water pollution due to presence of heavy metal is one of the major environmental crises. Unlike organic compounds metals cannot be degraded and can easily enter food chain through absorption by plants causing health hazard. Various methods has been used for remediation, like excavation and landfill, thermal treatment, acid leaching and electro-reclamation, but due to low efficiency, high cost, and large destruction of soil fertility and structure these approaches do not provide reasonable solutions[89]. One of the efficient biological processes for decontamination of soil is phytoremediation, which is the use of plants to extract, sequester, and detoxify pollutants. Phytoremediation includes phytoextraction, phytovolatilization, rhizofiltration, and phytostabilization[90]. The advantages of phytoremediation over other known process is its low cost, speed of deployment, preservation of natural soil properties, and reliance on solar energy[91]. The only backdraw of this process is that heavy metals can enter the food chain via animals grazing heavy metal-contaminated vegetation[92]. To overcome this backdraw, *P. hysterophorus* (Linn.) an unpalatable weed plant which reduce the chance of toxic metals entrance into the food chain. One study shows that *P. hysterophorous* for the remediation of lead contaminated soil. The study encouraged the use of gibberellic acid for lead phytoextraction by the weed[93].

Another study shows that the absorption of nickel from the aqueous solution by *P. hysterophorus.* It was concluded in the study that sulphuric acid treated carbonized Parthenium could be effective, low cost and easily available adsorbent for the removal of Ni (II) from dilute aqueous solution[94]. A study shows that dried powder of *P. hysterophorus* as an adsorbent for the removal of Cd from aqueous solution. The atomic absorbtion spectrophotometry of the filtrate obtained from batch process showed *P. hysterophorous* as an efficient absorbent of Cd (II). The maximum adsorption of Cd (II) ions was 99.7% when the pH range is 3-4. It was further showed by the desorption studies that 82% of Cd (II) can be recovered from the adsorbent when 0.1 M HCl solution is used as effluent[95]. Parthenium activated carbon is found to be equally effective as commercial grade activated carbon. It can be used as effective absorbent for *p*-cresol up to the concentration of 500 mg/l in aqueous medium[96]. Various reports are available which support biosorptive nature of *P. hysterophorous* weed for remove of methylene blue from dilute aqueous solution[97] and Cr (VI)[98].

Miscellaneous Use

In addition, Parthenium is the valuable source of potash, oxalic acid and high quality protein, which can be used in animal feed[99]. The dry leaf powder of *P. hysterophorus* causes wilting of the *Salvinia molesta* a weed, which cause a serious problem to aquatic creatures by choking the water bodies leading to its suffocation[100]. Another study shows that the use of *P. hysterophorus* in biogas production. The significant increase in methane content i.e upto 60-70% was achieved when 10% of weed is mixed with the cow dung[101]. A study shows that *P. hysterophorus* as a low cost raw material for the production of xylanases[102]. This weed is a source of potential energy[103]. Xylanases are hydrolytic enzyme which has various indrustrial applications. Phytochemical screening of *P. hysterophorus* showed the presence of different bio-constituents such as Alkaloids, Phenols, Flavonoids, Steroids, Cardiac Glycosides and Carbohydrates were present in ethanolic extract[104]. Free radical scavenging assay against the 1, 1-diphenyl-2-picryl-hydrazyl (DPPH) proved the strong antioxidant property of the plant[105]. The study shows that some P. hysterophorus extracts have various biological activities that could act synergistically against *H. pylori*[106]. Anticancer activity of parthenium phenolic extract against A-498 (IC50 0.5237 ìg/ml) and MDA-MB231 (IC50 and 0.2685 ìg/ml) cancerous cell lines indicated its potential to be used as anticancer agent[107]. Parthenium weed stem is boiled in water and used to remove the toothache and strong the gums. Ground root in water is used to remove boils and pimples. Its leaves extraction is used insomnia by pouring its drops in eyes[108]. It is carminative, leaves juice gives strength to the stomach and relief from constipation. Some people use it in fever also *P. hysterophorus* can be listed among various medicinal plants with potent antimicrobial property[109]. There are so many investigations reporting the antiviral, antifungal, antibacterial, antihelmintic, antimolluscal, and antiinflammatory properties of parthenium[110,111]. Antifungal property of *p. hysterophorus* has been reported by different investigators. Both plant and human pathogenic funguses viz., *Fusarium Solani*[112,113.] *Alternaria Alternata*[114,115] *Candidia albicans*[116] *Fusarium oxysporium*[117] *Aspergillus niger*[117,118,119] *Aspergillus flavus*[120] *Drechslera tetramera*[119] *Phoma glomerata*[119] *Aspergillus fumigates*[121] *Drechslera hawaiiensis*, *Alternaria alternate keissl*[122] *Fusarium monilifrome*[122] *Alternaria brassicae*, *Alternaria brassicicola*[123] *Saccharomyces cerevisiae*[120] *Bipolaris oryzae*[124] were reported. Antibacterial efficacy of *Parthenium hysterophorus* has also been reported by various scientists as: *Escherichia coli*[117] *Bacillus subtilis, Enterococcus spp.*[125] *Staphylococcus aureus*[118] *Salmonella typhimurium*, *S. epidermidis, V. cholerae*, *Shigella flexneri*[126] *Pseudomonas aeruginosa*[114] *Micrococcus luteus*[116] *Bacillus cereus*[120] *Klebsiella pneumoniae, Enterobactor aerogenes*[121] *Xanthomonas vesicatoria*, *Ralstonia solanacearum*[111].

CONCLUSION

The rapid spread of parthenium has been a risk to the biodiversity, sustainable production of many crops, human health and livestock. Control of parthenium is therefore crucial to boost productivity of many crops as well as to overcome the loss of biodiversity. The parthenium can be kept control by enhancing its use in different aspects. Over exploitation of the weed for the beneficial use should be promoted for the proliferation of the *P. hysterophorus*. Research should be encouraged for the potential utilization of this weed. Parthenium as the raw material for the bio fuel is the future prospect. The increased utilization of weed as, insecticide, pesticide, composite and the raw material for enzyme production can change the weed from a curse to a boon for civilization.

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