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## Review

# A Review on *Parthenium hysterophorus* L. a noxious alien weed

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*Parthenium hysterophorus* L. (Asteraceae) is an obnoxious weed occurring throughout the globe viz. America, Australia, South Africa, Mexico, India, Bangladesh, Pakistan, Nepal, Vietnam etc. This hitherto notorious plant causes allergic respiratory problems, contact dermatitis, mutagenicity in human and livestock. Crop production is drastically reduced owing to its allelopathy. Also aggressive dominance of this weed threatens biodiversity. In traditional medicine its decoction has been used for the treatment of many infectious and degenerative diseases. *Parthenium hysterophorus* L. confers many health benefits, viz. remedy for skin inflammation, rheumatic pain, diarrhoea, urinary tract infections, dysentery, malaria and neuralgia. *Parthenium* management would remain a great concern of the century. Management of *P. hysterophorus* L. by burning, chemical herbicides, eucalyptus oil and biological control by leaf-feeding beetle, stem-galling moth, stem-boring weevil and fungi have been carried out with variable degrees of success.

**Keywords:** *Hysterophorus*, Chemical Herbicides, Allelopathy, Mutagenicity, Diarrhoea, Eucalyptus Oil.

## INTRODUCTION

*Parthenium* (*Parthenium hysterophorus* L.) is an aggressive invasive alien weed species (Kohli *et al*; 2006, Ahmed *et al*; 2010). It belongs to the family Asteraceae. The word *Parthenium* is derived from the Latin parthenice (Bailey, 1960). In Homoeopathy system, allergies caused by *Parthenium* can be treated by a drug prepared from *Parthenium*. *Parthenium hysterophorus* L. is a herbaceous plant native of tropical and subtropical America (Romero *et al*; 2001). It is an annual ephemeral herb of neo-tropical origin which now has a pan-tropical distribution (Khan *et al*; 2010). It is documented in top 10

weeds in the world (Shabbir & Javaid, 2010). It was accidentally introduced in Indian subcontinent in 1955 through imported food grains (Rao *et al*; 1956, Maiti *et al*; 1983). It can cause significant and sometimes irreversible environmental and socio-economic impact at the genetic species and ecosystem levels (Hens & Boon, 2003). It was reported as *Parthenium* weed has the potential to decline adversely the herbaceous components of the vegetation up to 90% by its aggressive competition and allelopathic effect (APFISN 2007, Mahadevappa *et al*; 2001). and drastically retards the growth of many species. With the increasing concentration of *Parthenium* extracts the seed germination and growth of *Eragrostis* decreased significantly (Tefera, 2002). The sesquiterpene lactone parthenin that is biosynthesized by

this species is thought to play a role in its allelopathic interference with surrounding plants. Release of parthenin by aqueous extraction of fresh leaf material of *P. hysterophorus* L. under laboratory conditions proved to be sufficient to provide significant phytotoxicity, and the relative role of parthenin to overall phytotoxic effects of the crude extract could be estimated to 16–100% (Regina *et al.*; 2007). *Parthenium* root extracts decreased the germination and growth of maize and barley (Rashid *et al.*; 2008). Cold stratification reduced dormancy characteristics of parthenium weed seeds (Karlsson *et al.*; 2008). *Parthenium* can be used as a Green manure, compost, biocontrol, soil ameliorate that may improve physical, chemical and biological properties of the soils and is a source of readily available plant micro- and macro-nutrients. The integrated use of *Parthenium* in soil modifies the physico-chemical, biological and nutritional quality of the soil. *Parthenium* has great potentiality in agriculture due to its efficacy in modification of soil health and crop performance. Green manure and *Parthenium* extract may reduce its spreading and inhibit the weed growth as well as menace of human health hazards worldwide (Kishor *et al.*; 2010). The *Parthenium hysterophorus* compost contains two times more nitrogen, phosphorus and potassium than Farm Yard Manure (FYM) (Angiras, 2008; Channappagoudar *et al.*; 2007). *Parthenium* and its harmful effects can be effectively reduced by converting it as compost. Compost from this weed on application in soil enhanced its moisture level more than nitrogen, phosphorus and potassium (NPK) alone. Compost is a rich source of macro-and micronutrients, vitamins, enzymes, antibiotics, growth hormones and immobilized micro flora (Bhawalker, 1991).

### Scientific classification

Kingdom: Plantae  
Order: Asterales  
Family: Asteraceae  
Subfamily: Asteroideae  
Genus: *Parthenium*  
Species: *Hysterophorus*

### Phytochemistry of *Parthenium Hysterophorus* L

Isolation and structural elucidation of the active principles of *P. hysterophorus* L. is required to determine their chemical properties. Chemical analysis of *P. hysterophorus* L. has indicated that all its parts including trichomes and pollen contain toxins called sesquiterpene lactones (SQL). *P. hysterophorus* contains a bitter glycoside parthenin, a major sesquiterpene lactone.

Other phytotoxic compounds or allelochemicals are hysterin, ambrosin, flavonoids such as quercelaetin 3, 7-dimethylether, 6-hydroxyl kaempferol 3-O arabinoglucoside, fumaric acid (Maishi *et al.*; 1998). P-hydroxy benzoin and vanillic acid, caffeic acid, p coumaric, anisic acid, p-anisic acid, chlorogenic acid, ferulic acid, sitosterol and some unidentified alcohols Parthenin, hymenin and ambrosin are found to be the culprits behind the menacing role of this. This is a weed in provoking health hazards (Lata *et al.*; 2008). *Parthenium hysterophorus* L. from different geographical regions exhibited parthenin, hymenin, coronopilin, dihydroisoparthenin, hysterin, hysterophorin and tetraeurin A as the principal constituents of their sesquiterpene lactones (De La Fuente *et al.*; 1997). Hydroxyproline-rich glycoprotein is the major allergen in *P. hysterophorus* L. pollen (Gupta *et al.* 1996). Flowers of *P. hysterophorus* L. contain four acetylated pseudoguaianolides along with several known constituents (Das *et al.*; 2007). It also contains a novel sesquiterpenoid, charminarone, the first seco-pseudoguaianolide, along with several known compounds (Venkataiah *et al.* 2003). The chloroform extract of this weed carry three ambrosanolides (Chhabra *et al.* 1999).

### Hematological Studies of *Parthenium Hysterophorus* L

Haematological analysis was performed on whole blood using automated haematology analysers. Fourteen parameters of haemogram test, namely total leucocytes(103 $\mu$ L), granulocytes(%), lymphocytes(%), midpopulation(%), total RBC (106/ $\mu$ L), haemoglobin(g/dL), haematocrit(%), mean corpuscular volume, mean corpuscular haemoglobin (pg), mean corpuscular haemoglobin concentration(%), red cell distribution width(fL), platelet(103 / $\mu$ L), platelet distribution width(%) and mean platelet volume(%) were measured in control and treated rats following standard methods ( Yadav *et al.*; 2010).

### Impacts on Health

*Parthenium* causes general illness, asthmatic problems, irritations of skin and pustules on hand balls, stretching and cracking of skin and stomach pains on humans (Wiesner *et al.*; 2007). The pollen grains of *Parthenium Hysterophorus* L. cause several diseases like eczema, asthma, dermatitis, hay fever (kalazar) etc in human beings. Not only human beings, the weed also causes dermatitis in animals like cows and goats. When they eat the weed, their milk becomes bitter and drinking it for some length of time may cause death. The pollens of

the weed shed flowers of vegetables (tomato, chilli, brinjal) and inactivate nitrogen fixing bacteria in pulses due to secretion of a chemical substance (sesquiterpene lactones).

### Reducing Agricultural and Pasture Productivity

The adverse effects of *Parthenium* weed on crop production (Tamando *et al*; 2002) human and livestock health (Tudor *et al*; 1982, McFadyen, 1995, Nadeem *et al*; 2005) and biodiversity (Shabbir & Bajwa, 2006) are well documented. The allelopathic properties of unburnt (UR) and burnt (BR) residues of *P. hysterophorus* L. are high on the growth of winter crops, radish and chickpeas (Singh *et al*; 2003). The extract prepared from both UR and BR was toxic to the seedling length and dry weight of the test crops. BR extract was more toxic due to its highly alkaline nature. Growth studies conducted in soil amended with UR and BR extracts revealed phytotoxic effects towards test crops, UR being more active than BR unlike crude extracts. These effects were attributed to the presence of phenolics (Singh *et al*; 2003). Parthenin leaching as root exudate plays a pivotal role in allelopathic interference with surrounding plants (Belz *et al*; 2007). Parthenin has also been reported as a germination and radicle growth inhibitor in a variety of dicot and monocot plants and it enters the soil through the decomposing leaf litter (Gunaseelan, 1998). Burning of *P. hysterophorus* L. in fields reduced germination, biomass growth, plumule and radicle length of *Phaseolus mungo* (Kumar and Kumar; 2010). Poor fruiting of leguminous crops and reduction in chlorophyll content of crop plants were observed in *P. hysterophorus*-infested fields (Lakshmi and Srinivas, 2007). *Parthenium hysterophorus* L. played role as alternate host for crop pests functioning as an inoculum source. This weed has been reported to serve as a reservoir plant of scarab beetle, a pest of sunflower. *Parthenium hysterophorus* L. invasion causes changes in above-ground vegetation and below-ground soil nutrient contents, disturbing the entire grassland ecosystem in Nepal (Timsina *et al*; 2010). *Parthenium hysterophorus* L. is a serious invasive weed of pasture systems, reducing pasture productivity 90% (Evans, 1997). It has become a major weed of grazing lands in central Queensland and New South Wales in Australia. It squeezes grasslands and pastures, reducing the fodder supply. *P. hysterophorus* L. has dwindling effect on grass biomass of grazing fields in Queensland, Australia (Dhileepan, 2007).

### Biodiversity Loss Due To *Parthenium Hysterophorus* L

The invasive capacity and allelopathic properties have

rendered *P. hysterophorus* L. with the potential to disrupt the natural ecosystems. Very sparse or sometimes no other vegetation can be seen in *P. hysterophorus* L. dominated areas. It has been reported to be causing a total habitat change in native Australian grasslands, open woodlands, river banks and flood plains (Lakshmi and Srinivas, 2007). These weeds rapidly invade new surroundings often replace the indigenous species and pose a serious threat to biodiversity in India. Akter and Zuberi (2009) conducted an extensive survey on invasive alien species (IAS) and their impact on different land use types viz. road side, low land, fallow land, homestead and railway track in Bangladesh. Among others, *P. hysterophorus* L. exhibited the ability to invade and adapt to new habitats, thereby reducing the number of indigenous plants. The more vigorous mode of reproduction and the possession of an array of secondary metabolites give the weed the status of invasive alien species.

### Antibacterial Activities of *Parthenium Hysterophorus* L

The extract was very effective against some bacteria and showed the highest activity than standard antibiotics that were used in the study as shown in Table 1 below. Highest antibacterial activity was observed against *P. aeruginosa* and *C. freundii* by all types of organic extracts of inflorescence of *P. hysterophorus* L. Methanolic extract of inflorescence of *P. hysterophorus* L. was found to be antibacterial against all types of Bacterial strains used in this study and considered as broad spectrum antibacterial extract. All types of organic extracts were not active against *K. pneumoniae* except Methanolic extract which showed antibacterial activity against *K. pneumoniae* at 1000µg/ml. Aqueous extract was inactive against *E. coli*, *B. cereus*, *K. Pneumoniae*, *M. luteus* but showed good activity against *P. aeruginosa* and *Citrobacter freundii* both are gram negative bacteria. In methanolic extract, Inflorescence shows highest antibacterial activity of 5.66 mm even in low concentration of 125µg/ml and 18.66 mm in 1000µg/ml concentration against *C. freundii* and *M. luteus* respectively. The antibacterial activity of methanolic extract of inflorescence decreases in the order of *M. luteus* ≥ *C. freundii* > *P. aeruginosa* > *B. cereus* > *E. coli* > *K. pneumoniae*. Dichloromethane extract of inflorescence showed antibacterial activity in the order *M. luteus* > *P. aeruginosa* > *B. cereus* > *C. ferudii*. DCM showed no activity against *K. pneumoniae* and *E. coli*. Petroleum ether extract showed little activity of 4.33mm and 4.66mm against *P. aeruginosa* and *C. freundii* respectively in 1000 µg/ml and nil against other strains. The acetone extract showed antibacterial activity in the order of *P. aeruginosa* > *M. luteus* > *C. ferudii* > *B. cereus* and inactive

**Table 1** Effect of doses of methanolic extract of *Parthenium hysterophorus* L. on haematological parameters in rats

Parameters	Control	Treated %	Change in
Tot-leucocytes (103 / $\mu$ L)	8 $\pm$ 0.5	*5.7 $\pm$ 0.2	28 $\downarrow$
Granulocytes (%)	34.5 $\pm$ 1.1060	*46.6 $\pm$ 2.6457	11.80 $\uparrow$
Lymphocytes (%)	59 $\pm$ 2	*44.9 $\pm$ 4	14.10 $\downarrow$
Mid population (%)	6.2 $\pm$ 0.2	*8.5 $\pm$ 0.3818	2.30
Total RBC (106/ $\mu$ L)	6.25 $\pm$ 0.25	*5 $\pm$ 0.5	20 $\downarrow$
Hemoglobin (g/dl)	17.1 $\pm$ 0.1892	*10.2 $\pm$ 0.709	40 $\downarrow$
Haematocrit (%)	46.7 $\pm$ 0.1	*28.8 $\pm$ 0.9712	17.90 $\downarrow$
Mean corpuscular volume (fL)	56.7 $\pm$ 0.2516	54.2 $\pm$ 2.2	4 $\downarrow$
Mean corpuscular hemoglobin (pg)	20.7 $\pm$ 0.7762	19.1 $\pm$ 0.1	7 $\downarrow$
Mean Crop hemo. Conc.	36.6 $\pm$ 2	35.4 $\pm$ 2	1.20 $\downarrow$
Red cell distribution width f(1)	17.3 $\pm$ 0.6245	17.2 $\pm$ 0.1532	0.1 $\downarrow$
Platelet (103/ $\mu$ L)	135 $\pm$ 5	*553 $\pm$ 2	309 $\uparrow$
Red cell distribution width (%)	16.4 $\pm$ 0.5291	*17 $\pm$ 0.9165	0.60 $\uparrow$
Mean platelet volume (%)	8.8 $\pm$ 0.4%	8.3 $\pm$ 0.3055	0.50 $\downarrow$

Indicate significant ( $p < 0.01$ ) difference between control and treated groups when student's t- test was applied between treated and control group

against *E. coli* and *K. pneumoniae*. The inhibitory activities of all the extracts reported in table 6 are comparable with standard antibiotic Chloramphenicol.

#### Antifungal Activity of *Parthenium Hysterophorus* L

Different extracts of Inflorescence of *Parthenium hysterophorus* L. were also tested against different human pathogenic fungi such as *Microsporum gypseum*, *Penicillium chrysogenum*, *Rhizopus stolonifer*, *Aspergillus niger*, *Mucor* at concentration of 1000, 500, 250, 125  $\mu$ g/ml. Organic extracts of inflorescence of *Parthenium hysterophorus* L. displayed no activity against any type of fungi indicating that fungus are resistant to the tested plant. On the other hand aqueous extract of inflorescence of tested plant was found effective at higher concentrations of 1000  $\mu$ g/ml and 500  $\mu$ g/ml. The inhibitory activities of all the extracts reported in table 2 below are comparable with standard antibiotic nystatin.

#### Antiviral Activity of *P. Hysterophorus* L

Compound from *P. hysterophorus* L. was tested for antiviral activity against Japanese Encephalitis Virus in vitro (Vero cells) that no antiviral activity was found (Yadava and Khan, 2013).

#### Anti-inflammatory activity of *Parthenium hyssterophorus* L

The in-vivo anti-inflammatory activity was performed by the carrageenan induced rat paw edema. *Parthenium hysterophorus* L. shows highly significant anti-inflammatory activity at dose of 200mg/kg and a lesser effect was observed at a dose of 100mg/kg. The percentage change in paw volume was observed at 30min, 1 hr, 2hr, 3hr and 4hr. (Pandey *et al.*, 2012).

#### Antitumor Activity of *Parthenium Hysterophorus* L

The methanolic flower extract of *Parthenium hysterophorus* L. has been found to have antitumor effects in host mice bearing transplantable lymphocytic leukemia. The effect was more pronounced in terms of tumor size, tumor spread, and survival of the host. The potentiating effect of the extract was supported by biochemical autopsies relating to markers like glutathione level, cytochrome P-450 content, glutathione transferase, and UDP-glucuronyl transferase in liver tissue of the host cells. These neoplastic markers showed substantial alteration leading to slow development of tumors and increased survival of the host bearing lymphocytic leukemia (Mukherjee *et al.*).

#### Anticancer Activity of *Parthenium Hysterophorus* L

Anticancer activity of ethanolic extracts leaves of



Table Antifungal activity of *P.hysterophorus* L. extracts against pathogenic fungal strains

Test Organisms	Zone of inhibition (mm of diameter)																								
	Aqueous (µg/ml)					methanol (µg/ml)					Dichloromethane (µg/ml)					Petroleum Ether(µg/ml)					Acetone (µg/ml)				
	1000	500	250	100	50	500	250	100	50	25	500	250	100	50	25	500	250	100	50	25	500	250	100	50	25
				2	0				2	0				2	0				2	0				2	0
				5					5					5					5					5	
	11.66	6.33																							
	±	±0.3																							
	0.33	3																							
<b>Microsporium</b>																									
<b>Gyseum</b>																									
	33.31	16.3																							
	±	3±0.																							
<b>Penicillium</b>																									
<b>Chrysogenum</b>	0.88	33																							
	10.66	5.66																							
	±	±0.3																							
<b>Rhizopus</b>																									
<b>Stolonifer</b>	0.66	3																							
<b>Aspergillus</b>																									
<b>Niger</b>																									
<b>Mucor</b>																									

*Parthenium hysterophorus* L. extract was performed on K562 cancer cell lines by the Advanced Centre for Treatment Research and Education in Cancer (ACTREC) Mumbai, India. *Parthenium hysterophorus* L. showed significant anticancer activity on K562 human leukemia cancer cell line (Pandey *et al.*, 2012).

#### Thrombolytic Activity Study of *Parthenium Hysterophorus* L

Thrombolytic therapy reduces mortality and preserves left ventricular function in patients with myocardial infarction. All thrombolytic agents work by activating the enzyme plasminogen that clears the cross-linked fibrin mesh. In our study 100mg of methanolic extract was used as experimental drug. 5ml of blood samples were collected from volunteer and distributed into five separate pre-weighed ( $W_1$ ) microcentrifuge tubes. The blood specimen were centrifuged at 2500 rpm for five minutes and then incubated for 45 minutes at 37°C. After clotting of blood, serum was decanted and removed. Then weight of clotted blood ( $\Delta W$ ) was taken by subtracting the pre-weight ( $W_1$ ) from the weight of clot containing tube ( $W_2$ ) as  $-\Delta W = W_2 - W_1$ . Then 100µl extract of *P. hysterophorus* L. was added to the clot containing tube.

Similarly 100µl of streptokinase was added to clot of standard tube and 100µl of water was added to clot of blank tube those were used as positive and negative control respectively. Then all the tubes were incubated at 37°C for 90 minutes and weighed again for getting the weight variation among the pre weight and final weight ( $W_3$ ) that was achieved for clot lyses (thrombolysis) (Prasad *et al.*, 2006).

#### Ethnopharmaceutical Uses of *Parthenium Hysterophorus* L

Ethno historical accounts shows that medicinal plants have been used as a remedy for various human ailments, the reason of using these plants is that they contain certain types of chemical constituent which is having greater therapeutic value that produces a definite pharmacological actions on human body with lesser side effects (Pandey *et al.* 2012). The decoction of *P. hysterophorus* L. has been used in traditional medicine to treat fever, diarrhoea, neurologic disorders, urinary tract infections, dysentery, malaria and as emmenagogue (Surib-Fakim *et al.* 1996). Ethnobotanically, it is used by some tribes as remedy for inflammation, eczema, skin rashes, herpes, rheumatic pain, cold, heart trouble and gynaecological ailments. *Parthenium hysterophorus* L.

Table No of sample

No. of sample	Volunteer 1				Volunteer 2			
	W1	W2	W3	% clot lysis	W1	W2	W3	% clot Lysis
1	4.2492	4.317	4.2854	18.83	4.1215	4.2239	4.2082	15.33
2	4.1045	4.275	4.2524	13.26	4.0703	4.2665	4.2275	19.88
3	4.1035	4.183	4.1691	17.48	4.1393	4.2802	4.2473	23.35
Standard	4.1030	4.308	4.2075	49.02	4.1416	4.2538	4.1952	52.23
Blank	4.1495	4.317	4.3043	7.58	4.1326	4.3056	4.3026	1.73

has been found to be pharmacologically active as analgesic in muscular rheumatism, therapeutic for neuralgia and as vermifuge (Maishi *et al.* 1998). This weed is also reported as promising remedy against hepatic amoebiasis. Parthenin, the major constituent of the plant, exhibits significant medicinal attributes including anticancer property (Venkataiah *et al.* 2003). The methanol extract of the flowers showed significant antitumour activity and parthenin exhibited cytotoxic properties against T cell leukaemia, HL-60 and Hela cancer cell lines (Das *et al.* 2007). Previously, Ramos *et al.* (2002) had established the antitumour potential of *P. hysterothorus* L. extracts in vitro and in vivo with positive results in terms of tumour size reduction and overall survival of cell lines. Aqueous extract of *P. hysterothorus* L. has hypoglycaemic activity against alloxan-induced diabetic rats (Patel *et al.* 2008). Synthesis of silver nanoparticles by reducing silver ions present in the aqueous solution of silver nitrate complex using the extract of *P. hysterothorus* L is possible (Parashar *et al.* 2009).

### Benefits from *P. hysterothorus* L

#### Enhancement of crop productivity

*P. hysterothorus* L. can be used to increase crop production at minimal expenses and to diminish the current reliance on synthetic agrochemicals that degrade the environmental quality. The allelochemicals can be exploited as herbicides, insecticides, nematocides, fungicides and growth regulator. Pesticidal potential has been established in terms of ovicidal and anti-fleedant effects (Datta & Saxena, 2001). The allelochemicals also provide defence against herbivorous predators. Compost from this weed on application in soil enhanced its moisture level more than nitrogen, phosphorus and potassium (NPK) alone. *Parthenium hysterothorus* L. being rich in N, P, K, Ca, Mg and chlorophyll content is

ideally suited for composting. Anaerobic digestion of parthenium dried solids biodegrades the plant growth and conserves the NPK content. This can be applied as organic manure (Gunaseelan, 1998). *P. hysterothorus* L. weed is used as green manure for maize and mung bean production (Javaid 2008).

The effect of *P. hysterothorus* L. green manure and EM (effective microorganisms), a biofertilizer, on wheat (*Triticum aestivum* L.) cultivation was studied. Highest root biomass was recorded in 3% green manure-amended treatment. Spike length, number of grains per spike and grain yield gradually increased by increasing the quantity of green manure. There was 43–253% increase in grain yield over control due to various green manure treatments as compared with 96% increase due to NPK fertilizers over control (Javaid and Shah, 2010).

### Bioremediation of heavy metals and dyes by *P. hysterothorus* L

Environmental pollution with heavy metals has become a global phenomenon. Nickel (II) is present in the effluents of silver refineries, electroplating, zinc base casting and storage battery industries. At higher concentrations, nickel causes cancer of lungs, nose and bone. The dried biomass of *P. hysterothorus* L. is used for carbon preparation by mixing it with concentrated sulphuric acid (1:1.5 w/v ratio) and keeping it at 120°C for 24 h, followed by washing and drying. This sulphuric acid-treated carbonized Parthenium (SWC) could be an effective, easily available and low-cost adsorbent for the removal of Ni (II) from dilute aqueous solution (Lata *et al.* 2008).

Cadmium (Cd) is widely used in electroplating, plastic manufacturing, metallurgical processes and industries of pigments and Cd/Ni batteries. However, it is extremely toxic even in low dosages and responsible for causing renal disorder, high blood pressure, bone deformity and destruction of RBCs. Because of bioaccumulation, Cd (II) is considered as a priority pollutant by the US

Environmental Protection Agency. The efficiency of dried powder of *P. hysterophorus* L. as an adsorbent for removing Cd(II) from waste water is 99.7% at pH range 3-4. When 0.1 M HCl solution is used as effluent, the recovery of Cd(II) from the adsorbent is 82%.

Cresol, a phenol derivative, is found in effluents of petrochemical, oil and metal refineries, chemical and glass fibre manufacturing, ceramic and steel plants, phenolic resin manufacturing industries, etc. This toxic effluent is known to cause stomach tumours, corrode the eyes, skin and respiratory tracts and affect the central nervous system, cardiovascular system, lungs, kidney and liver, even leading to unconsciousness and death. Activated carbon prepared from *P. hysterophorus* L. by chemical activation using concentrated H<sub>2</sub>SO<sub>4</sub> is an effective adsorbent material. Parthenium-based activated carbon (PAC) is found to be as good as commercial based activated carbon (AC) for removal of p-cresol up to a concentration of 500 mg/l in aqueous solution. AC is an expensive activated carbon but PAC is inexpensive, easily available and does not need regeneration and thus promises sustainable utilization in p-cresol removal from industrial wastewater (Singh *et al.* 2008).

#### Weeds Eradication by *P. Hysterophorus* L

Salvinia (*Salvinia molesta* M.), water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*) choke off water bodies suffocating aquatic creatures. Dry *P. hysterophorus* L. leaf powder caused wilting and desiccation of above-water parts of these floating plants (Pandey, 1994). With the increasing concentration of *P. hysterophorus* L. extracts, the seed germination and growth of lovegrass (*Eragrostis*) decreased significantly (Tefera, 2002).

#### For Enzyme Production

Xylanases are hydrolytic enzymes that cleave xylans. The end products of xylan degradation have industrial applications for bio-fuel, artificial sweetener, animal feed production, baking and textile industry, clarification of fruit juices and coffee extraction. Besides, there has been an increasing interest in using xylanases for ecofriendly bleaching of pulp in paper industries. The potential of *P. hysterophorus* L. as low-cost raw material for xylanase production is well known. Considerably higher level of the enzyme production in medium containing *P. hysterophorus* L. confirms the feasibility of using this cheap resource as an alternative carbon source to save costs of the enzyme production process (Dwivedi *et al.* 2009).

#### *P. Hysterophorus* L. As Additive With Cattle Manure in Biogas Production

In the wake of oil crisis, energy generation from bio-wastes by anaerobic digestion has attracted immense attention. Energy crops are likely to be future sources of digester feed stocks for methane generation. *Parthenium hysterophorus* L. was mixed with cattle manure at a 10% level and allowed to digest anaerobically at room temperature in 3-l batch digesters. The chemical changes during the course of digestion and the effect of digested slurry (inoculum) on biogas production were investigated and significant increase in methane content was achieved. The methane content of the gas varied between 60 and 70% (Gunaseelan, 1987).

#### Golden Seal/Parthenium Extract

Golden Seal/Parthenium Extract is a combination of two herbs that help support and strengthen the immune system. Golden Seal/Parthenium Extract provides additional nutrition to the body helping cleanse and strengthen it, and focuses its action on stimulating the immune system. Golden seal and parthenium roots are well-known for their antibiotic properties. They are beneficial for treating a variety of symptoms, including fighting infection, both viral and bacterial. Parthenium root is a close relative to echinacea containing many of the same medicinal properties. Parthenium contains substances that helps soothe inflamed and irritated tissues, and is beneficial for treating fatigue, respiratory infections, tonsillitis and swollen glands.

#### Biological Control of *Parthenium Hysterophorus* L

Aqueous extracts of allelopathic grasses, allelopathic crops such as rice and dicotyledonous plants such as *Datura metel* significantly suppressed the germination and growth of parthenium weed (Javaid *et al.*, 2005, 2008, 2010; Javaid, 2010; Javaid & Anjum, 2006). Aqueous extracts of allelopathic trees viz., *Azadirachta indica* L. A. Juss., *Ficus bengalensis* L., *Melia azadarach* L., *Mangifera indica* L., and *Syzygium cumini* L. Skeels significantly reduced the germination and early seedling growth of parthenium (Shafique *et al.*, 2005).

#### Control of Parthenium by Marigold (*Tagetes Patula* L)

Parthenium is an obnoxious weed of worldwide occurrence, harmful to human and animal health, agriculture, environment and the natural biodiversity. The

weed reduces yields of crops and grasses. Marigold inhibits seed germination and growth of the weed. It also reduces population of the weed. In the next generation, reduction of parthenium population is as high as 85-100%. This has been found primarily due to competition and through allelopathy (affecting parthenium plants by releasing chemical substances including thicophene into soil through roots.) Built up of the phytotoxic substances of marigold origin prevent parthenium seed germination, growth of plants, and flower and seed production completely in 2-3 years. This technology appears to be economically rewarding for marigold flowers have good market. This can be achieved simply by spraying marigold seeds over parthenium infested area. The technology is simple, effective, economically rewarding, and ensures self perpetuating control of parthenium in wastelands. Marigolds to parthenium plant ratio of 0.5 to 4 appear effective for near complete control of parthenium. Adequate moisture availability in soil facilitates establishment of marigold in parthenium infested area.

### Control of Parthenium Hyterophorus L. By Fungi

Two fungal species namely *Gliocladium virens* and *Trichoderma viride* which have been widely used as seed dressing to prevent parthogenic damage have also been found effective for parthenium control.

### Control of Parthenium by Gliocladium Virus

*Gliocladium virus* and 10% neem oil separately as well as in combinations spray control parthenium and other broad leaf weeds like *Chenopodium album*, *Melilotus alba* and *Medicago sp.* In wheat crop, the fungus could be explored as a self control measure for non-cropped area also.

### Control of parthenium by Trichoderma viride and neem oil.

*Trichoderma viride* and neem oil separately as well as in combinations spray control parthenium under field conditions. The fungi have potential of becoming a self perpetuating means for control of parthenium under non-cropped area. *Trichoderma viride* also acts as an antidote for parthogens of parthenium that can possibly be used as biocontrol agents. If any of the parthogens attack crops, the *Trichoderma viride* can be used to overcome the problem.

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