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Potential uses of Parthenium *hysterophorous,* the obnoxious weed

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Abstract

Parthenium hysterophorous is an obnoxious weed and is largely spread all over the world. It widely affects the loss of natural vegetation in the areas of its growth. It has detrimental effects on human health and livestock and also reduces the agricultural produce. Because of its enormous availability, studies have been conducted to validate its employability. Researchers have shown that it can be used efficiently to a considerable level in various fields such as bio manure production & vermi-composting, bioremediation, as a substrate for the synthesis of biomolecules etc. Though the uses of it are explored very little, it has the potential that could be tapped for a few sustainable approaches.

Keywords: *Parthenium hysterophorous*, Parthenin, Bioremediation, Vermicomposting, Biological control

1. Introduction

Parthenium hysterophorous (commonly known as carrot weed, wild feverfew, congress grass, the scourge of India) is an aggressive, ubiquitous herbaceous, annual weed which belongs to one of the largest and exotic of plant kingdoms- Asteraceae/Compositae. An original inhabitant of West Indies and North-East Mexico[1] and an endemic in America, it has spread worldwide (into Africa,

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Australia, Asia and Pacific islands) during the last century and has become one of the world's most devastating weeds. It is a thermo and photo insensitive plant, and an enormously prolific seed producer with up to 25,000 seeds per plant which have the ability to disperse via vehicles, water, animals, wind etc, and germinate easily[2]. It has the ability to grow luxuriously in almost all types of soils round the year by rapidly inhabiting and competing against the other vegetation in its growing vicinity [3]. It is believed to have gained entry into the Indian subcontinent in the 1950s as a contaminant with the PL 480 wheat, which was procured in the year 1954 to provide food grains to the developing countries to eliminate malnutrition and starvation (Green Revolution era). Today, being highly prevalent, this obnoxious weed has infested approximately two million hectares of land in India [4].

This weed gains its reputation not only by its disruptive effects on natural ecosystems, but also because of its varied chemical composition. It affects human health by causing problems such as asthma, bronchitis, dermatitis and hay fever. And in animals, it taints the milk and meat products, thereby reducing the value of animal products [3]. The further sections of this article provide information on the effects of this weed of global importance and the possible ways of its employability.

2. Chemical analysis

A phytochemical analysis conducted on *P. hysterophorous* showed the presence of seven sesquiterpenes - lactones (SQLs) with ambrosanolides. Cornopilin, hymenin, confertdiolide, hysterin, tetraneurin, parthenin, p-methobenzoic acid were identified based on the spectral properties [5]. In another study, Maishi *et al* have reported the presence of a bitter glycoside, an SQL parthenin, an ambrosanolide hysterin, flavonoids such as quercelagetin, fumaric acid, p-hydroxy benzoic acid and vanillic acid [6]. A study by Gupta *et al* has shown the presence of an allergen - a 31kDa acidic glycoprotein named ParH1 from the pollen. This has shown binding to IgE antibodies in the parthenium sensitive subjects [7]. The study of methanol chloroform extracts of the air dried and powdered plant material showed the presence of parthenin, and

few of the known components such as tetraneurin and hysterone along with four new compounds which were analysed to be acetylated pseudoguaianolides having cytotoxic activity [8]. Venkataia *et al* isolated another secondary metabolite - a pseudoguaianolide known as charminarone from the whole plant extract [9]. Presence of three ambrosanolides was also discovered from the chloroform extracts of this plant [10]. Ramesh *et al* also showed the presence of pseudoguaianolides from the methanol chloroform extracts of the flowers of this plant [11]. However the SQLs are the major constituents of *Parthenium hysteororous* and parthenin being the predominant one, is present in all parts of the plant including trichomes, leaves as well as pollen.

3. Health hazards on humans and livestock

Due to the perennial nature of the plant and its profuse growth, the ill effects caused by the plant are also very common in all the seasons. The chemicals in the plant – parthenin and other SQLs which reside largely in stem and leaves are responsible for the allergic contact dermatitis. People affected with contact dermatitis present symptoms with discrete, flat papules and plaques on exposed areas of the body [12]. The dermatitis shows a pattern of progressing from an airborne contact infection to a mixed chronic dermatitis [4]. Dermatitis caused by parthenin is a T-cell mediated immune system injury and it manifests as papules and lesions and is shown to significantly increase the cytokines and interleukin concentrations in the affected persons [13]. Dermatitis by parthenin is inducted and perpetuated in most of the patients through Type 1 and type 4 hypersensitivity [14]. It induces chromosomal aberrations in blood lymphocytes of mice when exposed to parthenin [15]. In a study to prove the ability of parthenium to cause ill effects on human health, Maishi *et al* reported symptoms such as dermatitis, eczemia, itching on the sides of face and neck, allergic rhinitis as well as breathlessness [6]. It is shown to elevate the telomerase activity and reduce the terminal restriction fragment length in the T lymphocytes of patients affected with dermatitis [16]. The aqueous extracts of the plant when tested on *Salmonella* and on mouse for their mutagenic effect, the bacteria showed negative response, whereas, the toxicity of the extract was noticed

effectively on the mammalian cells. But none of the effect were causing any genotoxicity [17].

Along with the effects on human health, Maishi *et al* also reported that Parthenium has the ability to cause diarrhoea, severe popular erythematous eruptions, breathlessness and choking, and also sometimes death in animals [6]. It causes degenerative changes in the succinate dehydrogenase activity in the sheep [18]. Animals grazing on parthenium also get affected by alopecia, loss of pigmentation, dermatitis and diarrhoea. The milk and meat of cattle feeding on this weed also get tainted [19].

4. Effect on agricultural productivity

The invasiveness of the *Parthenium hysterophorous* is due to its ability to displace other species by means of allelopathy. The allelopathic interference on the surrounding plants is due to the role of allelochemicals - phenolics and SQLs. The SQL parthenin is released from various plant parts into soil and affects the emergence, early growth and development of crops and associated species [20, 21]. It is an invasive weed of pasture systems and reduces the pasture productivity by 90% and transforms river banks and food plains to monoculture scrublands [2]. Due to its rapid growth and establishment, the yield of crops reduces and is known to cause food and fodder scarcity. The release of parthenin and other phytochemicals into the soil during the decay process has a leading role in germination and reducing plant growth. A study conducted to check the effect of the ash of this plant on the growth of *Phaseolus mungo* showed that the increased concentrations of it had an adverse effect on the germination as well as plumule and radical length and plant productivity [22]. It is shown to result in poor fruiting as well as decreased chlorophyll content in leguminous plants in Southern India [23]. It has the potential of functioning as an alternate host (an inter season reservoir) for crop pests. In Queensland it was found to host a scarab beetle, a common pest of sunflower plants. It also attracts a number of bacterial pathogens causing plant diseases. It is also responsible for causing a reciprocal infection in *Phaseolus vulgaris* in

pre-flowering and pod formation stage by hosting a bacterial pathogen *Xanthomonas campestris* [3].

5. Potential uses of Parthenium

5.1. Use in bioremediation

One of the main sources of water pollution is due to the release of effluents from industries which carry varied contaminants (both organic as well as inorganic) that have diverse effects on the surroundings they come in contact with. Heavy metals such as lead, copper, cadmium, zinc, nickel are toxic to the environment even at lower concentrations. [24]. Nickel is lethal to humans at atmospheric conditions on exposure to 30ppm for about 30 minutes. It causes headache, dizziness, rapid respiration, cyanosis and extreme weakness. Another heavy metal cadmium is known to cause damage to kidney and bones and also leads to skeletal deformity, muscular cramps, and high blood pressure [25]. An organic compound p-cresol, commonly found in effluents, is a highly toxic chemical even at lower concentrations and promotes stomach ulcers. It is corrosive to eyes, skin and the respiratory track [26]. Hence there is an increasing need by the industries to remove these heavy metals as well as organic pollutants from the effluents and also to develop low cost materials to absorb these toxins. A considerable achievement is noticed in this regard. A sulphuric acid treated parthenium carbon on a monolayer was found to adsorb about 17.2mg of nickel per gram. The adsorption though mainly was dependant on pH, maximum adsorption of nickel was obtained in 4 hours duration[24]. The dried mass of parthenium was found to recover spontaneously about 99.7 percent of cadmium(Cd 2) from the effluent water in the pH range of 3-4[27]. In a comparative study between the adsorption capacity of Parthenium Activated Carbon(PAC) and Activated Carbon(AC), to determine the efficacy in removal of p-cresol, PAC was proved to be as effective as AC in the removal of p-cresol up to the concentration of 500mg/l in aqueous solutions. At the pH around 6 [26], sulphuric acid treated parthenium carbon and Phosphoric acid treated parthenium carbon were also shown to be effective in

adsorptive removal of methylene blue from aqueous solutions at the concentrations of 500mg/l [28].

6. Substrate for synthesis of biomolecules

Production of active biomolecules like enzymes by microbial sources is dependent entirely on the substrate and on the downstream processing. Industries in this line are also concerned about the environmental and economical aspects of any technology adapted. Replacement of highly expensive substrates with low cost alternatives is likely to decrease the production costs of commercially available enzymes. Dwivedi P *et al* have explored one such option of utilising Parthenium as a substrate for the production of alkali tolerant xylanase. The high hemi cellulosic content can be used as a source of xylooligosaccharides which may act as inducers for xylanase production on contrary to use of xylan in commercial practices. On cultivating a mutant strain of *Penicillium oxalicum* SAUE-3.510 on a mineral medium supplemented with parthenium weed, a significantly high level of xylanase was obtained which had a 1.87 fold increase in the enzyme activity. The enzyme thus obtained was active at a pH of about 9 and was stable for a period of 24 hours showing its tolerance to alkaline environment [29]. A dry powder of Parthenium was also used for the production of oxalic acid by the process of its oxidation. Oxalic acid of 98% purity was obtained when the plant material was treated with a mixture of Sulphuric acid and nitric acid, at a solid liquid ratio of 1:10 (w/v) in the presence of a catalyst -Ammonium vandate - at temperature of 750°C during the reaction period of 4 hours [30]. The utilization of plant biomass in the production of active biomolecules would thus help in the effective management of this weed.

6.1. Uses of Parthenium in biogas and bio manure production.

The obnoxious weed Parthenium gets digested along with the cattle manure. In a study to determine the digestibility of only Parthenium along with the inoculum of cattle manure slurry, Gunaseelan *et al* showed the digestibility of Parthenium and the dependency of gas production on the size of inoculum. A yield of 75% of methane was obtained from the Parthenium plant at 50%

concentration of the Parthenium solids when allowed to digest at ambient conditions for duration of 5 weeks. The use of this plant could be a potential means for methane generation considering its abundance.

The high concentrations of N, P, K, Mg and the chlorophyll content makes the plant ideal for composting. But also, the plant has high concentrations of phenolics and parthenin because of which it has negative effects on the growth and development of other plants in earlier stages when it is used as compost. The application of Parthenium compost in the maize fields leads to considerable increase in the soil moisture level as well as organic carbon status in the soil when compared to the application of NPK alone [31]. Several studies have shown that when the compost of parthenium is used along with other sources, it has indeed beneficial effects on the plants' growth. The combined use of parthenium compost and *Azotobacter* was shown to increase the acquisition of N, P, K and S in wheat when compared to the use of parthenium compost alone. Supplementation of N through parthenium beyond 50% through parthenium compost has harmful effects on wheat [32]. Similarly, a comparison of millipede compost of parthenium (MC) and ordinary parthenium compost (OPC) showed that OPC had wielded harmful effect on early growth and development of common wheat, whereas, the MC exerted more beneficial effects on the rate of seed germination and root elongation due to its higher nutrient content and reduced concentrations of allelopathic chemicals [33]. Parthenium can also be used in vermicomposting. A 25% parthenium and 75% cow dung mixture was shown to be optimum for the growth and reproduction of earthworms and hence it is beneficial as one of the feed components in vermicomposting [34].

6.2. Biological control of Parthenium

Biological control of this weed by means of insects is reported to have been practised mainly in Australia and India. Between 1978 and 1983, six insects were tested in Australia. *Epiblema strenuana* – a stem galling moth is one of the insects with real impact on the weed. Within four years of its release the insect had established

well in the parthenium infected regions and the plants were attacked with 20 to 30 larvae per plant and not letting it grow for more than 50 cm and much before seed production [35]. But still this plant remains as a serious weed. In India, a chrysomelid *Zygogramma biclorata* was released in 1984, and was shown to have positive effects in and around the agricultural lands of Bangalore. *Epiblema strenuana* when introduced in India, was found to develop on a major oil crop and was thus destroyed [35]. A stem boring weevil *Listronotus setosipennis* was shown to have significant detrimental effect on the plant height, number of leaves, flower production and plant biomass in the rosette plants than on preflowering and flowering plants in Queensland [36]. Parthenium plants were inhibited from germination, reduced chlorophyll content and respiration of the mature plants, along with increased water loss and complete wilting in 15 days time when exposed to volatile oils of eucalyptus [37]. Studies have also reported that a leguminous plant *Cassia sericea* and a flowering plant, marigold can outgrow parthenium weed and reduce its vigour [38]. A rust fungus *Puccinia abrupta* var. *partheniicola* also acts a biological agent by establishing the disease when inoculated in the parthenium affected regions at around temperatures of 15^0C and in the environment having dew period for a minimum of 6 hours [39].

Conclusion

Though the availability of the weed is enormous, the studies conducted on the various applications are still limited. The work done so far shows the ability of using this plant for multiple purposes. It can be used sustainably in bioremediation of heavy metals as well as organic pollutants. Parthenium can effectively be used to produce methane by composting and can also be used successfully as bio manure in right proportions. Even though, control of this weed is still not very successful, considerable achievements have been made in the axis of biological weed management. Taking the advantage of the abundance of the weed, the scope for its employability remains huge.

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