Plant Archives Volume 20 No. 1, 2020 pp. 2617-2623 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

AN INTRODUCTION OF *PARTHENIUM HYSTEROPHORUS* TO BE BOON FOR AGRICULTURAL LAND: UNDER HEAVY METAL CONTAMINATION

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Abstract

Recently, the contamination of agricultural land possesses major threats to human health and the environment. The catastrophic events comprising geologic activities and anthropogenic activities leave every year a huge amount of nutrient/metal ions in agricultural land/water bodies, they remain in soil for many years and are the potential cause of phytotoxicity or poisoning of the food chain. Generally metal ions are essential in trace amount for the normal development of animals and plants but become toxic when accumulated at higher concentrations. Among the number of practices, phytoremediation was initially proposed as an environmental cleanup technology for the remediation of metal contaminated land.

Key words: phytoremediation, heavy metal, agricultural land.

Introduction

Generally metals are pivotal in trace amount for the normal development of animals and plants but are toxic specifically on accumulations at higher concentrations. Natural as well as anthropogenic activities increased the input of metals into agricultural land and water bodies, resulting into extensive accumulation of metal ions up to toxic levels in the ecosystems. Metal ions are non-biodegradable in nature hence persist for many years in environment.

A number of practices are being used to mitigate the heavy metal from contamination sites. Furthermore, several methods are used for removal of heavy metals like ion exchange, electrochemical reduction, evaporation and reverse osmosis but these methods are very costly, taking long detention period and release toxic gases and waste materials in turn (Rao *et al.*, 2002). A number of practices are being used to reduce the level of nutrients as well as metal ions from agricultural land and water bodies. Among all, phytoremediation plays an increasingly important ecological and sanitary role for chemically polluted lands as well as water bodies (Antonkiewicz and Jasiewicz, 2002). The weed plants can easily reduce heavy metals (HMs) pollution from soil through phytoremediation. Plants have the genetic potential to clean up contaminated sites. On the other hand, the adaptation of phytoremediation technique has been found to be cost effective as well as easily available practices. Several authors adopt phytoremediation technique for easily absorption of heavy metals from contamination sites. They use different absorptive material in their experiment such as oat biomass (Gardea-Torresdey *et al.*, 2000), rice bran (Montanher *et al.*, 2005), moss peat (Ho *et al.*, 1995), melon seed husk (Okieman and Ohyenkpa, 1989), bagasse flyash (Srivastava *et al.*, 2007), sugarcane bagasse (Garg *et al.*, 2007), waste tea leaves (Ahluwalia and Goyal, 2005), *Parthenium hysterophorus* (Lata *et al.*, 2008; Lata *et al.*, 2007) (Table 1).

Parthenium hysterophorus belong to family Asteraceae, it shows some medicinal property and has several common names in different countries such as altamisa (chuchiate), quinine-weed and congress grass

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Table 1: Beneficiary applications of *Parthenium hysterophorus* in agricultural land.

S. No.	Mode of application	Effect	Reference
1.	As Green manure	increased the plant height, number of filled grains in ratoon rice.	Kishore *et al.*, 2010 Javaid, 2008
2.	Residual effect of Green manure	highest root and shoot biomassdry matter production highest in maize	Javid and Shah, 2008
3.	Insecticide and biopesticide	sesquiterpene lactones inhibit the growth of *Heliothis zea* insects	Isman and Rodriguez, 1983
4.	Roots and stems	mortality of mosquito larvae	Kumar *et al.*, 2012
5.	Composted of flowering part	higher N compared to poultry, vermicomposting and farmyard manure.	Channappagoudar *et al.*, 2007
6.	Composited with other plant materials	reduces its allelopathic inhibition potential on lettuce plant	Rao, 1956
7.	Ceedstock for vermicomposting	optimum growth and reproduction of*Eisenia fetida*	Chippendale and Panetta, 1994
8.	Residue allelopathy	delaying germination and reducingplant growth	Belz *et al.*, 2007
9.	Use of gibberellic acid for leadextraction by the weed	phyto-remediation of leadcontaminated soil	Hadi and Bano, 2009
10.	Sulphuric acid treatedcarbonized *Parthenium*	absorption of nickel from the aqueoussolution	Lata *et al.*, 2008
11.	Dried powder	adsorbent for the removal of Cd fromaqueous solution	Ajmal *et al.*, 2008
12.	Biosorptive nature	removal of methylene blue from diluteaqueous solution and Cr (VI)	Lata *et al.*, 2007
13.	Dry leaf powder	wilting of the *Salvinia molesta* an aquatic weed	Pandey, 1994; Venugopal and Mohanty, 2011
14.	Pre- and post-emergent applications of extracts athigh concentrations	decreased the seed germination andthe growth of *Eragrostis* sp.	Javaid, 2008
15.	Aqueous, methanolandn-hexaneextracts	significantly inhibit the Fusarium wilt in potato caused by *Fusarium solani*	Zaheer *et al.*, 2012
16.	Roots of plant	Chromium exclusion	Islam *et al.*, 2015

(gajar ghas) in Mexico, United States of America and India, respectively (Lata *et al.*, 2008; Espinosa-Rivero *et al.*, 2015). It is annual herbaceous weed species and a native of north-east Mexico, has now a days widely spread in China, India, United States of America, Pacific Islands, Australia, etc. This plant contains flavonoids like quercelagetin 3, 7 -dimethylether, 6- hydroxyl kaempferol 3-O arabinoglucoside, hymenin, ursolic acid, p-OH benzoin, corononropilin hydroxycorononropilin, tetraneurin A, charminerone, vanillic acid, caffeic acid, p-courmaric, p-anisic acid, chlorogenic acid, ferulic acid, sitosterol and some other alcohols hydroxy benzoin (Patel, 2011; Espinosa-Rivero *et al.*, 2015). Due to these chemicals, *P. hysterophorus* showed medicinal property for human and used as a treatment for headache, malaria, hay fever, gastrointestinal disorders and stomach ache and several skin diseases (Lata *et al.*, 2008; Espinosa-Rivero *et al.*, 2015). Raghu *et al.*, (2014) reported that root of *P. hysterophorus* is used to treat stomach ache or indigestion and dysentery related problems. Likewise to human, *P. hysterophorus* is also beneficial for plant, however, it secretes some terpenes comprising several phytotoxic compounds or allelochemicals like glycoside parthenin, hysterin, ambrosin (Patel, 2011).

Besides, the damaging effects of this plant on humans beings, animals as well as on plants have been well documented. It causes several health problems in human beings and animals, e.g. allergy (respiratory problems), burning, skin diseases, mutagenicity, black spots, blisters around eyes, rings, asthma, hay fever, etc (Ajmal *et al.*, 2006; Patel, 2011) (Fig. 1), in plants shows allelopathy resulting in reduced crop productivity and also exert aggressive dominance on threatens plants. The biomass of *P. hysterophorus* is available at zero prices throughout the year. Thus, in the present review we discuss the mechanism behind metal adsorption capacity and enhancement in crop productivity from contaminated sites by the catchment *Parthenium hysterophorus.*

Sources of heavy metals contamination

The catastrophic events like, geologic activities which includes weathering processes of rocks, flooding condition and anthropogenic activities such as urbanization, industrialization and irrational agricultural practices leave every year a huge amount of nutrient/metal ions in urban and peri-urban agricultural areas (Sarkar *et al.,* 2007). Mainly two activities are responsible for heavy metal contamination in soil and water which have resulted widespread occurrence of metal contamination in ecosystems. Firstly due to natural activities include weathering of parent rocks and volcanic eruptions (He *et al.,* 2005; Tchounwou *et al.,* 2012). On the other hand, secondly by involvement of anthropogenic activities such as rapid urbanization, industrialization and some geogenic activities enhanced production of heavy metal pollution in soil and water. The consequences of these activities produces several toxic heavy metals from household/ domestic, traffic emissions, pharmaceuticals, agricultural and industrial waste, as well as atmospheric sources results enhancement in permissible levels of metal ions in environment (He *et al.,* 2005). Generally, the contamination of heavy metals in environment through rapid industrialization that includes ore extraction processes, nuclear power stations, paper industries, batteries, leaded gasoline and paints, synthetic/chemical fertilizers, pesticides, sewage sludge, wastewater and repeated irrigation, coal and petroleum combustion residues, petrochemicals spillage etc. (Khan *et al.,* 2008; Zhang *et al.,* 2010; Arruti *et al.,* 2010).

Role of some common weed plants in heavy metal uptake

Natural as well as anthropogenic happenings increased the input of metals into agricultural land and water bodies and the levels of pollution have increased many folds in the last few decades. According to CPCB, (2011) in India the level of several organic as well as inorganic pollutants are much more above the permissible limits. Clemens, (2017) reported that *Arabidopsis halleri* and *Thlaspi caerulescens* plants are involved in detoxification and hyper-accumulation of toxic metals or ions. Similarly, different types of weed plants such as *Parthenium hysterophorus*, *Eclipta macroclada*, *Acanthopanax sciadophylloides*, *Solanum nigrum*, *Maytenus founieri* etc. are common metal hyper accumulator plants. Among them, *E. macroclada* was selected as a good metal accumulator especially Pb accumulator and *Brassica juncea*, *Ilex crenata*, *Sesbania drummondii* and *Clethra barbinervis* have potential capacity for phytoremediation of HMs (Yang *et al.,* 2005; Mohsenzadeh and Rad, 2011). Singh *et al.,* (2016) also reported that *Amaranthus hybridus* and *Solanum nigrum* weed plants accumulate high amount of Cd and Ni, whereas, E*clipta hirta* and *Xanthium strumarium* have high levels of Cu, Pb and Zn in same contamination site. Tanhan *et al.,* 2007 also reported that *low amount of Cd* and Zn are found in *Chromolaena odorata* (Siam weed) when collected from the contamination site. Besides, this Siam weed accumulate the high amount of Pb, Cd and Zn with increasing metal concentrations in nutrient solution culture condition. They widely grow in every part of the world as weeds and reduce the level of metal from soil and water bodies. Therefore, under changing environmental conditions the introduction of some techniques/ methods are being realized so that the agricultural contamination decrease with the help of catchment weeds.

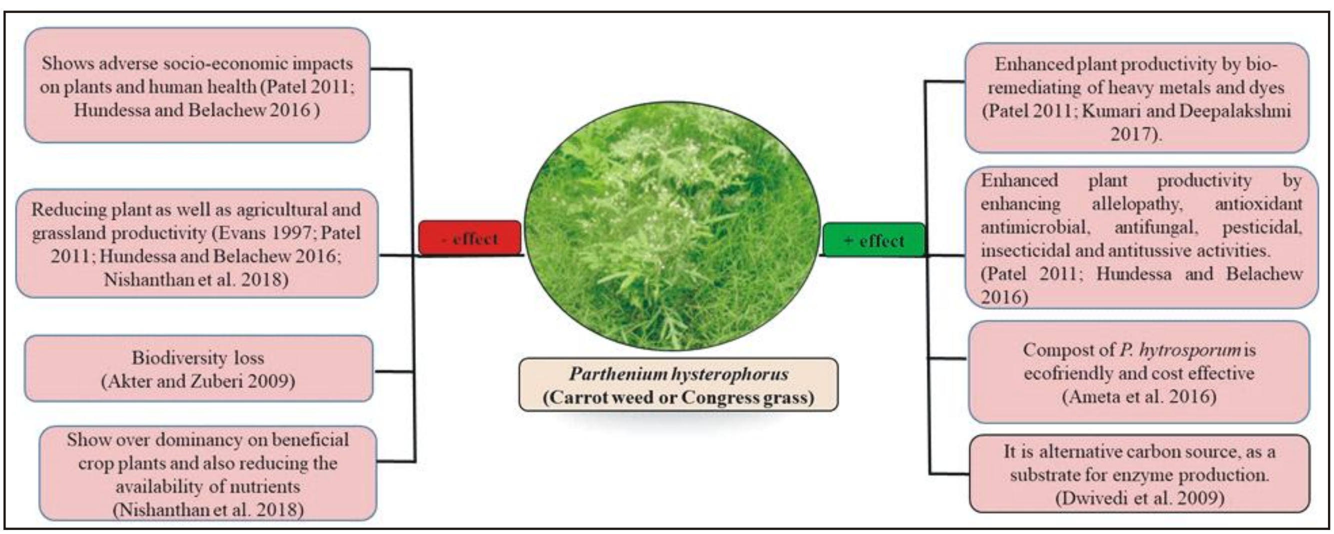

Fig. 1: The variability in applications of *Parthenium hysterophorus.*

Factors influencing heavy metal uptake characteristic of *Parthenium hysterophorus*

Parthenium hysterophorus absorb several toxic metal ions from their roots. The mobility and availability of heavy metals in the soil are usually low, due to interference of soil and plants. The soil factor includes soil texture and type, soil metal bioavailability, component of organic matter, soil pH, sources of heavy metal, chemical form or structure of elements in soil. Besides this plant factors also affects metal absorption by plant age, type of plant species, structure of root cells and presence of metal transporters and root rhizosphere processes, metal distribution in different parts of plant etc. (Rosselli *et al.*, 2003; Sanghamitra *et al.*, 2012; Sheoran *et al.*, 2016). Similarly, Jung, (2008) reported that soil pH, cation exchange capacity of soil, organic matter, soil type and interaction between essential elements, these factor influences the availability of metals in crops. In the same way, Luo and Rimmer, (1995) also reported that the interactions between root surface and metals within the plant can affect translocation and uptake of metals.

According to Sanghamitra *et al.*, (2012) the uptake of heavy metal like Zn by an invasive weed species *Parthenium hysterophorus* is adversely affected by both soil as well as plant factors. Generally the uptake of Zn is mostly dependent on soil pH. The availability of Zn is very low when the soil pH is more than 6, although under alkaline soils the availability of Zn is decreased due to lower solubility of Zn ions in soil (Hafeez *et al.*, 2013). An increase in soil pH, allows for lower accumulation of Cu and Zn metals in the plant tissues (Stratton and Rechcigl, 1998). Lata *et al.*, (2008) also reported that Ni(II) ions absorption is adversely affected by pH, at low soil pH, the level of H^+ ions enhanced, consequently H^+ ions compete with Ni(II) ions resulting in repulsive forces to operate thereby reducing binding sites of Ni(II) ions in *Parthenium hysterophorus*. Similarly, Musilova *et al.*, (2015) reported a number of factors such as soil content (the content of their mobile forms), soil reaction, pH, cation exchangeable capability, organic contents, soil texture and types etc to affect the accumulation of heavy metals like Zn, Cu, Ni, Pb, Cd in potato tubers.

Parthenium hysterophorus enhanced crop productivity

The *Parthenium hysterophorus*, facilitates accumulation or bounding of HMs in tissues, which may increase or else decrease the mobility of HMs and also prevent HMs leaching into groundwater. The growing plants of this noxious weed can easily ease HMs contamination from soil through phytoremediation. This weed can easily absorb heavy metal from soil and it has ability to reuse absorbed HMs in their normal metabolic process (Sanghamitra *et al.*, 2012). All parts of *P. hysterophorus* including root, stem, leaf, hair, trichomes and pollens produces several valuable secondary metabolites in tissues such as oils, alkaloids, flavonoids, pseudo guaianolides and phenolics (Javaid and Shafique, 2010) (Fig. 1) (Table 1). Several author reported that the secondary metabolites of this noxious weed exhibited allelopathy characteristics that can be used to increase crop production under harsh environmental conditions. The plant of *P. hysterophorus* produces some allelochemicals compounds which works against insects, herbs, nematodes, fungus and other growth reducing factors. It is also illustrated phytotoxicity as well as autotoxic effect on plants that act as herbicide and also help in growth regulation of some micro and macro flora under stress condition (Roy and Shaik, 2013; Pandey, 2009; Abbas *et al.*, 2013). Stems, leaves, roots and flowers of *P. hysterophorus* produces oils that enhanced crop productivity by showing antimicrobial, pesticidal, insecticidal and antitussive activities in soil (Roy and Shaik, 2013; Kumar *et al.*, 2013). It significantly enhanced the growth of agriculturally important plants. Lalitha *et al.*, (2012) also reported that flower leachate of this invasive weed has high amounts of auxin phytohormone, that promotes seed germination in *Phaseolus mungo* and the seeds have metal (Fe, Pb, Hg and Ni) tolerance capability. The unpalatable nature of *P. hysterophorus* to herbivores predator may restrict entry of toxic metals into the food chain (Hadi and Bano, 2009). Ajmal *et al.*, (2006) applied the dried powder of *Parthenium* which decreases about 99.7% Cd(II) ions from soil due to variation in soil pH. On the other hand, the extract of *Parthenium* also work against some pathogenic fungi and brinjal fruit borer insect (Belz *et al.*, 2007). Although it is problem-creating weed but, the compost of *P. hysterophorus* can be applied as organic manure in agriculture farms. It is ideally suited for composting due to presence of high amount of N, P, K, Ca, Mg and chlorophyll content in *P. hysterophorus*. Channappagoudar *et al.*, (2007) also reported that the compost of *P. hysterophorus* rich in several micro and macronutrients such as Mn, Zn, Cu and N, P, K and Fe respectively. While, it enhanced soil moisture level relative to NPK alone (Gunaseelan, 1998). Similarly, Kishor *et al.*, (2010) prepared compost of *P. hysterophorus* and measured its manure value. As compared to the edible crops, weeds show better tolerance to adverse environments. Therefore, it is an important option to find out the species of weeds which can nullify agriculture land associated contamination.

Conclusion and future prospective

In recent research, the adaptation of phytoremediation through catchment weeds is an advanced modern approach. This, technique/approach has been found to be cost effective and easily available practices. This is an eco-friendly, economically feasible and emerging technique for the restoration of environment contaminated with heavy metals. Also, the biomass of *P. hysterophorus* is used as manure and pesticide which can be free from dangerous chemicals. This kind of technique may not cause any adverse effect on the plant system. Compared to the engineering and technological tools, the phytoremediation technique is found to be the best technique for regulating the river health under nutrient/ heavy metal contamination condition. This compels the environmental scientists to look forward for an alternative strategy with a low cost. Also, the finding of this review will be helpful in understanding the mechanism behind nutrients/metals adsorption by weeds. In this context, in future it will become a boon for the human beings. The motive is to address the question that how *P. hysterophorus* growing in the catchment are able to reduce contamination of agricultural land and water bodies and if so, what mechanisms are spreading behind? Thus, in the context of above aspects *P. hysterophorus* which have long been considered as a menace in agriculture can also become the boon for farmers. It may provide a new base of research for agricultural scientists/ environmentalists to adopt the molecular approach for in depth evaluation.

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