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A review on phytoremediation capability of *Tagetes erecta* Linn. against heavy metals

Supriya Kumar Bose[1], Arpita Chakraborty[2], Keya Mandal[3], Dipti Das[4], Gopal Mistri[5], Sanjay Kar[6], Aritri Laha[7], Sabyasachi Ghosh[8*]

[1,2,8*]*Department of Biotechnology, School of life science, Swami Vivekananda University, Barrackpore, West Bengal-700121, India.*
[3]*Department of Environmental Science, Kalna College, Purba Bardhaman, West Bengal-713409, India.*
[4]*Department of Botany, Kalna College, Purba Bardhaman, West Bengal-713409, India.*
[5]*Department of Zoology, Kalna College, Purba Bardhaman, West Bengal-713409, India.*
[6]*Department of Botany, Midnapore College, Paschim Medinipur, West Bengal-721101, India.*
[7]*Department of Microbiology, School of life science, Swami Vivekananda University, Barrackpore, West Bengal-700121, India.*

***Corresponding author:-** Sabyasachi Ghosh*
[*]*Department of Biotechnology, School of life science, Swami Vivekananda University, Barrackpore, West Bengal-700121, India. Email: sabyasachig@svu.ac.in*

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Abstract

Now a days, Phytoremediation is treated as a set of emerging techniques that use several selected plants to contain, eradicate, immobilize or degrade contaminants from water and soil in order to clean the contaminated sites. Recent researches have directed to the application of non-edible floriculture plants having the capability to erase the toxic metals from polluted environment including their aesthetic value as a good proposal for phytoremediation. The plant *Tagetes erecta* Linn., locally recognized as Ganda Phul (Marigold) that belongs to the family of Asteraceae can grow widely in heavy metal stress of Cd, Cr, Pb etc. The plant species can absorb and accumulate varieties of contaminated heavy metals like Pb, Cr, As, Cd, Co, Hg etc. This article includes a brief overview about the toxic impact of the Cr, Cd, and Pb on the plant. In addition, the discussion highlights recent progress on the application of phytoremediation competence of the plant, *Tagetes erecta* Linn. concerning with the heavy metals.

Keywords: Phytoremediation, Ornamental plants, Heavy metals, Hyperaccumulator

1.Introduction:

In different sites of the world, the complication of environmental pollution has been assumed indiscriminately. Industrial revolution and population explosion are responsible for environmental pollution. About 60% of contaminants are mentioned to as heavy metals. These metals are investigated as the deadly pollutants because of their toxicity and non-biodegradable properties. All forms of ecological system are badly affected in the presence of such contaminants (Aina et al., 2019). Phytoremediation is treated as a set of emerging techniques which use many selected plant species to degrade, extract, immobilize or contaminants from water and also soil to clean up the polluted environment (Tangahu et al., 2011). In recent trends non edible floriculture plants having capability to remove heavy metals from contaminated site including their aesthetic values are being used as an alternative proposal for phytoremediation. The plant, *Tagetes erecta* Linn., locally known as Ganda Phul (Marigold), belongs to the family Asteraceae can grow widely in heavy metal stress of Cd, Cr, Pb etc.(Mahmood-ul-Hassan et al., 2020). *T. erecta* has been demonstrated as high Cd tolerance. The plant can trigger a number of stress mitigation strategies (Goswami & Das, 2017). *Tagetes erecta* has the potentiality of chromium (Cr) remediation from soil (Coelho et al., 2017). Lead-contaminated soil can benefit greatly from the effective phytoremediation of *T. erecta* (K. Shah et al., 2017b). The review article concerns with phytoremediation capability regarding heavy metals (Cr, Cd, and Pb) of *Tagetes erecta* Linn. including impacts of those toxic metals on the plant.

2.Genaral description about *Tagetes erecta* Linn.:

The plant, *Tagetes erecta* Linn. is locally known as Ganda Phul (Marigold) (figure 1). It is the plant of the Asteraceae family. It's a herbaceous perennial plant with a hight up to 3ft. The common species of marigold are *Tagetes ereta* Linn. and *Tagetes patula* Linn. which are popularly known as American marigold and French marigold respectively. The phyllotaxy is opposite or sub opposite. Leaves are pinnately compound and oblong in shape with dentate margin. The leaf blade is about 2 inches in length. Generally the flowers are orange or yellow in colour (Shetty et al., 2015).

The plant is grown in the elsewhere of tropics and subtropics including Bangladesh and India. It is the local species of wormer region of Mexico and America. It blooms flower from midsummer to frost. Type of inflorescence of the plant is capitulum and the head of the flower is about 5 cm in diameter. The inflorescence consists of numerous barren disc florets and one or more than one rows of ligulated fertile ray florets. The flowers consist of many phytoconstituents like Phenolic compounds, Tannins, Steroids, Flavonoids, Alkaloids Saponins and Triterpenoids (Kadam et al., 2013).

The plant species has strong and well developed root system which helps to grow the plant rapidly and also to survive the plant under the stress of soil contamination (Biswal et al., 2022).

In India, Marigold is cultivated in West Bengal, Tamil Nādu, Karnataka, Uttar Pradesh etc. Areas of 47.68 thousand hectares are used for cultivation of Marigold in India. The production of total loose flowers is 501.87 thousand MT from the above estimated areas. Temperature range of $20^0 – 30^0$C and sandy loam soil having the pH range of 7.0 - 7.5 are favourable for better growth though the plant can be grown in variety of soils. For betterment of yielding of flower NPK is used as nutrient @ 100:100:100 Kg/ha during land preparation. After transplantation of seedling Nitrogen as nutrient is applied as per requirement. Frequent irrigation is followed 4-5 days interval without stagnation of water. Damages due to fungal diseases have been observed such as Damping off, Powdery mild dew, Collar rot, Fusarium wilt etc. (Singh et al., 2020).

Figure 1: *Tagetes erecta* Linn.

3. Phytoremediation potentiality of *Tagetes erecta* Linn.:

Phytoremediation is treated as a set of emerging techniques which use many selected plant species for degradation, accumulation, immobilization or extraction of contaminants of polluted soil and water to clean up the environment (Figure 2). Many plant species can absorb and accumulate varieties of toxic metals including Lead (Pb), Cadmium (Cd), Arsenic (As), Chromium (Cr), Mercury (Hg), Cobalt (Co) etc. These non-biodegradable metals have harmful effect on biological system in both plant and animal bodies.

Phytoremediation now a days has become an very effective and affordable solution to extract or remove such hazardous substances from the polluted soil (Tangahu et al., 2011). Phytoremediation by using edible plants would not be a sustainable choice as accumulated metals by those plants might enter in the food chain. So non edible floriculture plants which are capable to remove heavy metals from polluted site including their aesthetic values are being used as an alternative proposal (Mahmood-ul-Hassan et al., 2020). Marigold (*Tagetes erecta* Linn), an elegant floriculture plant can grow widely in heavy metal stress due to their swift growth rate, adequate root system, capability of metal accumulation including wide adoptability in different types of soils. Thus, the non-edible plant species could be offered for phytoremediation to decontaminate polluted site (Biswal et al., 2022). T. erecta has the efficiency to be a pioneer on poor soil and that's why the plant might be preferably used for phytoremediation to clean those degraded areas due to heavy metal pollution (Coelho et al., 2017).

3.1 Chromium (Cr) extraction

Tagetes erecta L. was planted to test the plant's capacity to extract chromium (Cr) from tannery sludge using four different irrigation schedules based on the gradient in Cr content.

Those treatments were set as Control (CK), 51.25×10^3 mg kg^{-1} (T2), 20.50×10^3 mg kg^{-1} (T1), and 102.50×10^3 mg kg^{-1} (T3). Chromium content in leaves also has been reported 195.2 mg/Kg with the TF value 0.95-1.25 when the plant was grown in tannery sludge mixed soil (Miao & Yan, 2013). A previous study showed that *Tagetes erecta* had the potentiality of chromium remediation from soil. Cr content in leaf has been reported 280 to 364 mg/Kg with the value of 8-25 of transduction factor (TF) when the plant was grown in Cr added solution cultures at the concentration of 0.00, 0.04, 0.08, 0.12,0.16, and 0.24 mmol/L.(Coelho et al., 2017). DTPA extractable Chromium (Cr) content in the treated initial was 4.77 mg/kg whereas Cr content in post harvested soil of T. erecta was recorded up to 0.76 mg/kg. The experimental findings have revealed that after one season of cultivation, the plant had 84.1% remedial potential (Biswal et al., 2022).

3.2 Cadmium (Cd) extraction:

As per the study of Biswal et al., 2022, T. erecta is hyperaccumulator for cadmium (Cd) with the value of 12.1 of translocation factor (TF). TF >1 represents that the plant can withstand the metal and also can use the metal in a beneficial way. Therefore, it is the skill of a hyperaccumulator. DTPA extractable Cadmium (Cd) content in the initial soil was 16.4 mg/kg whereas Cd content in post harvested soil of T. erecta was recorded up to 14.4 mg/kg. The experimental findings have revealed that after one season of cultivation, the plant had 12.2% remedial potential. T. erecta has demonstrated as high Cd tolerance. The plant can exhibit a lot of biological mechanism to alleviate the stress. Cadmium tolerance by the plant was reported above phytotoxic levels with accumulation of 3675 mg Cd / kg DW in its above ground parts. As a result, the plant possessed a high extraction coefficient together with a high rate of shoot to root translocation ability. With those characteristics, its potential as a hyperaccumulator has been exposed. Till 150 mg /kg exogenous Cd, the metal content was reported in shoot 3567 ± 32.5 mg/ kg DW, in foliar parts 3783 ± 9.12 mg/ kg DW where as in the root 3206.5 ± 25.2 mg /kg DW of the plant (Goswami & Das, 2017).

A study has reported that *T. erecta* may be useful efficiently for the phytoremediation of Cd polluted soil. As per the investigation Cd content in different plant parts was gradually increased with the increasing concentration of Cd (@ 6, 12, 18, 24 and 30 mg/kg) in soil. Accumulation of Cd in leaf stem, inflorescence and root of Tagetes erecta L. grown in 30 mg/kg Cd amended soil was reported as 100.83±12.05 mg/kg, 41.02±2.83 mg/kg, 38.68±3.38 mg/kg and 9.52±0.93 mg/kg respectively (K. Shah et al., 2017a). Cadmium concentration in the dry matter of the plant grown in the Cd amended soil (@0.2 mg/kg) was reported 332.62 mg/kg with the TF 1.8- 2.4 (Sinhal et al., 2010). Range of Cd in the shoot of *T. erecta* planted in the soil which was irrigated with 150 ml solution of 2mg/L Cd twice daily was reported 17.9 to 50.3 mg/kg whereas in the flower 12.1 to 71.5 mg/kg with the TF 0.5 - 2.3 and 0.5 - 1.6 respectively (Thongchai et al., 2019). Cd content in aerial parts of the plant grown in Cd added Laterite soil (@10 -160 mg/kg) was recorded 100 to 318 mg/kg. The result has shown that Cd content in different plant parts was gradually increased with the increasing Cd concentration up to certain level (Madanan et al., 2021).

3.3 Lead (Pb) extraction:

Another study has reported that *T. erecta* would be fruitfully used to remediate the Pb contaminated soil. As per the investigation Pb content in different plant parts was gradually increased with the increasing Pb concentration (@ 500, 1000, 1500, 2000, and 2500 mg/kg) in soil. Lead (Pb) content in the stem, leaf, root, and flower of the plant grown in 2500 mg/kg lead amended soil was reported as 1954.35±90.46 mg/kg, 749.55±70.06 mg/kg , 618.28±53.82 mg/kg and 255.08±23.40 mg/kg respectively (K. Shah et al., 2017b). Lead content in the dry matter of the plant grown in the Pb amended soil (@3.7 mg/kg) was reported 399.16 mg/kg with the TF 1.9- 2.7 (Sinhal et al., 2010). Lead in the various aerial parts of the plant grown in the Pb amended laterite soil (@10 - 160 mg/kg) was recorded as 2.11 to 10.6 mg/kg. The result has shown that Pb content in different plant parts was gradually increased with the increasing Pb concentration up to certain level (Madanan et al., 2021).

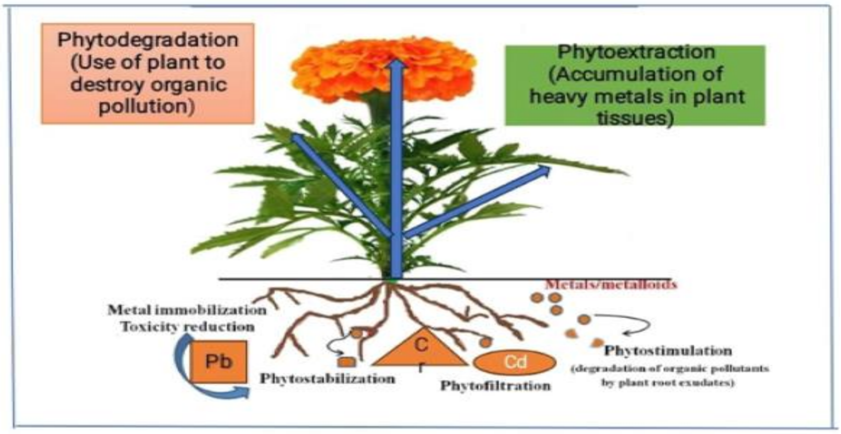

Figure 2: Diagram of different types of phytoremediation

4. Impact of the toxic heavy metals on *Tagetes erecta* Linn.:

Heavy metals are non-degradable, long persistent, abiotic element. Heavy metals, having of atomic high molecular weight have been distributed widely in the environment due to their multiple applications in agricultural, medical and technological industries. Each metal has its unique physical and chemical properties which are responsible for its specific toxicological mode of actions to the living cell. Mostly of the metals such as Pb, Cr, As, Cd, Ni etc. do not confer any significant function biochemically and physiologically in plant body. Those are treated as non-essential metals and responsible for adverse effects including cellular damage. Different mechanisms to tolerate heavy metal stress may be evolved as inclusion, accumulation and exclusion of the heavy metals depending upon the plant species. Heavy metals have effect on different biochemical response in plants such as chlorophyll content, enzyme inhibition, sugar content etc. (Aldoobie et al., 2013).
The physicochemical properties of soil such as pH, capacity, cation exchange, soil texture, organic matter, etc can influence the metal solubility and bioavailability. It has been reported that many plants can grow in heavy metal stress because - a) they can accumulate the metals in different aerial tissues by producing metal binding compound and b) they can condense the metals in their different aerial parts. Some effects on morphological, physiological and metabolic traits such as root elongation, plant hight, number of leaf and leaf area, wet and dry biomass, rate of photosynthesis, enzymatic activity etc. have been reported. Hyper activity of antioxidative enzymes of reactive oxygen species (ROS) have been revealed also to protect the metal stress (F. U. R. Shah et al., 2010).

4.1 Impact of Chromium (Cr):

Tagetes erecta L. was planted in tannery sludge irrigated with four different doses of Cr set as 102.50×10^3 mg kg^{-1} (T3), 51.25×10^3 mg kg^{-1} (T2), 20.50×10^3 mg kg^{-1} (T1), and Control (CK). *Tagetes erecta* L. biomass did not significantly change across the four treatments, according to the experience with phytoextraction of Cr (Miao & Yan, 2013). A previous experiment showed that few anatomical structures were modified of the treated plant than the normal at different concentration of Cr. At the range of 0.04 to 0.12 mmol Cr per litre, the thickness of spongy parenchyma was increased whereas reduced thickness of Palisade parenchyma was observed at 0.16 mmol per litre. This work has demonstrated that when Cr (III) concentration is increased during nutritional solution treatment, biomass decreases (Coelho et al., 2017).

4.2. Impact of Cadmium (Cd):

Based on empirical data utilising Cd-added soil (@ 6, 12, 18, 24 and 30 mg/kg), a negligible adverse impact was observed on plant growth indices, such as root and shoot length, plant height, total leaf area and dry and fresh weight per plant. A certain degree of influence was seen in several biochemical measures, including the amount of total protein, total sugar, free amino acids, starch and chlorophyll (K. Shah et al., 2017a). It has been found that plants can reduce Cd stress by boosting antioxidative defence pathways including a large number of enzymes that aid in the dissipation of reactive oxygen species (ROS). SEM revealed that Cd stress caused some modifications to the structural makeup of the root and leaf (Goswami & Das, 2017).

4.3. Impact of Lead (Pb):

The plant tolerated up to 200 mmol of Pb concentration. Significant increases were seen in antioxidant activity, dry weight, proline content, and root length. Plantlets' chlorophyll content, moist biomass, and shoot length showed negative effects following a 21-day exposure to metal (Pb) in hydroponic growing conditions (Bardiya-Bhurat et al., 2017). According to a prior study, *Tagetes erecta* L. saw relatively little detrimental impact on its growth parameters as a result of Pb buildup. Chlorophyll content, starch content, total sugar, total protein, free amino acid content and other biochemical parameters were progressively raised to a predetermined level (K. Shah et al., 2017b).

5.Conclusion:

Locally available Marigold (Tagetes erecta) plant can be used for phytoremediation as an affordable environment-friendly step for the reclamation of metal contaminated soil. In this review it has been found out that the plant can develop a lot of defence mechanism against toxic stress of Cr, Cd and Pb though some adverse impacts have been reported on it. The translocation factor values >1 has been reflected in my sphere of study. So, the plant would be useful for the remediation of polluted sites including cultivated land which are degraded due to contamination with chromium, cadmium and lead.

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