FINAL REPORT OF THE WORK DONE ON THE MAJOR RESEARCH PROJECT

[From 01-04-2013 to 31-03-2017]
F.No. 42-989/2013 (SR) Dated: 14-03-2013

Phytoremediation of hexavalent chromium polluted soil using some ornamental plants

Submitted to

ज्ञान - विज्ञानं विमुक्तये

UNIVERSITY GRANTS COMMISSION
BHADURSHAH ZAFAR MARG
NEW DELHI- 110 002

Submitted by

Dr. P.S. SHARAVANAN, M.Sc., M.Phil., Ph.D.
Assistant Professor
Principal Investigator
UGC-Major Research Project

DEPARTMENT OF BOTANY

[DST-FIST & UGC-SAP SPONSORED DEPARTMENT]

ANNAMALAI UNIVERSITY

ANNAMALAI NAGAR-608 002

TAMIL NADU- INDIA

2017

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PERFORMA FOR FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. TITLE OF THE PROJECT : Phytoremediation of Hexavalent Chromium Polluted Soil Using Some Ornamental Plants.

2. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR:

Dr. P.S.SHARAVANAN
Assistant Professor
Department of Botany
Annamalai University,
Annamalainagar-608 002.
Tamilnadu, India.
Mobile: +**91- 9443939852**
E-mail: **drpssharavanan@yahoo.co.in**

3. NAME AND ADDRESS OF THE INSTITUTION: Department of Botany
Annamalai University,
Annamalai Nagar – 608002

4. UGC APPROVAL LETTER NO. AND DATE: F.No:42-989/2013(SR) Dated: 14-03 2013

UGC EXTENSION LETTER NO. AND DATE: F.No:42-989/2013(SR) Dated 22-06-2016

5. DATE OF IMPLEMENTATION: 14.03.2013

6. TENURE OF THE PROJECT: 01.04.2013 to 31.03.2017

7. TOTAL GRANT ALLOTTED : Rs. 11,59,800/-

8. TOTAL GRANT RECEIVED : Rs.10,65,500/-

1st Instalment : **Rs. 6,88,300.00/-**

2nd Instalment : **Rs. 3,77,200.00/-**

9. FINAL EXPENDITURE : Rs. 10,59,848/-

10.TITLE OF THE PROJECT : Phytoremediation of Hexavalent Chromium Polluted Soil Using Some Ornamental Plants.

11. OBJECTIVES OF THE PROJECTS

The aim of the present study is to rehabilitate the hexavalent chromium polluted soil by using ornamental plants under phytoremediation processes for reducing the concentration of metal pollution in the soil to regulatory levels within a reasonable time frame of short duration. The objectives of the projects are as follows.

OBJECTIVES:

- To collect the some fast growing ornamental plants seeds.
- To grow the selected ornamental plants at different seasons in Ranipet area, Vellore district, Tamil Nadu and India.
- To screen and identify the most chromium (VI) accumulate ornamental plant in Ranipet area .(Hyper accumulator)
- To analyze the different concentration (Control (without VAM), 5gm,10gm,15gm,20gm and 25gm/kg of Cr^{6+} soil) of Arbuscular mycorrhizal (VAM) role and relation to morphometric variation of ornamental plants on hexavalent chromium polluted soil of Ranipet area, Vellore district.
- To investigate the physicochemical parameters of chromium (VI) polluted soil with different concentration (Control, 5gm,10gm,15gm,20gm and 25gm/kg of Cr^{6+} soil) of recommended amount of VAM treatments.
- To find out different treatment of Arbuscular mycorrhizal and effects of hexavalent chromium on germination, growth, morphological and yield parameters of hyper accumulator ornamental plant.
- To examine the effects of hexavalent chromium on biochemical constituents, enzymatic activities and mineral contents of hyper accumulator ornamental plant.
- To apply the collected data using statistical analysis and interpretation of experimental results.

12. WHETHER OBJECTIVES WERE ACHIEVED (GIVE DETAILS)

The major objective of the project is to get to know the influence of *Arbuscular mycorrhizal* (VAM) role and relation to morphometric variation of *Tagetes erecta* L. on hexavalent chromium polluted soil. The project also help to know the level rehabilitate the hexavalent chromium polluted soil within a reasonable time in experimental plot study. Also,

analyzed the different concentration (Control (without VAM), 5gm,10gm,15gm,20gm and 25gm/kg of Cr^{6+} soil) of *Arbuscular mycorrhizal* (VAM) role and relation to morphometric variation, physicochemical parameters, biochemical constituents and yield parameters of *Tagetes erecta* L.

13. ACHIEVMENTS FROM THE PROJECT

TARGETS PROPOSED AND ACHIEVED

Period of Study	Targets Proposed	Targets Achieved
6 Months	❖ Collections of relevant literature ❖ Collection of ornamental seeds and VAM (Mycorrhiza) from TNAU, Coimbatore. ❖ Preparation of Field from Ranipet area, Vellore district.	❖ Relevant literature was collected ❖ Four ornamental plant species seeds and VAM were collected from TNAU, Coimbatore. ❖ Field were selected and prepared from Ranipet area, Vellore district, Tamil Nadu and India.
12 Months	❖ To grow the selected ornamental plants from Ranipet area, Vellore district. ❖ VAM treatments apply at different concentrations on plants grow under Cr(VI) contaminated soil.	❖ Ornamental Plants were grown in Two seasons from summer and rainy season. ❖ The VAM treatments were applied at different concentrations such as Control (Without VAM, 5,10,15,20 and 25 gmVAM/ Kg of Cr^{6+} polluted soil.
18 Months	❖ To uproot the ornamental plants from Cr(VI) contaminated soil. ❖ To analyse the morphological parameters.	❖ The four different ornamental plants were grown in Cr^{6+} contaminated soil. ❖ Four ornamental plants were uprooted from Cr^{6+} contaminated soil. ❖ The morphometric analysis were completed on 30^{th} ,60^{th} and 90^{th} Days.
24 Months	❖ To identify the selected ornamental plants from BSI (Coimbatore). ❖ To screen the hyper accumulator ornamental	❖ Four ornamental plants were grown in Ranipet area, Vellore district. ❖ The plants were certified and identified from BSI,

	plants from Cr^{6+} polluted area of ranipet area.	Coimbatore. Identified plants made into herbarium. ❖ The ornamental plants were screened from Cr^{6+} contaminated soil, Ranipet area, Vellore district. ❖ The hyper-accumulated ornamental plant (*Tagetes erecta* L.) was screened among other three plants grown under Cr^{6+} polluted soil from Ranipet area.
30 Months	❖ To analyse the biochemical contents of *Tagetes erecta* L. ❖ To analyse the mineral contents of *Tagetes erecta* L.	❖ The biochemical parameters of *Tagetes erecta* L. root, stem and leaves were analysed from 30^{th} ,60^{th} and 90^{th} Days. ❖ The micro and macro nutrients of *Tagetes erecta* L. root, stem and leaves were analysed from 30^{th} ,60^{th} and 90^{th} Days.
36 Months	❖ To analyse the physico-chemical parameters of before and after treatment of VAM on Cr^{6+} contaminated soil. ❖ To analyse the uptake and metal accumulation Cr^{6+} on *Tagetes erecta* L. ❖ To find out the yield parameters of *Tagetes erecta* L. grow in Cr^{6+} polluted soil. ❖ To analyse the statistical methods of experimental data and interpretation of experimental results.	❖ The physico-chemical parameters were analysed from before and after VAM treated Cr^{6+} polluted soil. ❖ The Cr^{6+} metal uptake and accumulation of *Tagetes erecta* L plant samples were analysed ❖ The yield parameter of *Tagetes erecta* was completed after 90^{th} days on Cr^{6+} contaminated area of Ranipet area, Vellore district, Tamil Nadu and India. ❖ The morphological, biochemical, mineral contents and Yield data were statistically analysed and experimental results were interpreted.

The results of the present project proved that phyto-technology of hexavalent chromium polluted soil with influence of *Arbuscular mycorrhizal* (VAM) role and relation to phytoremediation processes of *Tagetes erecta* controlled the Cr^{6+} toxicity in soil and VAM improved the plant growth under Cr^{6+} stress conditions. These plans play an integral role in the comprehensive polluted soil waste management planning process for heavy metal contaminated soil and minimize the environmental impact.

14. Summary of the findings

In the present study of phytoremediation was carried out with treatment of VAM on (Vesicular arbuscular mycorrhiza-*Glomus intraradices*) hexavalent chromium contaminated soil by using *Tagetes erecta* plant and VAM was used for the functional role of soil amendment to reclamation of heavy metal contaminated soil. The processes of phytoremediation was carried out in experimental plot study to decline the percentage of higher concentration of hexavalent chromium in the soil and different concentration of VAM was used to for the following parameters on germination, growth, biochemical constituents, yield, enzymatic activities and minerals constituent of *Tagetes erecta* L. The uptake and accumulation of hexavalent chromium in the soil and in the plant was also investigated.

Seed collection

The seed crops of *Cosmos bipinnatus, Tagetes erecta,* belonging to the family Asteraceae and *Celosia cristata, Gomphrena globosa,* belonging to the family Amaranthaceae was selected for the reclamation of Cr^{6+} affected soil.

Preparation of VAM treatment (Arbuscular mycorrhiza)

The different concentrations of Control to (Without VAM), 5,10,15,20 and 25 gm VAM (Arbuscular mycorrhiza)/ kg of Cr^{6+} affected soil were prepared and soil amendment of VAM was used to treat seeds sown in the Hexavalent chromium polluted soil.

Varietal screening

In the sampling processes of varietal screening test, there are four ornamental plant species such as *Cosmos bipinnatus, Tagetes erecta, Celosia cristata,* and *Gomphrena globosa,* were selected and grown 30 to 90 DAS interval for their treatment of Control (without VAM), to 5,10,15,20 and 25 gm VAM/kg of soil. Among the concentration of

5,10,15 and 20 gm VAM/ kg of Cr^{6+} polluted soil significantly increased the germination percentage, vigour index, tolerance index, root and shoot lengths, number of leaves, total leaf area, total fresh weight, dry weight, pigment content of chlorophyll a, chlorophyll b, total chlorophyll, and growth of *Tagetes erecta* grown rapidly compare to other three ornamental plant species of *Cosmos bipinnatus, Celosia cristata,* and *Gomphrena globosa,* at hexavalent chromium polluted soil. The higher concentration of 25 gm VAM/ kg of soil slightly decreased the total bio-metabolism of above mentioned parameters for all the selected plant species.

The without treatment of VAM considered as control, it gives very low growth, yield, and biochemical constituents compare to higher concentration of 25 gm VAM/ kg of Hexavalent chromium polluted soil. From the varietal screening test, the best (tolerant) variety (*Tagetes erecta*) was selected and grown up to 90 DAS (yield). The morphometric parameters, biochemical constituents, mineral contents and enzymatic activities (catalase, peroxidase and polyphenoloxidase) were studied at an interval of 30 to 90 DAS. Followed by germination studies conducted to find out the variation in morphological, biochemical and mineral contents of *Tagetes erecta* with different concentration of VAM treatment under hexavalent chromium polluted soil.

The morphological parameters such as shoot length, root length, total number of leaves, total leaf area, fresh weight and dry weight were observed and recorded in the 30^{th}, 60^{th} and 90^{th} DAS (Day after seed sowing). The yield component such as number of flowers per plant, head or capitulam per plant, number of seeds per plant and seeds weight per plant was measured at the time of harvesting stage of 90^{th} DAS.

The biochemical changes of chlorophyll a, chlorophyll b, total chlorophyll, carotenoid, reducing sugar, non-reducing sugar, total sugar content, protein and amino acid contents of different parts of *Tagetes erecta* plant increased in proportion to the various concentration of VAM treatment under hexavalent chromium stress on infected soil. Proline content of *Tagetes erecta* decreased with increasing concentration of VAM treatment when compared to control and 25 gm VAM/kg of contaminated soil.

The enzymatic activities of catalase, Peroxidase and polyphenol oxidase were increased in control plants of (without Arbuscular mycorrhiza treatment) *Tagetes erecta* whereas reduction in the increasing concentration of VAM treatment respectively. The micro and macro nutrient contents of nitrogen, phosphorus, potassium, copper,

manganese, iron and zinc content of *Tagetes erecta* increased with an increasing concentration of VAM treatment when compare to control and 25 gm VAM treatment/kg of hexavalent chromium polluted soil.

The physico-chemical analysis of hexavalent chromium polluted soil was more toxic and alkalinity nature in control soil (without VAM). Whereas VAM treated (5,10,15,20 and 25 gm VAM/kg of Cr^{6+}) soil decreased the alkalinity up to neutral level and increased the optimum level of soil nutrients such as nitrogen, phosphorus and potassium in the contaminated soil and reduction of soil nutrients in the controlled (Without VAM treatment) type of Cr^{6+} soil samples.

15.Contribution to the society

The present study demonstrate the potential of *Tagetes erecta* plant under phytoremediation of hexavalent chromium contaminated soil with treatment of Arbuscular mycorrhiza concluded that, exposure to Cr^{6+} (Hexavalent chromium) metal with Arbuscular mycorrhiza resulted in enhanced Cr^{6+} accumulation in the tissues of *Tagetes erecta* plants, with comparatively high biomass production with no toxicity symptoms indicates that this plants can tolerate high metal concentrations and without treatment of VAM in control plant was seriously influenced and reduction of germination, growth, biochemical, mineral contents and yield of *Tagetes erecta* with effect of hexavalent chromium in the contaminated soil. Whereas the various concentration of (5,10,15,20 and 25 gm VAM/kg of Cr^{6+} soil) VAM treatment rise the plant development and yield, restrain the biochemical activities and rehabilitation for impurity of hexavant chromium polluted soil. We can recommended that *Tagetes erecta* plant with treatment of VAM (Arbuscular mycorrhiza) have high ability to phyto-extract and phyto-stabilized the Cr^{6+} metal from soil. Hence *Tagetes erecta* plant proved their phyto-technology efficiency for phytoremediation system to control the Cr^{6+} metal from soils and rehabilitate the contaminated areas.

16. WHETHER ANY Ph.D. ENROLLED/PRODUCED OUT OF THE PROJECT

Yes. Ph. D Enrolled and thesis submitted
Roll No : 1319030011
Candidate Name : Mr. K.KARTHIK, project fellow on 17.07.2013

17. NO. OF PUBLICATIONS OUT OF THE PROJECT

PUBLICATIONS

1. **Karthik .K**, **P.S.Sharavanan** and V.Arivalagan, 2014. Effects of Hexavalent Chromium Exposures and Control Measures through Phytoremediation. *International Journal of Reciprocal Symmetry and Theoretical Physics*, **Vol-1(2)**:111-115. **DOI prefix: 10.15590/ijrstp.**

2. **Karthik .K** and **P.S.Sharavanan**, 2014. Importance of overhead production of hexavalent chromium compounds and control measures of ecosystem imbalance by using phytoremediation. *International Journal of Research in Engineering and Bioscience*. **Vol-2(6)**:218- 222. **ISSN: 2321-743X**

3. **Karthik .K** and **P.S.Sharavanan**, 2016. Effect of hexavalent chromium on yield and biochemical components of *Tagetes erecta* (L). under Arbuscular mycorrhiza treatment. *Asian Journal of Environmental Science*, **Vol-11(1):** 64-71. **DOI: 10.15740/HAS/AJES/11.1/64-71.**

4. **Karthik .K** and **P.S.Sharavanan**, 2016. Effect of hexavalent chromium on germination and morphological changes of *Gomphrena globosa* (L). *International Journal of Environment, Agriculture and Biotechnology*, **Vol-1(4)**:744-747. **DOI: 10.22161/ijeab/1.4.19.**

PAPER PRESENTATIONS

National Seminars

- **Genetically modified plants and Human health –Phytoremediation.** paper presented in Interdisciplinary **National Seminar on "Production and consumption of genetically modified food" Sponsored by ICSSR.** Organized by Economics Wing DDE, Annamalai University on 18th and 19th of December-2013.

- **Utilization and Impacts of Biotechnology on Biodiversity.** paper presented in **National Seminar on "Emerging Trends in Biodiversity Conservation and Sustainable Utilization"**(NSBCS) Sponsored by UGC. Organized by Department of Botany, BharathiarUniversity,Coimbatore on 29th& 30 th January, 2014.

- **National Seminar on Achievements, Challenges and Opportunities in Plant Science Research**. Sponsored by UGC-SAP-DRS. Organized by Department of Botany,Annamalai University on 18 th and 19 th – March -2016.

National Conference

- **The importance of overhead production of hexavalent chromium compounds and control measures of ecosystem imbalance by using phytoremediation** paper presented in **National conference on " Biodiversity & Climate change adaptations, Current status, Trends and Policy responses" Sponsored by SERB-DST & MoES, New Delhi.** Organized by Department of Botany, St.Andrew's College (P.G), **Gorakhpur**, on 3rd and 4th **December-2014- [Uttar Pradesh].**

International Conference

- **Industrial importance and ecosystem damage of hexavalent chromium exposures control of phytoremediation technology "** paper presented in **International conference on " Herbal Medicine and Neuroendocrinology" (InChMan-2014) Sponsored by UGC-SAP.** Organized by Department of Zoology, **Annamalai University**, on 13th **October, 2014.**

Training Program

- IQAC Sponsored Staff training and development programme on **"Industrial effluent treatment [IET-2015] " Organized by Department of Chemical Engineering, Annamalai University on 18**th March-2015.