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# PHYTOREMEDIATION OF FLUORIDE (F-) FROM WATER USING GERMINATED SEEDS

**N. Gandhi,** Research Scholar, Centre for Environment and Climate Change, School of Environmental Sciences, Jawaharlal Nehru Institute of Advanced Studies, Hyderabad, India.

**D. Sirisha,** Head, Centre for Environment and Climate Change, School of Environmental Sciences, Jawaharlal Nehru Institute of Advanced Studies, Hyderabad, India.

**Smita Asthana,** Reader, Department of Chemistry, St.Ann's College for Women, Mehdipatnam, Hyderabad, Telangana, India.

**Abstract:** *Phytoremediation is defined as the treatment of environmental pollutants using plants that alleviate the environmental problem without the need to excavate the contaminant material and dispose it elsewhere. Plants are specifically selected to remove specific pollutants such as metals, pesticides, solvents, explosives and crude oils. Phytoremediation has many advantages over other traditional pollution removal methods such as cost, decreased environmental disruption and it is more aesthetically pleasing. The present study was focused on removal of fluoride from the industrial effluent water and artificially polluted water using the seeds of Eleusine coracana (Ragi), Pennisetum glaucum (Bajra), Setaria italica (Korra), Sorghum bicolor (Jowar). Seeds were germinated using a paper and cloth germination procedure. After germination, the seed plants were placed in fluoride contaminated water. Fluoride levels were measured using spectrophotometer at regular time intervals. The experiments, removal of fluoride ions by the above-mentioned seeds, were conducted at three different conditions i.e. aerobic, anaerobic, laboratory condition, and all the conditions favour the phytoremediation process. Among these, Pennisetum glaucum (Bajra) shown good results in all three conditions. During phytoremediation process, drastic colour change was observed in industrial effluent and the percentage removal of fluoride ions was high, which indicates that the phytoremediation has followed the strategy of phytoextraction. During and after phytoremediation the effect of concentration, effect of dosage and effect of contact time were also studied. We observed that as the concentration increases, the percentage removal decreases, as the dosage increases the percentage removal also increases and as the contact time increases the* *percentage removal increases up to optimum level. All the seeds were found to be efficient in the removal of fluoride except Setaria italica (Korra), from industrial effluent and each seed was observed to have a specific function in all the three conditions.*

**Key words:** *Phytoremediation, Eleusine coracana (Ragi), Pennisetum glaucum (Bajra), setaria italica (Korra), sorghum bicolor (Jowar), Phytoextraction.*

## INTRODUCTION:

The term bioremediation is sometimes thought to be synonymous with phytoremediation, but these terms describe two completely different methods. Although both seek to exploit living organisms to alter contaminated environments, bioremediation involves the manipulation of microbial populations, and phytoremediation concerns the use of higher plants. Bioremediation refers to a process through which metal contaminants are modified as a direct result of microbial activity (NRC, 1999). The objective may be to mobilize, immobilize, or reduce the toxicity of pollutants in soil or water depending on the ultimate goals of remediation.

Recently, a promosing alternative remediation technique, called phytoremediation that can be utilized in certain situations to replace other costly methods has been explored (Shimp et al. 1993, Huang et al, 2004, Kakitani et al, 2006). Phytoremediation is the use of plants to absorb certain contaminants from soil or water through a plant's root system into the body of the plant where they are stored and ultimately disposed (Huang et al. 2004). The optimal results for successful phytoremediation would be the maximum removal of heavy metals from contaminated water with a minimal level of phytotoxicity to the plant tissues. The interaction between phytotoxicity, pollutant accumulation and plant species is highly complex and requires research. The objectives of this study were to evaluate the removal of fluoride by four species of germinated seeds.

## ADVANTAGES OF PHYTOREMEDIATION

The most important of phytoremediation Advantages are:

- Variety of organic and inorganic compounds is amenable to the phytoremediation process.
- Phytoremediation can be used either as an in situ or ex situ application (USEPA, 2000; Raskin and Ensley, 2000). In situ applications are frequently considered

because minimizes disturbance of the soil and surrounding environment and reduce the spread of contamination via air and waterborne wastes.

- It is a green technology and when properly implemented is both environmentally friendly and aesthetically pleasing to the public (Raskin and Ensley, 2000). As a green technology, it is applicable for different kinds of organic and inorganic pollutants and provides aesthetic benefits to the environment by using trees and creating green areas, which is socially and psychologically beneficial for all (Ghosh and Singh, 2005; Lewis, 2006). This green technology is suitable for large areas in which other approaches would be expensive and ineffective (Vidali, 2001; Prasad and Freitas, 2003).
- Phytoremediation does not require expensive equipment or highly-specialized personnel, and it is relatively easy to implement.
- The greatest advantage of phytoremediation is its low cost compared to conventional clean-up technologies (USEPA, 2000; Raskin and Ensley, 2000). For example, the cost of cleaning up one acre of sandy loam soil with a contamination depth of 50 cm with plants was estimated at $60,000-$100,000 compared to $400,000 for the conventional excavation and disposal method (Anonymous, 1997).
- Disposal sites are not needed.
- It is more likely to be accepted by the public as it is more aesthetically pleasing then traditional methods.
- It avoids excavation and transport of polluted media thus reducing the risk of spreading the contamination.
- It has the potential to treat sites polluted with more than one type of pollutant (Hegedus et al., 2009).
- Furthermore, the expan-sion of contaminants to air and water is reduced by preventing leaching and soil erosion that may result from wind and water activity (Pivetz, 2001; Ghosh and Singh, 2005).

## DISADVANTAGES AND LIMITATIONS OF PHYTOREMEDIATION

In contrast to its many positive aspects, phytoremediation does have a few disadvantages and limitations that are:

- It is restricted to the rooting depth of remediative plants.
- Remediation with plants is a lengthy process, thus it may take several years or longer to clean up a hazardous waste site, and the contamination may still not be fully remediated (USEPA, 2000a). Time is the most serious limitation of phytoremediation, because this approach may require several years for effective remediation (Vidali, 2001; Rajakaruna et al., 2006).
- The use of invasive, non-native species can affect biodiversity.
- The consumption of contaminated plants by wildlife is also of concern. Harvested plant biomass produced from the process of phytoextraction may be classified as a RCRA hazardous waste, therefore subject to proper handling and disposal.
- Moreover, preserving the vegetation in extensively contaminated areas is complicated (Vidali, 2001), and human health could also be threatened by entering the pollutant into the food chain through animals feeding on the contaminated plants (Pivetz, 2001).
- Unfavourable climate is another important consideration because it can limit plant growth and phyto mass production, thus decreasing process efficiency (USEPA, 2000b).

## MATERIALS & METHODS:

**Seeds selected for removal of Fluoride:**

The seeds used for removal of chromium are shown in Figure-1, i.e.

i. *Eleusine coracana* (ragi,)
ii. *Pennisetum glaucum* (bajra,)
iii. *Setaria italica* (korra,)
iv. *Sorghum bicolor* (jowar)

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Germinated seeds of *Eleusine coracana*

Germinated seeds of *Pennisetum glaucum*

Germinated seeds of *Setaria italica*

Germinated seeds of *Sorghum bicolor*

**Figure-1: Germinated seeds of selected for present investigation**

**Seed Germination:**

- Collect 200 gms of each seeds that are used for the experiment.
- Drop the seeds into a vessel of distilled water and keep them aside.
- Let them soak for about 24 hours.
- Filter the seeds, place them in a towel, knot it tightly, and keep them in a dark place.
- After 24 hours we see the seeds germinated

**Experimental Method:**

The removal of fluoride were carried out by using the germinating seeds in three different conditions to know which environment is suitable for the removal and which conditions favours the removal process . The experimental setup were categorized as follows,

**1. Laboratory condition :**

- A normal grade reagent bottles are used for laboratory condition.
- The bottles are filled with standard solution and desired concentration with selected seeds.
- They are kept at normal room temperature.

**2. Aaerobic condition :**

- Conical flasks of 250ml are used for aerobic conditions.

- The flasks are filled with standard solution and desired concentration with selected seeds.
- Air is pumped into flask at a rate of 3lit/min at pressure of 0.02mpa.
- They are kept in normal room temperature.

**3. Anaerobic condition :**

- Biological oxygen demand (BOD) bottles are used for anaerobic conditions.
- The bottles are filled with standard solution and desired concentration with selected seeds.
- They are kept at 30-33 ± $2^0$c temperature.
- There is no air supply as this is anaerobic condition.
- The bottles are covered with suitable caps, which will not allow the air to enter into it.

The initial and final concentration of fluoride was directly measured with spectrophotometer by using SPADNS dye method. To estimate the percentage removal of fluoride from aqueous solution the following equation was used

$$Removal\ of\ Fluoride = \frac{C_{intial} - C_{final}}{C_{intial}}\ X\ 100$$

## RESULTS & DISCUSSION:

**Effect of Contact time:**

To check the efficiency of *Eleusine coracana* (ragi), *Pennisetum glaucum* (bajra), *Setaria italica* (korra), *Sorghum bilocor* (jowar) seeds to remove fluoride ions from aqueous solution at regular time interval, Batch experiments were performed by taking a series of reagent bottles with constant fluoride ion concentration (4 mg/1lit) and 5 gm of germinated seeds of above mentioned separately, and samples are drawn after regular time intervals to check the % removal of fluoride from solution at aerobic condition (3lit/min at pressure of 0.02mpa), as described in materials and methods. The percentage removal of fluoride with four different germinated seeds at different time intervals (i.e. 24 hours, 48 hours, 72 hours) at aerobic condition shown in a graphical representation in Figure-2. From the figure-2, it can be concluded that all the four seeds as the capacity to remove fluoride. The percentage removal is increased with increase in contact time with all the germinated seeds used in this experiment except the sample treated with germinated seeds of *Setaria italica*. At 24, 48 and 72 hours the high percentage removal observed with *Pennisetum glaucum* (bajra), seeds at lowest percentage removal with *Setaria italica* seeds. There is no significant change in percentage removal was observed at 48 hours and 72 hours time intervals in samples treated with *Eleusine coracana* (ragi) seeds. However, significant change was observed in samples treated with *Pennisetum glaucum* (bajra) and *Sorghum bilocor* (jowar) germinated seeds.

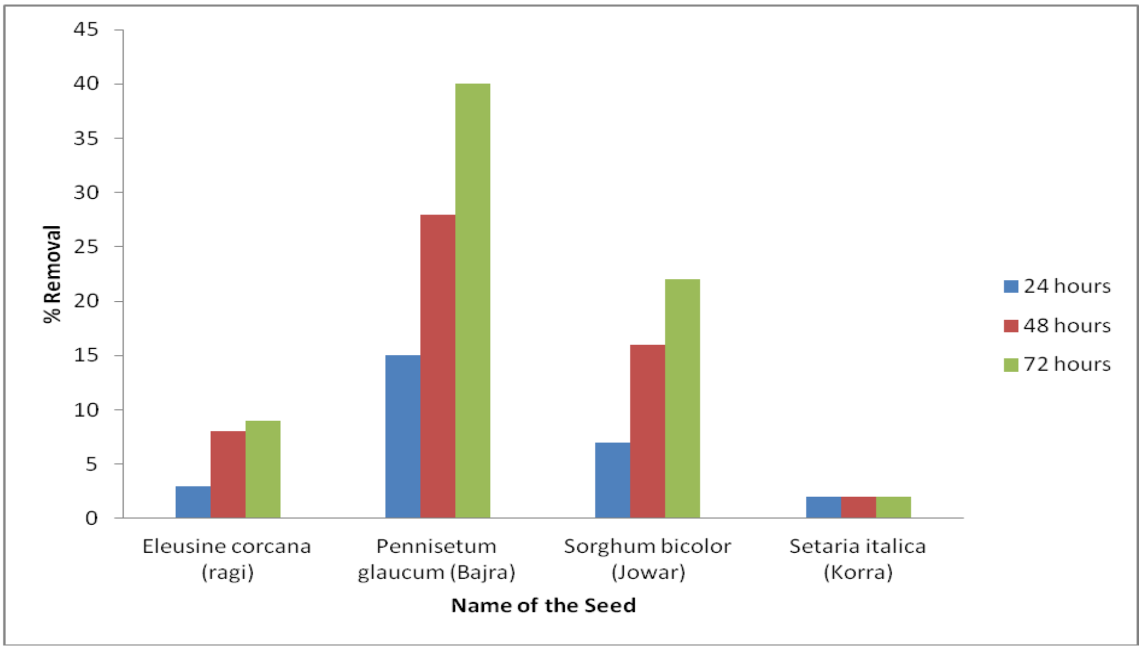


**Figure-2: Removal of fluoride (Aerobically) by different germinated seeds**

The same batch experiments were conduted in anaerobic condition where there is no supply of air and light, to check the efficiency of germinated seeds to remove fluoride ions, from aqueous solution. The percentage removal of fluoride at regular time interval (i.e. 24, 48 and 72 hours) are shown Figure-3. From the figure-3, it was observed even the anaerobic condition also favors the removal process. The percentage removal is increased with increase in contact time with all the germinated seeds used in this experiment in anaerobic condition. The percentage removals at three different time intervals with all treatment are lower than aerobic conditions and almost equal to laboratory condition (Figure-4). From the above experiments it can be concluded that anaerobic and laboratory conditions are favorable and easy way to remove fluoride from aqueous solution with all the germinated seeds used in the present study, except *Setaria italica* germinated seeds.

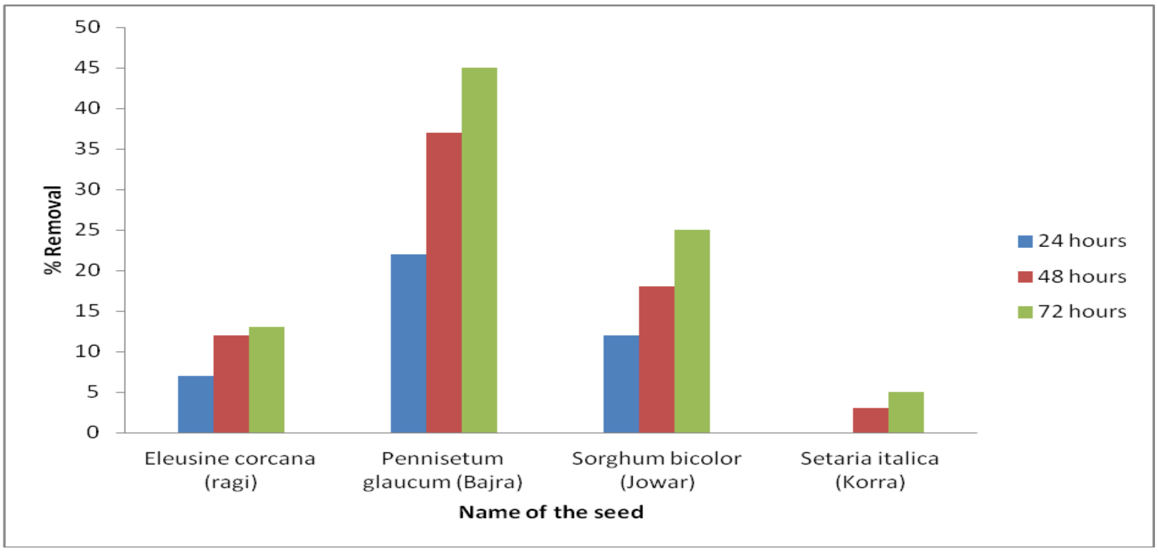


**Figure-3: Removal of fluoride (Anaerobically) by different germinated seeds**

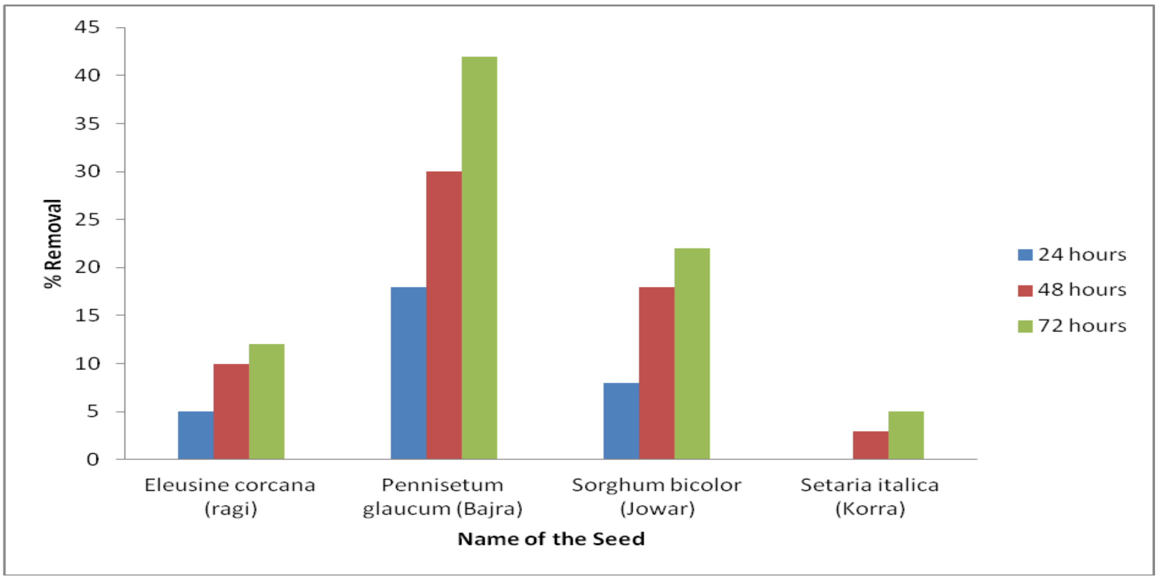


**Figure-4: Removal of Fluoride (Lab/Room condition) by different germinated seeds**

**Effect of germinated seeds dosage on fluoride removal**

To find out the effect of dosage of germinated seeds on fluoride removal the experiments were conducted by taking 4 mg/L fluoride solution with various dosages of *Eleusine coracana* (Ragi), *Pennisetum glaucum* (Bajra), *Setaria italica* (Korra), *Sorghum bicolor* (Jowar) seeds i.e. 1 gm/L to 10 gm/L. Water samples were treated for 72 hours contact time period. The results were shown in figure-5 to figure-7. From the figures it is observed that the percentage removal of fluoride is increased with increase in amount of germinated seeds at all three experimental conditions.

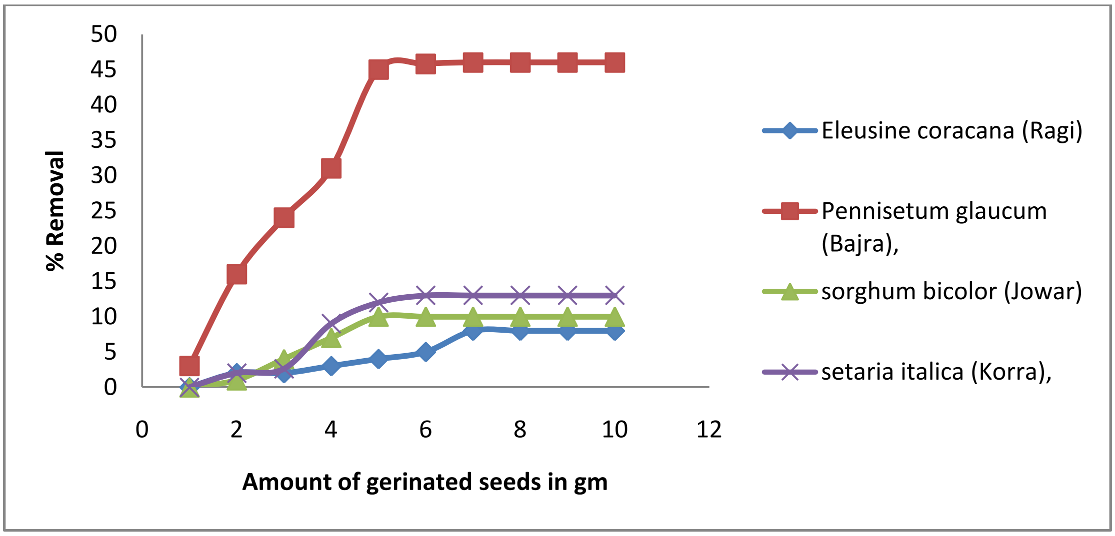


**Figure-5: Effect of germinated seeds dosage (Aerobically) on fluoride removal**

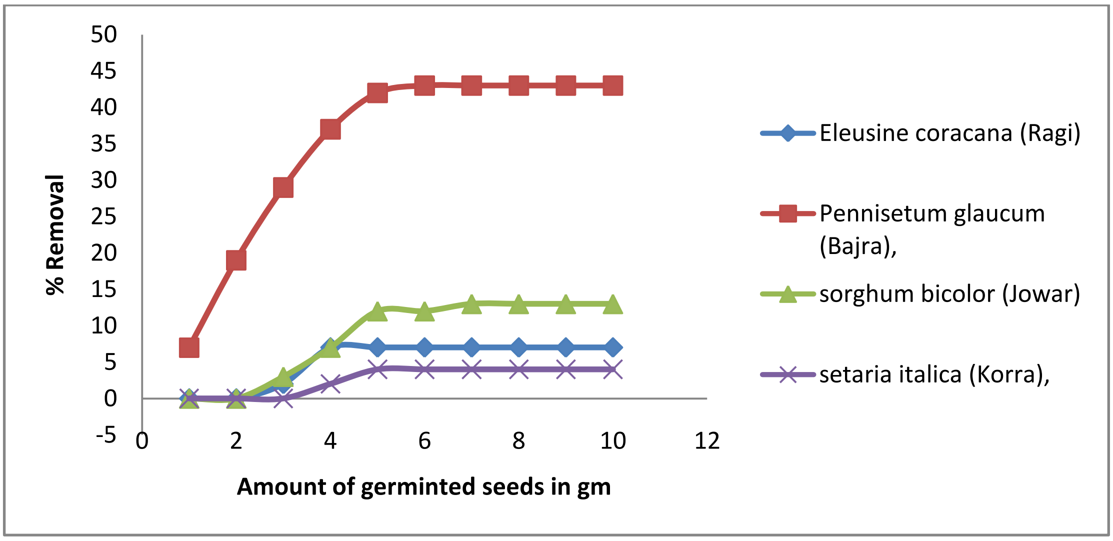


**Figure-6: Effect of germinated seeds dosage (Anaerobically) on fluoride removal**

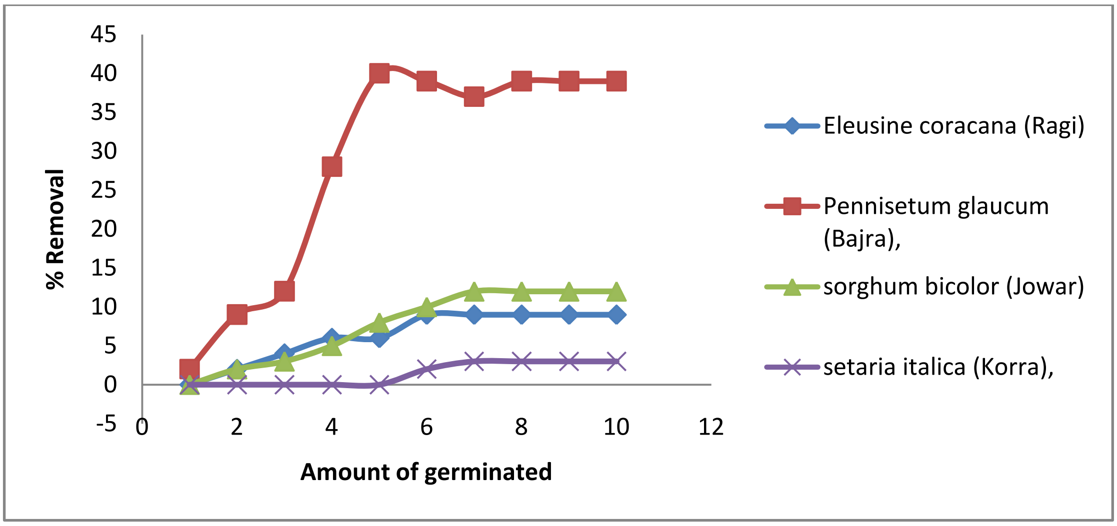


**Figure-7: Effect of germinated seeds dosage (Laboratory) on fluoride removal**

The maximum percentage removal was observed with *Pennisetum glaucum* (Bajra), at all three different experimental conditions compare to other germinated seeds used in present study. The best % removal 40, 42 and 45 at Laboratory, Anaerobic and Aerobic conditions with 5 gm/L *Pennisetum glaucum* (Bajra), seeds respectively. A very poor removal of fluoride was observed with *Setaria italica* (Korra), in all three different conditions even at higher seed dosage.

**Effect of initial fluoride concentration on phytoremediation:**

To evaluate the effect of initial fluoride concentration on phytoremediation of fluoride at constant seed dosage the batch experiments were performed by taking different concentrations of fluoride ranging from 1 mg/L to 10 mg/L at constant 5 gm of seed dosage. The samples were treated for 72 hours at three different experimental conditions and the results were shown in figure-8 to figure-10. From the figures it is observed that the percentage removal of fluoride is decreased with increase in initial fluoride concentration with all the four seeds used in present investigation.

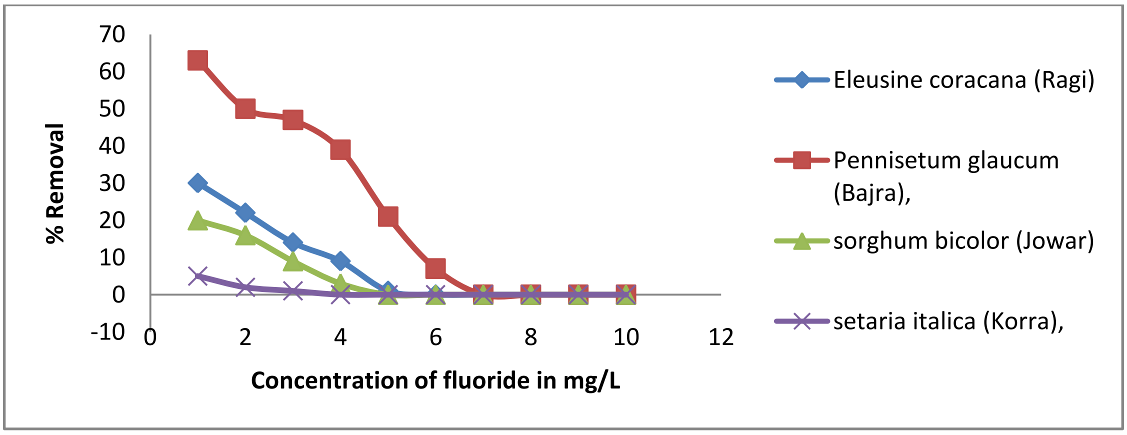


**Figure-8: Effect of initial fluoride concentration on % removal at aerobic condition**

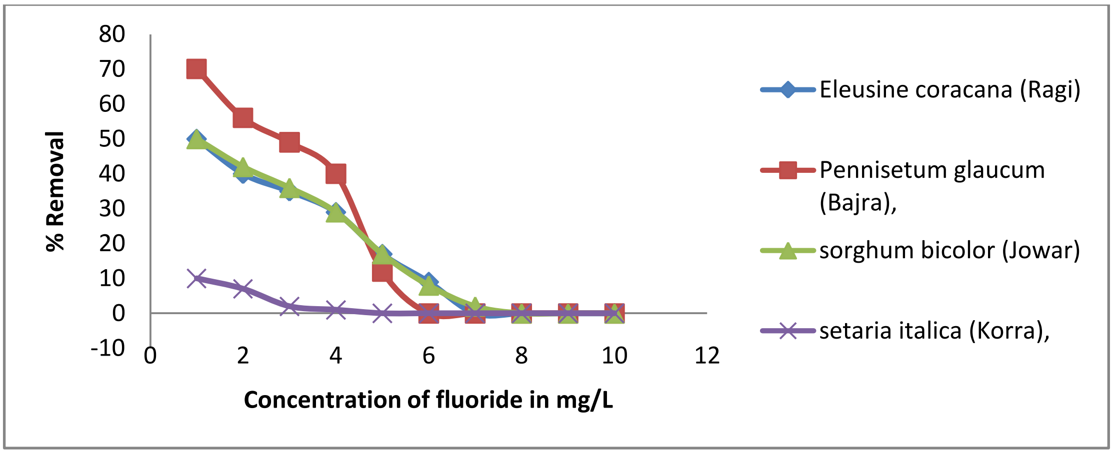


**Figure-9: Effect of initial fluoride concentration on % removal at anaerobic condition**

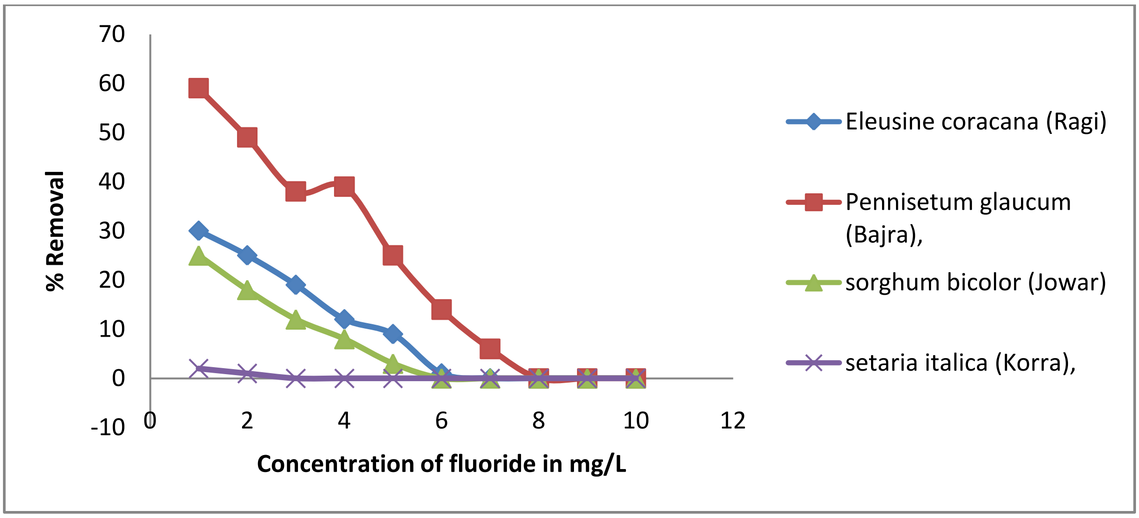


**Figure-10: Effect of initial fluoride concentration on % removal at laboratory condition**

**Application:**

The developed method was applied for the electroplating industry wastewater (which has 4.40 mg/L fluoride) was treated with 5 gm of *Pennisetum glaucum* (Bajra), and the removal efficiency was found to be promising when compared with other removal methods. Results were shown in figure-11. Therefore, it is reasonable to consider this proposed approach to be a novel approach to be applied as adequate pre-treatment in advanced water treatment.

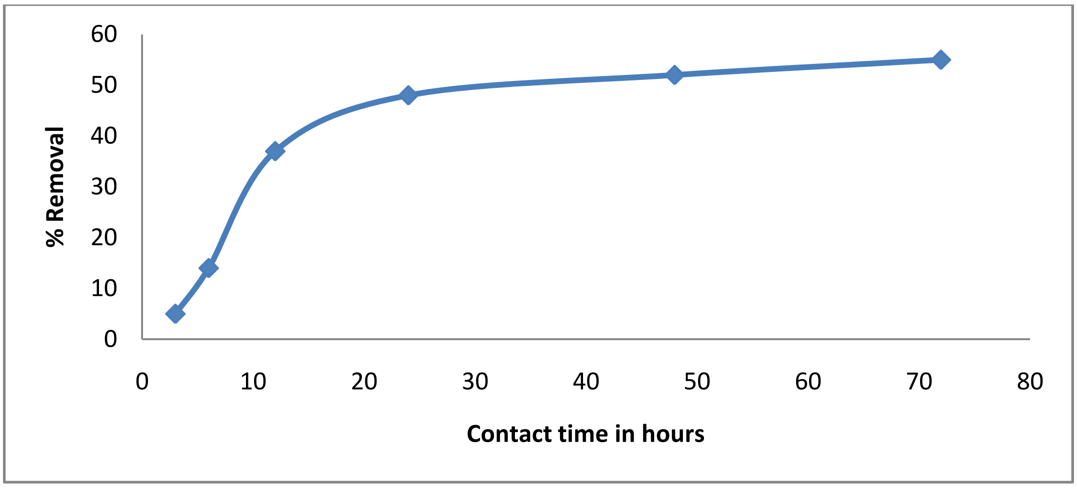


**Figure-11: Removal of fluoride from electroplating industrial wastewater using *Pennisetum glaucum* (Bajra) germinating seeds.**

## CONCLUSION:

The phytoremediation of fluoride by using germinated seeds were shown effective % removal with *Pennisetum glaucum* (Bajra) germinated seeds at all three experimental conditions. These results were concluding that fluoride can be remediate by using germinating seeds in a eco friendly method. These types of technologies will prove useful in environmental cleanup procedures. Hence, attempts on remediation of fluoride contaminated water by phytoremediation method fulfil the National policy of Eco-friendly development and create socio-economic, scientific development among the environmentalists, agriculturalists and scientists who involved in the application of this technique. The above described low cost remediation method will help the poor and rural people who suffering with hyper fluoridation.

## REFERENCES:

1. Anonymous. (1997). Recent developments for in situ treatment of metal contaminated soils. Available Online: http://clu-in.org/techfocus
2. Gandhi, N. Sirisha, D and Smita Asthana. (2015). Germination of seeds in soil samples of heavy traffic zones of Hyderabad telangana, India. *Environmental Science-An Indian Journal. Vol. 10(6), 2.4-214.*
3. Gandhi, N. Sirisha, D and Chandra Sekhar, K.B. (2014). Phytoremediation of Chromium (VI) in water using Germinated Seeds. Published in proceeding of National Conference on Water, Environment and Society (NCWES- 2014), Organized by Center for Water Resources, Institute of Science and Technology (IST), Jawaharlal Nehru Technological University Hyderabad, (JNTUH) Kukatpally, during 30 june – 1st July 2014.
4. Gandhi, N. Sirisha, D and Smita Asthana. (2015). Phytoremediation of Lead (Pb) Contaminated Soil by Using Sorghum bicolor *Research & Reviews in Bio Sciences.* Vol.10 (9), 333 – 342.
5. Gandhi, N., Sirisha, D and Chandra Sekhar, K.B. (2013). Phytoremediation of Chromium and Fluoride in Industrial wastewater by using aquatic plant *Ipomea aquatica*. *South pacific journal of Pharma and Bio Sciences,* Vol. 1(1), 001-004.
6. Ghosh M, Singh S.P. (2005). A review on phytoremediation of heavy metals and utilization of it's by products. *Appl. Ecol. Environ.* Res. 3(1): 1-18.
7. Hegedusova A, Jakabova S, Simon L. (2009). Induced phytoextraction of lead from contaminated soil. *Acta Universitatis Sapientiae Agric. Environ*. 1: 116 – 122.
8. Huang, W. H., Poynton, C.Y., Kochian, L. V. and Elless, M. P. (2004). Phytofiltration of arseic from drinking water using hyper-accumulating ferns*. Environmental Science and Technology* 38: 3412-3417.

9. Huang, X.-D., El-Alawi, Y., Penrose, D.M., Glick, B.R., Greenberg, B.M. (2004). A multi-process phytoremediation system for removal of polycyclic aromatic hydrocarbons from contaminated soil. *Environ. Poll.* doi: 10.1016/j.envpol.2003.09.031,
10. Kakitani, T., T. Hata, T. Kajimota, and Y. Imamura.( 2006). Designing a purification process for chromium, copper, and arsenic contaminated wood. *Waste Management* 26: 453- 458.
11. Lewis, A.C. (2006). Assessment and comparison of two phytoremediation systems treating slow-moving groundwater plumes of TCE. Master thesis. Ohio University p.158.
12. Nuclear Regulatory Legislation 105$^{th}$ Congress , Dec-1999.
13. Pivetz, B.E. (2001). Ground Water Issue: Phytoremediation of contaminated soil and ground water at hazardous waste sites pp.1-36.
14. Prasad, M.N.V and Freitas H. (2003). Metal hyperaccumulation in plants-Biodiversity prospecting for phytoremediation technology. *Electron. J. Biotechnol.* 6(3): 285-321.
15. Rajakaruna, N., Tompkins, K.M and Pavicevic, P.G. (2006). Phytoremediation: An affordable green technology for the clean-up of metal-contaminated sites in Sri Lanka. *Ceylon J. Sci. (Biological Sciences).* 35: 25-39.
16. Raskin, I and Ensley B.D. (2000). Phytoremediation of toxic metals: Using plants to clean up the environment. John Wiley & Sons, Inc. Publishing, New York. P. 304.
17. Shimp, J.F., Tracy, J.C., Davis, L.C., Lee, E., Huang, W., Erickson, L.E and J.L. Schnoor, (1993). Beneficial effects of plants in the remediation of soil and groundwater contaminated with organic materials. *Crit. Rev. Environ. Sci. Technol.* 23:41-77.
18. USEPA (United States Environmental Protection Agency), (2000a). Electrokinetic and Phytoremediation In Situ Treatment of Metal-Contaminated Soil: State- of-the-Practice. Draft for Final Review. EPA/542/R-00/XXX. US Environmental Protection Agency,Office of Solid Waste and Emergency Response Technology Innovation Office, Washington, DC.
19. USEPA (United States Protection Agency), (2000b). Introduction to Phytoremediation. EPA 600/R-99/107. U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH.
20. Vidali, M. (2001). Bioremediation. An overview. *Pure Appl. Chem.* 73(7): 1163-1172.