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# Comparative Assessment Of Hyper-Accumulator And Phyto-Remedial Capabilities Of *Brassica Juncea* And *Zea Mays* In Lead Contaminated Soil

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**Abstract**

*Phytoremediation is the process of removing soil contaminants by suitable plants. It is a very cheap and economical way to decontaminate soil and water by simple process of absorption. The present work has been designed to choose a suitable plant which can efficiently absorb heavy metals without being affected. The Phyto-remedial property of mustard and maize was compared for lead contaminated soil. Results confirmed Mustard to be more suitable for lead uptake as compared with Maize. Fresh and dry weight of plants gradually decreased with increase in concentration of lead in the soil. Duration of the observation was from August to October 2022. Concentration of lead varied from 5 mg kg$^{-1}$ to 20 mg kg-1. After treatment, the amount of lead absorbed in Mustard and Maize was estimated by the Atomic Absorption Spectrophotometry method.*

**Key words:** Lead, Phytoremediation, Indian Mustard, Maize, Atomic Adsorption Spectroscopy (AAS)

## INTRODUCTION

The presence of heavy metals at high concentration negatively affects the growth of agricultural produce (Roy et al.,2005). The increase in the use of fertilizer, pesticide, and fungicide which contain a wide variety of heavy metals that are non-biodegradable and can get accumulated by living organisms. Heavy metals are non-biodegradable, which cause a critical concern to the environment through their action as a mutagenic/ carcinogenic compound. But many of the heavy metals like mercury, lead, cadmium, silver and arsenic even in minute concentrations have a wide range of ill effects on humans and plants. These heavy metals, if accumulated even in small amounts, can do great damages. Some heavy metals show carcinogenic and mutagenic properties inside living organisms (Wu et al.,2018). Presence of higher concentrations of heavy metals in soil has a very negative effect on plants biomass and agricultural productivity (Roy et al., 2005). Many physical and chemical processes have been developed for treatment of heavy metals accumulated in soil, but most of these techniques are expensive, uneconomical, and can generate secondary contaminants. Phytoremediation basically means the use of plants and associated soil microbes to reduce the toxic effects of contaminants. Plants which can accumulate high amounts of heavy metal in their tissues and produce a good amount of biomass are being used. Since biomass production is a determining factor in selection of plants for this purpose (Khalid et al., 2018). Plants that accumulate metals in high concentrations are referred to as “hyper-accumulators” (Visoottiviseth et al. 2002).

India accounts for 275,561,163 of the 800 million children suffering from Lead poisoning. Exposure to high levels of Lead may cause anemia, weakness, and kidney and brain damage. Lead can cross the placental barrier, which means pregnant women who get exposed to lead also expose their unborn child to it. It can damage a developing baby's nervous system and it can even cause death in severe cases (WHO.org).

This study has been undertaken to assess the ability of Indian Mustard and Maize to remediate Lead from contaminated soil and its effect on overall change in biomass production.

**Methodology**

**Soil preparation**

Soil for the clay pots were prepared by mixing Natures plus potting mixed with Nature's Plus Organic fertilizer and Nature's Plus Vermicompost in 3:1:1 ratio.

**Soil Analysis**

Physical and Chemical properties of the prepared soil sample

1.Soil pH and electrical conductivity (EC) were determined in 1:1 soil to water suspensions and supernatant, respectively (Jones,2001)

2.Organic matter was measured with the ignition method (Schulte and Hopkins,1996)

3.Total contents of Pb was measured in the soil samples following the aqua regia (Sabiene et al., 2004) then the samples were measured by using atomic absorption spectroscopy (AAS).

**Sowing of seeds**

Seeds of *Brassica juncea* and *Zea mays* were soaked in water for 24 hrs separately in a bowl and they were implanted in a seed germination tray which was filled with Nature's plus coco peat and Nature plus vermicompost in the ratio 3:1. Seeds were buried 3 inches deep in the soil and were covered with plastic wrap to create a humid environment and the seedlings were watered regularly for about 2 weeks until a few sets of leaves came out. Both sets of plants germinated in about 2-3 days and were ready for transplanting.

**Lead treatment to the developing plant**

A stock solution of lead was prepared with double distilled water in different concentrations of 5 mg kg-1, 10 mg kg-1, 15 mg kg-1, 20 mg kg-1 and it was used to contaminate the soil in which *Brassica juncea* and *Zea mays* were being grown for 4 weeks.

**Plant Harvest and Analysis**

After treating the plant for 2 months with different concentrations of Lead stock solution, resultant plants were gently removed from the pots, washed thoroughly with distilled water, then dried at 100°C. Dried matter were grinded to fine powder with the help of pestle and mortar, then 1g of both Maize and Mustard was digested separately with a mixture of (1:1 V/V) aqua regia and were kept on hot plate stirrer for 2 hour at 60°C. The concentration of Lead and Cadmium were determined using atomic absorption spectroscopy (AAS).

**Result and Discussion**

**Table 1**: Physicochemical characteristics of the soil before treatment

| Properties | Unit | Value |
|---|---|---|
| 1. pH | - | 6.10±10 |
| 2. EC | $dsm^{-1}$ | 0.25±4 |
| 3. Organic Matter | % | 3.601 |
| 4. Total Pb | mg $kg^{-1}$ | 0.571 |
| 5. Texture class | - | Loamy clay |

**Table 2**: Physicochemical characteristics of the soil after treatment with lead

| Properties | Unit | Value |
|---|---|---|
| 1. pH | - | 9.05±5 |
| 2.EC | $dsm^{-1}$ | 2.5±3 |
| 3.OrganicMatter | % | 2.3 |
| 4.Total Pb | mg $kg^{-1}$ | 0.664 |
| 5.Texture class | - | Loamy clay |

**Table 3**: Result of Lead concentration in soil sample obtained from AAS

| Sample Label | Conc. (mg/ L) | %RSD | Mean Absorption |
|---|---|---|---|
| Cal Blank | | 1.024 | 0.0004 |
| Standard 1 | 1.000 | 1.56 | 0.0004 |
| Standard 2 | 2.000 | 1.45 | 0.0031 |
| Standard 3 | 3.000 | 1.56 | 0.0034 |
| Standard 4 | 4.000 | 1.59 | 0.0050 |
| Sample 1 | 0.571 | 1.61 | 0.0047 |
| Sample 2 | 0.664 | 1.67 | 0.0041 |

**Effect of Lead on the plants**

**Mustard**

*Brassica juncea* has eight developmental stages that are germination, leaf development, stem elongation, inflorescence, fruit development, ripening and senescence. *Brassica juncea* life cycle is 90 days. But it was observed only for 60 days. Following table shows the change in morphology as observed due to increase in the concentration of lead in soil.

| Time Duration | Stage | Lead Concentration | Morphological change |
|---|---|---|---|
| 1st Week | Germination | - | Seeds germinated in 2-3 days and at the end of week cotyledons emerged through the soil surface. |
| 2nd Week | Leaf Development | - | Cotyledons completely unfolded, stem size increased and leaf were rounded in shape |
| 3rd and 4th Week | Leaf Development | - | Few internodes formed, Leaves started to develop serrated margins |
| 5th Week | Stem Development | 5 mg $kg^{-1}$ | Plant showed normal growth. |
| 6th Week | Stem Development | 10 mg $kg^{-1}$ | Small plants started drying, Yellowing of leaves |

| | | | |
|---|---|---|---|
| 7th Week | Inflorescence emergence | 15 mg $kg^{-1}$ | Few plants died, Leaves near base dried in some plant |
| 8th Week | Inflorescence emergence | 20 mg $kg^{-1}$ | Most of the plants continued to show normal growth. |

**Maize**

*Zea mays* has four distinct phases in its life cycle: germination, vegetative, reproductive. Its life cycle is 120-150 days. We only observed its life cycle for 60 days. Following table shows gradual change in morphology as observed after gradual increase in the concentration of lead in the soil:

| Time Period | Phase | Lead Concentration | Morphological Changes |
|---|---|---|---|
| 1st Week | Germination | - | Corn seed germinated on the 2nd day and radicals formed. In 3-4 days plumule also developed |
| 2nd Week | Vegetative | - | Leaves development took place. Stem elongation |
| 3rd-4th Week | Vegetative | - | Leaves unfold 2-3 leaves present on every plant. |
| 5th Week | Vegetative | 5 mg $kg^{-1}$ | Stem elongation continued |
| 6th Week | Vegetative | 10 mg $kg^{-1}$ | Leaves near the bases started drying |
| 7th Week | Vegetative | 15 mg $kg^{-1}$ | Plants growth slow, small plants died |
| 8th Week | Vegetative | 20 mg $kg^{-1}$ | Some leaves started yellowing and growth was stagnant |

Although most of the plants survived at the end of the treatment but growth rate was retarded. Few leaves dried near the base also due to increase in the concentration of lead. Zea *mays* showed faster germination and growth rate than *Brassica juncea*, still Maize in comparison to Mustard was more affected.

**Table 3-** Result of AAS of *Brassica juncea* and *Zea mays*

| Sample Label | Conc. (mg/L) | %RSD | Mean Absorption |
|---|---|---|---|
| Cal Blank | —- | 1.077 | 0.0004 |
| Standard 1 | 1.000 | 1.46 | 0.0004 |
| Standard 2 | 2.000 | 1.41 | 0.0021 |
| Standard 3 | 3.000 | 1.46 | 0.0033 |
| Standard 4 | 4.000 | 1.45 | 0.0040 |
| Mustard | 0.542 | 1.47 | 0.0047 |
| Corn | 0.264 | 1.33 | 0.0041 |

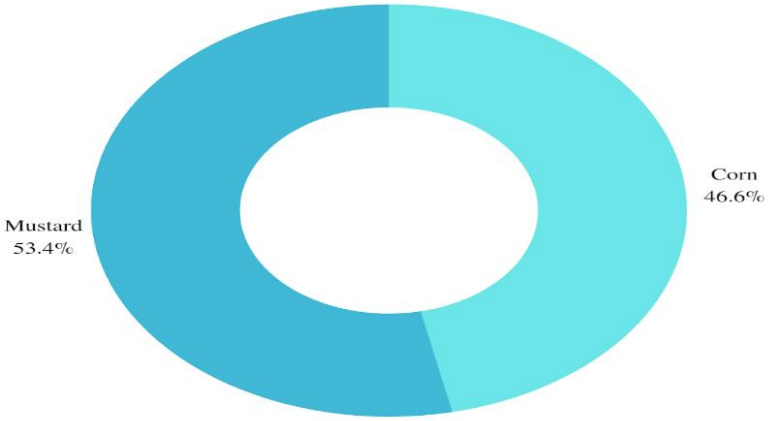


Fig.20: Pie chart showing % absorbtion of Lead

## Conclusion

This study was focussed on to identify the Phyto-remedial and hyper-accumulatory abilities of *Brassica juncea* and *Zea mays* in Lead Contaminated soil. On the basis of the results obtained, *Brassica juncea* was found to be a better Hyper-accumulator than *Zea mays.* Morphological analysis of both plants during the Lead treatment, *Brassica juncea* was less affected as compared to *Zea mays*. Additional studies are still required to find out whether accumulated lead is stored only in leaves, stems or might be in the seeds. Further investigation is to be performed for phyto-remedial properties of *Brassica juncea* and *Zea mays* for heavy metals in combination with plant growth promoters in order to maximize the removal efficiency of heavy metals.

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