

## Hong Kong Student Science Project Competition 2022

Template of Extended Abstract (Investigation Design Proposal)  
(Word Limit: 1,000 words, Pages: 2 pages only)

**Team Number: JDBC298**

**Project Title: Research on the efficiency in the purification of contaminated soil using 3 kinds of hyperaccumulators.**

**Project Type: Investigation Design Proposal**

**To our best knowledge and after thorough literature research, as at 24/12/2021 , there are / are no\* similar works. If there are, the reference links are as below:**

<https://link.springer.com/article/10.1023/B:WATE.0000044862.51031.fb>

<https://www.sciencedirect.com/science/article/pii/S0305736499909708>

<https://link.springer.com/article/10.1007/s00267-004-0171-1>

<https://semspub.epa.gov/work/03/2095110.pdf>

<https://www.osti.gov/biblio/274159>

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### I. Background

Due to rapid urbanization, the rate of consumption of electronics has been increasing exponentially in Hong Kong throughout the years, thus a tremendous amount, 70,000 tonnes, of electronic waste is generated per year<sup>1</sup>, in which an estimated of 20% is disposed in landfills or recycling industry workhouses situated in New Territories, for example Yuen Long. In addition, there has been shipping of foreign electronic wastes for industrial purposes<sup>2</sup>, these electronic wastes are inevitably hazardous, as some might contain heavy metals such as nickel, copper, zinc, cadmium, mercury etc. Since these heavy metals have a relatively high density, they cannot biodegrade easily in the soil and water and thus persist in nature, moreover most of them are particularly toxic, which can bring irreversible damage to the ecosystem located around those wastelands, ultimately, the contamination of soil might lead to severe pollution of drinking water and food<sup>3</sup>, being exposed in such environment can bring irrevocable harm to the human body.

Various methods have been developed to remove heavy metals from soil, however most of them involve the usage of chemical substances. We are uncertain whether these chemical substances would bring any adverse effects to the surrounding environment. Therefore we implemented a radical idea of using plant roots to intake the heavy metals from soil and groundwater called Phytoremediation.

What is phytoremediation? Phytoremediation is a bioremediation process that uses various types of

plants to remove, transfer, stabilize or destroy contaminants present in soil and groundwater<sup>4</sup>. According to research, phytoremediation is proven to be beneficial and effective in removing heavy metals in soil<sup>5</sup>. It is an economically feasible, solar-powered autotrophic system, as a result it can be easily installed and maintained, it is an effective green cleaning method with vast potential for research and development{6,7}.

With this in mind, we are investigating three separate species of plants, Brassica Juncea, Helianthus annuus, Hordeum vulgare; and we aim to analyze their abilities to absorb Ni, Pb and Zn accordingly.

Although we have achieved some progress in this field, our knowledge of the dynamics of plant–metal interaction is still emerging. We need a multi-interdisciplinary approach in order to commercialize this technology.

With this in mind, we as a group are trying to tide over and bridge the research gap in terms of which species of plants (I.e.Brassica Juncea, Helianthus annuus, Hordeum vulgare) are and will indefinitely be the best or one of the best species in terms of the phytoremediation of heavy metals, Let us take a deep dive into the steps of the experiment and mechanisms.

## References

<sup>1</sup><https://www.scmp.com/news/hong-kong/health-environment/article/2158836/hong-kong-government-takes-greener-approach-e#:~:text=About%2070%2C000%20tonnes%20of%20waste%20electrical%20and%20electronic,the%20rest%20is%20dumped%20locally%20in%20a%20landfill.>

<sup>2</sup><https://www.greenpeace.org/hongkong/issues/health/update/30639/%e3%80%90%e8%aa%bf%e6%9f%a5%e6%89%8b%e8%a8%98%e3%80%91%e8%90%bd%e7%8f%be%e5%a0%b4%e7%9d%87%e6%a3%95%e5%9c%b0%e4%ba%82%e8%b1%a1-8%e7%b1%b3%e9%ab%98%e5%9e%83%e5%9c%be%e5%b1%b1%e7%9a%84%e9%9c%87%e6%92%bc/>

<sup>3</sup><https://www.hk01.com/%E7%A4%BE%E6%9C%83%E6%96%B0%E8%81%9E/100093/%E9%9B%BB%E5%AD%90%E5%9E%83%E5%9C%BE%E7%A6%8D%E6%B8%AF-14E8%BE%B2%E5%A0%B4%E6%9F%93%E9%87%8D%E9%87%91%E5%B1%AC-%E5%85%83%E6%9C%97%E8%BE%B2%E5%A4%AB%E8%A2%AB%E8%BF%AB%E4%BC%91%E8%80%95>

<sup>4</sup>[https://www.researchgate.net/publication/306543535\\_Advantages\\_and\\_disadvantages\\_of\\_phytoremediation\\_A\\_concise\\_review](https://www.researchgate.net/publication/306543535_Advantages_and_disadvantages_of_phytoremediation_A_concise_review)

<sup>5</sup><https://grist.org/science/pfas-is-contaminating-farms-can-hemp-help/>

<sup>6</sup><https://www.azocleantech.com/news.aspx?newsID=31194>

## II. Objective(s)

To evaluate the standardization of phytoremediation in terms of eliminating heavy metals in contaminated soils and increase the sustainability of the protocols necessary to eliminate heavy metals

from contaminated soil.

### III. Hypothesis

These three species of plants that we've used (I.e.Brassica Juncea, Helianthus annuus, Hordeum vulgare) are better and more efficient at absorbing heavy metals from contaminated soils when compared to everyday household plants (I.e. Photos,Snake plant,Aloe vera).

By using the microwave digestion method,we are able to find the uptake of heavy metals by each specific individual plant through the medium of the aqueous solution.

### IV. Methodology

List out the materials to be used:

- 1) Fixed amount of aqueous solution of zinc sulphate, nickel sulphate and lead nitrate
- 2) 3 types of germinated seeds planted in soil, 15 seeds each (2 weeks germinated)
- 3) 12 identical cups with same volume
- 4) Light source (lamp)

Describe the **experimental protocol** including the set-up of **control experiment** (if any), **repeated experiment** (if any), and its scientific theory

-The experimental set ups:

Each type of seeds are planted in individual cups

-Plants planted in hydroponics with an equal amount and concentration of aqueous solution of zinc sulphate, nickel sulphate and lead nitrate for each plant.

-The control experiment features distilled water as the base for planting, other factors are identical

- Amount of liquid used
- Amount of seeds
- Planting environment

-Experimental steps:

- 1) Put 5 germinated seeds into 9 identical cups (3 cups for each species)
- 2) Plant the seeds with same amount of aqueous solutions (hydroponics) for each cup
- 3) Take 1mL of aqueous solution as sample to measure the heavy metal amount weekly
- 4) Repeat step 3 for 1 month
- 5) Remove the seeds, measure the change in the amount of heavy metals in aqueous solution and seeds, compare with previous results

-3 Extra experimental set-up for each type of plant to ensure the change in heavy metal is not due to the seeds' individual variables .

-Control setups:

- 1) 3 cups without seeds
- 2) Put in same amount of aqueous solution as that in the experimental set up

-To ensure any changes in the amount of heavy metals in aqueous solution is due to the presence of seeds but not by anything else

-Scientific theory:

- Since the rate of absorption of heavy metals is in the form of ions (minerals), the rate of absorption is directly related to the rate of transpiration, which is related to the transport of water and minerals in the plant via the xylem tissues. In order to facilitate the transport of water into the plants, root hair cells of plants will absorb minerals actively to lower the water potential inside the root hair cells, the minerals are accumulated and binded to the cell wall, vacuoles in plant cells, this is why plants can absorb minerals, however there are different factors affecting the uptake of minerals, there are external and internal factors, including temperature, intensity of light, pH value, particle size, root surface area and more, we propose that seeds with greater growth rate are equipped with a larger root surface area to absorb the essential nutrients, thus higher rate of uptake of heavy metals.

Indicate with the support of reasons, the **analysis** to be used in the investigation

- Microwave digestion of the evaporated remaining aqueous solution (salt) and dried seeds
- Microwave digestion is a common method for scientists/chemist to detect the presence of both inorganic or organic samples
- This helps us to identify the amount of heavy metals before and after the experiment, thus proving that the seeds absorbed the heavy metals for growth

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## V. Expected Results and Impact of research

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Describe the **expected results** with the selected approach

- Heavy metal contaminated solution that becomes free of heavy metal/ a less concentrate of heavy metals.

Discuss **limitation** and compare with existing related works (if any)

-A few pots of experimental setup are having too much margin and lack accuracy, as plants come in different varieties and sizes, more control setups should be done in order to measure more reliable data of plants absorbing heavy metals. In addition, different climates might lead to different performance in the plants.

Discuss the importance or impact of the research and how it is applicable to real life

-As seen in the background, there has been a recent issue of contaminated rivers, ponds. By identifying and testing out species that are most effective in absorbing heavy metals under similar situations as hyperaccumulators.

Using the plant as an accumulator to clean contaminated pools lets animals in these areas live on as use of chemicals to “cleanse” is avoided. These plants are also able to live by themselves in nature as accumulators, therefore, they don't need much attention to care.

## VI. Conclusion

The conclusion of the design of the project, has been evaluated and synthesized to be able to provide a base for which species of plants could be that headway to finding greener and more sustainable future as for the elimination of heavy metals from contaminated soils. The way forward with this research is that, we are able to lay a foundation to future research on the absorption of heavy metals in contaminated soils.

**Our project is developed based on our school's previous project and the enhancement is as below:**

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