



**ASSESSMENT OF AQUATIC PLANTS AND EXPRESSION PROFILING OF
POTENTIAL GENES INVOLVED IN ARSENIC PHYTOREMEDIATION**

By

AIN FARIHAH BINTI ZULKIFLI

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Science**

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fulfilment of the requirement for the degree of Master of Science

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AIN FARIHAH BINTI ZULKIFLI

March 2023

Chair : Noor Azmi bin Shaharuddin, PhD
Faculty : Biotechnology and Biomolecular Sciences

Despite comprehensive usage in industries, Arsenic (As) contamination has resulted in greater health effects for the public. Among various technologies used to clean up these contaminants, phytoremediation is chosen as an alternative and cost-effective method where plants are used as remediating agents. This project aimed to screen aquatic plants that can tolerate As and profile selected plant genes expression involved in the As uptake. Six plants including *Pontederia crassipes*, *Salvinia molesta*, *Epiprenum aureum*, *Neptunia oleracea*, *Nymphoides indica*, and *Limnocharis flava*, were exposed to varying concentrations of As for 14 days for preliminary screening. After selection, the plants were exposed to the same treatment but with a higher range of As concentrations. All biochemical reactions were measured, and total arsenic uptake in all plants' parts was determined. Total RNA of control and treated samples was isolated, converted, and reverse-transcribed and all products were analysed. The studies showed that *N. oleracea*, *S. molesta* and *P. crassipes* plants were capable of tolerating different concentrations of As. Therefore, they were selected for further studies on their biochemical reaction under As treatment. However, only *P. crassipes* had been shown to accumulate As in all of the plants' parts with the highest accumulation were measured with 2.08 mg/L, 1.57 mg/L and 0.90 mg/L at 80 ppm of As concentrations in roots, leaves and stems, respectively. The Reverse-Transcription PCR analyses showed that the targeted genes, Heat shock protein (*Hsp90*) in both control and treated samples were highly expressed on Day 1 with 11.25 % and 8.40 %, respectively, but later decreased on Day 2 by 3.03-fold and 1.32-fold, respectively. As for the Heat shock protein 70 (*Hsp70*), the gene in both control and treated samples expressed more on Day 2 with 1.73 % and 4.95 %, respectively, compared to Day 1. On Day 3 of the treatment, both genes in treated samples barely showed any expression compared to control samples, but both genes' expressions in control samples were reduced by the end of the treatment. In conclusion, phytoremediation using hyperaccumulator *P. crassipes* could uptake As at high concentrations ranging from 30 - 100 ppm and accumulate them at different plant

tissues. Therefore, the data obtained from this study can further utilize this species in remediating As in contaminated water.

Keywords: Arsenic, Phytoremediation, PCR, *Heat shock protein*

SDG: GOAL 6: Clean Water and Sanitation



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

**PENILAIAN TERHADAP TUMBUHAN AKUATIK DAN UNGKAPAN
PEMPROFILAN GEN YANG BERPOTENSI TERLIBAT DALAM
FITOREMEDIASI ARSENIK**

Oleh

AIN FARIHAH BINTI ZULKIFLI

Mac 2023

Pengerusi : Noor Azmi bin Shahrudin, PhD
Fakulti : Bioteknologi dan Sains Biomolekul

Oleh kerana penggunaannya yang meluas dalam industri, pencemaran Arsenik (As) telah menyebabkan kesan yang lebih besar terhadap kesihatan masyarakat. Di antara pelbagai teknologi yang digunakan untuk membersihkan bahan cemar ini, fitoremediasi telah dipilih sebagai kaedah alternatif dan menjimatkan kos di mana tumbuh-tumbuhan digunakan sebagai agen pemulihan. Tujuan projek ini adalah untuk memilih tumbuh-tumbuhan akuatik yang boleh bertahan dengan As, dan untuk memprofilkan pengekspresan gen-gen tumbuhan terpilih yang terlibat dalam pengambilan As. Enam tumbuhan termasuk *Pontederia crassipes*, *Salvinia molesta*, *Epiprenum aureum*, *Neptunia oleracea*, *Nymphoides indica*, dan *Limnocharis flava*, telah didedahkan kepada kepekatan As yang berlainan selama 14 hari bagi pemilihan awal. Setelah dipilih, tumbuh-tumbuhan tersebut telah dirawat dengan kaedah yang sama, tetapi dengan julat kepekatan As yang lebih tinggi. Semua tindak balas biokimia telah diukur dan jumlah keseluruhan pengambilan arsenik di semua bahagian tumbuhan telah dikenal pasti. Jumlah RNA dari sampel kawalan dan yang telah dirawat telah diasingkan, ditukar, dan ditranskripsikan secara berbalik dan semua hasil produk telah dianalisis. Hasil kajian telah menunjukkan bahawa tumbuhan *N. oleracea*, *S. molesta*, dan *P. crassipes* mampu untuk bertoleransi dengan kepekatan As yang berbeza. Oleh itu, tumbuh-tumbuhan ini telah dipilih untuk menjalani kajian yang lebih lanjut mengenai tindak balas biokimia mereka di bawah rawatan As. Walau bagaimanapun, hanya *P. crassipes* yang dilihat dapat mengumpulkan As di semua bahagian tumbuhan, iaitu sebanyak 2.08 mg/L, 1.57 mg/L dan 0.90 mg/L pada 80 ppm dari kepekatan As, dengan masing-masing di dalam akar, daun dan batang. Analisis Transkripsi-berbalik PCR telah menunjukkan bahawa gen yang disasarkan iaitu Heat shock protein 90 (*Hsp90*) di dalam kedua-dua tumbuhan kawalan dan yang dirawat lebih terepresi pada hari pertama, masing-masing dengan 11.25 % dan 8.40 %, akan tetapi kemudiannya telah berkurang pada hari ke-2, masing-masing dengan 3.03 dan 1.32 kali ganda. Manakala bagi gen Heat shock protein 70 (*Hsp70*), gen ini lebih

terekspresi di dalam kedua-dua tumbuhan kawalan dan yang dirawat pada hari ke-2 dengan masing-masing 1.73 % dan 4.95 %, jika dibandingkan dengan hari pertama rawatan. Pada hari ke-3 rawatan, kedua-dua gen di dalam tumbuhan yang dirawat telah menunjukkan hampir tiada ekspresi jika dibandingkan dengan tumbuhan kawalan, akan tetapi ekspresi bagi kedua-dua gen di dalam tumbuhan kawalan juga telah berkurang pada penghujung rawatan. Kesimpulannya, fitoremediasi menggunakan hiperakumulator *P. crassipes* mampu menyerap As pada kepekatan As yang tinggi di antara 30 – 100 ppm dan mengumpulkannya di dalam tisu yang berbeza pada tumbuhan. Oleh itu, data yang diperolehi dari kajian ini dapat digunakan untuk memanfaatkan spesies ini dengan lebih lanjut untuk pemulihan As di dalam air yang tercemar.

Kata kunci: Arsenik, Fitoremediasi, PCR, *Heat shock protein*

SDG: MATLAMAT 6: Air Bersih dan Sanitasi

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree Master of Science. The members of the Supervisory Committee were as follows:

Noor Azmi Shaharuddin, PhD

Associate Professor
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Chairman)

Azzreena Mohamad Azzeme, PhD

Senior Lecturer
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Member)

Mohd. Yunus Abd Shukor, PhD

Professor
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Member)

Siti Aqlima Ahmad, PhD

Associate Professor
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Member)

Mas Jaffri Masarudin, PhD

Associate Professor
Faculty of Biotechnology and Biomolecular Sciences
Universiti Putra Malaysia
(Member)

ZALILAH MOHD SHARIFF, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 08 August 2024

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LIST OF ABBREVIATIONS

As(III)	Arsenite
As(V)	Arsenate
Na ₂ HAsO ₄ ·7H ₂ O	Arsenate Dibasic Heptahydrate
NGS	Next Generation Sequencing
DEG	Differentially Expressed Gene
KEGG	Kyoto Encyclopedia of Genes and Genomes
A _{net}	Photosynthesis Rate
G _s	Stomatal Conductance
E	Transpiration Rate
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectrophotometer
RT-PCR	Reverse-Transcription Polymerase Chain Reaction
DMRT	Duncan's Multiple Range Test
NWQS	National Water Quality Standards
SGQ	Sediment Quality Guidelines
USEPA	United States Environmental Protection Agency

CHAPTER 1

INTRODUCTION

1.1 Introduction

The nature of surface water extensively deteriorates through growth in human activities in the water supply. This condition has been the primary concern to the public (Mahler et al., 2014). An increase in the human population and the requirement for better life quality have resulted in greater demand for high water quality (Liyanage and Yamada, 2017). This has led to the formation of a large number of individual sewages, along with institutional, domestic and industrial dissipation which goes into the water bodies. Wastes disposed of at landfills will form leachate over time and may contain trace metals that could pollute the soil (Kaur et al., 2015). This situation can lead to ecosystem disturbance, thus affecting human health and animal life near the landfill (Nannoni et al., 2015). The authorities and the public should implement community awareness and education regarding the preserving water supplies, including aquatic and marine habitats. Still, inadequate knowledge has been emphasized of minor fluvial (Ribeiro-Brasil et al., 2020). Better water quality is required for the agricultural and industrial sectors, human existence and domestic usage.

Currently, heavy metal pollution caused by the release of industrial waste containing heavy metals has been emphasized due to its possibility of threatening marine habitats (Azizi et al., 2016). The term “heavy metal” is described according to its position in the periodic table and its toxicity; it depends on the concentration available to cells of a living system (Engwa et al., 2019; Koller and Saleh, 2018; Appenroth, 2010). Heavy metals in discharge sediments may have originated from natural sources, such as soil erosion or anthropogenic contamination (Pang et al., 2015; Azzellino et al., 2019), including industrial release effluent and agricultural waste. This, includes heavy metal Arsenic (As), which can be found naturally in organic and inorganic forms (Wen et al., 2021; Domínguez-Álvarez, 2020). Arsenic has been regarded as a dangerous contaminant especially when it is present in drinking water (Samal et al., 2021). The inorganic form of this toxicant exists in trivalent, Arsenite, As(III) and pentavalent, Arsenate, As(V) (Manirethan et al., 2020; Penezic et al., 2020). In addition, As(III) is more toxic than As(V) (Guo et al., 2019).

A few cases of Arsenic contamination in Malaysia have been reported. For instance, the samples in fish bodies have shown a significantly high accumulation of Arsenic (approximately 100,000 ppb) (Hubadillah et al., 2020). This case was due to bauxite mining near Pengorak River, Pahang, Malaysia. In 2019, the Linggi River, located at Negeri Sembilan, Malaysia, was set by the National Water Quality Standards for Malaysia (NWQS) under class II demanding conventional water supplies treatment (Razak et al., 2021). It was reported that this area had been polluted by different heavy metals, including

Arsenic, with a mean concentration of 36.1 mg/kg-1. These pollutions are to be eradicated to reduce damage occurred to the environment.

Physical and chemical remediation strategies have been implemented for heavy metal contamination, including Arsenic. However, they are generally costly, often result in the demolition of water or soil characteristics, and are harmful to the environment (Bahadur et al., 2017). Several studies on heavy metal pollution treatment by phytoremediation have been explored, where this strategy utilizes plants to remove the pollutants from contaminated sites (Solomou et al., 2022). This remediation method is a more eco-friendly, dependable and cost-effective benefit (Hu et al., 2021). Several studies have been carried out to find suitable macrophytes for phytoremediation and further recognize the genes involved in the process, which could enhance the phytoremediation capabilities via genetic engineering.

In the presence of toxic heavy metals, plants have established detailed defence mechanisms to protect themselves against the harmful effects caused by the contaminants (Yadav et al., 2021). Other than biochemical changes, it has been reported that molecular modifications also occurred with heavy metal stress (Jamla et al., 2022). For example, the transporter-related genes have been documented to be upregulated in selenium-rich rice, which may elevate the selenium absorption in plants (Jiao et al., 2022). Likewise, the metal transport proteins encoded by heavy metal ATPase genes (*HMA*s) have helped to facilitate Cadmium (Cd) and Zinc (Zn) translocation from the roots to the higher parts of plants (Li et al., 2022). These proteins, specifically the *HMA2*, *HMA3* and *HMA4*, facilitate the Cd uptake and further detoxify the metals into the xylem (Ullah et al., 2022). Yang et al. (2022) revealed that the integration of As(III) with phytochelatin via *phytochelatin synthase* (*PCs*) in the roots of *Arabidopsis thaliana* minimized the metal root-to-shoot migration. The overexpression of these genes may cause plants to develop a high tolerance towards the toxicants, thus effectively sustaining their structure or altering the gene's function to detoxify the toxic metal into a less toxic compound.

1.2 Problem statement

Lately, an expansion of the human population has driven to increasing demand for high water quality, not only for daily usage by individuals, but also for the use of agriculture, industrial and other needs. This condition thus creates a high number of wastes produced, eventually becoming one of the leading causes of increased water contamination levels in Malaysia. This situation can lead to ecosystem disturbance, thus affecting human beings' health and the animal life near the landfill (Nannoni et al., 2015).

A few methods have already been used to clear nature from these kinds of pollutants, but most are pricey and hard to obtain the optimum output. At present, phytoremediation is a potential, eco-friendly and cost-effective alternative to

eliminate contaminants from polluted soil and water (Parveen et al., 2021; Nedijimi, 2021).

1.3 Hypothesis

The hypotheses of this study were:

- i. All selected aquatic plants can tolerate a high concentration of Arsenic.
- ii. The different concentrations of Arsenic have different physiological effects on the selected aquatic plants.

1.4 Objectives

This study focused on determining and assessing the potential phytoremediation of arsenic (As) by selected indigenous aquatic plants and the characterization of genes involved in the response towards Arsenic. The specific objectives of this study were:

- i. To determine the aquatic plants that could tolerate high concentrations of Arsenic.
- ii. To study the physiological changes in selected aquatic plants under Arsenic treatment.
- iii. To characterize the expression of plant genes involved in the Arsenic-stress responses using the Reverse-Transcription Polymerase Chain Reaction (RT-PCR).

REFERENCES

- Abbas, G., Murtaza, B., Bibi, I., Shahid, M., Niazi, N. K., Khan, M. I., Amjad, M., Hussain, M. and Natasha. (2018). Arsenic uptake, toxicity, detoxification, and speciation in plants: Physiological, biochemical, and molecular aspects. *International Journal of Environmental Research and Public Health*, 15, 59.
- Ahmad, S. Z. N., Wan Salleh, W. N., Ismail, A. F., Yusof, N., Mohd Yusop, M. Z. and Aziz, F. (2020). Adsorptive removal of heavy metal ions using graphene-based nanomaterials: Toxicity, roles of functional groups and mechanisms. *Chemosphere*, 248, 126008.
- Ahsan, M., Younis, A., Jaskani, M. J., Tufail, A., Riaz, A., Schwinghamer, T., Tariq, U. and Nawaz, F. (2018). Heavy metal accumulation imparts structural differences in fragrant Rosa species irrigated with marginal quality water. *Ecotoxicology and Environmental Safety*, 159, 240–248.
- Alam, M. Z., Hoque, M. A. and Carpenter-Boggs, L. (2020). Identification of practical amendments to mitigate soil arsenic levels in peas. *Rhizosphere*, 16, 100268.
- Alam, M. R., Rahman, M. M., Tam, N. F. Y., Yu, R. M. K. and MacFarlane, G. R. (2022). The accumulation and distribution of arsenic species and selected metals in the saltmarsh halophyte, spiny rush (*Juncus acutus*). *Marine Pollution Bulletin*, 175, 113373.
- Ali, H., Khan, E. and Ilahi, I. (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals: Environmental persistence, toxicity, and bioaccumulation. *Journal of Chemistry*, 2019, 1-14.
- Ali, S., Abbas, Z., Rizwan, M., Zaheer, I. E. Z., Yavas, I., Ünay, A., Abdel-DAIM, M. M., Hasanuzzaman, M. and Kalderis, D. (2020). Application of floating aquatic plants in phytoremediation of heavy metals polluted water: A review. *Sustainability*, 12, 1–33.
- Alikasturi, A. S., Kamil, M. Z. A. M., Shakri, N. A. A. M., Serit, M. E., Rahim, N. S. A., Shaharuddin, S., Anuar, M. R. and Radzi, A. R. M. (2019). Phytoremediation of copper in mineral, distilled and surface water using *Limnocharis flava* plant. *Materials Today: Proceedings*, 19, 1489–1496.
- Amna, S., Qamar, S., Turab Naqvi, A. A., Al-Huqail, A. A. and Qureshi, M. I. (2020). Role of sulfur in combating arsenic stress through upregulation of important proteins, and *in-silico* analysis to study the interaction between phosphate transporter (PHO1), arsenic and phosphate in spinach. *Plant Physiology and Biochemistry*, 157, 348–358.
- Ansari, A. A., Naeem, M., Gill, S. S. and AlZuaibr, F. M. (2020). Phytoremediation of contaminated waters: An eco-friendly technology based on aquatic macrophytes application. *Egyptian Journal of Aquatic Research*, 46, 371–376.

- Antoniadis, V., Shaheen, S. M., Stärk, H. J., Wennrich, R., Levizou, E., Merbach, I. and Rinklebe, J. (2021). Phytoremediation potential of twelve wild plant species for toxic elements in a contaminated soil. *Environment International*, *146*, 106233.
- Appenroth, K. (2010). Definition of “Heavy Metals” and their role in biological systems. *Soil Heavy Metals*, *19*, 19–30.
- Asgher, M., Ahmed, S., Sehar, Z., Gautam, H., Gandhi, S. and Khan, N. A. (2021). Hydrogen peroxide modulates activity and expression of antioxidant enzymes and protects photosynthetic activity from arsenic damage in rice (*Oryza sativa* L.). *Journal of Hazardous Materials*, *401*, 123365.
- Atabaki, N. (2021). Effects of arsenic on physiology, anatomy and transcriptomes of aquatic plants [Master dissertation, Universiti Putra Malaysia]. UPM eTheses Portal.
- Atabaki, N., Shaharuddin, N. A., Ahmad, S. A., Nulit, R. and Abiri, R. (2020). Morphological, physiological, and removal efficiency for phytoremediation of arsenic-polluted water. *Plants*, *9*, 1500.
- Azizi, S., Kamika, I. and Tekere, M. (2016). Evaluation of heavy metal removal from wastewater in a modified packed bed biofilm reactor. *PLoS ONE*, *11*, 1–13.
- Azizur Rahman, M. and Hasegawa, H. (2011). Aquatic arsenic: Phytoremediation using floating macrophytes. *Chemosphere*, *83*, 633-646.
- Azzellino, A., Colombo, L., Lombi, S., Marchesi, V., Piana, A., Andrea, M. and Alberti, L. (2019). Groundwater diffuse pollution in functional urban areas: The need to define anthropogenic diffuse pollution background levels. *Science of the Total Environment*, *656*, 1207–1222.
- Bahadur, A., Ahmad, R., Afzal, A., Feng, H., Suthar, V., Batool, A., Khan, A. and Mahmood-ul-hassan, M. (2017). The influences of Cr-tolerant rhizobacteria in phytoremediation and attenuation of Cr (VI) Stress in Agronomic Sunflower (*Helianthus annuus* L.), *Chemosphere*, *179*, 112–119.
- Bali, A. S. and Sidhu, G. P. S. (2021). Arsenic acquisition, toxicity and tolerance in plants - From physiology to remediation: A review. *Chemosphere*, *283*, 131050.
- Bhaduri, A. M. and Fulekar, M. H. (2012). Assessment of arbuscular mycorrhizal fungi on the phytoremediation potential of *Ipomoea aquatica* on Cadmium uptake. *3 Biotech*, *2*, 193–198.
- Bhat, J. A., Faizan, M., Bhat, M. A., Huang, F., Yu, D., Ahmad, A., Bajguz, A. and Ahmad, P. (2022). Defense interplay of the zinc-oxide nanoparticles and melatonin in alleviating the arsenic stress in soybean (*Glycine max* L.). *Chemosphere*, *288*, 132471.

- Bhatt, P., Gangola, S., Bhandari, G., Zhang, W., Maithani, D., Mishra, S. and Chen, S. (2020). New insights into the degradation of synthetic pollutants in contaminated environments. *Chemosphere*, 268, 128827.
- Bhattacharya, S., Sharma, P., Mitra, S., Mallick, I. and Ghosh, A. (2021). Arsenic uptake and bioaccumulation in plants: A review on remediation and socio-economic perspective in Southeast Asia. *Environmental Nanotechnology, Monitoring & Management*, 100430.
- Boisa, N., Bird, G., Brewer, P. A., Dean, J. R., Entwistle, J. A., Kemp, S. J. and Macklin, M. G. (2013). Potentially harmful elements (PHEs) in scalp hair, soil and metallurgical wastes in Mitrovica, Kosovo: The role of oral bioaccessibility and mineralogy in human PHE exposure. *Environment International*, 60, 56–70.
- Boyce, W. T., Sokolowski, M. B. and Robinson, G. E. (2020). Genes and environments, development and time. *Proceedings of the National Academy of Sciences of the United States of America*, 117, 23235–23241.
- Briffa, J., Sinagra, E. and Blundell, R. (2020). Heavy metal pollution in the environment and their toxicological effects on humans. *Heliyon*, 6, 1-26.
- Broek, B. V. D., Wuyts, C. and Irobi, J. (2021). Extracellular vesicle-associated small heat shock proteins as therapeutic agents in neurodegenerative diseases and beyond. *Advanced Drug Delivery Reviews*, 179, 114009.
- Cao, Q., Yang, L., Ren, W., Song, Y., Huang, S., Wang, Y. and Wang, Z. (2021). Spatial distribution of harmful trace elements in Chinese coalfields: An application of WebGIS technology. *Science of the Total Environment*, 755, 142527.
- Cao, Z., Pan, J., Yang, Y., Cao, Z., Xu, P., Chen, M. and Guan, M. (2020). Water management affects arsenic uptake and translocation by regulating arsenic bioavailability, transporter expression and thiol metabolism in rice (*Oryza sativa* L.). *Ecotoxicology and Environmental Safety*, 206, 111208.
- Carpente, L., Cerdeira-Pena, A., Lorenzo-Freire, S. and Places, Á. S. (2019). Optimization in Sanger sequencing. *Computers and Operations Research*, 109, 250–262.
- Chandanshive, V. V., Rane, N. R., Gholave, A. R., Patil, S. M., Jeon, B. H. and Govindwar, S. P. (2016). Efficient decolorization and detoxification of textile industry effluent by *Salvinia molesta* in lagoon treatment. *Environmental Research*, 150, 88–96.
- Chauhan, R., Awasthi, S., Tripathi, P., Mishra, S., Dwivedi, S., Niranjana, A., Mallick, S., Tripathi, P., Pande, V. and Tripathi, R. D. (2017). Selenite modulates the level of phenolics and nutrient element to alleviate the toxicity of arsenite in rice (*Oryza sativa* L.). *Ecotoxicology and Environmental Safety*, 138, 47–55.

- Chen, H., Yin, X., Guo, L., Yao, J., Ding, Y., Xu, X., Liu, L., Zhu, Q. H., Chu, Q. and Fan, L. (2021). PlantscRNAdb: A database for plant single-cell RNA analysis. *Molecular Plant*, *14*, 855–857.
- Chen, J. X., Cao, Y., Yan, X., Chen, Y. and Ma, L. Q. (2021). Novel *PvACR3;2* and *PvACR3;3* genes from arsenic-hyperaccumulator *Pteris vittata* and their roles in manipulating plant arsenic accumulation. *Journal of Hazardous Materials*, *415*, 125647.
- Chen, Y., Han, Y. H., Cao, Y., Zhu, Y. G., Rathinasabapathi, B. and Ma, L. Q. (2017). Arsenic transport in rice and biological solutions to reduce arsenic risk from rice. *Frontiers in Plant Science*, *8*, 1-11.
- Crous, K. Y., Uddling, J. and De Kauwe, M. G. (2022). Temperature responses of photosynthesis and respiration in evergreen trees from boreal to tropical latitudes. *New Phytologist*, 1-22.
- Cruz, Y., Villar, S., Gutiérrez, K., Montoya-Ruiz, C., Gallego, J. L., Delgado, M. del P. and Saldarriaga, J. F. (2021). Gene expression and morphological responses of *Lolium perenne* L. exposed to Cadmium (Cd²⁺) and Mercury (Hg²⁺). *Scientific Reports*, *11*, 1–11.
- Cortés-Maldonado, L., Marcial-Quino, J., Gómez-Manzo, S., Fierro, F. and Tomasini, A. (2020). A method for the extraction of high quality fungal RNA suitable for RNA-seq. *Journal of Microbiological Methods*, *170*, 105855.
- Cui, X., Zhang, J., Wang, X., Pan, M., Lin, Q., Khan, K. Y., Yan, B., Li, T., He, Z., Yang, X. and Chen, G. (2021). A review on the thermal treatment of heavy metal hyperaccumulator: Fates of heavy metals and generation of products. *Journal of Hazardous Materials*, *405*, 123832.
- da Silva, A. A., de Oliveira, J. A., de Campos, F. V., Ribeiro, C., Farnese, F. dos S. and Costa, A. C. (2018). Phytoremediation potential of *Salvinia molesta* for arsenite contaminated water: role of antioxidant enzymes. *Theoretical and Experimental Plant Physiology*, *30*, 275–286.
- Daddy, F., Abubakar, S. and Owotunse, S. (2002). Effects of different sources of water on water hyacinth growth performance. International Conference on Water Hyacinth, *95*, 130–140.
- Das, D., Sen, P., Purkayastha, S., Saha, A. K., Roy, A., Rai, P., Sen, S., Saha, S., Senapati, B. K., Biswas, T. and Bhattacharyya, S. (2021). A perfect PCR based co-dominant marker for low grain-arsenic accumulation genotyping in rice. *Ecotoxicology and Environmental Safety*, *212*, 111960.
- de las Torres, A. I. G., Giráldez, I., Martínez, F., Palencia, P., Corns, W. T. and Sánchez-Rodas, D. (2020). Arsenic accumulation and speciation in strawberry plants exposed to inorganic arsenic enriched irrigation. *Food Chemistry*, *315*, 126215.

- de Souza, T. D., Borges, A. C., Matos, A. T. de, Veloso, R. W. and Braga, A. F. (2018). Kinetics of arsenic absorption by the species *Eichhornia crassipes* and *Lemna valdiviana* under optimized conditions. *Chemosphere*, 209, 866–874.
- Deng, X., Chen, B., Chen, Y., Lu, L., Yuan, X., Yang, Y. and Zeng, Q. (2021). Variations in root morphological indices of rice (*Oryza sativa* L.) induced by seedling establishment methods and their relation to arsenic accumulation in plant tissues. *Environmental Pollution*, 281, 116999.
- di Donato, M. and Geisler, M. (2019). HSP90 and co-chaperones: a multitaskers' view on plant hormone biology. *FEBS Letters*, 593, 1415–1430.
- Di, X., Zheng, F., Norton, G. J., Beesley, L., Zhang, Z., Lin, H., Zhi, S., Liu, X. and Ding, Y. (2021). Physiological responses and transcriptome analyses of upland rice following exposure to arsenite and arsenate. *Environmental and Experimental Botany*, 183, 104366.
- Diarra, I., Kotra, K. K. and Prasad, S. (2020). Assessment of biodegradable chelating agents in the phytoextraction of heavy metals from multi-metal contaminated soil. *Chemosphere*, 128483.
- Dogan, T. and Karacali, B. (2013) Automatic Identification of highly conserved family regions and relationships in genome wide datasets including remote protein sequences. *PLoS ONE*, 8, e75458.
- Dolphen, R. and Thiravetyan, P. (2019). Reducing arsenic in rice grains by leonardite and arsenic-resistant endophytic bacteria. *Chemosphere*, 223, 448–454.
- Domínguez-Álvarez, J. (2020). Capillary electrophoresis coupled to electrospray mass spectrometry for the determination of organic and inorganic arsenic compounds in water samples. *Talanta*, 212, 120803.
- Dong, C. L., Zhu, F., Lu, M. X. and Du, Y. Z. (2021). Characterization and functional analysis of Cshsp19.0 encoding a small heat shock protein in *Chilo suppressalis* (Walker). *International Journal of Biological Macromolecules*, 188, 924–931.
- Du, J., Li, Q., Zhao, R., Yang, J., Zhou, S., Chen, C., Zhang, M., Zhao, D. and An, S. (2021). Effect of influent salinity on the selection of macrophyte species in floating constructed wetlands. *Journal of Environmental Management*, 282, 111947.
- Du, Y., Wu, Q., Kong, D., Shi, Y., Huang, X., Luo, D., Chen, Z., Xiao, T. and Leung, J. Y. S. (2020). Accumulation and translocation of heavy metals in water hyacinth: Maximising the use of green resources to remediate sites impacted by e-waste recycling activities. *Ecological Indicators*, 115, 106384.

- Engwa, G. A., Ferdinand, P. U., Nwalo, F. N. and Unachukwu, M. N. (2019, June 19). Mechanism and health effects of heavy metal toxicity in humans. *IntechOpen*. Retrieved January 10, 2022, from <https://www.intechopen.com/chapters/64762>
- Farooq, M. A., Hong, Z., Islam, F., Noor, Y., Hannan, F., Zhang, Y., Ayyaz, A., Mwamba, T. M., Zhou, W. and Song, W. (2021). Comprehensive proteomic analysis of arsenic induced toxicity reveals the mechanism of multilevel coordination of efficient defense and energy metabolism in two *Brassica napus* cultivars. *Ecotoxicology and Environmental Safety*, 208, 1-11.
- Favas, P. J., Pratas, J., Varun, M., D'Souza, R. and Paul, M. S. (2014). Phytoremediation of soils contaminated with metals and metalloids at mining areas: Potential of native flora. *Environmental Risk Assessment of Soil Contamination*, 485-517.
- Feng, N., Yu, J., Zhao, H., Cheng, Y., Mo, C., Cai, Q. and Li, Y. (2017). Efficient phytoremediation of organic contaminants in soils using plant–endophyte partnerships. *Science of the Total Environment*, 583, 352–368.
- Finnegan, P. M. and Chen, W. (2012). Arsenic toxicity: the effects on plant metabolism. *Frontiers in Physiology*, 3, 1–18.
- Forsgren, E., Locke, B., Semberg, E., Laugen, A. T. and Miranda, J. R. De. (2017). Sample preservation, transport and processing strategies for honeybee RNA extraction: Influence on RNA yield, quality, target quantification and data normalization. *Journal of Virological Methods*, 246, 81–89.
- Gautam, A., Pandey, A. K. and Dubey, R. S. (2020). Unravelling molecular mechanisms for enhancing arsenic tolerance in plants: A review. *Plant Gene*, 23, 100240.
- Ghorbani, A., Pishkar, L., Roodbari, N., Pehlivan, N. and Wu, C. (2021). Nitric oxide could allay arsenic phytotoxicity in tomato (*Solanum lycopersicum* L.) by modulating photosynthetic pigments, phytochelatin metabolism, molecular redox status and arsenic sequestration. *Plant Physiology and Biochemistry*, 167, 337–348.
- Goswami, A., Banerjee, R. and Raha, S. (2010). Mechanisms of plant adaptation/memory in rice seedlings under arsenic and heat stress: expression of heat-shock protein gene *HSP70*. *AoB PLANTS*, 2010, 1–9.
- Goupil, P., Souguir, D., Ferjani, E., Faure, O., Hitmi, A. and Ledoigt, G. (2009). Expression of stress-related genes in tomato plants exposed to arsenic and chromium in nutrient solution. *Journal of Plant Physiology*, 166, 1446–1452.

- Grabherr, M. G., Haas, B. J., Yassour, M., Levin, J. Z., Thompson, D.A., Amit, A., Adiconis, X., Fan, L., Raychowdhury R., Zeng, Q., Chen, Z., Mauceli, E., Hacohen, N., Gnirke, A., Rhind, N., di Palma, F., Birren, B. W., Nusbaum, C., Lindblad-Toh, K., Bruce W., Friedman, N. and Regev, A. (2013). Trinity: reconstructing a full-length transcriptome without a genome from RNA-Seq data. *Nature Biotechnology*, 29, 644–652.
- Guarino, F., Miranda, A., Castiglione, S. and Cicatelli, A. (2020). Arsenic phytovolatilization and epigenetic modifications in *Arundo donax* L. assisted by a PGPR consortium. *Chemosphere*, 251, 126310.
- Gull, A., Lone, A. A. and Wani, N. U. I. (2019, October 7). Gene expression and phenotypic traits. *IntechOpen*. Retrieved January 20, 2022, from <https://www.intechopen.com/chapters/66714>
- Guo, J., Ci, S., Cai, P. and Wen, Z. (2019). Loading NiCo alloy nanoparticles onto nanocarbon for electrocatalytic conversion of arsenite into arsenate. *Electrochemistry Communications*, 104, 106477.
- Gupta, A. and Balomajumder, C. (2015). Phytoremediation of heavy metals and its mechanism: A brief review. *Journal of Integrated Science and Technology*, 3, 51-59.
- Hall, J. L. (2002). Cellular mechanisms for heavy metal detoxification and tolerance. *Journal of Experimental Botany*, 53, 1–11.
- Hasan, M. K., Cheng, Y., Kanwar, M. K., Chu, X. Y., Ahammed, G. J. and Qi, Z. Y. (2017). Responses of plant proteins to heavy metal stress—a review. *Frontiers in Plant Science*, 8, 1–16.
- Hasanuzzaman, M., Nahar, K., Hakeem, K. R., Öztürk, M. and Fujita, M. (2015). Arsenic toxicity in plants and possible remediation. *Soil Remediation and Plants*, 16, 433-501.
- Hasibuan, A. A., Yuniati, R., and Wardhana, W. (2020). The growth rate and chlorophyll content of water hyacinth under different type of water sources. IOP Conference Series: *Materials Science and Engineering*, 902, 1-6.
- Hatami, M., Khanizadeh, P., Bovand, F. and Aghaee, A. (2021). Silicon nanoparticle-mediated seed priming and *Pseudomonas* spp. inoculation augment growth, physiology and antioxidant metabolic status in *Melissa officinalis* L. plants. *Industrial Crops and Products*, 162, 1-18.
- Hemalatha, D., Narayanan, R. and Sanchitha, S. (2020). Removal of zinc and chromium from industrial wastewater using water hyacinth (*E. crassipes*) petiole, leaves and root powder: Equilibrium study. *Materials Today: Proceedings*.

- Hernández, L. E., Sobrino-Plata, J., Montero-Palmero, M. B., Carrasco-Gil., Flores Cáceres, M. L., Ortega-Villasante, C., and Escobar, C. (2015). Contribution of glutathione to the control of cellular redox homeostasis under toxic metal and metalloid stress. *Journal of Experimental Botany*, 66, 2901-2911.
- Hill, J. M. (2014). Investigations of growth metrics and $\delta^{15}\text{N}$ values of water hyacinth (*Eichhornia crassipes*, (Mart.) Solms-Laub) in relation to biological control. *Aquatic Botany*, 114, 12–20.
- Hosamane, S. N. (2012). Removal of arsenic by phytoremediation - A Study of two plant species. *International Journal of Scientific Engineering and Technology*, 224, 218–224.
- Hossain, M., Mestrot, A., Norton, G. J., Deacon, C., Islam, M. R. and Meharg, A. A. (2021). Arsenic dynamics in paddy soil under traditional manuring practices in Bangladesh. *Environmental Pollution*, 268, 115821.
- Hu, N., Chen, S., Lang, T., Zhang, H., Chen, W., Li, G. and Ding, D. (2021). A novel method for determining the adequate dose of a chelating agent for phytoremediation of radionuclides contaminated soils by *M. cordata*. *Journal of Environmental Radioactivity*, 227, 106468.
- Hubadillah, S. K., Othman, M. H. D., Gani, P., Sunar, N. M., Tai, Z. S., Koo, K. N., Pauzan, M. A. B., Ismail, N. J. and Shahrul Nizan Shikh Zahari, S. M. (2020). Integrated green membrane distillation-microalgae bioremediation for arsenic removal from Pengorak River Kuantan, Malaysia. *Chemical Engineering and Processing - Process Intensification*, 153, 1–8.
- Hussain, A., Priyadarshi, M. and Dubey, S. (2019). Experimental study on accumulation of heavy metals in vegetables irrigated with treated wastewater. *Applied Water Science*, 9, 1–11.
- Huynh, A. T., Chen, Y. C. and Tran, B. N. T. (2021). A small-scale study on removal of heavy metals from contaminated water using water hyacinth. *Processes*, 9, 1–9.
- Hwang, S. G., Chapagain, S., Lee, J. W., Han, A. R. and Jang, C. S. (2017). Genome-wide transcriptome profiling of genes associated with arsenate toxicity in an arsenic-tolerant rice mutant. *Plant Physiology and Biochemistry*, 120, 40–51.
- Idrees, N., Sarah, R., Tabassum, B. and Abd_Allah, E. F. (2020). Evaluation of some heavy metals toxicity in *Channa punctatus* and riverine water of Kosi in Rampur, Uttar Pradesh, India. *Saudi Journal of Biological Sciences*, 2, 1191–1194.
- Islam, A., Saha, P. K., Iqbal, M., Islam, N. and Nayeem, A. (2016). Removal of arsenic by water hyacinth from arsenic contaminated water. *International Journal of Agricultural Papers*, 1, 36–41.

- Ismail, A. and Naji, A. (2011). Assessment of metals contamination in Klang River surface sediments by using different indexes. *Environment Asia*, 4, 30-38.
- Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B. and Beeregowda, K. N. (2014). Toxicity mechanism and health effects of some heavy metals. *Interdisciplinary Toxicology*, 7, 60–72.
- Jamla, M., Khare, T., Joshi, S., Patil, S., Penna, S. and Kumar, V. (2021). Omics approaches for understanding heavy metal responses and tolerance in plants. *Current Plant Biology*, 27, 1-16.
- Jasrotia, S., Kansal, A. and Mehra, A. (2017). Performance of aquatic plant species for phytoremediation of arsenic-contaminated water. *Applied Water Science*, 7, 889–896.
- Jatav, K. S. and Singh, R. P. (2015). Phytoremediation using algae and microphyte: II. *Phytoremediation: Management of Environmental Contaminants*, 2, 291-296.
- Jawed, A., Kar, P., Verma, R., Shukla, K., Hemanth, P., Thakur, V. K., Pandey, L. M. and Gupta, R. K. (2022). Integration of biological control with engineered heterojunction nano-photocatalysts for sustainable and effective management of water hyacinth weed. *Journal of Environmental Chemical Engineering*, 10, 106976.
- Jiao, L., Zhang, L., Zhang, Y., Wang, R., Lu, B. and Liu, X. (2022). Transcriptome analysis provides new insight into the distribution and transport of selenium and its associated metals in selenium-rich rice. *Environmental Pollution*, 301, 1-13.
- Johnová, P., Skalák, J., Saiz-Fernández, I. and Brzobohatý, B. (2016). Plant responses to ambient temperature fluctuations and water-limiting conditions: A proteome-wide perspective. *Biochimica et Biophysica Acta*, 1864, 916–931.
- Kadhun, S. A., Ishak, M. Y., Zulkifli, S. Z. and Hashim, R. (2015). Evaluation of the status and distributions of heavy metal pollution in surface sediments of the Langat River basin in Selangor Malaysia. *Marine Pollution Bulletin*, 101, 391-396.
- Kamran, M. A., Bibi, S. and Chen, B. (2022). Preventative effect of crop straw-derived biochar on plant growth in an arsenic polluted acidic ultisol. *Science of the Total Environment*, 812, 151469.
- Kaur, M., Soodan, R. K., Kumar, V., Katnoria, J. K. and Nagpal, A. (2015). Sustainable solutions for solid waste management: A Review. *International Journal of Advanced Research in Biological Sciences*, 2, 79–86.

- Kaya, C., Sarioglu, A., Ashraf, M., Alyemeni, M. N. and Ahmad, P. (2022). The combined supplementation of melatonin and salicylic acid effectively detoxifies arsenic toxicity by modulating phytochelatins and nitrogen metabolism in pepper plants. *Environmental Pollution*, 297, 118727.
- Khan, S., Jabeen, R., Deeba, F., Waheed, U., Khanum, P. and Iqbal, N. (2021). Heat shock proteins: Classification, functions and expressions in plants during environmental stresses. *Journal of Bioresource Management*, 8, 85-97.
- Kochan, N., Yazgı Tütüncü, G. and Giner, G. (2021). A new local covariance matrix estimation for the classification of gene expression profiles in high dimensional RNA-Seq data. *Expert Systems with Applications*, 167, 114200.
- Koller, M. and Saleh, H. M. (2018, June 27). Introductory chapter: Introducing heavy metals. *IntechOpen*. Retrieved January 10, 2022, from <https://www.intechopen.com/chapters/59857>
- Kumar, V., Ferreira, L. F. R., Sonkar, M. and Singh, J. (2021). Phytoextraction of heavy metals and ultrastructural changes of *Ricinus communis L.* grown on complex organometallic sludge discharged from alcohol distillery. *Environmental Technology and Innovation*, 22, 101382.
- Larrañaga, A. and Lizundia, E. (2019). A review on the thermomechanical properties and biodegradation behaviour of polyesters. *European Polymer Journal*, 121, 109296.
- Li, D., He, T., Saleem, M. and He, G. (2022). Metalloprotein-specific or critical amino acid residues: Perspectives on plant-precise detoxification and recognition mechanisms under cadmium stress. *International Journal of Molecular Sciences*, 23, 1-20.
- Li, S., Wang, P., Su, Z., Lozano, E., Lamaster, O., Grogan, J. B., Weng, Y., Decker, T., Findeisen, J. and McGarrity, M. (2018). Endocide-induced abnormal growth forms of invasive Giant Salvinia (*Salvinia molesta*). *Scientific Reports*, 8, 1–15.
- Lin, H. J., Rong, C. X., Jiu, B. B., Li, B. X., Yu, Q. J., Gan, L. H. and Zhang, Z. Y. (2018). Effects of chromium on pyrolysis characteristic of water hyacinth (*Eichornia crassipes*). *Renewable Energy*, 115, 676–684.
- Little, A. J., Sivarajah, B., Frendo, C., Sprague, D. D., Smol, J. P. and Vermaire, J. C. (2020). The impacts of century-old, arsenic-rich mine tailings on multi-trophic level biological assemblages in lakes from Cobalt (Ontario, Canada). *Science of the Total Environment*, 709, 136212.
- Liyanage, C. P. and Yamada, K. (2017). Impact of population growth on the water quality of natural water bodies. *Sustainability*, 9, 1-14.

- Lu, X., Dun, H., Lian, C., Zhang, X., Yin, W. and Xia, X. (2017). The role of peu-miR164 and its target *PeNAC* genes in response to abiotic stress in *Populus euphratica*. *Plant Physiology and Biochemistry*, 115, 418–438.
- Lucena-Aguilar, G., Sánchez-López, A. M., Barberán-Aceituno, C., Carrillo-Ávila, J. A., López-Guerrero, J. A. and Aguilar-Quesada, R. (2016). DNA source selection for downstream applications based on DNA quality indicators analysis. *Biopreservation and Biobanking*, 14, 264–270.
- Mahler, R., Barber, M. and Shafii, B. (n.d.). Water pollution issues and concerns in the Pacific Northwest, USA. *WIT Transactions on Ecology and the Environment*, 182, 63–74.
- Mamun, A. A. and Zainuddin, Z. (2013). Sustainable river water quality management in Malaysia. *International Islamic University Malaysia Engineering Journal*, 14, 29–42.
- Manirethan, V., Raval, K. and Balakrishnan, R. M. (2020). Adsorptive removal of trivalent and pentavalent arsenic from aqueous solutions using iron and copper impregnated melanin extracted from the marine bacterium *Pseudomonas stutzeri*. *Environmental Pollution*, 257, 113576.
- Manisalidis, I., Stavropoulou, E., Stavropoulos, A. and Bezirtzoglou, E. (2020). Environmental and health impacts of air pollution: A review. *Frontiers in Public Health*, 8, 1–13.
- Maresca, V., Lettieri, G., Sorbo, S., Piscopo, M. and Basile, A. (2020). Biological responses to Cadmium stress in liverwort *Conocephalum conicum* (Marchantiales). *International Journal of Molecular Sciences*, 21, 1–12.
- Martínez-Castillo, J. I., Saldaña-Robles, A. and Ozuna, C. (2022). Arsenic stress in plants: A metabolomic perspective. *Plant Stress*, 3, 1-11.
- Marrugo-Negrete, J., Enamorado-Montes, G., Durango-Hernández, J., Pinedo-Hernández, J., and Díez, S. (2017). Removal of mercury from gold mine effluents using *Limnocharis flava* in constructed wetlands. *Chemosphere*, 167, 188–192.
- Martin, G. D., Coetzee, J. A., Weyl, P. S. R., Parkinson, M. C. and Hill, M. P. (2018). Biological control of *Salvinia molesta* in South Africa revisited. *Biological Control*, 125, 74–80.
- Masindi, V. and Muedi, K. L. (2018, June 27). Chapter: Environmental contamination by heavy metals. *IntechOpen*. Retrieved October 20, 2021, from <https://www.intechopen.com/chapters/60680>
- Massoud, R., Hadiani, M. R., Hamzehlou, P. and Khosravi-Darani, K. (2019). Bioremediation of heavy metals in food industry: Application of *Saccharomyces cerevisiae*. *Electronic Journal of Biotechnology*, 37, 56–60.

- Mawia, A. M., Hui, S., Zhou, L., Li, H., Tabassum, J., Lai, C., Wang, J., Shao, G., Wei, X., Tang, S., Luo, J., Hu, S. and Hu, P. (2021). Inorganic arsenic toxicity and alleviation strategies in rice. *Journal of Hazardous Materials*, 408, 1-21.
- Meyer, G. A. (1998). Pattern of defoliation and its effects on photosynthesis and growth of goldenrod. *Functional Ecology*, 12, 270–279.
- Mirza, N., Mahmood, Q., Maroof Shah, M., Pervez, A. and Sultan, S. (2014). Plants as useful vectors to reduce environmental toxic arsenic content. *The Scientific World Journal*, 2014, 1-11.
- Mishra, D., Shekhar, S., Singh, D., Chakraborty, S. and Chakraborty, N. (2018). Heat shock proteins and abiotic stress tolerance in plants. *Regulation of Heat Shock Protein Responses*, 13, 41–69.
- Mitra, S., Chakraborty, A. J., Tareq, A. M., Emran, T. Bin, Nainu, F., Khusro, A., Idris, A. B., Khandaker, M. U., Osman, H., Alhumaydhi, F. A. and Simal-Gandara, J. (2022). Impact of heavy metals on the environment and human health: Novel therapeutic insights to counter the toxicity. *Journal of King Saud University - Science*, 34, 1-21.
- Mostofa, M. G., Rahman, M. M., Nguyen, K. H., Li, W., Watanabe, Y., Tran, C. D., Zhang, M., Houga, M., Fujita, M. and Tran, L. S. P. (2021). Strigolactones regulate arsenate uptake, vacuolar-sequestration and antioxidant defense responses to resist arsenic toxicity in rice roots. *Journal of Hazardous Materials*, 415, 125589.
- Motitsoe, S. N., Coetzee, J. A., Hill, J. M. and Hill, M. P. (2020). Biological control of *Salvinia molesta* (D.S. Mitchell) drives aquatic ecosystem recovery. *Diversity*, 12, 1-22.
- Mubarak, M., Shaija, A. and Suchithra, T. V. (2021). Experimental evaluation of *Salvinia molesta* oil biodiesel/diesel blends fuel on combustion, performance and emission analysis of diesel engine. *Fuel*, 287, 119526.
- Mustafa, H. M. and Hayder, G. (2020). Recent studies on applications of aquatic weed plants in phytoremediation of wastewater: A review article. *Ain Shams Engineering Journal*, 1-11.
- Nabi, A. and Naeem, M. (2019). Arsenic toxicity induced changes in growth, photosynthetic pigments, antioxidant machinery, essential oil, menthol and other active constituents of menthol mint (*Mentha arvensis L.*). *Journal of Essential Oil Bearing Plants*, 22, 1333-1348.
- Nannoni, F., Santolini, R. and Protano, G. (2015). Heavy element accumulation in *Evernia prunastri* lichen transplants around a municipal solid waste landfill in Central Italy. *Waste Management*, 43, 353–362.

- National Research Council (US) Committee on Medical and Biological Effects of Environmental Pollutants (1977). Biologic effects of arsenic on plants and animals. in arsenic - medical and biologic effects of environmental pollutants (pp. 121–127). *National Academy Press* (US), Washington (DC).
- Nedjimi, B. (2021). Phytoremediation: a sustainable environmental technology for heavy metals decontamination. *SN Applied Sciences*, 3, 1–19.
- Neumann, D., Lichtenberger, O., Günther, D., Tschiersch, K. and Nover, L. (1994). Heat-shock proteins induce heavy-metal tolerance in higher plants. *Planta*, 194, 360–367.
- Ng, Y. S. and Chan, D. J. C. (2016). Wastewater phytoremediation by *Salvinia molesta*. *Journal of Water Process Engineering*. 15, 107-115.
- Nizam, N. U. M., Hanafiah, M. M., Noor, I. M. and Karim, H. I. A. (2020). Efficiency of five selected aquatic plants in phytoremediation of aquaculture wastewater. *Applied Sciences*, 10, 1-11.
- O'Driscoll, A., Belogradov, V., Carroll, J., Kropp, K., Walsh, P., Ghazal, P. and Sleator, R. D. (2015). HBLAST: Parallelised sequence similarity - A Hadoop MapReducable basic local alignment search tool. *Journal of Biomedical Informatics*, 54, 58–64.
- Onakpa, M. M., Njan, A. A. and Kalu, O. C. (2018). A review of heavy metal contamination of food crops in Nigeria. *Annals of Global Health*, 84, 488–494.
- Owens, C. S., Smart, R. M. and Dick, G. O. (2014). Effects of pH on growth of *Salvinia molesta* Mitchell. *Journal of Aquatic Plant Management*, 52, 93–96.
- Palansooriya, K. N., Shaheen, S. M., Chen, S. S., Tsang, D. C. W., Hashimoto, Y., Hou, D., Bolan, N. S., Rinklebe, J. and Ok, Y. S. (2020). Soil amendments for immobilization of potentially toxic elements in contaminated soils: A critical review. *Environment International*, 134, 1-29.
- Panchy, N., Lehti-Shiu, M. and Shiu, S. H. (2016). Evolution of gene duplication in plants. *Plant Physiology*, 171, 2294–2316.
- Pang, H., Lou, Z., Jin, A., Yan, K., Jiang, Y., Yang, X., Chen, C. A. and Chen, X. (2015). Contamination, distribution, and sources of heavy metals in the sediments of Andong tidal flat, Hangzhou Bay, China. *Continental Shelf Research*, 110, 72–84.
- Park, C. J. and Seo, Y. S. (2015). Heat shock proteins: A review of the molecular chaperones for plant immunity. *Plant Pathology Journal*, 31, 323–333.
- Parveen, S., Bhat, I. U. H., Khanam, Z., Rak, A. E., Yusoff, H. M. and Akhter, M. S. (2022). Phytoremediation: In situ alternative for pollutant removal from contaminated natural media: A brief review. *Biointerface Research in Applied Chemistry*, 12, 4945–4960.

- Patel, M. and Parida, A. K. (2022). Salinity mediated cross-tolerance of arsenic toxicity in the halophyte *Salvadora persica* L. through metabolomic dynamics and regulation of stomatal movement and photosynthesis. *Environmental Pollution*, 300, 1-18.
- Paz-alberto, A. M. and Sigua, G. C. (2013). Phytoremediation: A green technology to remove environmental pollutants. *American Journal of Climate Change*, 2, 71–86.
- Penezic, A., Tercier-Waeber, M. Lou, Abdou, M., Bossy, C., Dutruch, L., Bakker, E. and Schäfer, J. (2020). Spatial variability of arsenic speciation in the Gironde Estuary: Emphasis on dynamic (potentially bioavailable) inorganic arsenite and arsenate fractions. *Marine Chemistry*, 223, 103804.
- PerkinElmer, Inc. (2021, August 31). Rapid analysis of water using ICP Optical Emission Spectroscopy. *AZoCleantech*. Retrieved on March 10, 22 from <https://www.azocleantech.com/article.aspx?ArticleID=1299>
- Piacentini, D., Ronzan, M., Fattorini, L., Della Rovere, F., Massimi, L., Altamura, M. M. and Falasca, G. (2020). Nitric oxide alleviates Cadmium- but not Arsenic-induced damages in rice roots. *Plant Physiology and Biochemistry*, 151, 729–742.
- Pilla, R. S., Kitska, D. J., and Loader, C. (2005). Statistical analysis of modified complete randomized designs: Applications to chemo-orientation studies. *Journal of Experimental Biology*, 208, 1267–1276.
- Priya, S. E. and Senthamil Selvan, P. (2017). Water hyacinth (*Eichhornia crassipes*) – An efficient and economic adsorbent for textile effluent treatment – A review. *Arabian Journal of Chemistry*, 10, S3548–S3558.
- Razak, M. R., Aris, A. Z., Zakaria, N. A. C., Wee, S. Y. and Ismail, N. A. H. (2021). Accumulation and risk assessment of heavy metals employing species sensitivity distributions in Linggi River, Negeri Sembilan, Malaysia. *Ecotoxicology and Environmental Safety*, 211, 111905.
- Rehman, A. U., Nazir, S., Irshad, R., Tahir, K., ur Rehman, K., Islam, R. U. and Wahab, Z. (2021). Toxicity of heavy metals in plants and animals and their uptake by magnetic iron oxide nanoparticles. *Journal of Molecular Liquids*, 321.
- Renu, K., Chakraborty, R., Haritha, M., Rajeshwari, K., Famurewa, A. C., Madhyastha, H., Vellingiri, B., George, A. and Abilash, V. G. (2021). Molecular mechanism of heavy metals (Lead, Chromium, Arsenic, Mercury, Nickel and Cadmium) induced hepatotoxicity – A review. *Chemosphere*, 271, 129735.

- Rezania, S., Ponraj, M., Talaiekhosani, A., Mohamad, S. E., Md Din, M. F., Taib, S. M., Sabbagh, F. and Sairan, F. M. (2015). Perspectives of phytoremediation using water hyacinth for removal of heavy metals, organic and inorganic pollutants in wastewater. *Journal of Environmental Management*, 163, 125–133.
- Ribeiro-Brasil, D. R. G., Torres, N. R., Picanço, A. B., Sousa, D. S., Ribeiro, V. S., Brasil, L. S. and Montag, L. F. de A. (2020). Contamination of stream fish by plastic waste in the Brazilian Amazon. *Environmental Pollution*, 266, 1-11.
- Robert, C., Bancal, M. O., Ney, B. and Lannou, C. (2005). Wheat leaf photosynthesis loss due to leaf rust, with respect to lesion development and leaf nitrogen status. *New Phytologist*, 165, 227–241.
- Safa, M., O'Carroll, D., Mansouri, N., Robinson, B. and Curline, G. (2020). Investigating arsenic impact of ACC treated timbers in compost production (A case study in Christchurch, New Zealand). *Environmental Pollution*, 262, 1-7.
- Samal, A. C., Bhattacharya, P., Biswas, P., Maity, J. P., Bundschuh, J. and Santra, S. C. (2021). Variety-specific arsenic accumulation in 44 different rice cultivars (*O. sativa* L.) and human health risks due to co-exposure of arsenic-contaminated rice and drinking water. *Journal of Hazardous Materials*, 407, 124804.
- Samsami, S., Mohamadi, M., Sarrafzadeh, M. H., Rene, E. R. and Firoozbahr, M. (2020). Recent advances in the treatment of dye-containing wastewater from textile industries: Overview and perspectives. *Process Safety and Environmental Protection*, 143, 138–163.
- Savvides, A. M. and Fotopoulos, V. (2018). Two inexpensive and non-destructive techniques to correct for smaller-than-gasket leaf area in gas exchange measurements. *Frontiers in Plant Science*, 9, 1-9.
- Slot, M., Rifai, S. W. and Winter, K. (2021). Photosynthetic plasticity of a tropical tree species, *Tabebuia rosea*, in response to elevated temperature and [CO₂]. *Plant, Cell & Environment*, 44, 2347-2364.
- Solomou, A. D., Germani, R., Proutsos, N., Petropoulou, M., Koutroumpilas, P., Galanis, C., Maroulis, G. and Kolimenakis, A. (2022). Utilizing mediterranean plants to remove contaminants from the soil environment: A short review. *Agriculture*, 12, 1–19.
- Surgun-Acar, Y. and Zemheri-Navruz, F. (2019). 24-Epibrassinolide promotes arsenic tolerance in *Arabidopsis thaliana* L. by altering stress responses at biochemical and molecular level. *Journal of Plant Physiology*, 238, 12–19.
- Roychowdhury, R., Khan, M. H., and Choudhury, S. (2018). Arsenic in rice: An overview on stress implications, tolerance and mitigation strategies. *Plants Under Metal and Metalloid Stress*. 401–415.

- Sany, S.B.T., Salleh, A., Rezayi, M., Saadati, N., Narimany, L. and Tehrani, G.M. (2013). Distribution and contamination of heavy metal in the coastal sediments of Port Klang, Selangor, Malaysia. *Water, Air, & Soil Pollution*, 224, 1-18.
- Sejati, A. W., Buchori, I., Kurniawati, S., Brana, Y. C. and Fariha, T. I. (2020). Quantifying the impact of industrialization on blue carbon storage in the coastal area of Metropolitan Semarang, Indonesia. *Applied Geography*, 124, 102319.
- Shah, M. F. and Nordin, R. (2019, March 14). Number rise: 2,775 people affected by Pasir Gudang chemical pollution. *The Star*. Retrieved from <http://www.thestar.com.my/news/nation/2019/03/14/numbers-rise-2,775-people-affected-by-pasir-gudang-chemical-pollution/>
- Sharma, D. and Masison, D. (2009). *Hsp70* structure, function, regulation and influence on yeast prions. *Protein & Peptide Letters*, 16, 571–581.
- Sharma, P., Jha, A. B., Dubey, R. S. and Pessarakli, M. (2012). Reactive oxygen species, oxidative damage, and antioxidative defense mechanism in plants under stressful conditions. *Journal of Botany*, 2012, 1–26.
- Sharma, P. and Pandey, S. (2014). Status of phytoremediation in world scenario. *International Journal of Environmental Bioremediation & Biodegradation*, 2, 178-191.
- Siddiqui, F., Tandon, P. K. and Srivastava, S. (2015). Analysis of arsenic induced physiological and biochemical responses in a medicinal plant, *Withania somnifera*. *Physiology and Molecular Biology of Plants*, 21, 61–69.
- Singh, A. (2021, May 20). How to acclimate tissue culture plants. *Plant Cell Technology*. Retrieved on March 19, 2023 from <https://www.plantcelltechnology.com/blog/how-to-acclimate-tissue-culture-plants/>
- Sinha, D. and Prasad, P. (2020). Health effects inflicted by chronic low-level arsenic contamination in groundwater: A global public health challenge. *Journal of Applied Toxicology*, 40, 87–131.
- Sitko, K., Gieroń, Ż., Szopiński, M., Zieleźnik-Rusinowska, P., Rusinowski, S., Pogrzeba, M., Daszkowska-Golec, A.m Kalaji, H. M. and Małkowski, E. (2019). Influence of short-term macronutrient deprivation in maize on photosynthetic characteristics, transpiration and pigment content. *Scientific Reports*, 9, 1–12.
- Smith, D. R. (2020). Depositing annotated sequences in GenBank: there needs to be a better way. *Briefings in Functional Genomics*, 19, 337–338.

- Tan, Q., Lv, Y., Zhao, F., Zhou, J., Yang, Y., Liu, Y., Zhang, M., Lu, F., Wei, Y., Chen, X., Zhang, R., Chen, C., Wu, B., Zhang, X., Li, C., Huang, H., Cao, J., Cao, Z., Yu, D., Ji, J. S., Zhao, S. and Shi, X. (2021). Association of low blood arsenic exposure with level of malondialdehyde among Chinese adults aged 65 and older. *Science of the Total Environment*, 758, 143638.
- Tangahu, B. V., Rozaimah, S., Abdullah, S., Basri, H., Idris, M., Anuar, N. and Mukhlisin, M. (2011). A review on heavy metals (As, Pb, and Hg) uptake by plants through phytoremediation. *International Journal of Chemical Engineering*, 2011, 1-31.
- Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K. and Sutton, D. J. (2014). Heavy metals toxicity and the environment. *National Institute of Health*, 101, 133-164.
- Tiwari, S., Ketan Sarangi, B. and Avatar Pandey, R. (2014). Efficacy of three different plant species for arsenic phytoextraction from hydroponic system. *Environmental Engineering Research*, 19, 145–149.
- Tsai, T. L., Kuo, C. C., Hsu, L. I., Tsai, S. F., Chiou, H. Y., Chen, C. J., Hsu, K. H. and Wang, S. L. (2021). Association between arsenic exposure, DNA damage, and urological cancers incidence: A long-term follow-up study of residents in an arseniasis endemic area of northeastern Taiwan. *Chemosphere*, 266, 129094.
- Turek, A., Wieczorek, K. and Wolf, W. M. (2019). Digestion procedure and determination of heavy metals in sewage sludge-An analytical problem. *Sustainability*, 11, 4–10.
- ul Haq, S., Khan, A., Ali, M., Khattak, A. M., Gai, W. X., Zhang, H. X., Wei, A. M. and Gong, Z. H. (2019). Heat shock proteins: Dynamic biomolecules to counter plant biotic and abiotic stresses. *International Journal of Molecular Sciences*, 20, 1–31.
- Ullah, I., Mateen, A., Ahmad, M. A., Munir, I., Iqbal, A., Alghamdi, K. M. S., Al-Solami, H. M. and Siddiqui, M. F. (2022). Heavy metal ATPase genes (HMAs) expression induced by endophytic bacteria, "AI001, and AI002" mediate cadmium translocation and phytoremediation. *Environmental Pollution*, 293, 1-7.
- Upadhyay, M. K., Shukla, A., Yadav, P. and Srivastava, S. (2019). A review of arsenic in crops, vegetables, animals and food products. *Food Chemistry*, 276, 608–618.
- Urban, J., Ingwers, M., McGuire, M. A. and Teskey, R. O. (2017). Stomatal conductance increases with rising temperature. *Plant Signaling and Behavior*, 12, e1356534.
- Veschasit, O., Meksumpum, C. and Meksumpum, S. (2012). Heavy metals contamination in water and aquatic plants in the Tha Chin River, Thailand. *Kasetsart Journal – Natural Science*, 46, 931-943.

- Wahab, A., Ismail, S. S., Abidin, E. Z. and Praveena, S. (2014). *Neptunia oleracea* (water mimosa) as phytoremediation plant and the risk to human health: A review. *Advances in Environmental Biology*, 8, 187–194.
- Wan, Y., Wang, Z., Xia, J., Shen, S., Guan, M., Zhu, M., Qiao, C., Sun, F., Ying, L., Li, J., Lu, K. and Qu, C. (2020). Genome-wide analysis of phosphorus transporter genes in *Brassica* and their roles in heavy metal stress tolerance. *International Journal of Molecular Sciences*, 21, 1–26.
- Wang, F., Chen, Z., Pei, H., Guo, Z., Wen, D., Liu, R. and Song, B. (2021). Transcriptome profiling analysis of tea plant (*Camellia sinensis*) using Oxford Nanopore long-read RNA-Seq technology. *Gene*, 769, 145247.
- Wang, J., Wan, Y., Cheng, L., Xia, W., Li, Y. and Xu, S. (2020). Arsenic in outdoor air particulate matter in China: Tiered study and implications for human exposure potential. *Atmospheric Pollution Research*, 11, 785–792.
- Wang, P., Chen, X., Xu, X., Lu, C., Zhang, W. and Zhao, F. J. (2018). Arsenate induced chlorosis 1/ translocon at the outer envelope membrane of chloroplasts 132 protects chloroplasts from arsenic toxicity. *Plant Physiology*, 178, 1568–1583.
- Wang, X., Fernandes de Souza, M., Li, H., Tack, F. M. G., Ok, Y. S. and Meers, E. (2021). Zn phytoextraction and recycling of alfalfa biomass as potential Zn-biofortified feed crop. *Science of the Total Environment*, 760, 143424.
- Weerasinghe, A. and Ariyawansa, S. (2008). Phyto-remediation potential of *Ipomoea aquatica* for Cr (VI) mitigation. *Chemosphere*, 70, 521–524.
- Wei, S., Kohda, Y. H., Inoue, C. and Chien, M. (2021). Expression of *PvPht1;3*, *PvACR2* and *PvACR3* during arsenic processing in root of *Pteris vittata*. *Environmental and Experimental Botany*, 182, 1–7.
- Wen, Z., Xi, J., Lu, J., Zhang, Y., Cheng, G., Zhang, Y. and Chen, R. (2021). Porous biochar-supported MnFe₂O₄ magnetic nanocomposite as an excellent adsorbent for simultaneous and effective removal of organic/inorganic arsenic from water. *Journal of Hazardous Materials*, 411, 1-12.
- Wilson, J. R., Holst, N. and Rees, M. (2005). Determinants and patterns of population growth in water hyacinth. *Aquatic Botany*, 81, 51–67.
- Wilson, M. L., Cai, Y., Hanlon, R., Taylor, S., Chevreux, B., Setubal, J. C., Tyler, B. M. and Peccoud, J. (2013). Sequence verification of synthetic DNA by assembly of sequencing reads. *Nucleic Acids Research*, 41, 1–11.
- Wong, K. W., Yap, C. K., Nulit, R. and Hamzah, M. S. (2017). Effects of anthropogenic activities on the heavy metal levels in the clams and sediments in a tropical river. *Environmental Science and Pollution Research*, 24, 116–134.

- Wu, Y., An, Q., Li, D., Wu, J. and Pan, C. (2019). Comparison of different home/commercial washing strategies for ten typical pesticide residue removal effects in kumquat, spinach and cucumber. *International Journal of Environmental Research and Public Health*, 16, 1–20.
- Wuana, R. A., Okieimen, F. E. and Imborvungu, J. A. (2010). Removal of heavy metals from a contaminated soil using organic chelating acids. *International Journal of Environmental Science & Technology*, 7, 485-496.
- Xu, C., Zhu, J., Yu, H., Yu, H., Yang, Y., Fu, Q., Zhan, D., Wang, Y., Wang, H., Zhang, Y., Li, T., El-Sheekh, M. M., Peng, L. and Xia, T. (2021). Recyclable cascading of arsenic phytoremediation and lead removal coupled with high bioethanol production using desirable rice straws. *Biochemical Engineering Journal*, 21, 107950.
- Xu, Z. S., Li, Z. Y., Chen, Y., Chen, M., Li, L. C. and Ma, Y. Z. (2012). Heat shock protein 90 in plants: Molecular mechanisms and roles in stress responses. *International Journal of Molecular Sciences*, 13, 15706–15723.
- Yadav, B., Chhaya, Dubey, R., Gnanasekaran, P. and Narayan, O. P. (2021). OMICS approaches towards understanding plant's responses to counterattack heavy metal stress: An insight into molecular mechanisms of plant defense. *Plant Gene*, 28, 1-15.
- Yan, A., Wang, Y., Tan, S. N., Mohd Yusof, M. L., Ghosh, S. and Chen, Z. (2020). Phytoremediation: A promising approach for revegetation of heavy metal-polluted land. *Frontiers in Plant Science*, 11, 1–15.
- Yang, J., Teng, Y., Song, L. and Zuo, R. (2016). Tracing sources and contamination assessments of heavy metals in road and foliar dusts in a typical mining city, China. *PLoS ONE*, 11, e0168528.
- Yang, Y., Zhang, L., Huang, X., Zhou, Y., Quan, Q., Li, Y. and Zhu, X. (2020). Response of photosynthesis to different concentrations of heavy metals in *Davidia involucreta*. *PLoS ONE*, 15, e0228563.
- Yang, Z., Yang, F., Liu, J. L., Wu, H. T., Yang, H., Shi, Y., Liu, J., Zhang, Y. F., Luo, Y. R. and Chen, K. M. (2022). Heavy metal transporters: Functional mechanisms, regulation, and application in phytoremediation. *Science of the Total Environment*, 809, 1-21.
- Yap, C. K., Peng, S. H. T. and Leow, C. S. (2019). Contamination in Pasir Gudang Area, Peninsular Malaysia: What can we learn from Kim Kim River chemical waste contamination? *Journal of Humanities and Education Development*, 1, 82–87.
- Ye, L., Wang, L. and Jing, C. (2020). Biotransformation of adsorbed arsenic on iron minerals by coexisting arsenate-reducing and arsenite-oxidizing bacteria. *Environmental Pollution*, 256, 113471.

- Yin, Q., Tian, T., Kou, M., Liu, P., Wang, L., Hao, Z. and Yue, M. (2020). The relationships between photosynthesis and stomatal traits on the Loess Plateau. *Global Ecology and Conservation*, 23, e01146.
- Yin, N., Zhao, Y., Wang, P., Du, H., Yang, M., Han, Z., Chen, X., Sun, G. and Cui, Y. (2021). Effect of gut microbiota on In vitro bioaccessibility of heavy metals and human health risk assessment from ingestion of contaminated soils. *Environmental Pollution*, 279, 116943.
- Zanella, L., Fattorini, L., Brunetti, P., Rocciotiello, E., Cornara, L., D'Angeli, S., Rovere, F. D., Cardarelli, M., Barbieri, M., di Toppi, L. S., Degola, F., Lindberg, S., Altamura, M. M. and Falasca, G. (2016). Overexpression of *AtPCS1* in tobacco increases Arsenic and Arsenic plus Cadmium accumulation and detoxification. *Planta*, 243, 605–622.
- Zemanová, V., Popov, M., Pavlíková, D., Kotrba, P., Hnilička, F., Česká, J. and Pavlík, M. (2020). Effect of arsenic stress on 5-methylcytosine, photosynthetic parameters and nutrient content in arsenic hyperaccumulator *Pteris cretica* (L.) var. *Albo-lineata*. *BMC Plant Biology*, 20, 1–10.
- Zhang, J., Hamza, A., Xie, Z., Hussain, S., Brestic, M., Tahir, M. A., Ulhassan, Z., Yu, M., Allakhverdiev, S. L. and Shabala, S. (2021). Arsenic transport and interaction with plant metabolism: Clues for improving agricultural productivity and food safety. *Environmental Pollution*, 290, 117987.
- Zhang, J., Martinoia, E. and Lee, Y. (2018). Vacuolar transporters for cadmium and arsenic in plants and their applications in phytoremediation and crop development. *Plant and Cell Physiology*, 59, 1317–1325.
- Zhang, K., He, S., Sui, Y., Gao, Q., Jia, S., Lu, X. and Jia, L. (2021). Genome-Wide Characterization of *HSP90* gene family in cucumber and their potential roles in response to abiotic and biotic stresses. *Frontiers in Genetics*, 12, 1-16.
- Zhang, X., Mei, X., Wang, Y., Huang, G., Feng, F., Liu, X., Guo, R., Gu, F., Hu, X., Yang, Z., Zhong, X. and Li, Y. (2020). Stomatal conductance bears no correlation with transpiration rate in wheat during their diurnal variation under high air humidity. *PeerJ*, 8, 1–16.
- Zhao, R., Xie, C. T., Xu, Y., Ji, D. H., Chen, C. S., Ye, J., Xu, X. M. and Wang, W. L. (2020). The response of *Pyropia haitanensis* to inorganic arsenic under laboratory culture. *Chemosphere*, 261, 1-10.
- Zhou, J., Li, Z., Xiao, G., Zhai, M., Pan, X., Huang, R. and Zhang, H. (2020). *CYP71D8L* is a key regulator involved in growth and stress responses by mediating gibberellin homeostasis in rice. *Journal of Experimental Botany*, 71, 1160–1170.

Zhou, Y., Lei, J., Zhang, Y., Zhu, J., Lu, Y., Wu, X. and Fang, H. (2018). Determining discharge characteristics and limits of heavy metals and metalloids for wastewater treatment plants (WWTPs) in China based on statistical methods. *Water*, 10, 1–17.

Zhu, Y. G. and Rosen, B. P. (2009). Perspective for genetic engineering for the phytoremediation of arsenic-contaminated environments: from imagination to reality?. *Current Opinion in Biotechnology*, 176, 139–148.

Zulfiqar, F. and Ashraf, M. (2022). Antioxidants as modulators of arsenic-induced oxidative stress tolerance in plants: An overview. *Journal of Hazardous Materials*, 427, 127891.

