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Bioremediation Potential of Heavy Metal and Pesticide-Tolerant Poacea Endophytes from an Open Pit Mining Area in Benguet, Philippines

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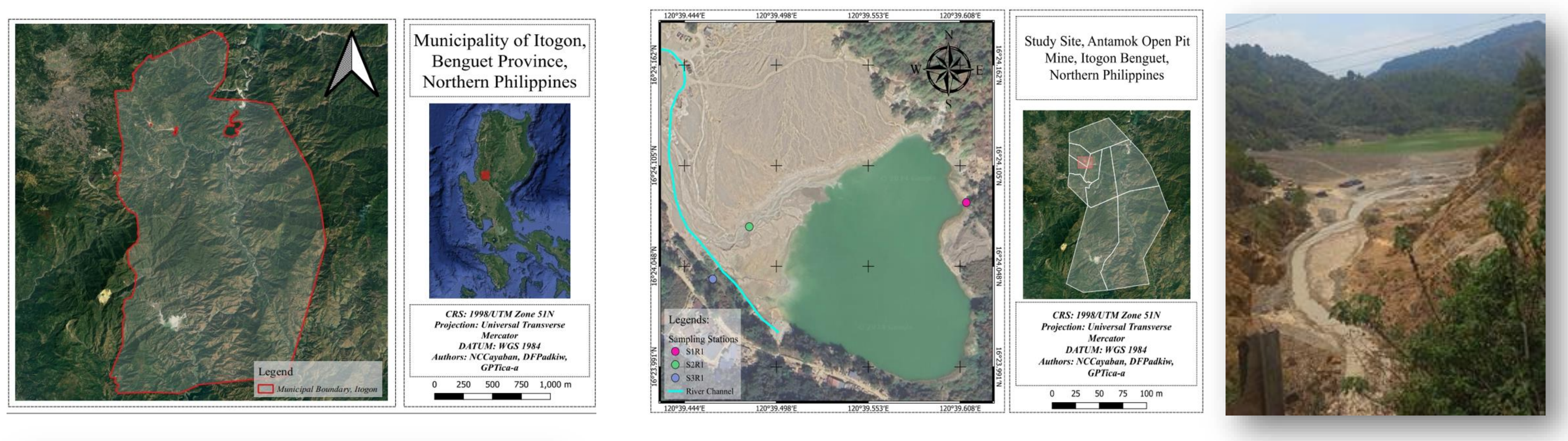
INTRODUCTION & AIM

- Heavy metal and chemical pesticides are two of the most common pollutants in agricultural soils in Benguet, a province in the highlands of northern Philippines, where mining and agriculture are the biggest drivers of the economy.
- Members of the *Poaceae* family of grasses have been identified as hyperaccumulators of metals such as Lead (Pb), Arsenic (As), Cadmium (Cd), Copper (Cu), and Zinc (Zn) (Sladkovska et al., 2022).
- Microorganisms associated with the *Poaceae* family, such as endophytes, in the cortical tissue of the roots and rhizosphere bacteria can contribute to the bioremediation of organic and inorganic contaminants in the soil and enhance plant health and development (Guarino *et al*., 2020).
- Few studies have presented a dual tolerance of microorganisms and their potential to remediate both heavy metal- and organophosphate pesticide-contaminated areas.
- This study recovered and characterized endophytic bacteria and fungi from *Poaceae* plants growing on mine tailings at Antamok Open Pit in Itogon, Benguet, and screened them for tolerance to Hg, Cd, Pb, Z, and Cu, as well as for the OP pesticides, chlorpyrifos and malathion; and evaluated their mechanism for bioremediation facilitated by enzymatic activities, biosurfactant production, radical scavenging potential, and plant growth-promoting characteristics.

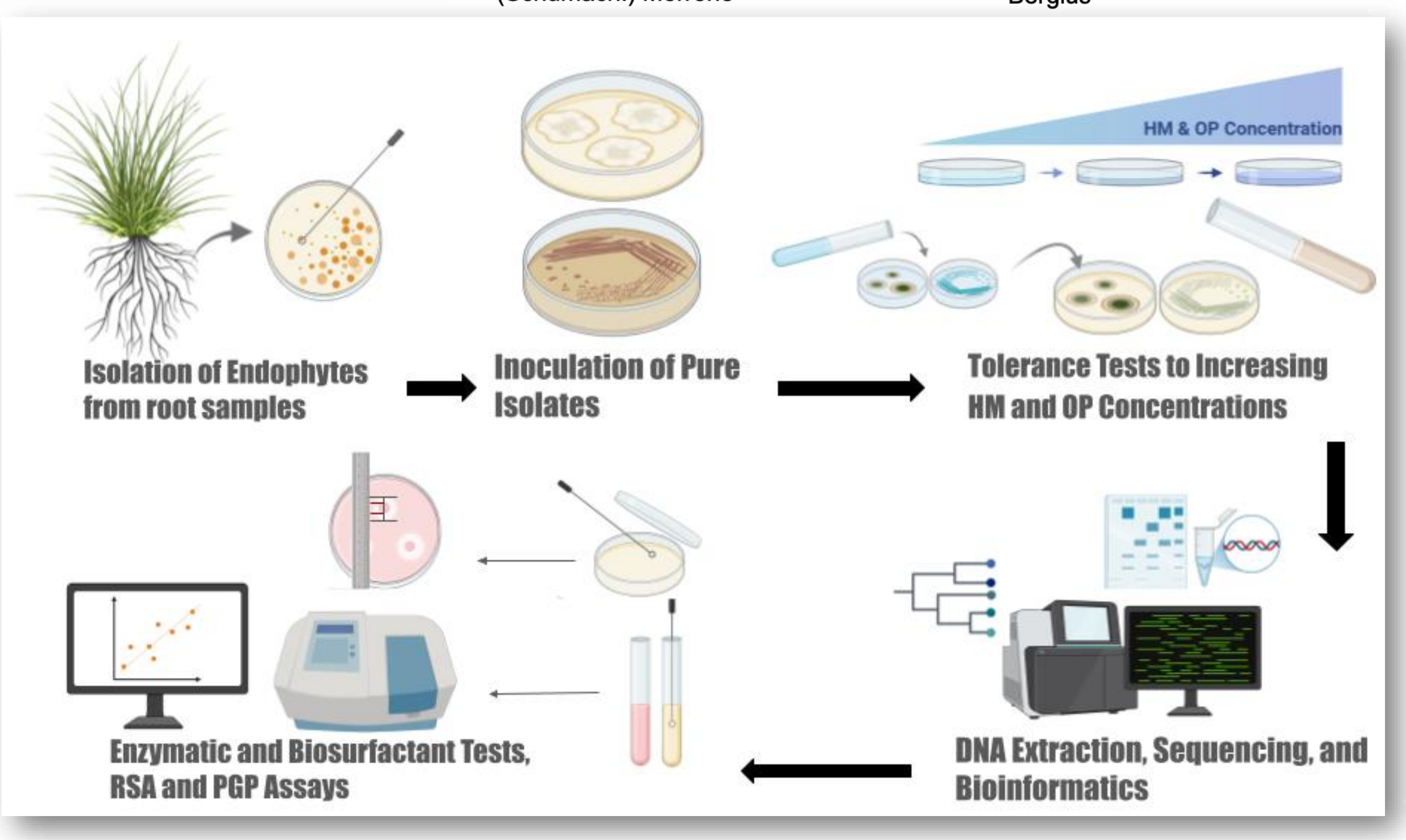
METHOD



Cenchrus purpureus (Schumach.) Morrone

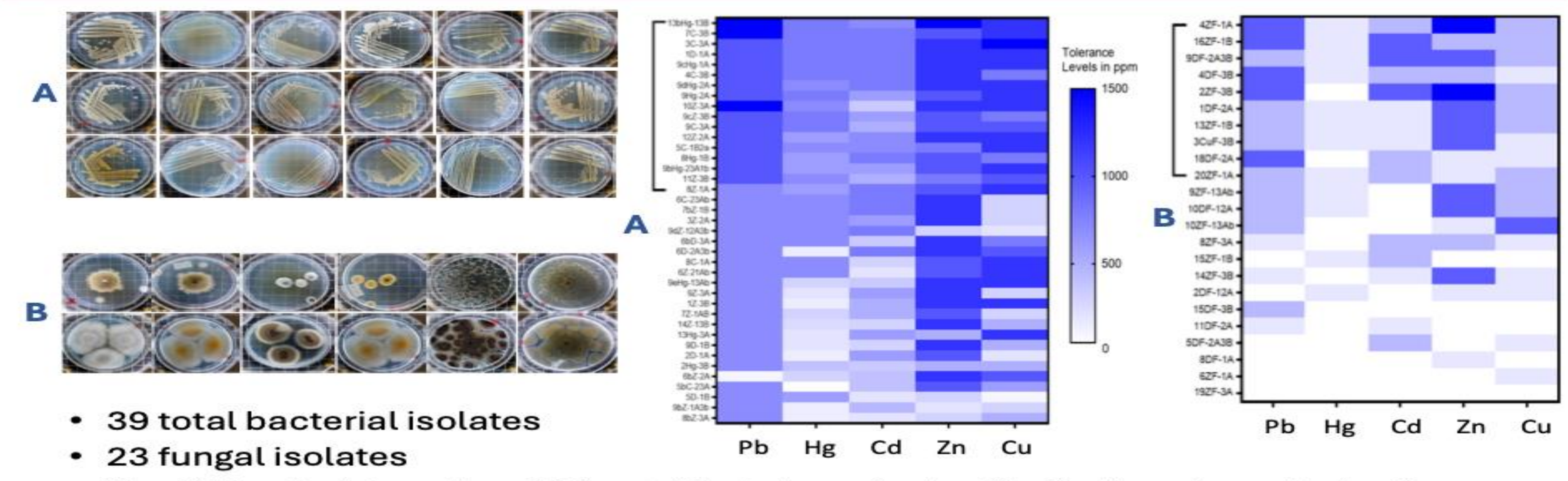
Saccharum spontanaeum L.

Paspalum conjugatum P.J. Bergius



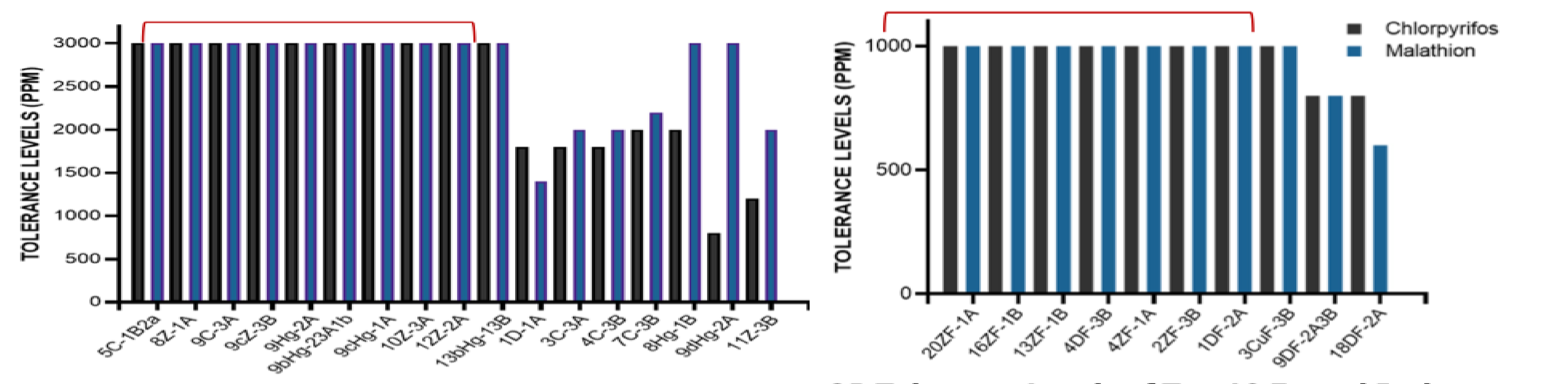
RESULTS & DISCUSSION

RECOVERED ENDOPHYTIC BACTERIA (A) AND FUNGI (B) AND THEIR MIC TOLERANCE TO HM



- 39 total bacterial isolates
- 23 fungal isolates
- Top 17 bacterial and top 10 fungal isolates selected for further characterization

RESISTANCE OF HM-TOLERANT ENDOPHYTES TO CHLORPYRIFOS AND MALATHION

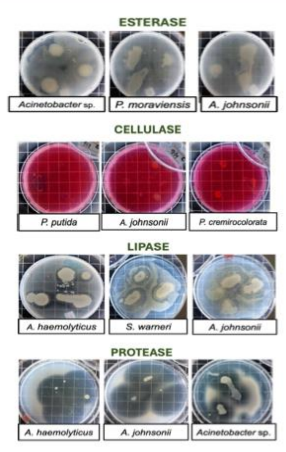


OP Tolerance Levels of Top 17 Bacterial Isolates

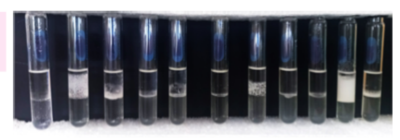
OP Tolerance Levels of Top 10 Fungal Isolates

ENZYMATIC AND BIOSURFACTANT ACTIVITIES OF BACTERIAL ISOLATES

CODE	BACTERIAL ISOLATES	LIPASE	ESTERASE	BIOSUR FACTANT (%)
9Hg-2A	*Acinetobacter haemolyticus*	-	-	44.19
9cHg-1A	*Acinetobacter johnsonii*	+	-	10.0
9bHg-23A1b	*Acinetobacter sp.*	-	+	2.33
5C-1B2a	*Pseudomonas cremoricolorata*	-	-	2.33
12Z-2A	*Bacillus cereus*	-	-	0
13bHg-13B	*Acinetobacter haemolyticus*	+	-	23.26
9cZ-3B	*Pseudomonas putida*	-	-	6.67
8Z-1A	*Staphylococcus warneri*	-	+	2.22
9C-3A	*Pseudomonas moraviensis*	+	-	46.51
10Z-3A	*Staphylococcus saprophyticus*	-	+	11.63



BIOSURFACTANT PRODUCTION



Bacterial Isolates	Biosurfactant Index
Acinetobacter haemolyticus	44.19
Acinetobacter johnsonii	10.0
Acinetobacter sp.	2.33
Pseudomonas cremoricolorata	2.33
Bacillus cereus	-
Acinetobacter haemolyticus	23.26
Pseudomonas putida	6.67
Staphylococcus warneri	2.22
Pseudomonas moraviensis	46.51
Staphylococcus saprophyticus	11.63

Fungal Isolates	Biosurfactant Index
Penicillium chrysogenum	28.0
Aspergillus japonicus	4.2
Aspergillus fumigatus	4.0
Aspergillus aculeatus	20.0
Penicillium citrinum	4.0
Penicillium crustosum	13.0
Bjerkandera atroalba	0.0
Aspergillus aculeatus	4.0

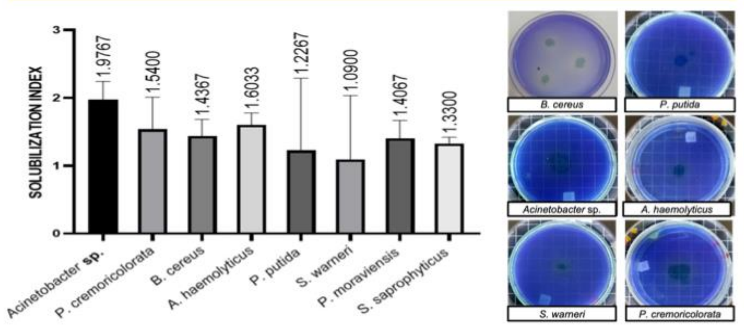
RADICAL SCAVENGING ACTIVITY (%) OF MICROBIAL ISOLATES USING DPPH ASSAY

Bacterial Isolates	Cu	Pb	Zn	Cd	Hg	Control
Acinetobacter haemolyticus	47.4	12.4	49.6	15.8	21.8	24.8
Acinetobacter johnsonii	43.2	35.0	22.9	9.0	21.1	9.0
Acinetobacter sp.	20.7	19.9	29.0	6.0	30.8	14.7
Pseudomonas cremoricolorata	36.1	37.6	35.0	6.4	36.5	16.9
Bacillus cereus	48.1	38.7	52.3	10.2	18.4	22.6
Acinetobacter haemolyticus	40.2	40.2	32.2	13.9	17.3	7.1
Pseudomonas putida	15.4	11.7	39.5	12.0	36.5	10.9
Staphylococcus warneri	26.3	35.3	42.1	38.0	20.7	53.0
Pseudomonas moraviensis	35.3	25.6	50.4	15.4	25.2	17.3
Staphylococcus saprophyticus	11.3	36.8	15.0	32.7	17.7	13.2

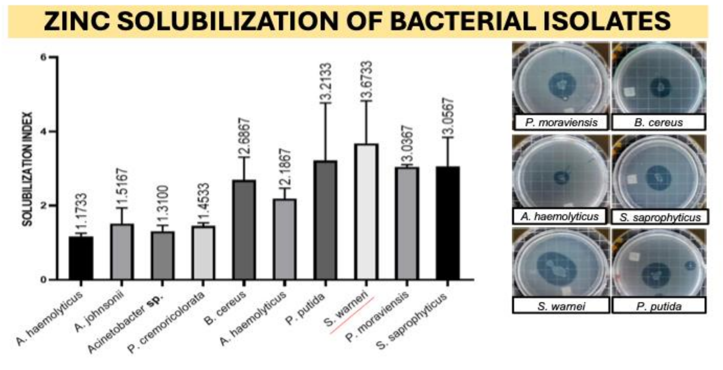
Fungal Isolates	Cu	Pb	Zn	Cd	Hg	Control
Penicillium chrysogenum	29.3	56.9	29.3	39.0	19.1	58.5
Aspergillus japonicus	27.8	59.8	31.1	54.8	37.2	41.8
Aspergillus fumigatus	41.1	72.5	40.5	0.6	33.6	59.0
Aspergillus aculeatus	34.1	53.3	44.6	54.3	25.1	61.4
Penicillium citrinum	42.5	75.1	36.3	38.9	41.0	68.6
Penicillium crustosum	47.3	73.3	31.9	87.0	39.9	58.3
Bjerkandera atroalba	31.5	46.9	48.6	58.4	37.4	47.9
Aspergillus aculeatus	27.4	53.6	35.1	50.3	31.5	51.4

PLANT GROWTH PROMOTION

PHOSPHATE SOLUBILIZATION OF BACTERIAL ISOLATES

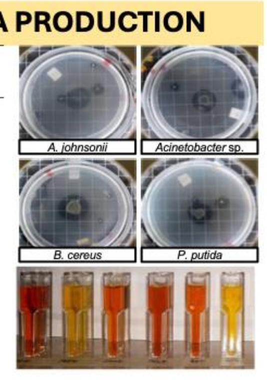


ZINC SOLUBILIZATION OF BACTERIAL ISOLATES

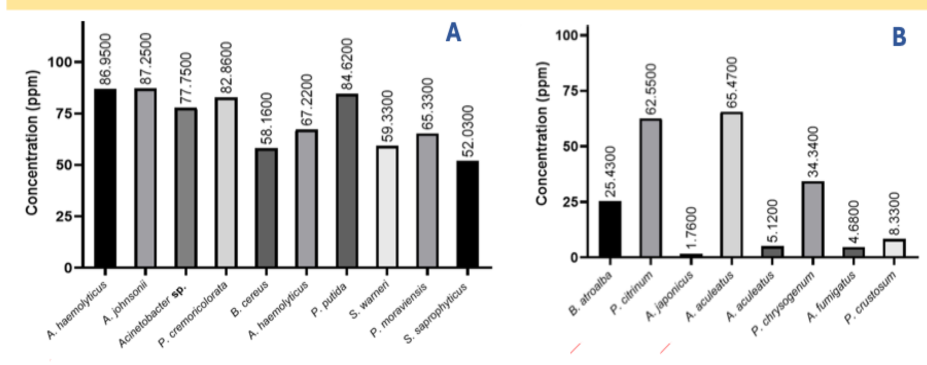


NITROGEN FIXATION AND AMMONIA PRODUCTION

Isolates	Nitrogen fixation	Ammonia
Acinetobacter haemolyticus	-	107.74
Acinetobacter johnsonii	+	108.61
Acinetobacter sp.	+	115.07
Pseudomonas cremoricolorata	-	115.06
Bacillus cereus	+	116.68
Acinetobacter haemolyticus	-	117.76
Pseudomonas putida	+	110.69
Staphylococcus warneri	+	103.10
Pseudomonas moraviensis	+	112.22
Staphylococcus saprophyticus	+	103.16



IAA PRODUCTION OF BACTERIAL (A) AND FUNGAL (B) ISOLATES



CONCLUSION

Positive Bioremediation Potential of Top Isolates

Present mechanisms to counteract different stresses, which are not necessarily through the degradation of OP

Potential applications in the development of a consortium-based biofertilizer for use on plants in polluted environments.

FUTURE WORK / REFERENCES

- Sladkovska, T., Wolski, K., Bujak, H., Radkowski, A., & Sobol, Ł. (2022). A review of research on the use of selected grass species in removal of heavy metals. Agronomy, 12(10), 2587.
- Guarino, C., Marziano, M., Tartaglia, M., Prigioniero, A., Postiglione, A., Scarano, P., & Sciarrillo, R. (2020). Poaceae with PGPR bacteria and arbuscular mycorrhizae partnerships as a model system for plant microbiome manipulation for phytoremediation of petroleum hydrocarbons contaminated agricultural soils. Agronomy, 10(4), 547.