

# Heavy Metal Uptake Efficiency of Alfalfa, Barley, Indian Mustard and *Atriplex* from Contaminated Desert Soil

HAMED ADNAN ALAQEEL

- Oil contaminated soil is a common problem within the oil production area.





# Objective

- Determine the efficiency of alfalfa, Indian mustard, *Atriplex*, and barley seedlings for remediation of oil-contaminated soil.



# I. Clean and oil-contaminated soils

- Clean soil and oil-contaminated soil.
- Plants used: Alfalfa, barley, and indian mustard.
- Period 50 days.

## II. Heavy metals mix

- Clean commercial soil mix.
- Plants: Alfalfa, Barley, Indian Mustard and Atriplex
- Heavy metal mix were four types:
  - 1X:  $\text{Pb}(\text{NO}_3)_2$  at 75 mg/L +  $\text{CdSO}_4$  at 20 mg/L +  $\text{CuSO}_4$  at 5 mg/L +  $\text{NiSO}_4$  at 10 mg/L +  $\text{Na}_3\text{VO}_4$  at 10 mg/L.
  - 10X:  $\text{Pb}(\text{NO}_3)_2$  at 750 mg/L +  $\text{CdSO}_4$  at 200 mg/L +  $\text{CuSO}_4$  at 50 mg/L +  $\text{NiSO}_4$  at 100 mg/L +  $\text{Na}_3\text{VO}_4$  at 100 mg/L.
- ETHYLENEDIAMINETETRAACETIC ACID (EDTA)
  - 1X + EDTA
  - 10X + EDTA
  - At 50 mM (50ml)

# Methods used to evaluate the present of heavy metal

- Heavy metals in the soil were measured.
  - Inductively coupled plasma atomic emission spectroscopy (ICP-AES).
- Total petroleum hydrocarbons were measured.
  - Gas chromatography with flame ionization detection (GC-FID)

# Result

## I .Clean and oil-contaminated soils

Growth of barley, alfalfa, Indian mustard in control and oil-contaminated soil.

a: clean soil; b: 0.8% TPH and c: 3% TPH



## Level of Vanadium, Lead, Nickel and Copper Content in Oil-contaminated Soil

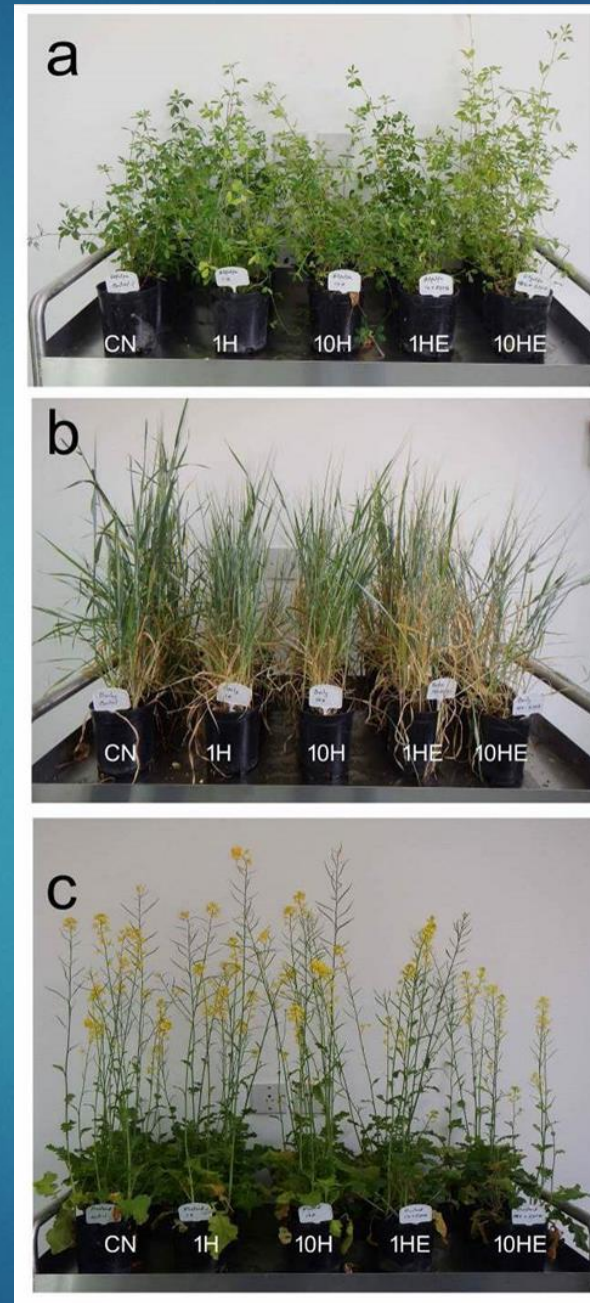
Heavy metal	Control soil without plants	Soil contain Barley	Soil contain Indian Mustard	Soil contain Alfalfa
Vanadium	17.43 ± 0.13 <sup>a</sup>	15.50 ± 3.51 <sup>a</sup>	12.97 ± 1.11 <sup>b</sup>	14.70 ± 0.55 <sup>b</sup>
Lead	2.43 ± 0.26 <sup>a</sup>	2.16 ± 0.24 <sup>a</sup>	1.71 ± 0.12 <sup>b</sup>	2.11 ± 0.21 <sup>a</sup>
Nickel	14.27 ± 1.73 <sup>a</sup>	13.24 ± 1.42 <sup>ab</sup>	8.39 ± 0.45 <sup>b</sup>	9.43 ± 0.62 <sup>ab</sup>
Copper	4.62 ± 0.06 <sup>a</sup>	3.72 ± 0.59 <sup>a</sup>	3.87 ± 0.2 <sup>a</sup>	4.04 ± 0.31 <sup>a</sup>



# Result

## II. Heavy metals mix

- (a) alfalfa
- (b) barley
- (c) Indian mustard



# Level of Cadmium Content

Plant	Control	1H	1H+EDTA	10H	10H + EDTA
<b>Cd – root</b>					
<b>Alfalfa</b>	0.54 ± 0.01 <sup>a</sup>	1.55 ± 0.22 <sup>a</sup>	2.58 ± 0.52 <sup>a</sup>	4.46 ± 0.21 <sup>a</sup>	19.90 ± 0.60 <sup>a</sup>
<b>Barley</b>	0.67 ± 0.09 <sup>a</sup>	3.02 ± 0.27 <sup>b</sup>	0.76 ± 0.02 <sup>a</sup>	3.69 ± 1.05 <sup>a</sup>	4.57 ± 1.24 <sup>b</sup>
<b>Indian mustard</b>	1.05 ± 0.42 <sup>a</sup>	0.85 ± 0.16 <sup>c</sup>	0.85 ± 0.21 <sup>a</sup>	5.92 ± 1.05 <sup>a</sup>	6.36 ± 0.36 <sup>b</sup>
<b>Cd - shoot</b>					
<b>Alfalfa</b>	0.72 ± 0.03 <sup>a</sup>	0.76 ± 0.05 <sup>a</sup>	0.76 ± 0.00 <sup>a</sup>	1.34 ± 0.02 <sup>a</sup>	2.02 ± 0.40 <sup>ab</sup>
<b>Barley</b>	0.67 ± 0.09 <sup>a</sup>	0.71 ± 0.07 <sup>a</sup>	0.79 ± 0.21 <sup>a</sup>	1.95 ± 0.43 <sup>a</sup>	1.58 ± 0.33 <sup>a</sup>
<b>Indian mustard</b>	0.75 ± 0.06 <sup>a</sup>	1.03 ± 0.07 <sup>a</sup>	2.00 ± 0.12 <sup>a</sup>	5.36 ± 0.77 <sup>a</sup>	8.77 ± 0.59 <sup>b</sup>

# Level of Lead Content

Plant	Control	1H	1H+EDTA	10H	10H + EDTA
<b>Pb – root</b>					
<b>Alfalfa</b>	1.90 ± 0.30 <sup>a</sup>	6.81 ± 2.4 <sup>a</sup>	3.10 ± 1.00 <sup>a</sup>	9.65 ± 2.65 <sup>a</sup>	20.35 ± 0.55 <sup>a</sup>
<b>Barley</b>	3.55 ± 0.05 <sup>a</sup>	6.40 ± 2.5 <sup>a</sup>	4.15 ± 0.65 <sup>a</sup>	8.50 ± 2.00 <sup>a</sup>	16.20 ± 0.40 <sup>b</sup>
<b>Indian mustard</b>	3.81 ± 0.41 <sup>a</sup>	4.75 ± 1.55 <sup>a</sup>	6.70 ± 2.10 <sup>a</sup>	11.85 ± 0.25 <sup>a</sup>	18.80 ± 3.50 <sup>ab</sup>
<b>Pb - shoot</b>					
<b>Alfalfa</b>	1.45 ± 0.05 <sup>a</sup>	1.50 ± 0.10 <sup>a</sup>	1.50 ± 0.00 <sup>a</sup>	1.65 ± 0.15 <sup>a</sup>	3.05 ± 0.95 <sup>a</sup>
<b>Barley</b>	1.35 ± 0.15 <sup>a</sup>	1.20 ± 0.41 <sup>a</sup>	1.90 ± 0.70 <sup>a</sup>	2.45 ± 0.95 <sup>ab</sup>	7.74 ± 1.87 <sup>a</sup>
<b>Indian mustard</b>	1.40 ± 0.00 <sup>a</sup>	2.10 ± 0.20 <sup>a</sup>	1.85 ± 0.05 <sup>a</sup>	2.60 ± 0.10 <sup>b</sup>	4.65 ± 0.85 <sup>a</sup>

# Level of Copper Content

Plant	Control	1H	1H+EDTA	10H	10H + EDTA
Cu - root					
Alfalfa	14.55 ± 0.95 <sup>a</sup>	10.14 ± 2.57 <sup>a</sup>	13.75 ± 1.25 <sup>a</sup>	8.72 ± 0.08 <sup>a</sup>	14.00 ± 1.70 <sup>a</sup>
Barley	13.35 ± 2.15 <sup>a</sup>	10.40 ± 0.50 <sup>a</sup>	9.30 ± 0.20 <sup>a</sup>	8.70 ± 0.10 <sup>a</sup>	15.65 ± 2.25 <sup>a</sup>
Indian Mustard	17.85 ± 3.65 <sup>a</sup>	26.35 ± 14.35 <sup>a</sup>	15.25 ± 0.85 <sup>a</sup>	9.50 ± 0.40 <sup>a</sup>	13.70 ± 0.90 <sup>a</sup>
Cu - shoot					
Alfalfa	4.30 ± 0.00 <sup>a</sup>	3.95 ± 0.25 <sup>a</sup>	7.30 ± 0.00 <sup>a</sup>	3.90 ± 0.10 <sup>a</sup>	10.00 ± 1.10 <sup>a</sup>
Barley	5.40 ± 0.40 <sup>a</sup>	4.46 ± 0.25 <sup>b</sup>	6.30 ± 0.30 <sup>a</sup>	4.10 ± 0.30 <sup>a</sup>	7.52 ± 0.68 <sup>a</sup>
Indian Mustard	5.85 ± 1.25 <sup>a</sup>	4.55 ± 0.05 <sup>ab</sup>	6.90 ± 0.20 <sup>a</sup>	4.10 ± 0.20 <sup>a</sup>	6.20 ± 0.40 <sup>a</sup>

# Level of Nickel Content

	Control	1H	1H+EDTA	10H	10H + EDTA
<b>Ni - root</b>					
<b>Alfalfa</b>	8.15 ± 0.85 <sup>a</sup>	15.75 ± 4.05 <sup>a</sup>	13.60 ± 1.80 <sup>a</sup>	16.90 ± 3.60 <sup>a</sup>	15.85 ± 4.05 <sup>a</sup>
<b>Barley</b>	14.30 ± 2.20 <sup>a</sup>	25.70 ± 0.30 <sup>a</sup>	17.15 ± 6.25 <sup>ab</sup>	46.30 ± 25.90 <sup>a</sup>	29.95 ± 21.05 <sup>a</sup>
<b>Indian Mustard</b>	36.65 ± 15.85 <sup>a</sup>	14.50 ± 1.70 <sup>a</sup>	11.55 ± 1.65 <sup>b</sup>	16.80 ± 0.20 <sup>a</sup>	15.00 ± 4.70 <sup>a</sup>
<b>Ni - shoot</b>					
<b>Alfalfa</b>	2.40 ± 0.90 <sup>a</sup>	3.95 ± 2.55 <sup>a</sup>	1.80 ± 0.30 <sup>a</sup>	2.45 ± 0.15 <sup>a</sup>	1.75 ± 0.15 <sup>a</sup>
<b>Barley</b>	3.85 ± 1.15 <sup>a</sup>	4.08 ± 0.68 <sup>a</sup>	6.20 ± 0.80 <sup>a</sup>	1.70 ± 0.30 <sup>a</sup>	4.56 ± 0.04 <sup>b</sup>
<b>Indian Mustard</b>	5.75 ± 3.45 <sup>a</sup>	2.10 ± 0.20 <sup>a</sup>	3.45 ± 0.35 <sup>a</sup>	1.50 ± 0.10 <sup>a</sup>	3.15 ± 1.15 <sup>ab</sup>

# Level of Vanadium Content

Plant	Control	1H	1H+EDTA	10H	10H + EDTA
V – root					
Alfalfa	7.15 ± 0.05 <sup>a</sup>	11.45 ± 0.95 <sup>a</sup>	11.15 ± 2.95 <sup>a</sup>	31.75 ± 3.85 <sup>a</sup>	35.65 ± 2.95 <sup>a</sup>
Barley	7.35 ± 0.35 <sup>a</sup>	10.65 ± 0.35 <sup>a</sup>	10.90 ± 0.80 <sup>a</sup>	35.20 ± 12.40 <sup>ab</sup>	63.20 ± 10.00 <sup>a</sup>
Indian Mustard	7.60 ± 1.50 <sup>a</sup>	16.55 ± 5.35 <sup>a</sup>	9.05 ± 1.05 <sup>a</sup>	47.30 ± 3.50 <sup>b</sup>	50.50 ± 4.50 <sup>a</sup>
V - shoot					
Alfalfa	2.85 ± 0.05 <sup>a</sup>	3.05 ± 0.15 <sup>a</sup>	3.00 ± 0.00 <sup>a</sup>	2.95 ± 0.05 <sup>a</sup>	3.20 ± 0.0 <sup>a</sup>
Barley	2.65 ± 0.35 <sup>a</sup>	2.35 ± 0.75 <sup>a</sup>	3.15 ± 0.85 <sup>a</sup>	5.05 ± 2.05 <sup>a</sup>	2.40 ± 0.50 <sup>a</sup>
Indian Mustard	2.75 ± 0.05 <sup>a</sup>	4.15 ± 0.35 <sup>a</sup>	3.05 ± 0.05 <sup>a</sup>	3.00 ± 0.20 <sup>a</sup>	2.25 ± 0.05 <sup>a</sup>



# Level of Heavy Metal Content

Treatment	Cd	Pb	Cu	Ni	V
<b>Root</b>					
Control	0.21 ± 0.02 <sup>a</sup>	1.74 ± 0.37 <sup>a</sup>	258.00 ± 65.00 <sup>a</sup>	8.58 ± 1.35 <sup>ab</sup>	7.54 ± 0.89 <sup>ab</sup>
1H	0.19 ± 0.00 <sup>a</sup>	2.26 ± 0.24 <sup>ab</sup>	270.67 ± 66.97 <sup>a</sup>	8.43 ± 0.97 <sup>a</sup>	6.87 ± 1.33 <sup>ab</sup>
1H+EDTA	0.20 ± 0.02 <sup>a</sup>	2.80 ± 0.54 <sup>ab</sup>	378.00 ± 36.25 <sup>ab</sup>	18.03 ± 4.17 <sup>b</sup>	10.87 ± 0.72 <sup>b</sup>
10H	0.38 ± 0.13 <sup>ab</sup>	3.21 ± 0.04 <sup>b</sup>	294.67 ± 45.12 <sup>a</sup>	11.07 ± 0.78 <sup>ab</sup>	9.59 ± 0.49 <sup>ab</sup>
10H+EDTA	0.58 ± 0.07 <sup>b</sup>	3.34 ± 0.72 <sup>b</sup>	598.00 ± 88.46 <sup>b</sup>	17.47 ± 0.52 <sup>ab</sup>	6.82 ± 0.64 <sup>a</sup>
<b>Shoot</b>					
Control	0.20 ± 0.02 <sup>a</sup>	0.46 ± 0.01 <sup>a</sup>	12.50 ± 1.11 <sup>a</sup>	0.70 ± 0.08 <sup>a</sup>	0.79 ± 0.08 <sup>a</sup>
1H	0.20 ± 0.02 <sup>a</sup>	0.52 ± 0.04 <sup>a</sup>	16.53 ± 2.21 <sup>a</sup>	0.88 ± 0.05 <sup>a</sup>	0.80 ± 0.06 <sup>a</sup>
1H+EDTA	0.22 ± 0.02 <sup>a</sup>	3.90 ± 0.54 <sup>b</sup>	226.67 ± 19.88 <sup>b</sup>	4.71 ± 0.17 <sup>b</sup>	0.66 ± 0.04 <sup>a</sup>
10H	0.17 ± 0.01 <sup>a</sup>	0.56 ± 0.04 <sup>a</sup>	20.40 ± 3.79 <sup>a</sup>	2.64 ± 0.57 <sup>c</sup>	0.69 ± 0.03 <sup>a</sup>
10H+EDTA	0.82 ± 0.12 <sup>b</sup>	5.46 ± 0.72 <sup>b</sup>	221.67 ± 35.93 <sup>b</sup>	4.35 ± 0.32 <sup>b</sup>	0.64 ± 0.02 <sup>a</sup>



# Conclusion

- Significant reduction on heavy metal (Ni, Pb, and V) in oil-contaminated soil using alfalfa and Indian mustard.
- Barley can tolerate the toxicity of oil-contaminated soil better than other plants, but remediation process wasn't so efficient.
- EDTA did improve heavy metal uptake by the plants.
- Roots accumulate more Cd comparing to Shoots.
- Maximum accumulation of Cd was observed in barley roots.
- At present of EDTA alfalfa root accumulate more Cd comparing to other plants.

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