OKRA LEAVES AS AN ECONOMICAL SORBENT FOR THE REMOVAL OF NICKEL, COPPER LEAD AND CADMIUM FROM DRINKING/ WASTE WATER

Saima Q. Memon and M.I Khaskheli

Institute for Advance Research Studies in Chemical Sciences, University of Sindh, Jamshoro, Pakistan

Metal ion pollution

- The oldest toxin known to man
- Toxic in relatively low concentrations
- Do not degrade into harmless end product
- Bioaccumulation in living organisms

Metal ion pollution

Sources:

- Erosion of natural rock deposits
- Mine activities
- Refineries waste water
- waste from industries of electroplating
- Sewage producers industries
- Corrosion of pipes
- Paints
- Deficient disposal of rechargeable batteries

Tolerable limits of metal uptake

Metal	Uptake Limit
Nickel	0.70 mg/L.
Copper	2mg/L
Cadmium	0.003 mg/L
Lead	1.2-1.3 mg/kg

Health Effects

Metal	Health Effects
Nickel	skin allergies, lung fibrosis, LT-cancer of the respiratory tract
Copper	ST-Gastrointestinal problems LT- Kidney and liver damage
Cadmium	LT- Renal and hepatic failures, blood and bones damage
Lead	I- Development problems A- Kidney damage, cause high blood pressure, stroke, and cancer

LT- long term, ST- short term, A-adults, I-Infants

Common Treatment Technologies

- Chemical precipitation
- reverse osmosis
- ion-exchange
- filtration
- evaporative recovery

Disadvantages:

- Usually expensive
- Inefficient for treatment of effluents containing metal ions in the range of 100 mg/l

An Alternative

Adsorption

- **Synthetic**

Modified Adsorbents e.g.
Chelate modified XADs

- Usually expensive
- Need organic solvents

An Alternative

Natural Adsorbents

Rice Husk, Sawdust, Peanut husk, Fungal biomass

- Most are modified (with mineral acids, EDTA)
- Mostly used for 1 to 3 metal ions.

Objectives

- The present study pretends to remove toxic metals (Ni, Cu, Cd, and Pb) using Okra leaves as sorbent.

OKRA Leaves – A Potential adsorbent

Scientific name: *Abelmoschus esculentus* (L.) Moench

Family:Malvaceae (Mallow family)

Common name: Okra, Lady's finger

Distribution: Okra is grown in tropical regions and the relatively warmer temperate regions

Leaves: The hand-shaped leaves are 10 to 20 centimeters long with 5 to 7 lobes

Experimental Design

Washed

Dried (80 ˚C) Crushed

Dried leaves in metal ion solution

Metal ion solution (0-200 mg/L)

25±1°C

Sample were taken out at different time interval

Samples were acidified

Analyzed by AAS

Data manipulation

The percentage adsorption of all four metal ions was determined using following equations.

$$\%Sorption = \frac{A_i - A_f}{A_i} \times 100$$

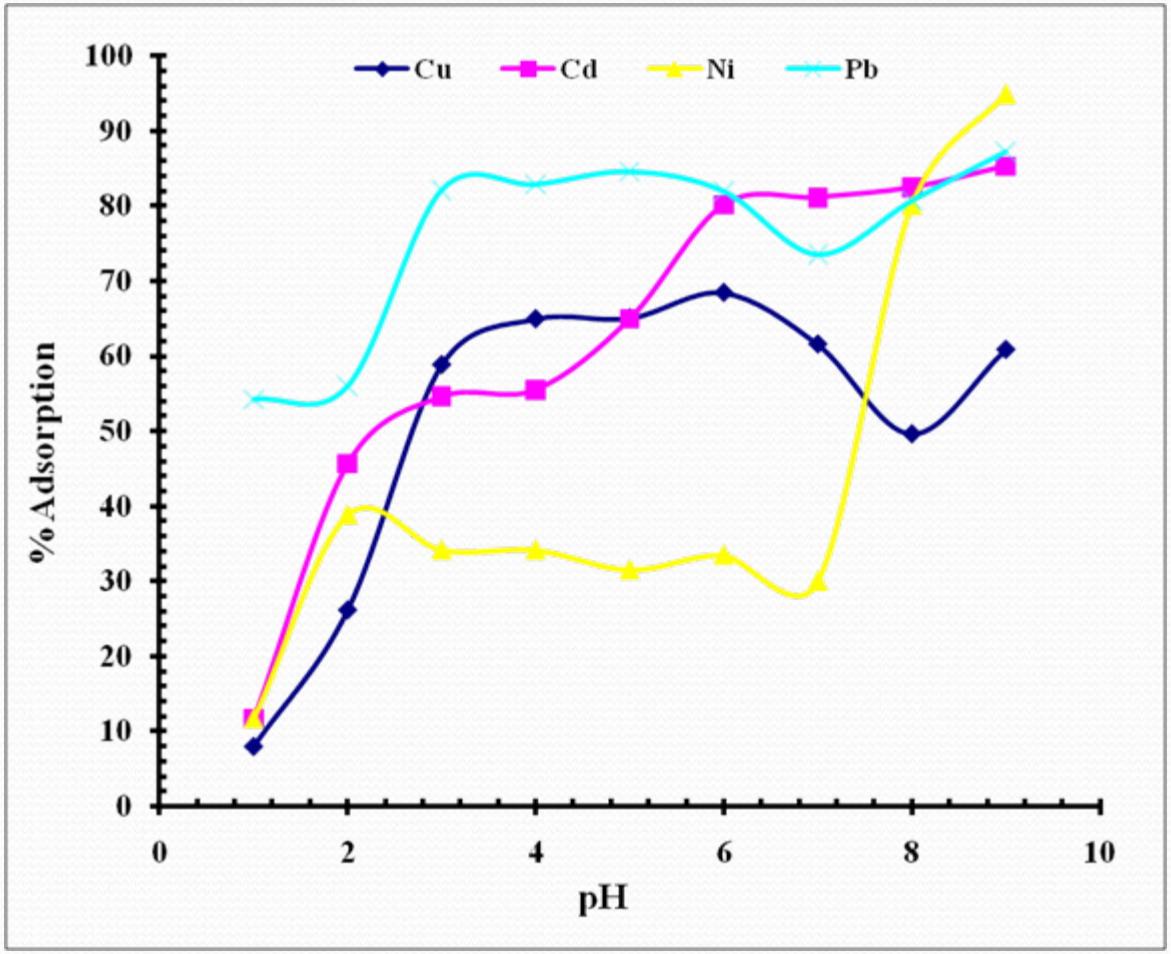
where

A_i = Absorbance of solution before adsorption

A_f = Absorbance of solution after adsorption

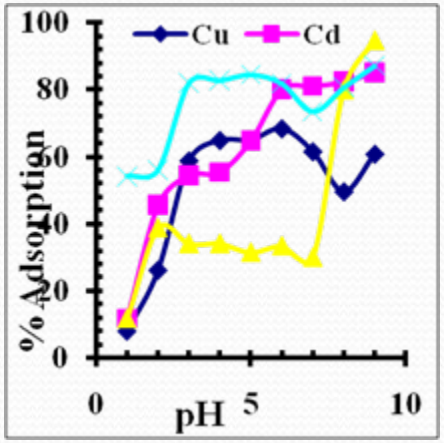
Adsorption Optimization

Effect of pH

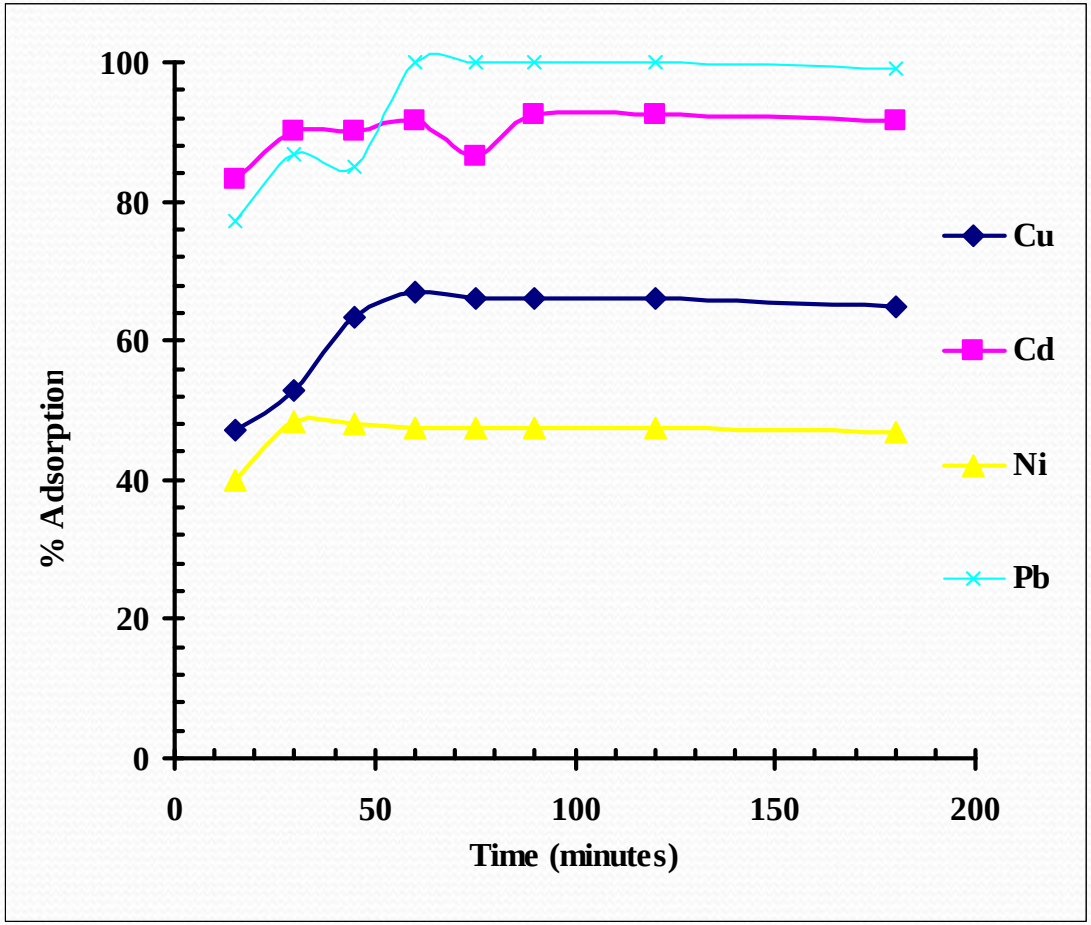


Metal ion species at different pH

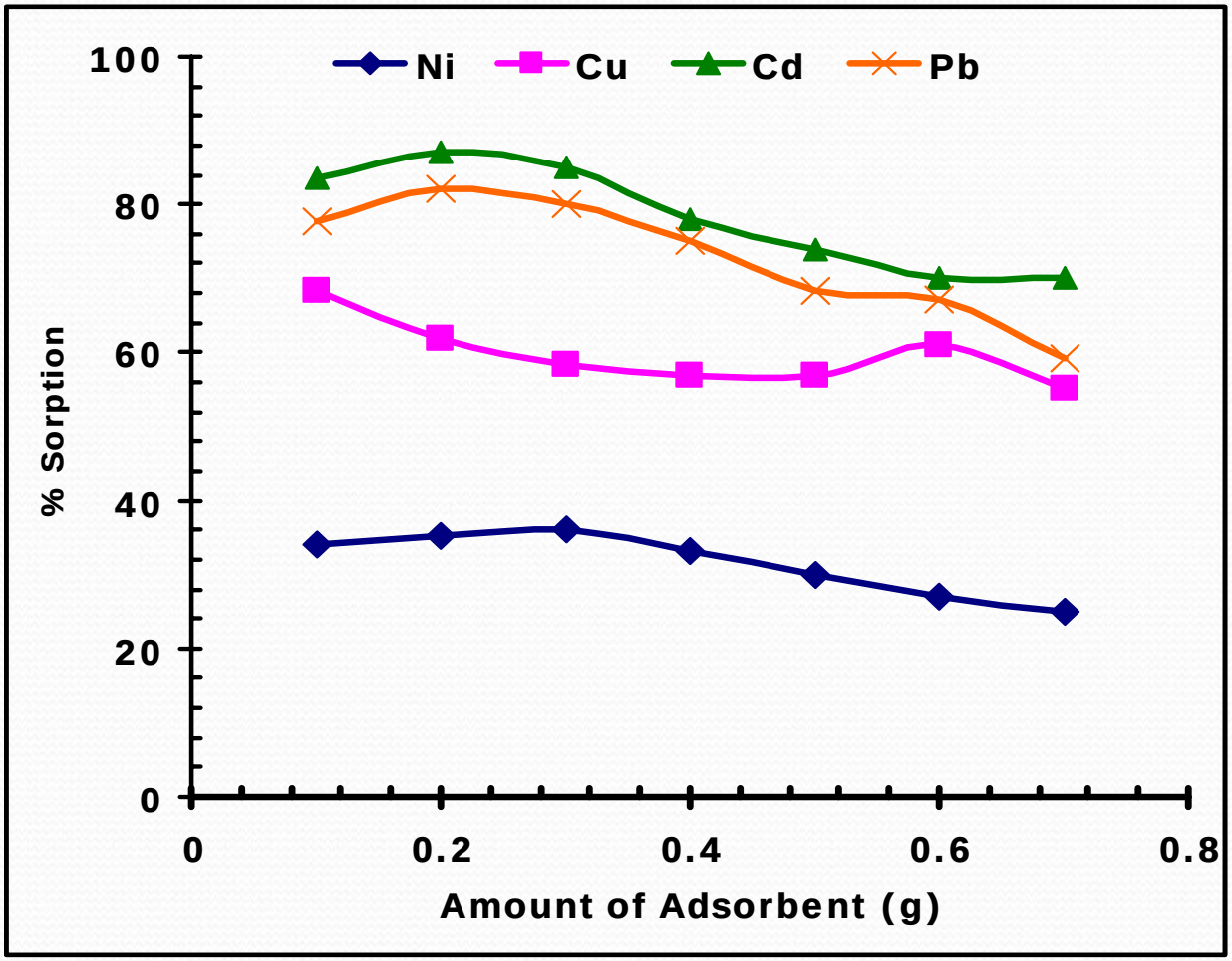
Metal	Species at pH 6	Species at pH 8
Ni	~ 100% Ni^{2+},	~ 100% Ni^{2+},
Cu	~100 Cu^{2+}	~20% $Cu(OH)^{+}$, 40% $Cu(OH)_2$, ~40% Cu^{2+}
Cd	~100 Cd^{2+}	~100 Cd^{2+}
Pb	~9% $Pb(OH)^{+}$, ~91% Pb^{2+}	~50% $Pb(OH)^{+}$, ~9% $Pb(OH)_2$ ~ 41% Pb^{2+}



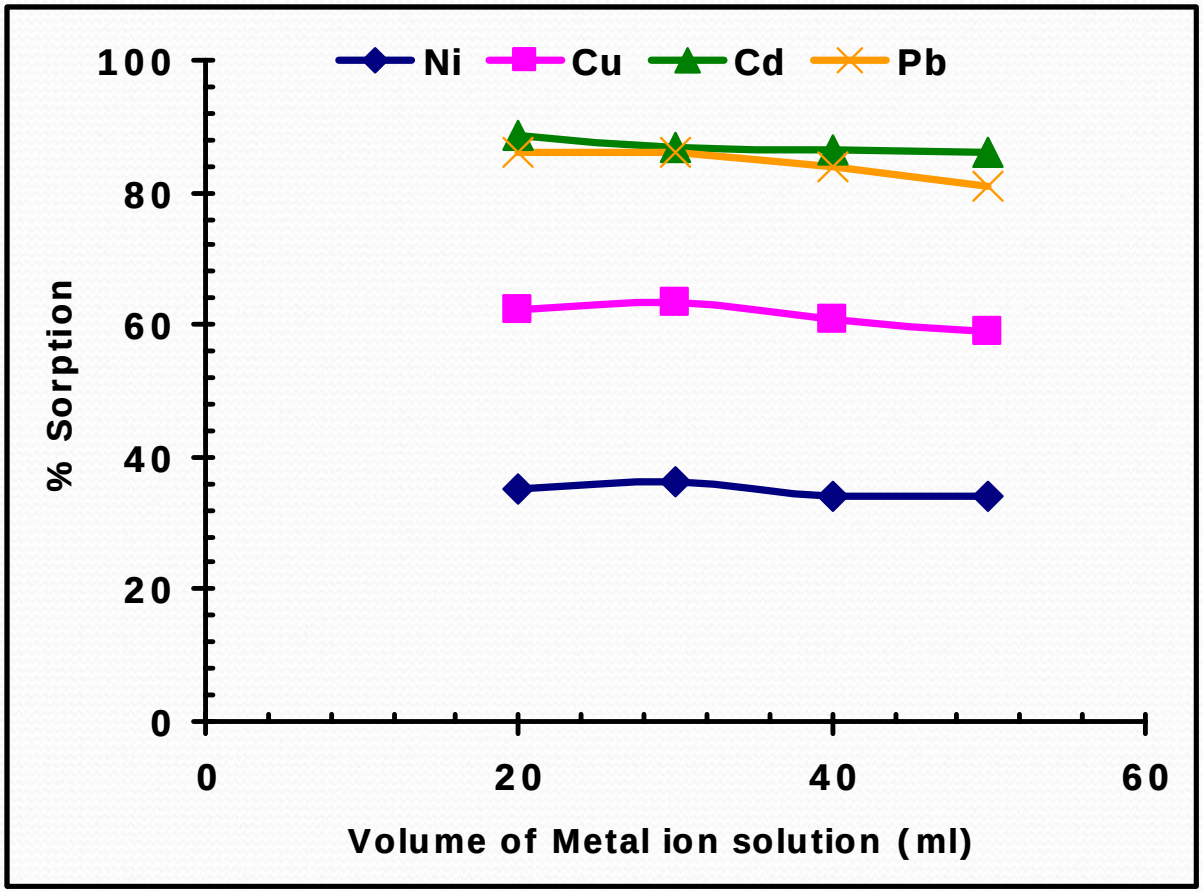
Uptake of Ni, Cu, Cd and Pb as a function of time



Amount of adsorbent



Volume optimization



Adsorption Isotherms

Langmuir Adsorption Isotherm

- Adsorption proceeds to monolayer formation only
- All sites are equivalent
- The surface is uniform

$$\frac{C_e}{C_{ads}} = \frac{1}{Qb} + \frac{C_e}{Q}$$

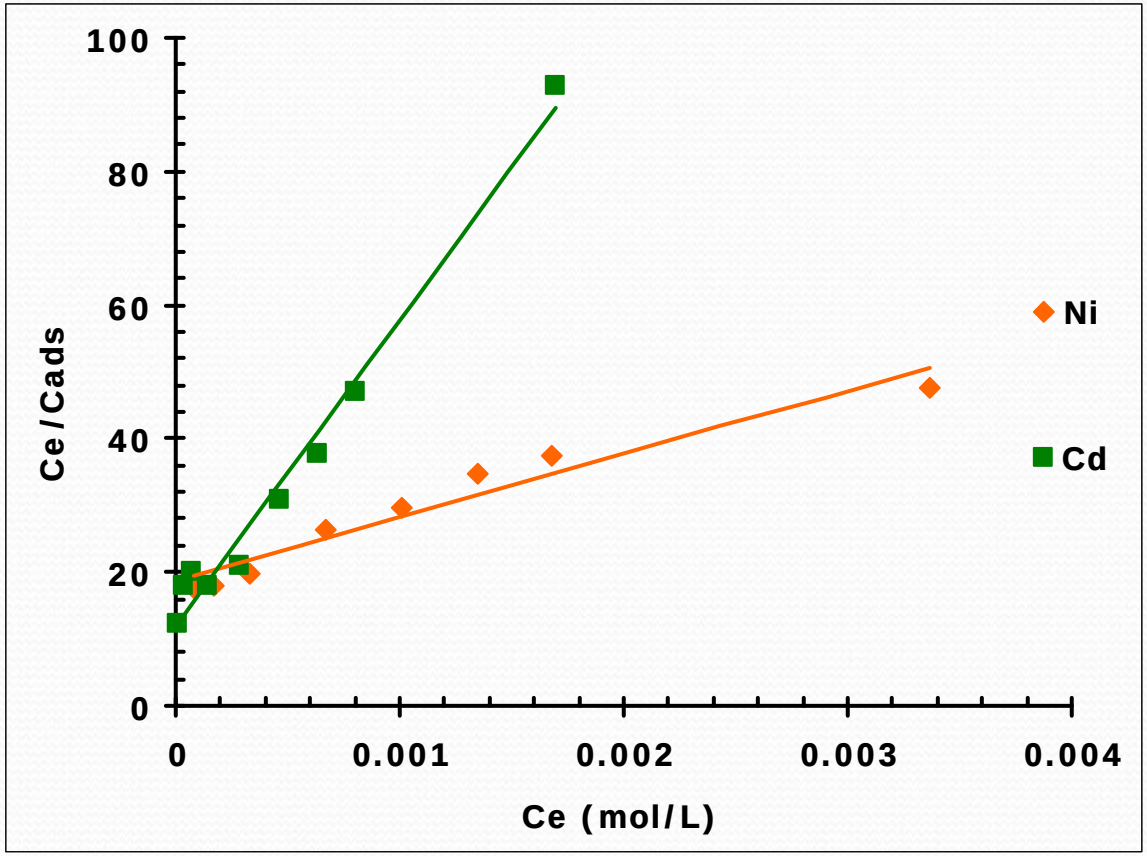
C_e = Concentration of metal ions in aqueous phase (mol L^{-1})

C_{ads} = Amount of metal ions at surface molg^{-1}

Q = Monolayer Adsorption Capacity

b = constant related to the binding energy

Langmuir Adsorption Isotherm



r Ni = 0.972

r Cd = 0.991

Adsorption Isotherms

Freundlich Adsorption isotherm

$$\log C_{ads} = \log K_f + \frac{1}{n} \log C_e$$

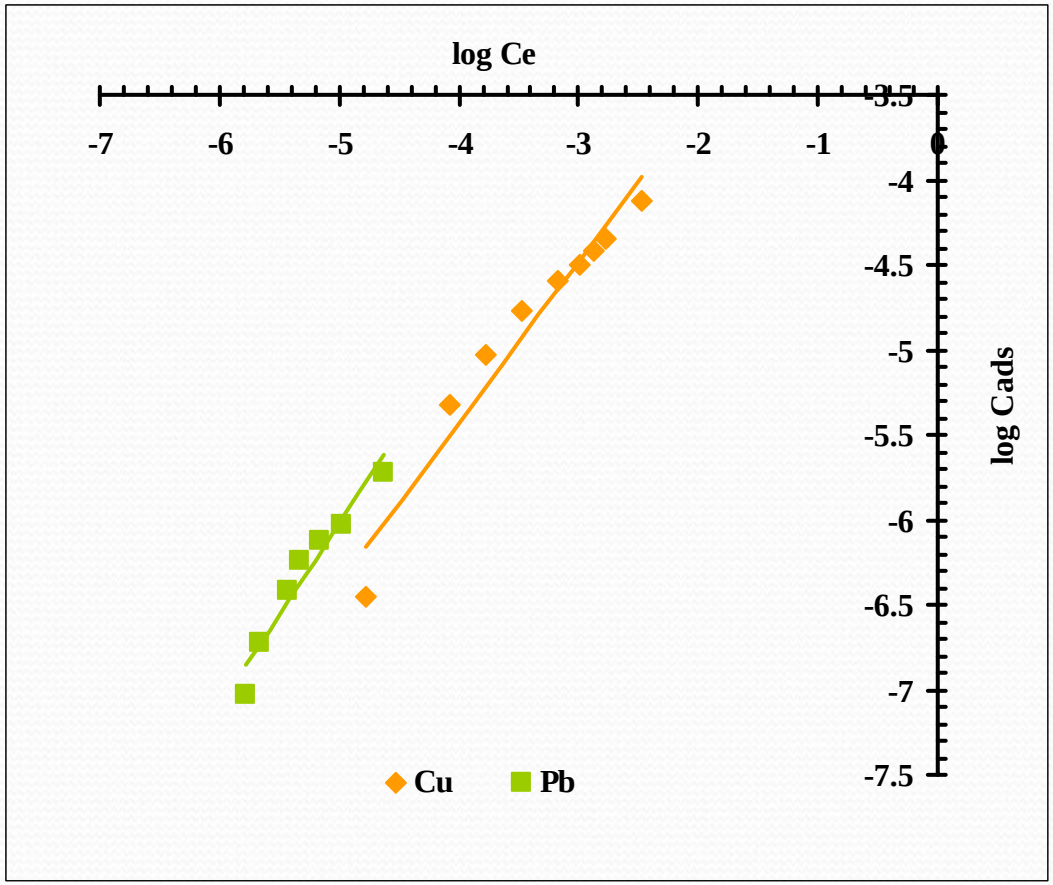
C_e = Concentration of metal ions in aqueous phase (mol $L^{-1)}$

C_{ads} = Amount of metal ions at surface (molg^{-1})

k_f = Relative Adsorption Capacity (mmol/g)

n = Values indicative of adsorption intensity

Freundlich Adsorption isotherm



r Cu = 0.9713

r Pb = 0.970

Adsorption Isotherms

Dubinin and Radushkevich (D-R) Adsorption Isotherm

$$\ln C_{ads} = \ln X_m - \beta\varepsilon^2$$

where ε (polanyi potential) is $RT \ln(1 + 1/Ce)$,

Ce the equilibrium concentration of metal in solution (mol L^{-1}) is the

Cads = Amount of metal ions at surface (molg-1) Xm is the adsorption capacity (mol g−1)
R is the gas constant (kJ mol^{-1} K^{-1})
T is the temperature (K).
The value of β is a constant and is used to calculate adsorption energy (mol^2 kJ^{-2}).

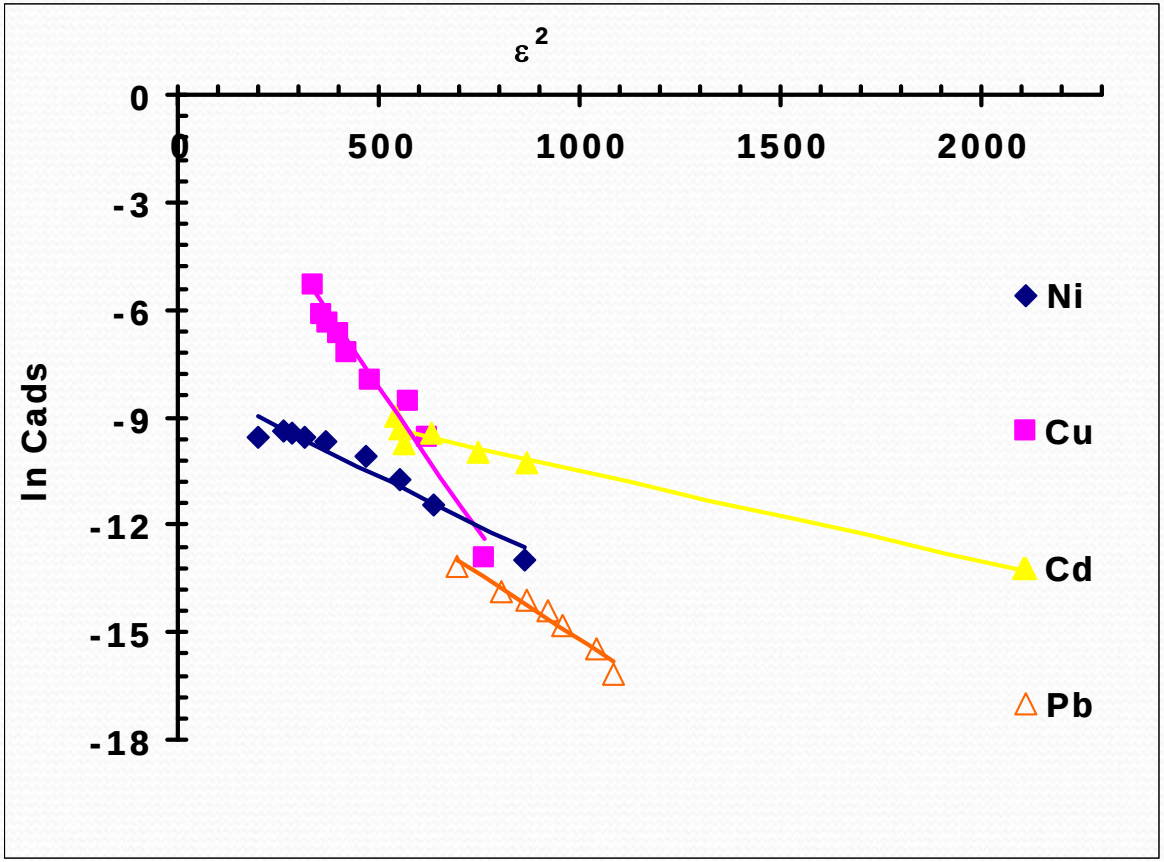
Dubinin and Radushkevich (D-R) Adsorption Isotherm

Ni: 0.971

Cu:0.982

Cd:0.987

Pb: 0.977

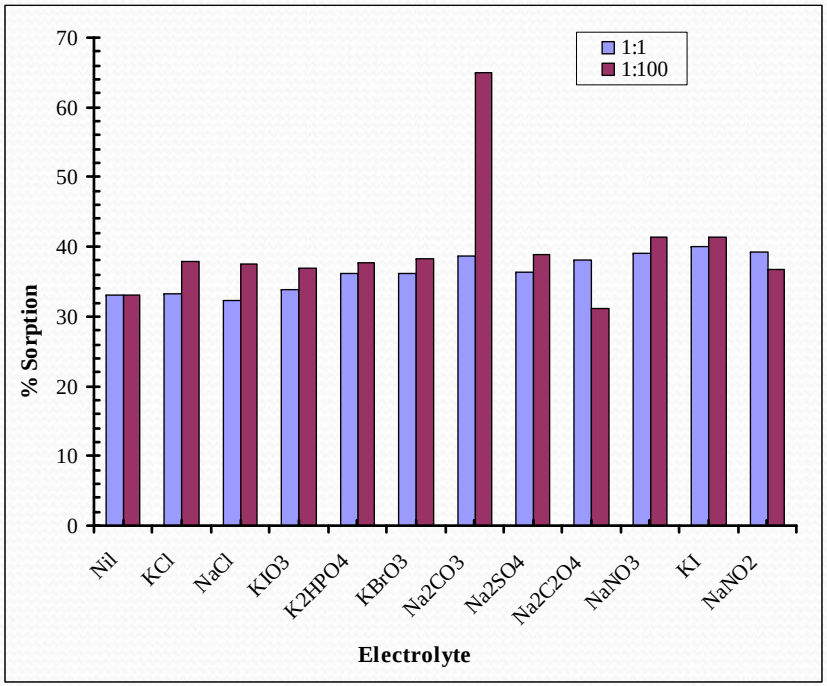


Adsorption Isotherm Constants

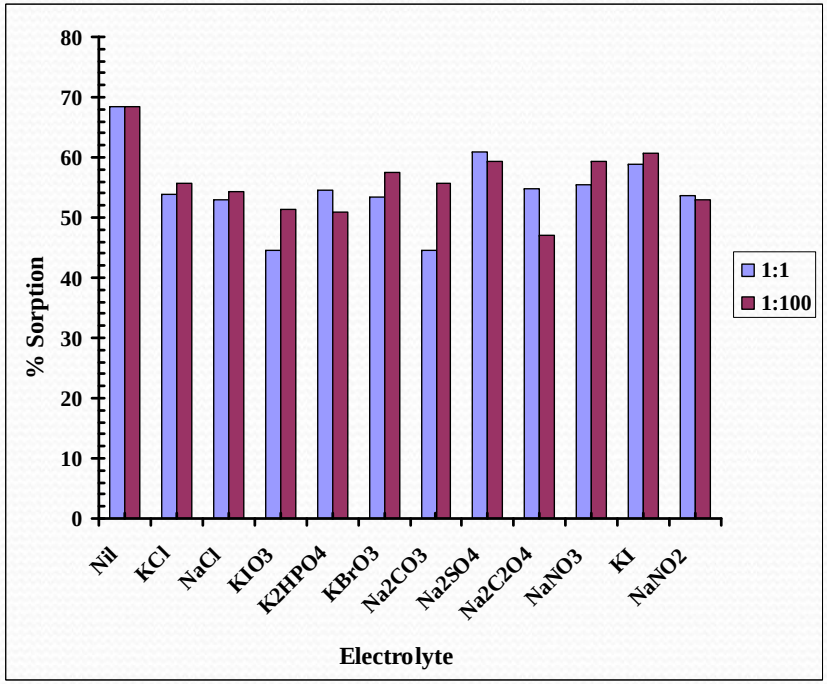
Metal	Langmuir Capacity (mg/g)	Freundlich Capacity (mg/g)	1/n	D-R	
				Capacity (mg/g)	Energy (kJ/mol)
Ni	7.2	Not obeyed	-	2.155	11.8
Cu	Not obeyed	43.75	0.90	453	7.58
Cd	3.02	Not obeyed	-	18.82	15.4
Pb	Not obeyed	102	0.79	81	8.2

- Energy of adsorption is in the range of 9-15 for Ni and Cd and 7-8 for Cu and Pb.
- The order of maximum metal uptakes calculated by D-R isotherm $Cu^{2+} > Pb^{2+} > Cd^{2+}$ and Ni^{2+}

Effect of Electrolyte Ratio

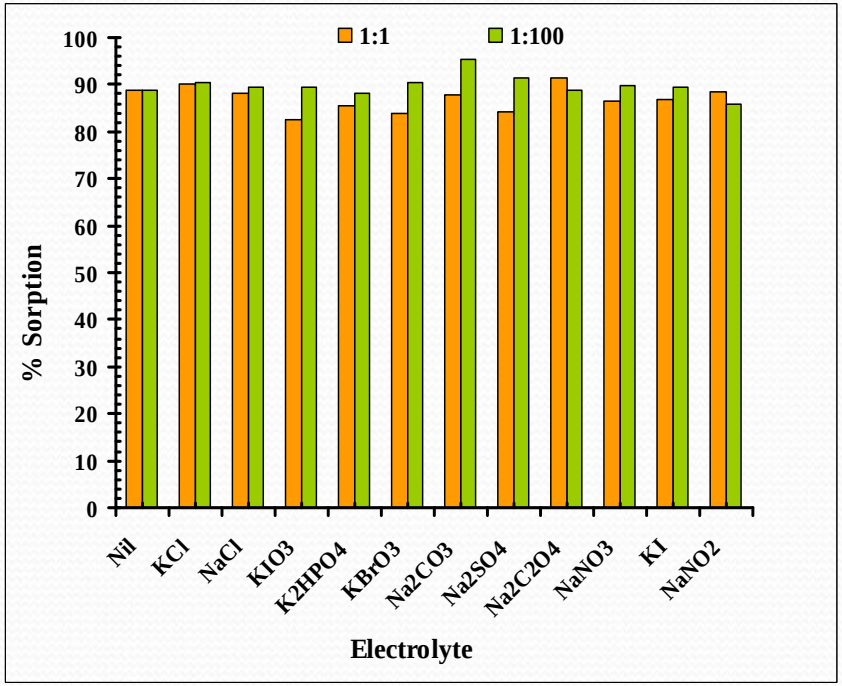


Nickel

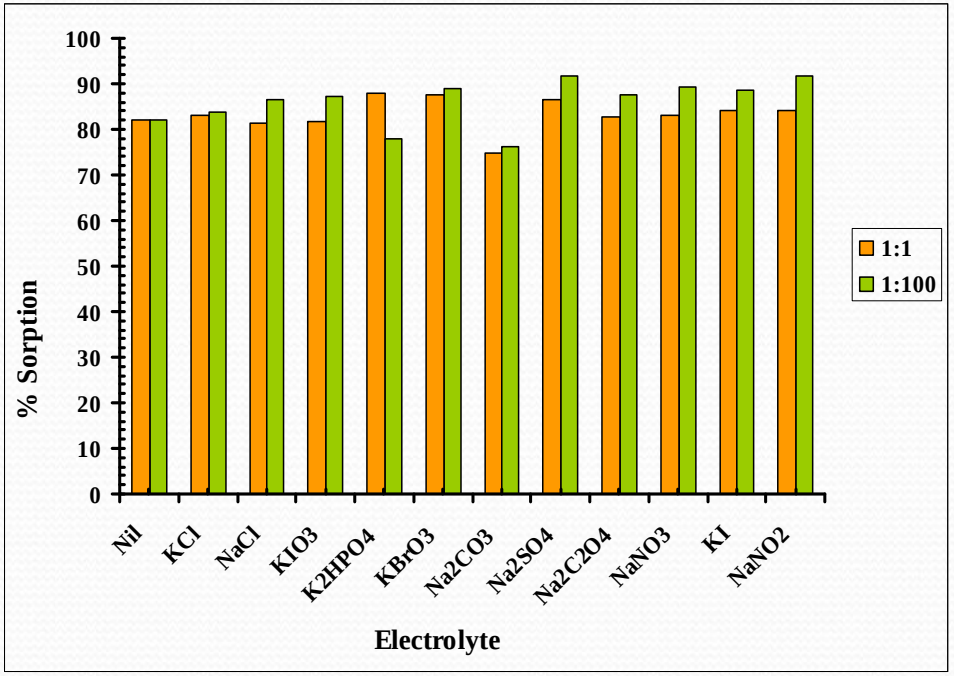


Copper

Effect of Electrolyte Ratio



Cadmium



Lead

Applications

Sample Collection: from Sadique Abad, Pakistan and Jamshoro, Pakistan

- Filtered
- Amount of metal ions before adsorption was determined
- Adsorption (Removal) at optimized conditions
- Adsorption after addition of known amount of metal ion

Water Sample analysis

Sample Type	Amount of metal added (mg/L)	% Removal			
		Ni	Cu	Cd	Pb
Ground water	0 2.0 3.0	35.45 38.73 49.91	40.21 44.67 48.04	89.96 91.20 91.25	88.37 90.76 90.99
Ground water	0 4.0 8.0	54.78 58.87 57.41	49.62 53.95 59.39	84.65 87.27 88.30	86.08 88.95 90.95
Waste water	0 4.0 8.0	38.47 38.20 38.52	49.67 50.01 51.38	78.78 86.21 88.62	83.43 89.28 91.35
Tap Water	0 7.0 12.0	34.91 48.01 53.42	48.18 53.01 57.76	85.96 93.93 95.15	81.81 84.66 91.92

n=3

Conclusions

- This work explores removal efficiency of okra waste material to remove Nickel, copper, cadmium and lead simultaneously from aqueous solutions.
- Okra leaves can be successfully used to remove all these metal ions from real samples.
- Okra leaves shows better efficiency for Cd and Pb removal than Ni and Cu removal


THANKS