Toxic metals adsorption from water by recycling waste product

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Outline

1. Introduction
2. Scope of the study
3. Methodology
4. Results and Discussion
5. Conclusions & Recommendation

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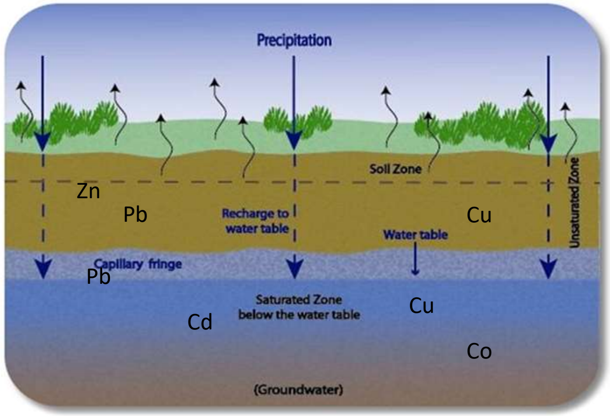
INTRODUCTION

- Mining, ore smelting, leather tanning, pulp industry, painting, pesticide, and pharmaceutical manufacturing industries release metal contaminants
- Toxic metals such as lead (Pb), Copper (Cu), Cadmium (Cd), Zinc (Zn), Arsenic (As), Chromium (Cr), Cobalt (Co), and Nickle (Ni) etc.
- Many of the heavy metals are well known to be a mutagen causing cancer



INTRODUCTION

Fig: Industrial discharges

INTRODUCTION

Table 1: Heavy metal concentration (ppm) of the studied wastewater samples [1]

Samples	Ni	Mn	Cr	Zn	Cd	Pb	Cu
1	5.36	1	0.52	1.44	0.84	3.2	0.52
2	4.36	1.88	0.72	1.4	1.4	10	2.24
3	1.6	1.84	1	1.44	1.92	5.2	2.4
4	3.28	0.88	0.92	2	0.8	12.8	1.32
5	9	0.52	1.24	1.68	1.04	4.8	1.4
Saudi Standard (MWE, 2006)	5	0.2	0.1	2	0.01	0.1	0.4
WHO Standard (2006)	10	1	1	5	0.1	0.1	1

- **Heavy metal contamination in the coastal region of Jeddah City**

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INTRODUCTION

Figures : Slag production from metal mining site

KSA Mining:

- Gold and Base Metals ,
- Phosphate,
- Aluminium,
- Industrial Minerals - including magnesite, kaolin and low-grade bauxite

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SCOPE OF THE STUDY

- The use of nickel smelter slags (e.g. an iron oxide and iron silicate bearing waste from Ni-ore smelting) in Cu, Pb, Cd and Zn removal by adsorption
- To experimentally investigate the adsorption capacity and rate of adsorption of metal species by smelter waste product in the laboratory batch test, and assess the potential utilization of the slag as a reactive medium in the treatment of metal contaminated water.
- Determined the kinetics of Copper (Cu), lead (Pb), Zinc (Zn) and Cadmium (Cd) uptake by recycling slag
- Explored the benefits of using renewable waste products for water and wastewater treatment industry

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METHODOLOGY

Reactive slag waste product

- Nickel smelter slag, an industrial waste, was obtained from Vale Canada Copper Cliff Smelter, Sudbury, Ontario

Methodology

Reactive slag waste product

- The components of the bulk slag were also analyzed using PAN-analytical PW-2400 Wavelength Dispersive XRF (X-Ray Fluorescence) after roasting 1 g of slag to loss of ignition

- Hitachi SU6600 Field Emission Scanning Electron Microscope (FESEM) was also used to scan the surface of the samples.

- The changes of surface charge on reactive media with different pHs were determined by Surpass Anton Parr Analyzer

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Methodology

Table 1: Composition of Ni smelter slag and other slags

Major Constituent	**Iron/Blast furnace slag** [12]	**Steel Slag** [12]	**Cu smelter Slag** [11]	**Ni smelter Slag** (the present study)
FeO	0.45%	42-84%	39%	57.3%
SiO_2	40%	18%	31%	39.7%
CaO	30-40%	25-55%	3.95%	1.27%
Al_2O_3	15%	3%	2.4%	2.45%
MgO	0.1%	0.57%	2.82%	1.23%
TiO_2			0.19%	0.23%

Methodology

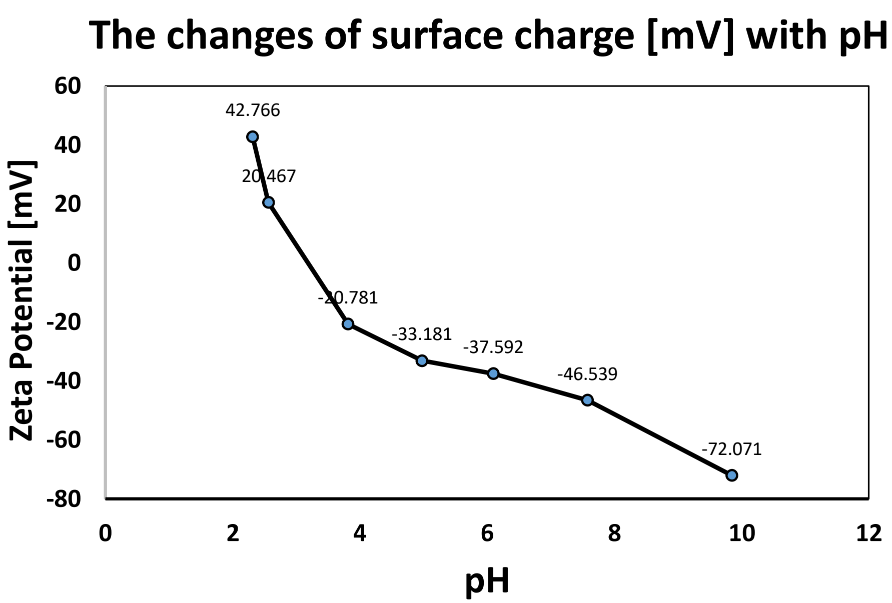

Figure 1: Electro kinetic Analysis of Nickel smelter slag showing pzc using the Surpass Anton Parr Analyser

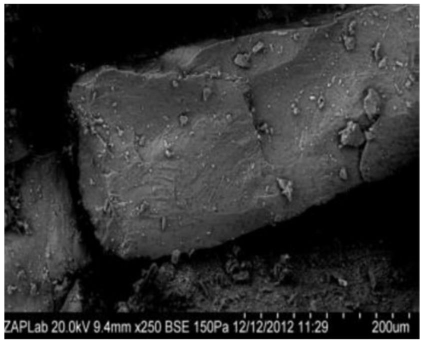

Figure 2: Representative SEM micrographs

Methodology

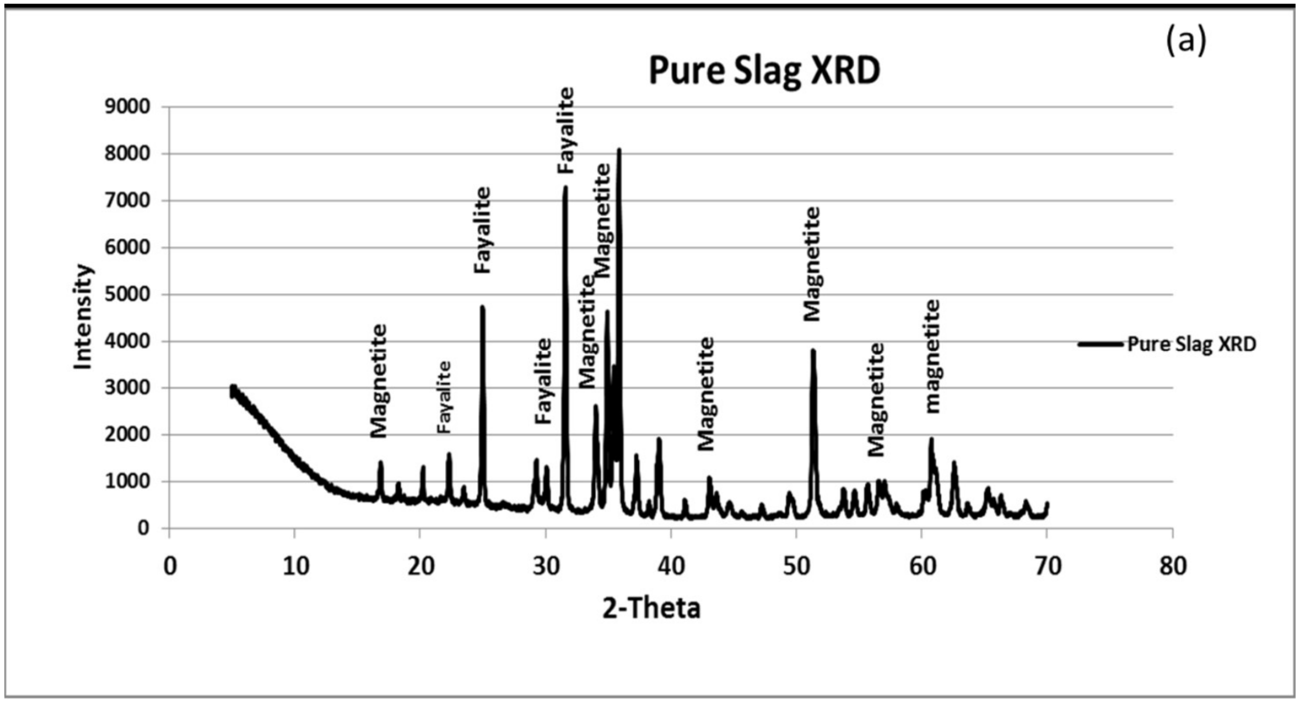

Figure 3: XRD patterns showing fresh Ni smelter slag

Fayalite-mixed iron oxide loaded slag- Fe 2p

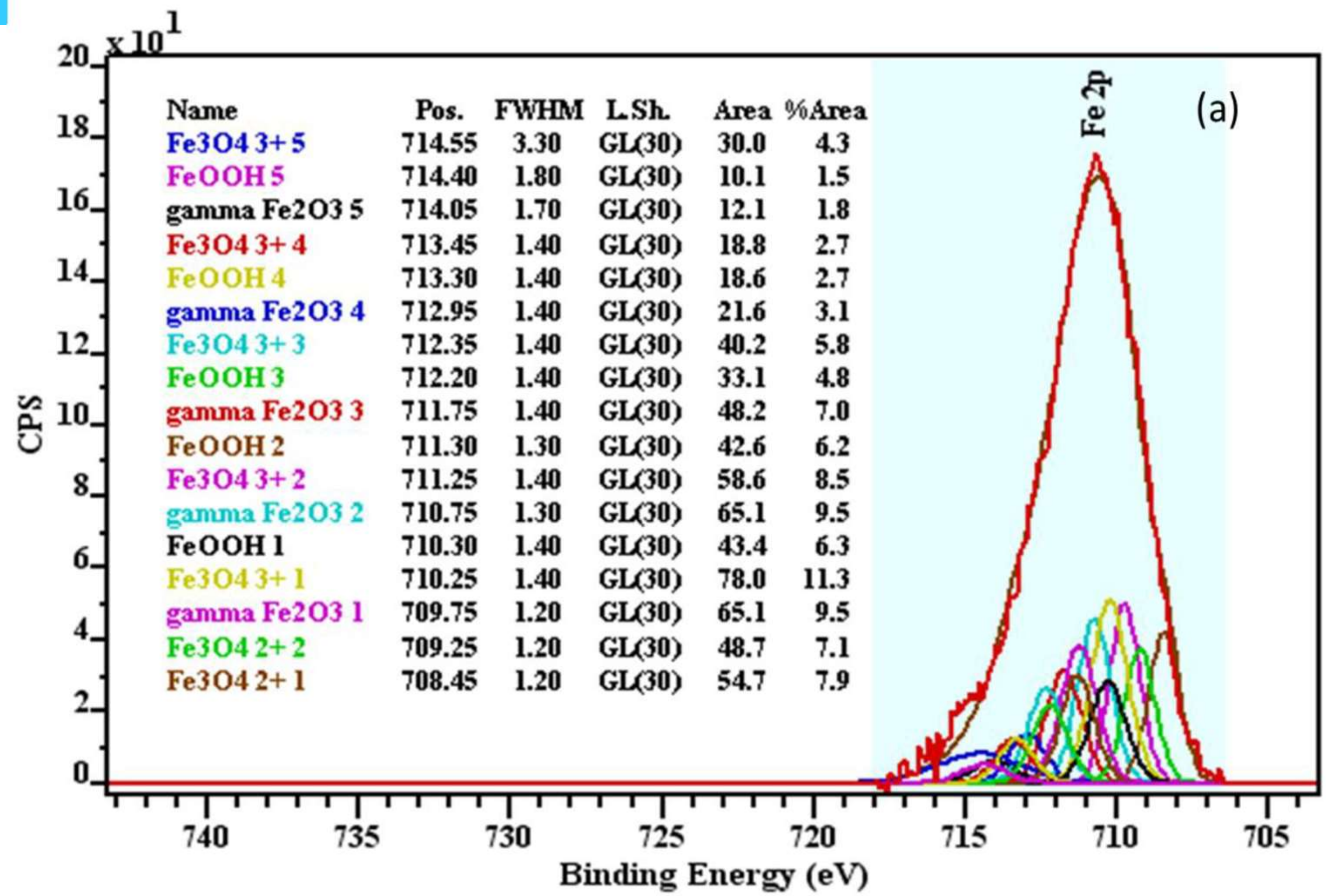

Fig 4: XPS spectra fresh slag

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Methodology

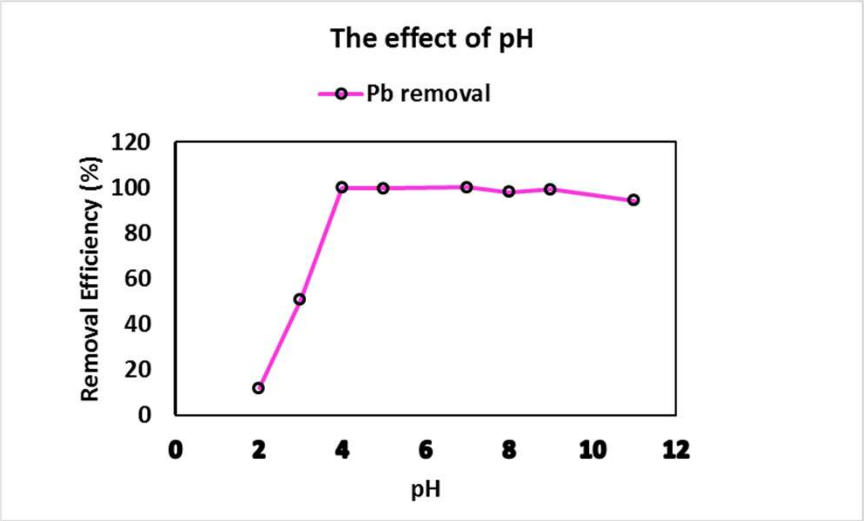
Batch Test

Batch experiment was conducted by shaking known amounts of nickel slag with certain mL metal solutions in 125-mL Erlenmeyer flask at room temperature ($23^{o}C \pm 2^{o}C$). This test measured the adsorption efficiency of smelter slag.

All experiments were carried out in triplicate on the rotary shaker (New Jersey, USA) at a shaking speed of 170 rpm

- **Effect of particle size**
- **Effect of other ions**
- **Equilibrium adsorption tests**
- **Desorption tests**

RESULTS



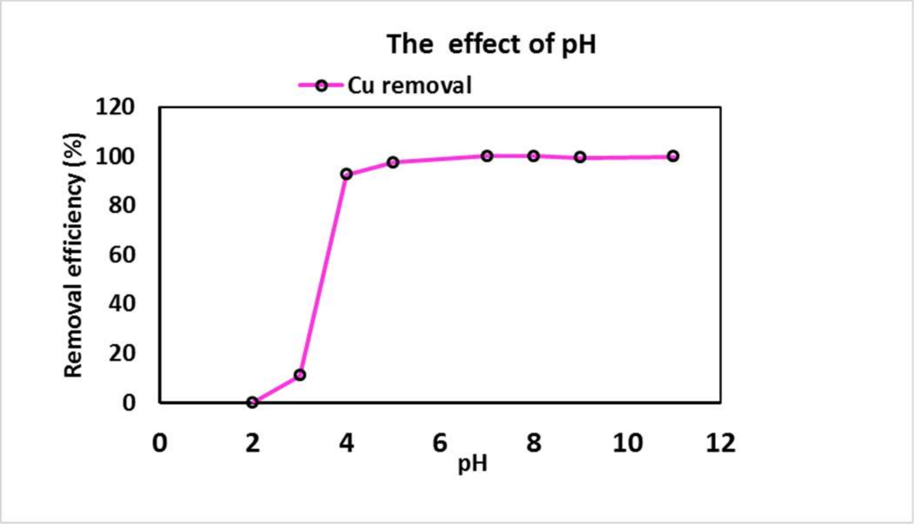


Figure 5: The effect of pH on the removal of Cu and Pb by nickel smelter slag (initial concentration: 10 mg/L, slag dose: 10 g/L, contact time: 10 hours, shaking speed: 170 rpm, temperature: 25^0C). standard deviation: ±0.601; standard error: ±0.36

Results

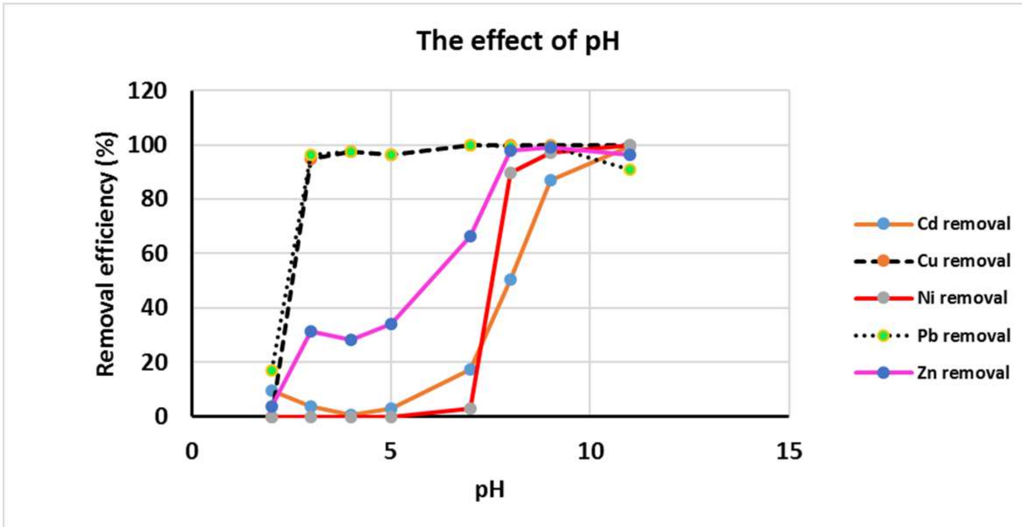


Figure 6: The effect of pH on the removal of Cu, Cd, Ni, Pb and Zn from mixed solutions. (Initial concentration for all metals: 10 mg/L; except for Cd concentration: 7 mg/L; slag dose: 10 g/L, contact time: 10 hours, shaking speed: 170 rpm, temperature: 25^{0}C, pH= 5; standard deviation: ±0.432; standard error: ±0.436)

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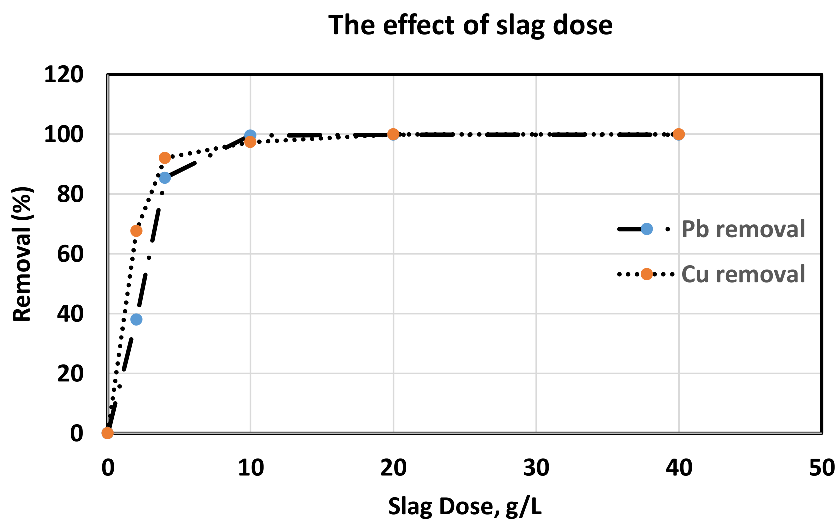
Results



<u>Figure 7:</u> Effect of slag dose on removal of Pb or Cu by nickel smelter slag (Initial concentration: 10 mg/L, contact time: 10 hours, shaking speed: 170 rpm, temperature: 25^0C)

Results

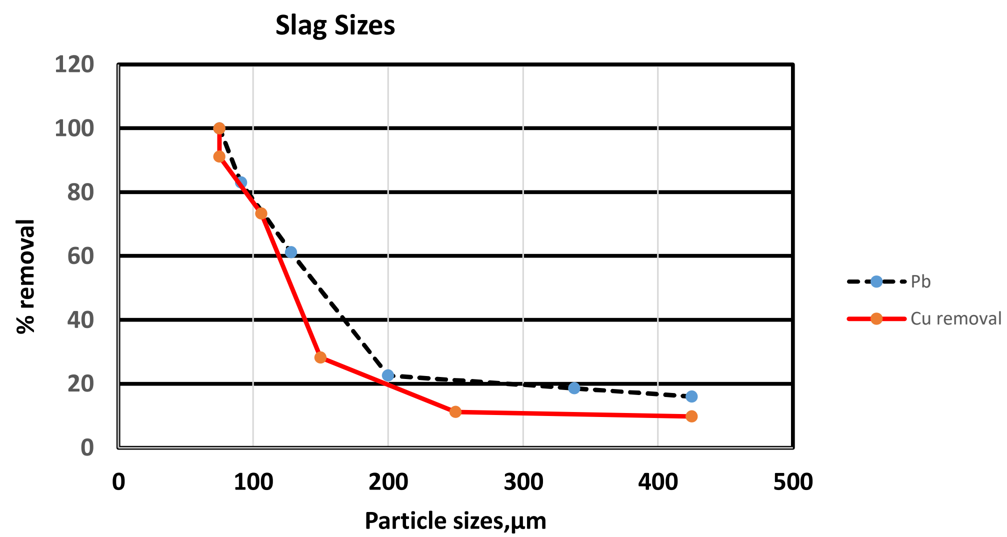


Figure 8: Effect of slag sizes on removal of Pb or Cu by nickel smelter slag (Initial concentration: 10 mg/L, contact time: 10 hours, shaking speed: 170 rpm, temperature: 25^{0}C)

Results

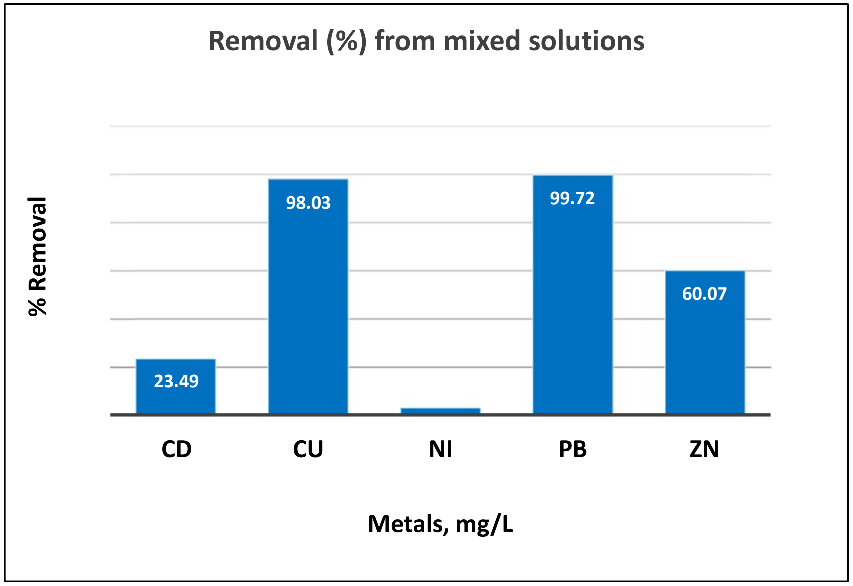
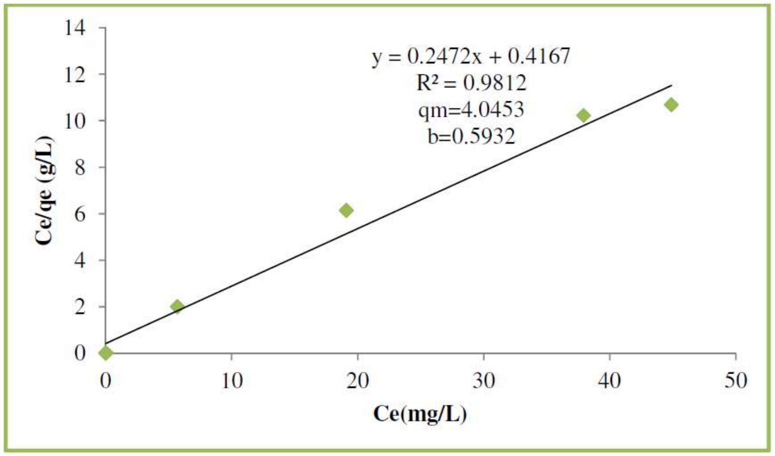
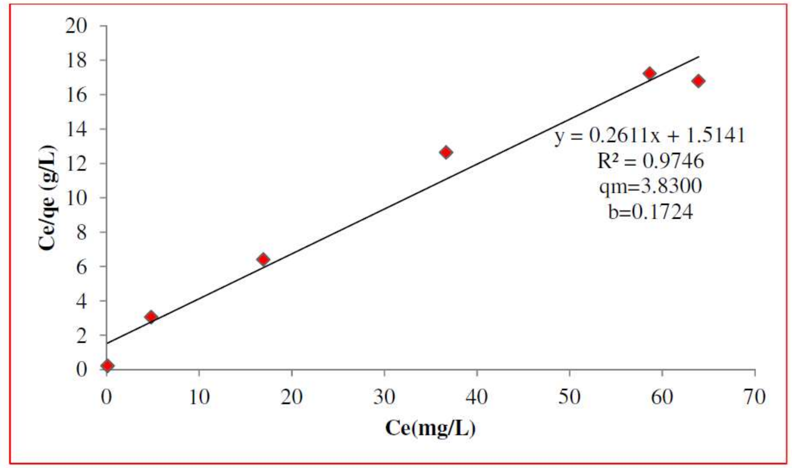


Figure 9: Effect of multi cations on removal of Pb or Cu by nickel smelter slag (Initial concentrations, (Cu,Ni, Pb, and Zn): 10 mg/L and Cd = 7 mg/L, contact time: 10 hours, shaking speed: 170 rpm, temperature: 25^0C)

Results



(a) Pb



b) Cu

Figure 10: Langmuir isotherm plot for adsorption of (a) Pb and (b) Cu by nickel smelter slag (initial concentration: 10-100 mg/L, slag dose: 10 g/L, contact time: 24 hours, shaking speed: 170 rpm, temperature: 25^0 C)

Results

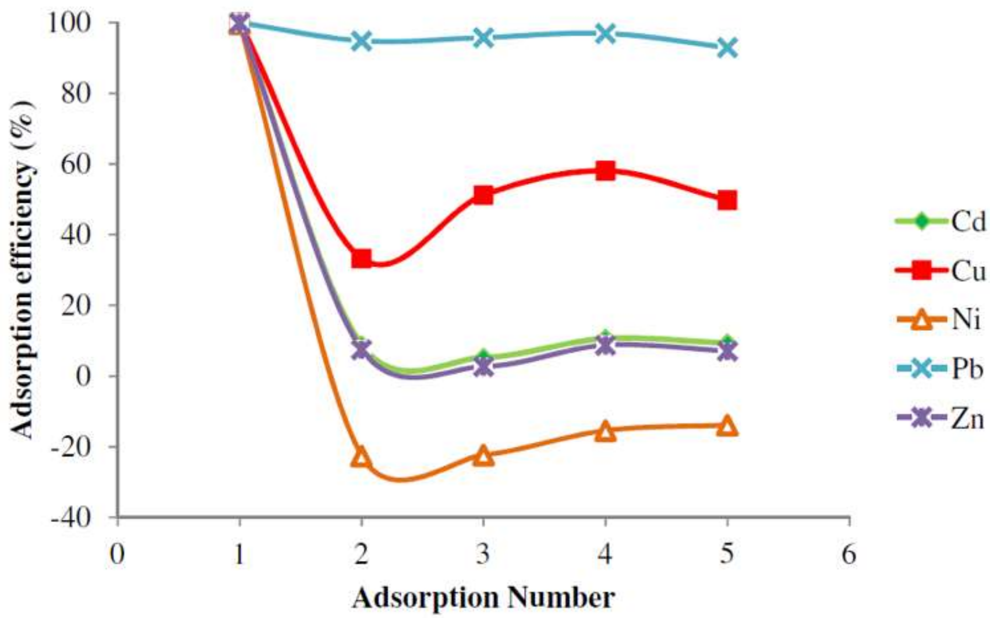


Figure 11: Removal of (a) Pb, (b) Cu and (C) mixed metals by nickel smelter slag in 5 cycles of adsorption (initial concentration: 7-10 mg/L, slag dose: 80 g/L, contact time: 10 hours, shaking speed: 170 rpm, temperature: 25º C)

CONCLUSIONS & RECOMMENDATION

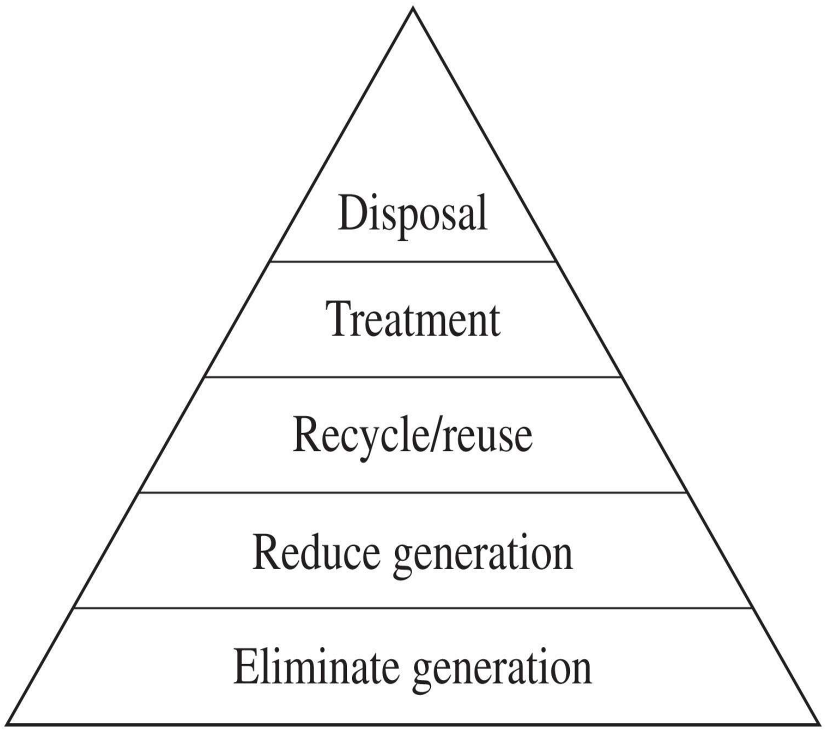
- The only major cost related to the use of recycled Ni smelter slag in a reactive permeable barrier would be that of crushing.

- Low-cost, effective technologies and inexpensive treatment materials that are readily available and easily reusable offer attractive options in engineering applications..

- However, in comparison to the large footprint and the cost involved in slag disposal, it would seem that using crushed slag for environmental remediation is advantageous, both from the economic and sustainability points of view.

Conclusions & Recommendation

- The development of green technology using recycled or reused waste products as well as proposing the methods how to reduce the amount of industrial waste for disposal.
- Slag recycling can reduce or eliminate the cost of final disposal as well as environmental contamination.
- Application of reactive slag for In Situ site remediation technology



Disposal
Treatment
Recycle/reuse
Reduce generation
Eliminate generation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