# Copper slag used for abrasive blasting and heavy metal contamination , case study Van Phong bay, Vietnam

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# Problem statement

The use of copper slag as an abrasive blasting agent from shipping industry raises environmental concern about heavy metal pollution Van Phong bay


A study of the potential dispersion of heavy metals from copper slag waste and sediment needs to be carried out

# Objectives

- Quantify the degree of contamination of sediment and soil

- Assess the risk in relation with heavy metals present in copper slag waste, sediment and soil

# Methodology (Sampling)

## ***Marine sediment***

- 19 surface sediment samples were collected near the shipping factory (500m interval)

- One deep core sediment (0 – 1.5m) was collected at the alluvial spit connected to the sea

# Soil

## *At the dump site*


- Distance: 10m, 20m, 50m, 70m, 90m and 110m

- 2 deep core sample (0-60cm) and (0-1.6m)

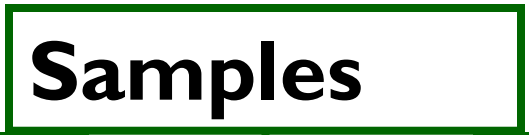
**Red points** : deep core soil samples
**Green points:** surface soil samples

## *At the shipping factory*


- Distance: 100m and 150m

- 1 deep core sample (0 – 2.5m)

# Methodology

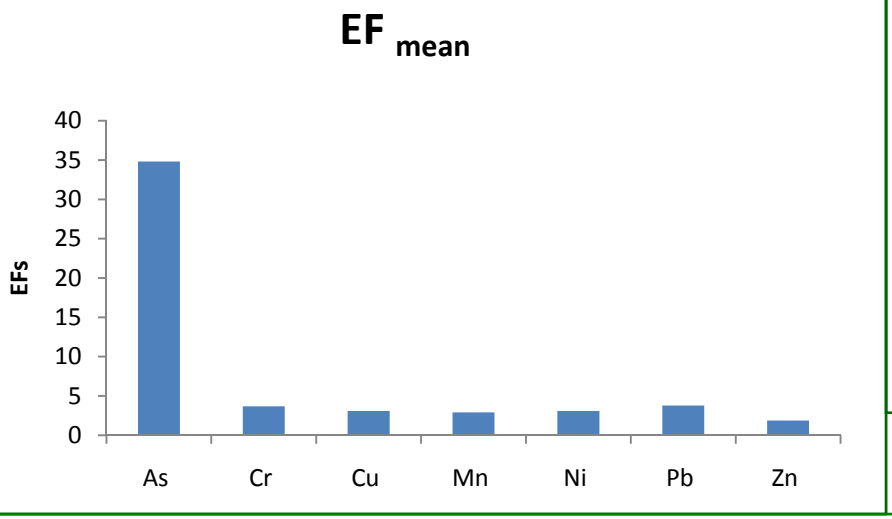



| Characterization | Contamination assessment | Leaching test |
|---|---|---|
| -Grain size analysis<br><br>-Total element concentrations<br><br>-Organic matter<br><br>-CEC<br><br>- XRD analysis | -Based on Sediment Quality Guidelines<br><br>- Based on Quantitative heavy metal pollution indices (Enrichment Factor :EF, Geo accumulation Index : $I_{geo,}$ ,PLI: Pollution Load Index and Risk assessment Code: RAC) | - Examine actual and potential mobility: single extraction with $CaCl_2$(0.01M), NaCl(30g/L), EDTA(0.05M), $CH_3COOH$(0.43M)<br><br>- Influence of pH on long term release of heavy metals : $pH_{stat}$ leaching test |

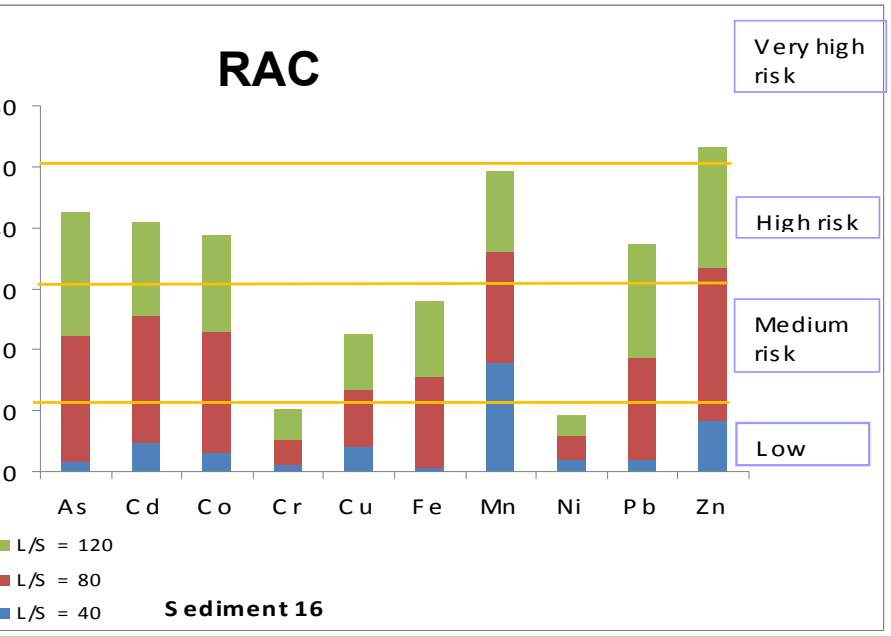
# Results

| Characteristics of samples | | |
|---|---|---|
| Marine sediment | Soil | Copper slag waste |
| ***Sediments***: low clay and organic matter content and low CEC, high carbonate content.<br><br>- A strong positive correlation between (Al, Fe, K and organic matter) and some heavy metals (As, Pb and Zn) | ***Surface soil***: low clay and organic matter content and low carbonate content<br><br>- High concentration of Fe, Zn, Cu, Mn, Pb, As and Cr in sample near the dump site<br><br>***Soi core:*** high concentration of Fe, Zn, Cu, Mn, Pb, As and Cr at the surface (0-5cm) | - XRD analysis: amorphous phases, Fayalite, and Magnetite phases<br><br>- High concentrations of Fe, Zn, Cu, Mn, Pb, As and Cr<br><br>- Low CEC |

# Assessment of contamination - sediment



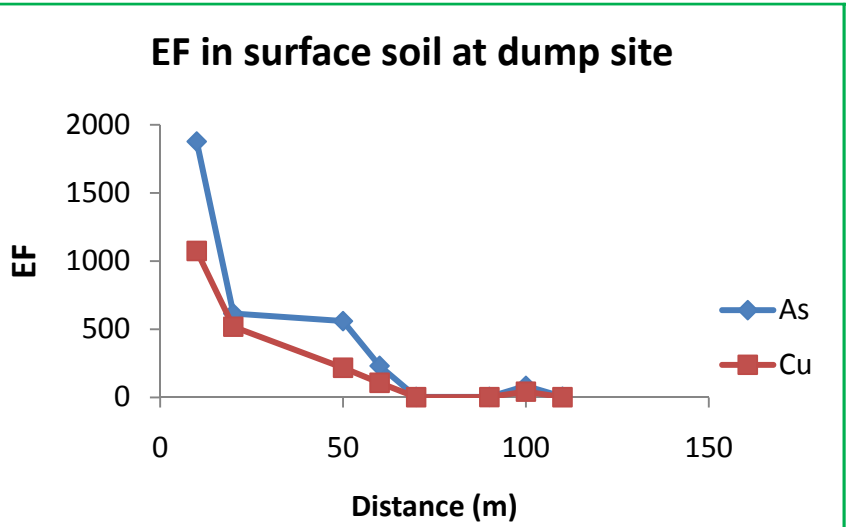

EF ≤ 1: no enrichment
1 < EF ≤3: minor enrichment
3 < EF ≤ 5: moderately enrichment
5 < EF ≤ 10: moderately severe enrichment
10 < EF ≤ 25: severe enrichment
25 < EF ≤ 50: very severe enrichment
EF > 50: extremely severe enrichment

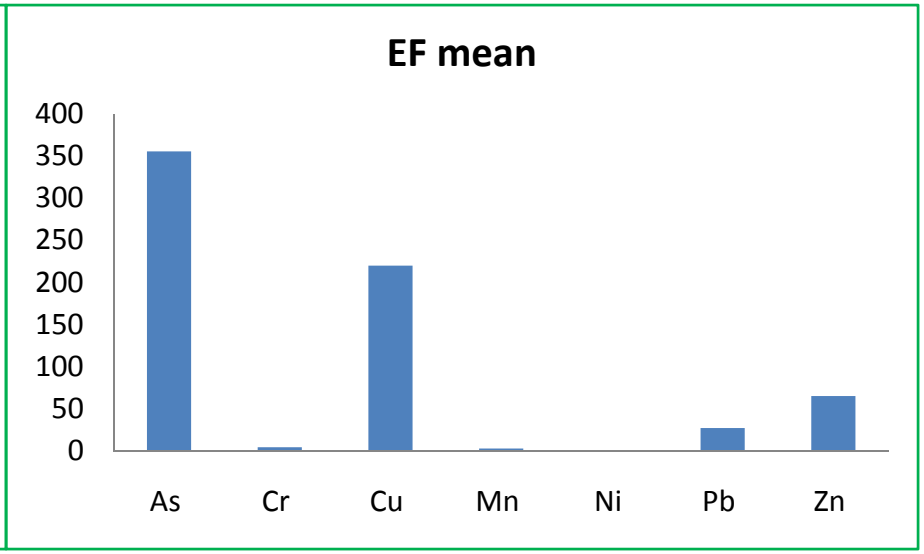


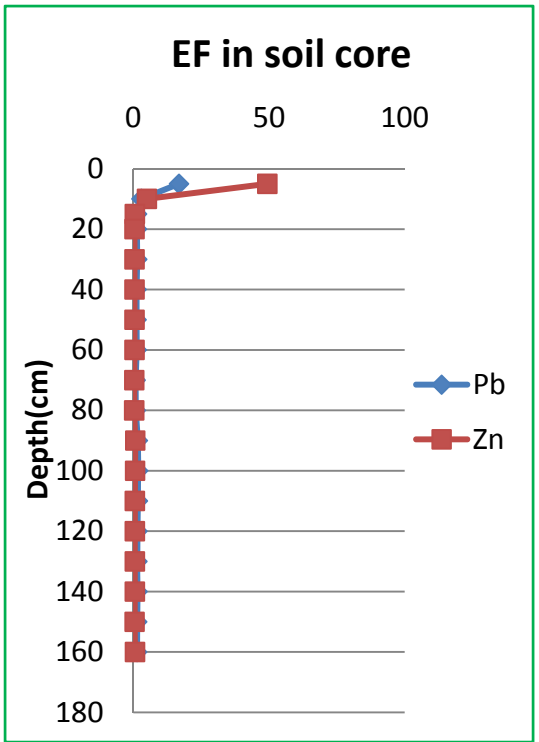

As shows the greatest concern because of its high EF

Concerning both RAC and total metal concentration: Zn, Cu, Pb and As possess a high risk

# Assessment of contamination - soil



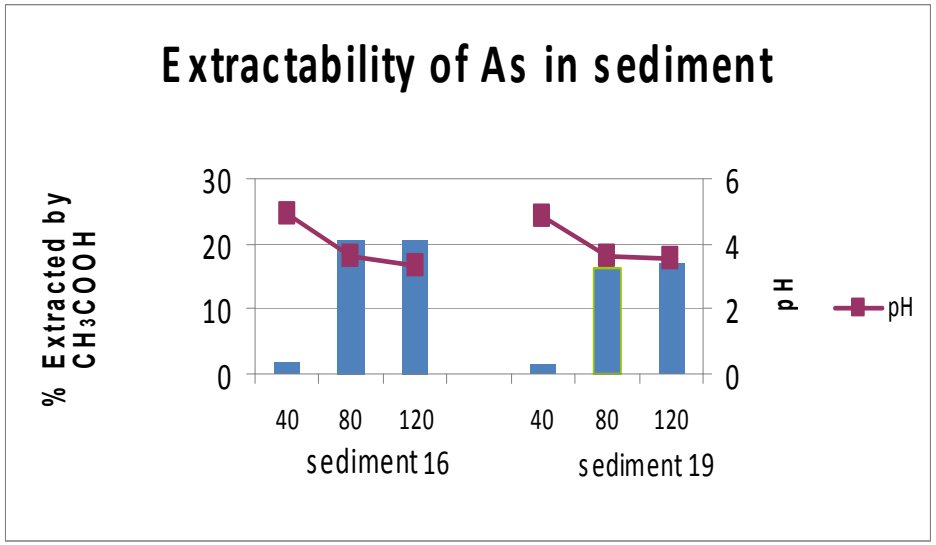




- As, Cu, Pb and Zn show the high concern
- EF decrease with distance and depth

⇒ Dispersion of fine waste particles by wind

# *Actual mobility and potential mobility*

- Actual mobility (extraction with $CaCl_2$ 0.01M) : low
- Potential mobility (extraction with NaCl 0.5M, EDTA 0.05M, $CH_3C00H$ 0.43M) : highest efficiency with $CH_3COOH$




## Sediments

- Most of heavy metals reached the highest extractability at pH < 4
- pH changed during extractions

## Copper slag waste

- Most of heavy metals released in similar amounts in the three extraction steps
- No significant variation in pH during extraction

# *Comparison between acidification and complexation*

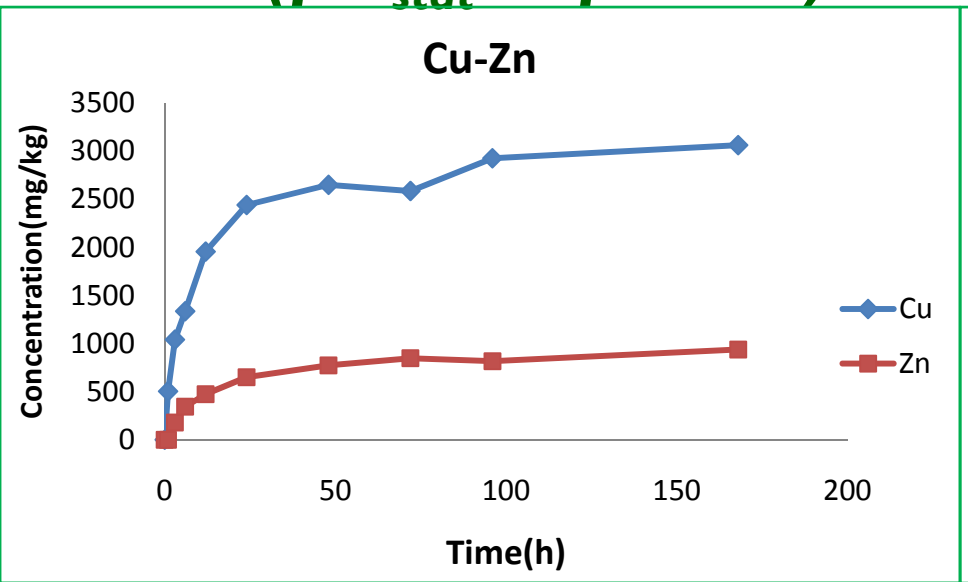
Ratios of percentage extracted by EDTA and $CH_3COOH$ in sediments

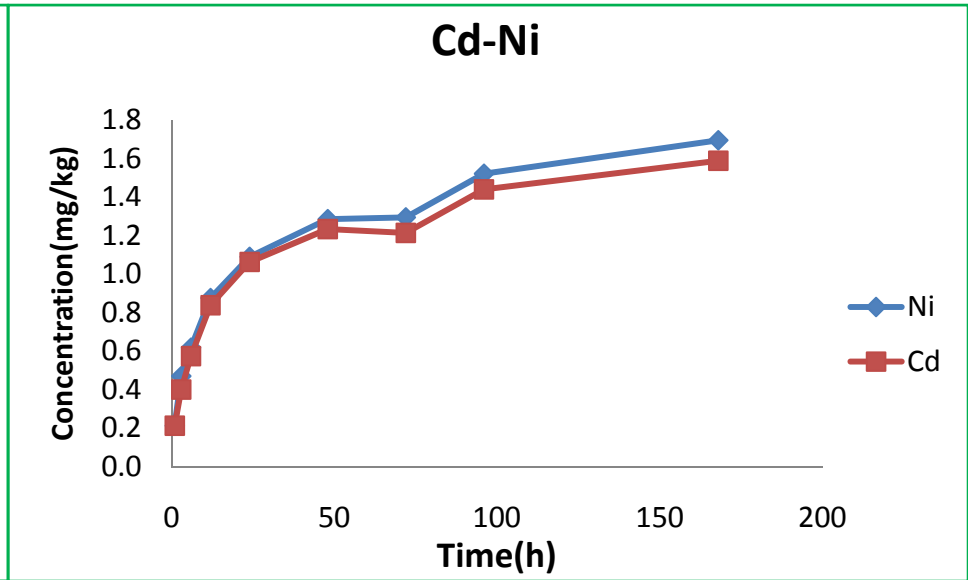
| | As | Ca | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 0.3 | 0.2 | **1.7** | 0.3 | 0.1 | 0.9 | 0.2 | 0.3 | 0.5 | **2.3** | 0.6 |
| 19 | 0.4 | 0.2 | **1.3** | 0.3 | 0.1 | 0.8 | 0.2 | 0.4 | 0.5 | **2.1** | 0.6 |

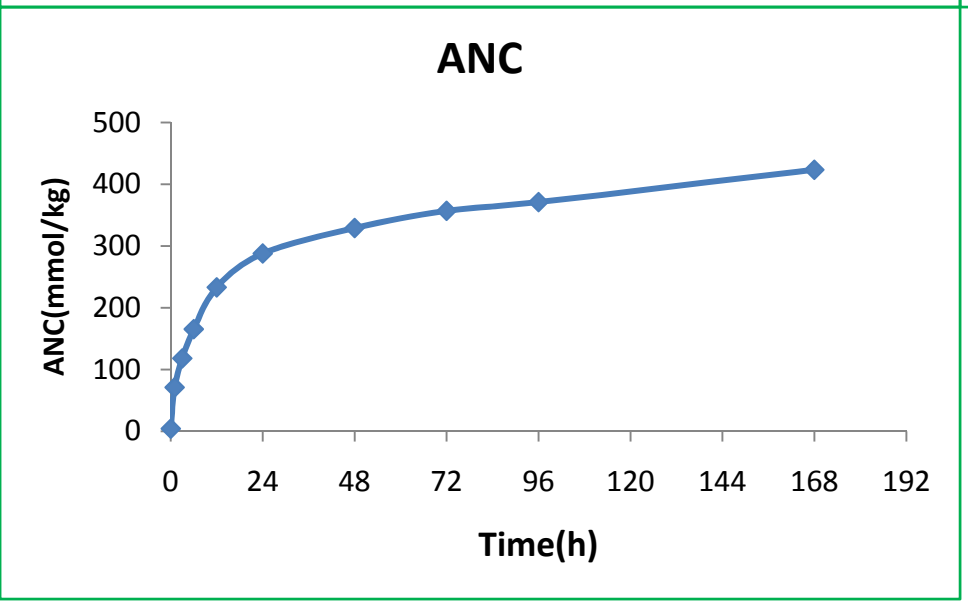
Ratios of percentage extracted by EDTA and $CH_3COOH$ in Copper slag wastes

| | As | Ca | Cd | Co | Cr | Cu | Fe | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 0.01 | 0.4 | 0.1 | 0.02 | 0.03 | 0.6 | 0.02 | 0.1 | 0.3 | 0.1 | 0.2 |
| 21 | 0.01 | 0.3 | 0.1 | 0.02 | 0.03 | 0.7 | 0.01 | 0.1 | 0.2 | 0.1 | 0.2 |

# *Long term release of heavy metals under influence of pH on Soil ($pH_{stat}$ at pH = 4)*

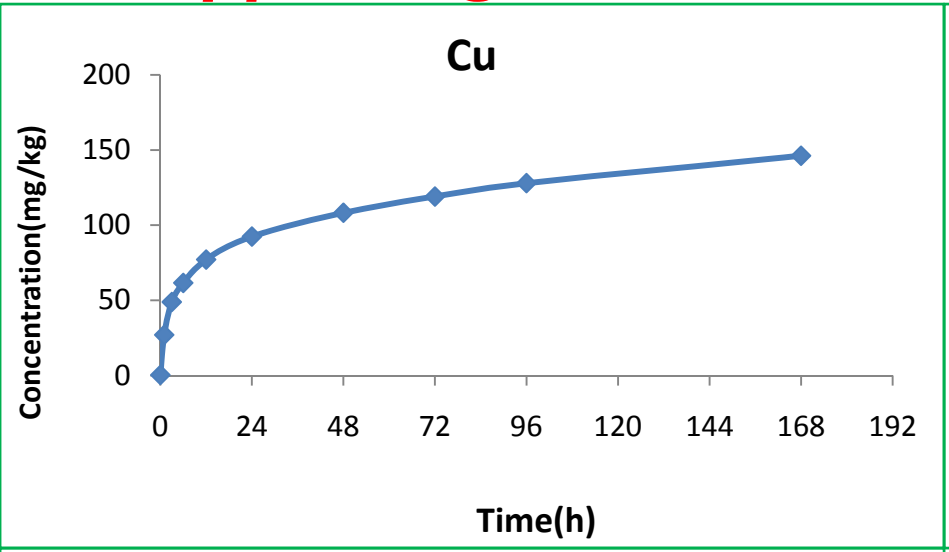


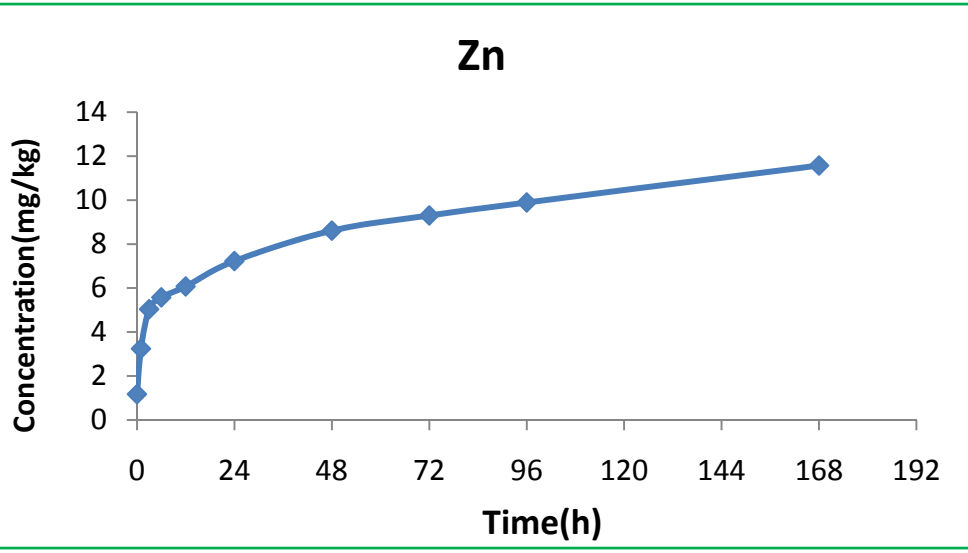



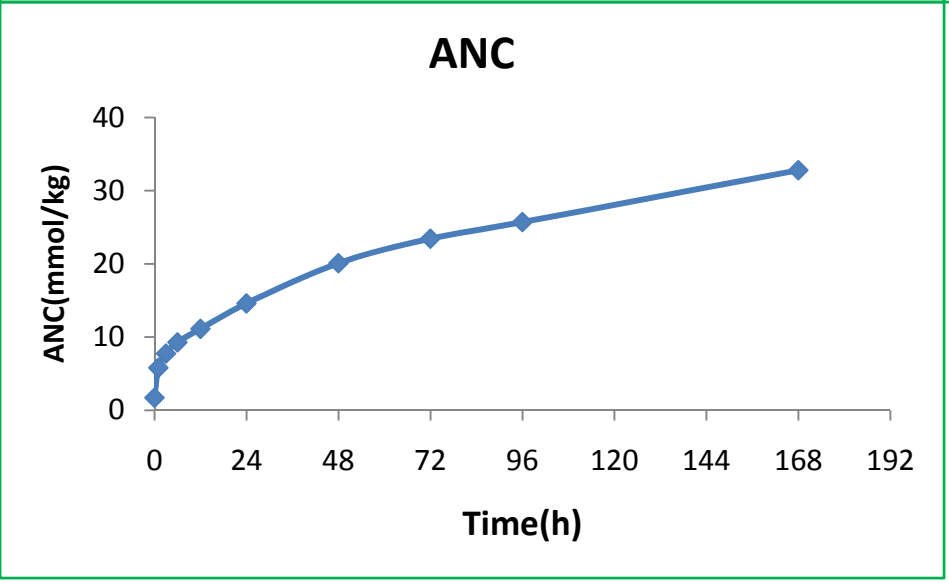




- High release of Cu and Zn
- Low release of other heavy metals
- Re adsorption at 72h
- ANC of soil higher than copper slag waste

# *Long term release of heavy metals under influence of pH on copper slag waste*




- High release of Cu
- Low release of other heavy metals
- Low ANC

# *Conclusion - Outlook*

- Low actual mobility of heavy metals from sediment and copper slag waste

- Heavy metals in the sediments and the copper slag waste samples were not mobilized easily with an organic complexation agent.

- Acidification had a more significant effect on heavy metal release in sediments (except Cd and Pb)

-High release of Cu and Zn in surface soil near the dump site

# *Conclusion - Outlook*

- Establish the ***local background*** concentrations of heavy metals

- Assess the ***potential recycling*** of copper slag waste as construction material (brick or aggregate)

- ***Sea water exposure*** test to assess the alteration of solid phases through time of copper slag waste

- ***Mineralogical analysis*** to study solid phase alteration through time of exposure of copper slag waste under different environmental conditions (sea water, acid)

- ***Bioavailability test*** to determine the hazards of the heavy metals from copper slag waste to organisms

# Thank you for your attention