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Response Surface Approach for Recovery and Optimization of Cu^{2+} from polluted soil.

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INTRODUCTION & AIM

1.1 Introduction

Cu^{2+} is a type of metal that is widely distributed in nature. This element may combine with other elements to produce alloys and has several beneficial qualities. The demand for Cu^{2+} consumption has increased dramatically in the current environment of rapid economic growth. Refractory Copper Oxides have been developed and used due to this scarcity. The most prevalent Copper Oxide minerals are Malachite and Azurite, which are followed by other Copper soluble salts, Chrysocolla, Zigueline, Copper Sulphate, Copper Phosphate, and Copper Arsenate.

For human and environmental health, metal pollution in the soil is a serious issue in many developed nations worldwide. Remedial procedures are necessary to remove pollutants from polluted soils at many industrial sites. The two most popular heavy metal treatment methods are hydrometallurgy and pyrometallurgy. Pyrometallurgy is mainly applied to minerals that contain a lot of Copper or Nickel. Hydrometallurgy has the advantage of recovering cobalt simultaneously with less expense and energy.

1.2 Main objective

To optimise the recovery of Cu^{2+} from contaminated soil using Response Surface Methodology, specifically through Central Composite Design.

1.3 Specific Objectives

I. To characterize polluted soil using XRF and FTIR.
II. To evaluate the effect of pH, soil to solution ratio, acid concentration and string speed on Cu^{2+} recovered.
III. To optimize Cu^{2+} recovered using RSM, Central Composite Design.

METHOD

Materials and Chemicals : Soil collected from VUT ground was used as the matrix for leaching, 98.5% Copper Sulphate was used to pollute the soil,98% Sulfuric Acid was used to leach out Cu^{2+} from polluted soil, 32% Hydrochloric Acid and 98% Sodium Hydroxide were used to adjust pH throughout the experiments and helps in breaking down the Copper-bearing minerals to make Cu^{2+} more accessible.

Characterization techniques:

- Fourier-transform Infrared Spectroscopy (FTIR)
- X-ray fluorescence (XRF)

Experimental setup:

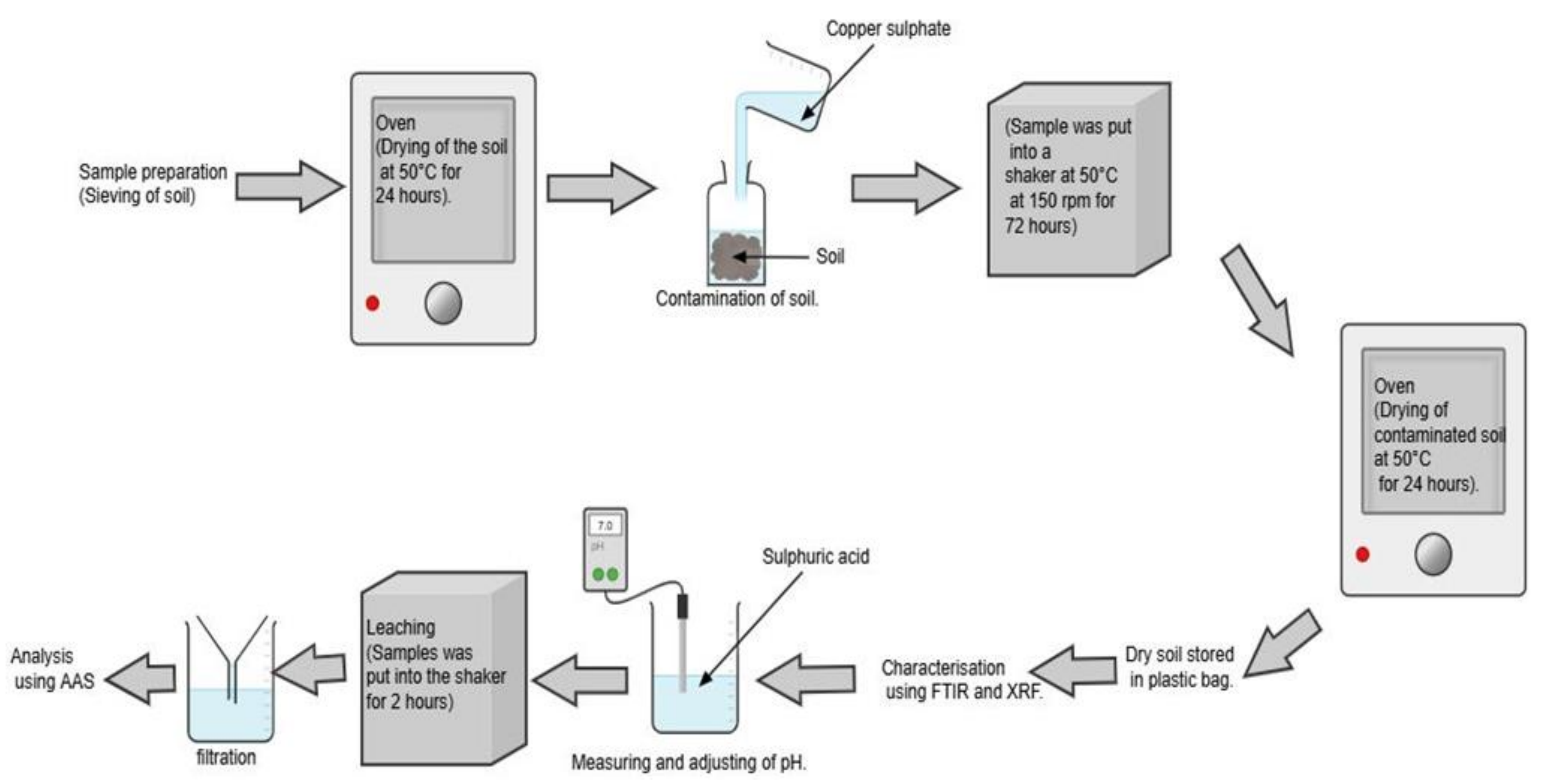

Figure 1: Experimental procedure

RESULTS & DISCUSSION

1. XRF Analysis

Table 1: Chemical compositions of polluted soil used.

Component	Result	Unit	Intensity
Al_2O_3	10.5	Mass %	1.74
SiO_2	54.2	Mass %	6.73
P_2O_5	1.93	Mass %	0.19
CaO	2.90	Mass %	0.67
TiO2	2.14	Mass %	0.61
Fe_2O_3	23.5	Mass %	9.55
ZrO_2	0.26	Mass %	0.43
CuO	3.11	Mass %	1.09

2. FTIR spectrum

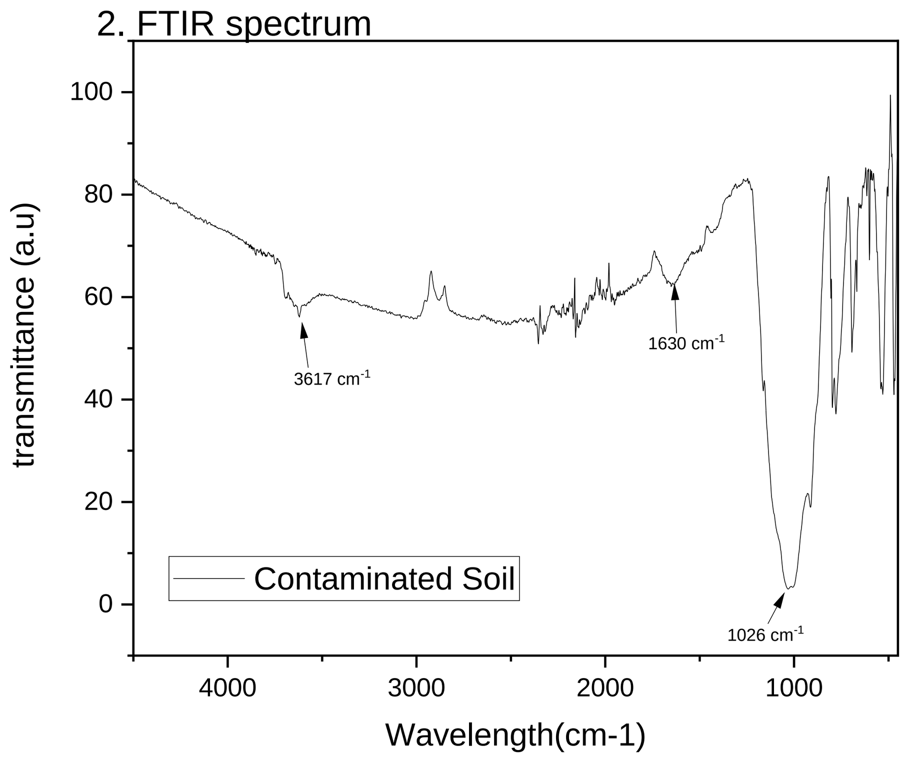

Figure 2: FTIR spectra for polluted soil.

3. Response Surface graphs.

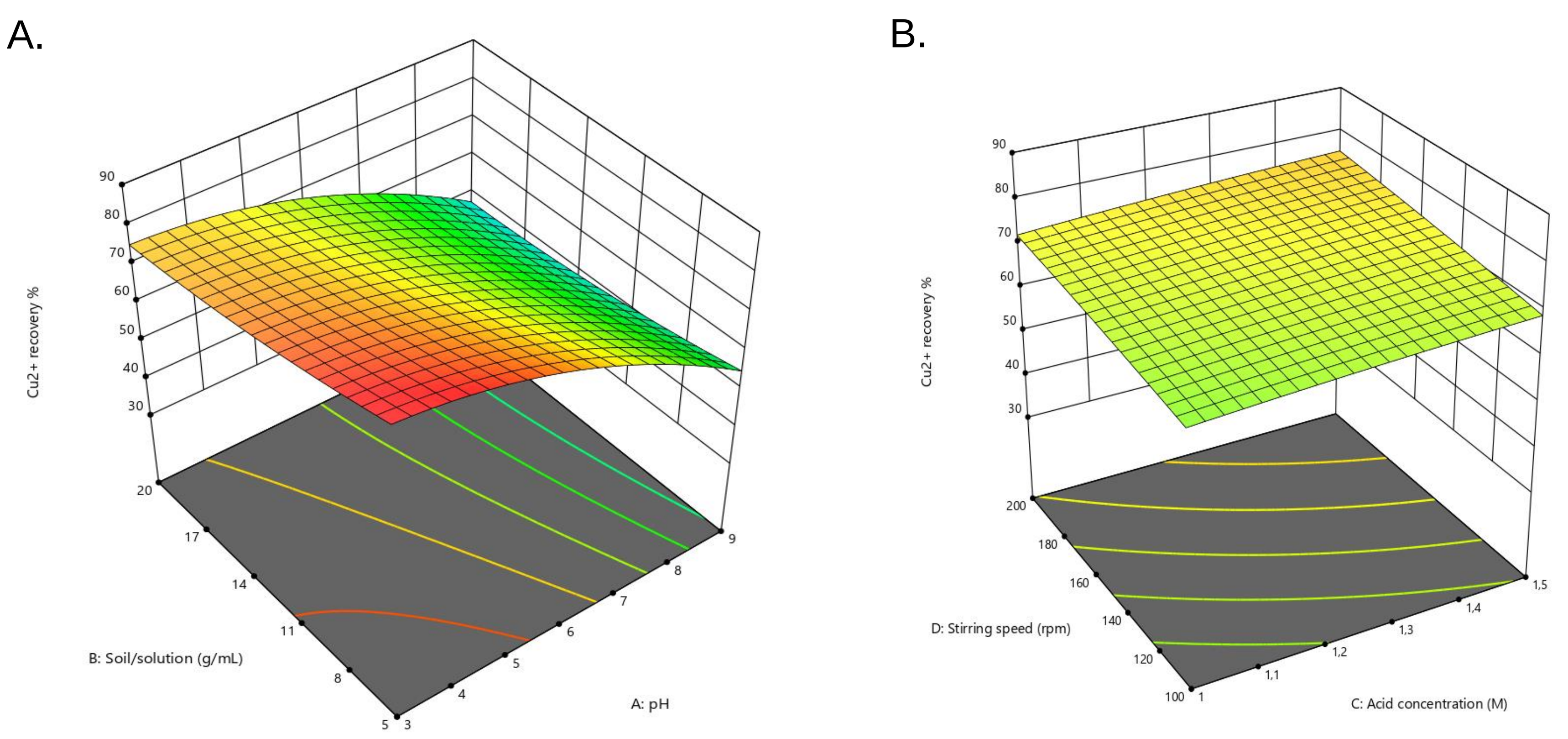

Figure 3: Response surface graphs (A)pH vs soil/solution (B) acid concentration vs stirring speed.

4. Optimization

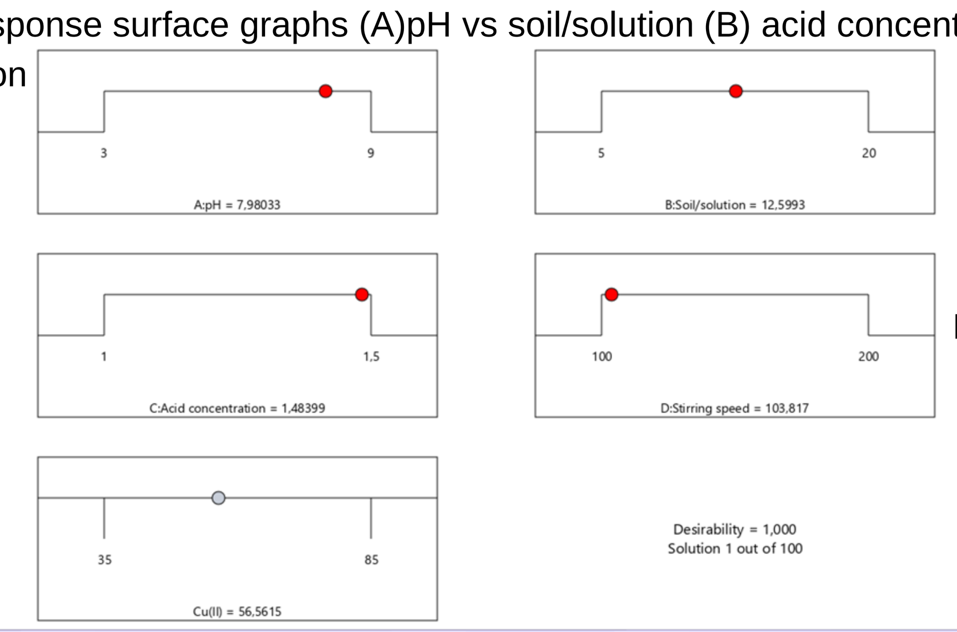

Figure 4: Optimization results.

CONCLUSION

- The soil was successfully contaminated this is indicated by the presence of CuO that is confirmed by XRF and functional groups that can interact with Copper ions confirmed by FTIR.
- pH was identified the most critical factor on recovery percentage with high F-value of 51.58.
- The optimal conditions achieved were a pH of 7.98, soil-to-solution ratio of 12.59 g/mL, acid concentration of 1.48 M, and stirring speed of 103.817 rpm, resulting in a maximum Cu^{2+} recovery rate of 56.56%.

FUTURE WORK / REFERENCES

Future works:Test a wider range of pH levels to improve Cu^{2+} recovery and understand how extreme pH conditions can affect soil quality.

Banza, M., Rutto, H. and Seodigeng, T. (2023) 'Soil and sediment contamination: An international application of artificial neural network and shrinking core model for copper (II) and lead (II) leaching from contaminated soil using ethylenediaminetetraacetic acid', Soil and Sediment Contamination: An International Journal, 00, pp. 1–21.