Investigation of copper recovery process from flotation tailings

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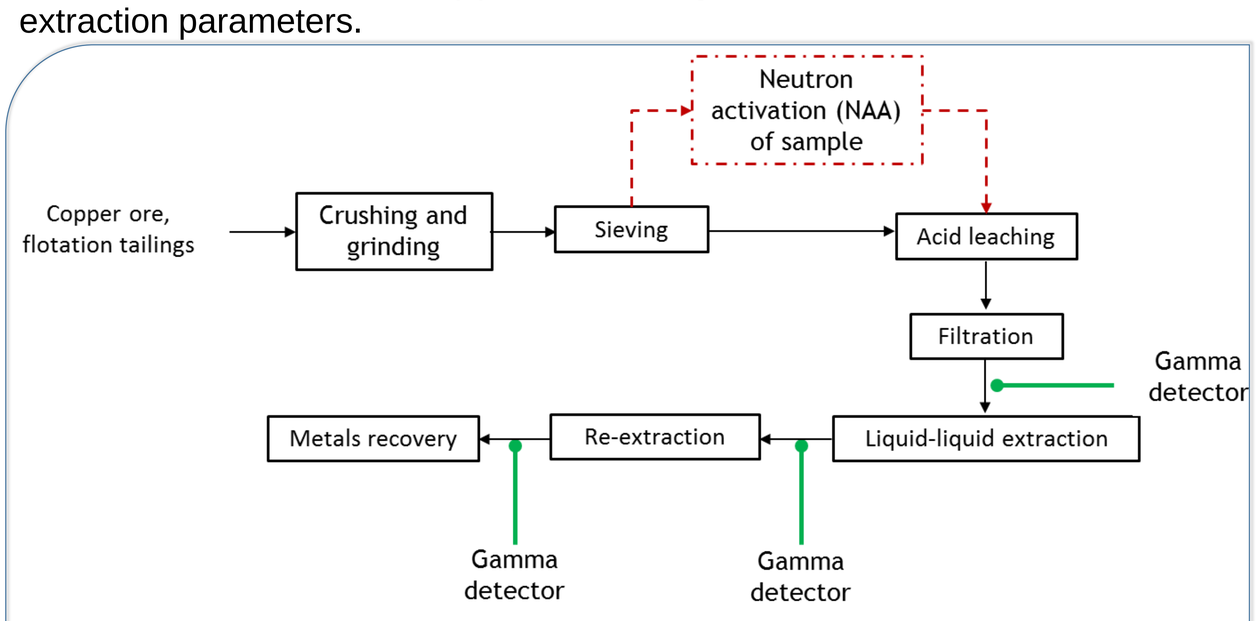
Background of the study

Copper mining and ore processing is one of the most stable and profitable branch of the Polish economy and one of the fastest growing industry. Commonly used technologies causes high losses of valuable metals into solid wastes streams. The development and implementation of hydrometallurgical technologies might be a solution which is feasible for high elements recovery and decreasing hazardous impact of the wastes storage on the environment. Radiotracer methods are the suitable tool for process investigation since most of the elements involved may be activated and their radioactive isotopes can be easily detected.

Methodology

Isotope of copper ^{64}Cu was selected as a radiotracer. Natural copper consists of 2 different isotopes: ^{65}Cu (30.9%) and ^{63}Cu (69.1%). Flotation tailings samples were irradiated and activated in MARIA Research Reactor (Świerk, Poland). The irradiated sample was mixed with some inactive portion of the milled flotation waste. Spectrum measurement was measured using a scintillation detector NaI (size 3x3”). The leaching process was conducted in a glass reactor equipped with a pump, filter system and gamma-spectrometer. The material was dissoluted using various acids in a wide range of their concentrations. The concentration of the leached of copper (as well as other metals) was calculated on the basis of the ratio of peaks height in the spectrum. The results were approved by ICP-MS analyses. The second step was extraction process for the selective recovery of Cu(II) from nitric acid aqueous solutions by Acorga P50 ligand. The process was carried out into two steps mixer-settler installation. The effect of the aqueous feed solution pH was examined, the Acorga P50 extractant concentration, and also the rate of extraction of Cu(II) were investigated. The results showed that almost 98% of copper was recovered in a solution after stripping under the optimal extraction parameters.



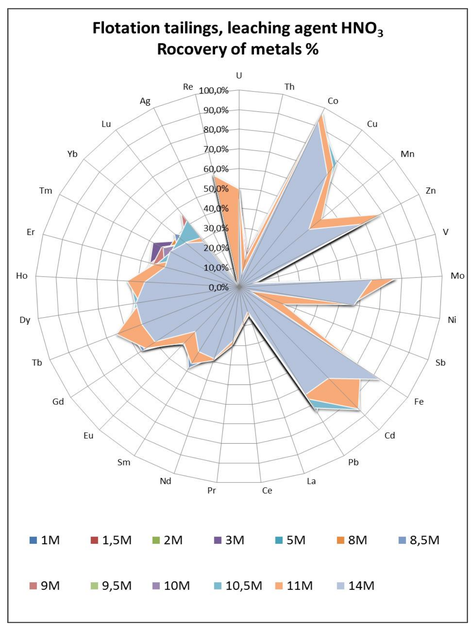
General scheme of processes for the metals recovery.

Leaching investigation results

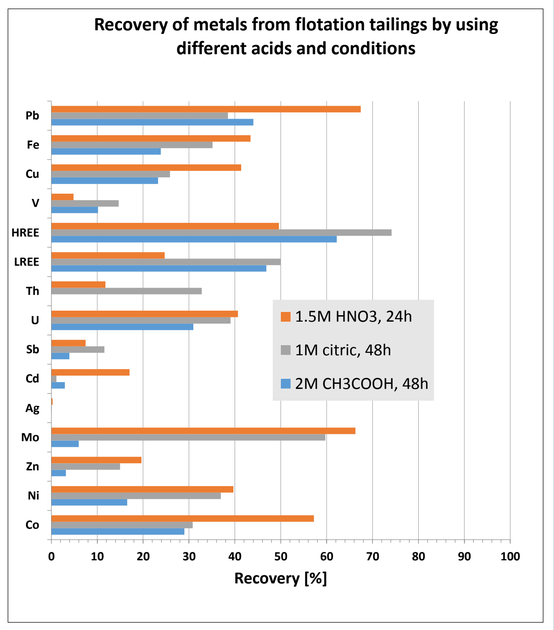
- The copper concentration, as a main metal, was at less than 1% in the flotation tailings
- Type of acid, its concentration and leaching time are the main factors responsible for the degree of metal recovery.
- Optimal conditions of metal leaching require to use > 8M HNO_3 and for 24 hours of the process.
- The quantitative analysis of leached copper were performed by ICP-MS and radiotracer method (^{64}Cu).

Element	Flotation tailings (ppm)
Co	124
Ni	70
Zn	524
Mo	35
Ag	61
Cd	3
Sb	4
U	6
Th	4
LREE - La, Ce, Pr, Nd, Sm, Eu	56
HREE - Gd, Tb,Dy, Ho, Er, Tm,Yb, Lu	9
V	137
Cu	10687
Mn	1239
Fe	8880
Pb	3088

ICP-MS analysis.



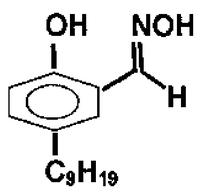
Exemplary results of leaching process using nitric acid at different concentrations.



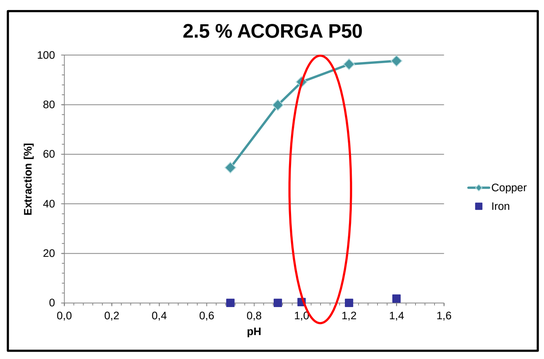
Exemplary results of recovery of metals from flotation tailings by using different acids and conditions.

Optimal parameters of the system for efficient and selective extraction of copper:

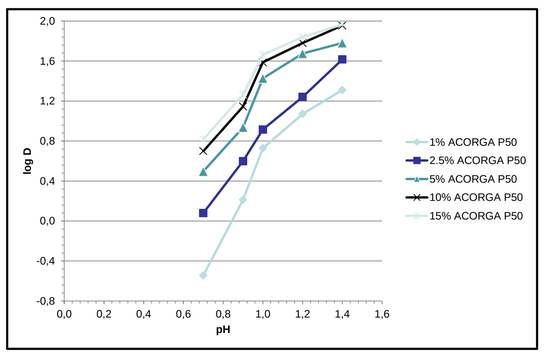
Organic phase: 2.5 % (v/v) ACORGA P50 in kerosene
Aqueous phase: pH = 1.2 - feed solution
O/A ratio = 1/1 mL
t = 20 min
T = 25 ±2 °C
Speed of mixing: 800 rpm
One-stage extraction process
<u>> 98 % extraction of Cu</u>



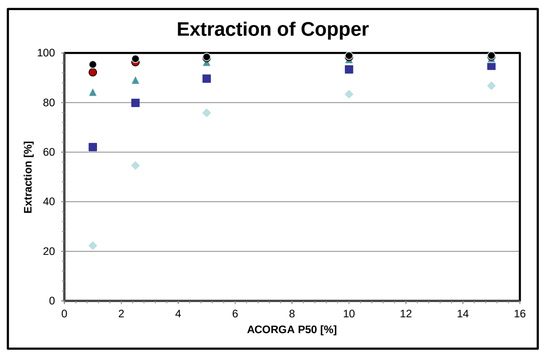
ACORGA P50
(LIX 860N-I),
5-nonylsalicylaldoxime
(2-hydroxy-5-nonylbenzaldehyde oxime)



pH = 1.2 and 2.5% ACORGA P50:
> 98 % extraction of Cu and no extraction of Fe.



Equilibrium measurements: effect of the equilibrium pH-value on Cu(II) distribution ratios, D, for different concentrations of ACORGA P50.



The effect of the equilibrium ACORGA P50 concentration and pH-value on copper extraction at 25 ±2 °C.

Pilot plant mixer-settlers system for the continuous countercurrent solvent extraction process (SX Kinetics Inc., Canada).

<u>Stripping of Cu(II) from the organic phase after extraction:</u>
1M HNO_3 / H_2SO_4 - aqueous solution;
three-stage stripping process;
~100% yield
Organic phase is regenerated and can be reused in the extraction process in the closed loop.

Acknowledgments
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