RADIOTRACER METHODS FOR ORE AND FLOTATION TAILINGS LEACHING

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Background of the study

The 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. However, commonly used technologies lead to high losses of valuable and so-called deficit metals (rare earths, uranium and copper as well) in solid wastes streams (Fig.1). The development and implementation of hydrometallurgical technologies is a solution which is feasible for a higher elements recovery efficiency and decreasing hazardous impact of the wastes storage on the environment (Fig.2). 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. The separation efficiency, process kinetics and flow dynamics of hydrometallurgical systems can be therefore qualitatively and quantitatively evaluated.

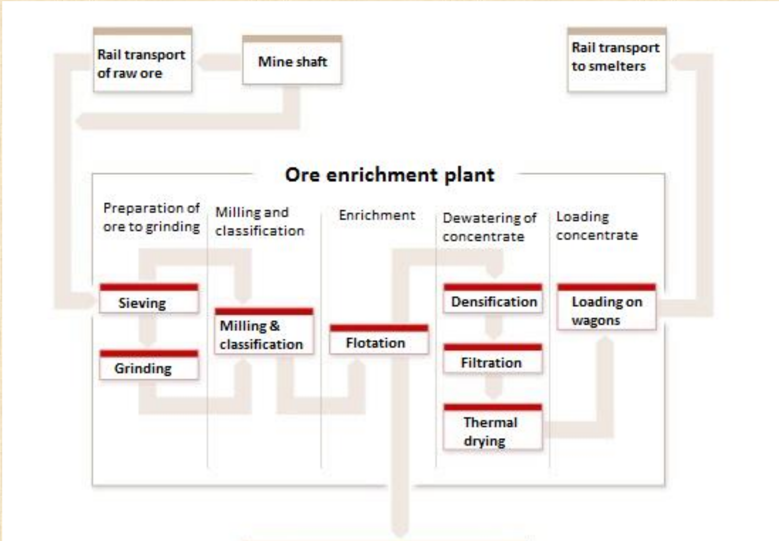


Fig.1 A block diagram of processing copper ore in KGHM Polska Miedź. Source: kghm.com

Each year there are 20 to 26 million tons of flotation wastes

Fig.2 **Żelazny Most Reservoir**, with the area of 13.95 km² and total capacity of 700M m³ is currently the largest such facility in Europe and one of the largest in the world.

Methodology

- The objective of the project is to elaborate an efficient method for recovery of copper and some critical metals from the various raw materials (ore, flotation tailings) using radiotracers for the process optimization. The radiotracers (activated ^{64}Cu) were used to determine leaching efficiency instead of some common analytical techniques. Obtained metal solution will be separated at mixer settlers and ion exchangers which are also optimized by radiotracers methods (Fig. 3).
- The raw material was crushed and sieved to obtain a 0.2-0.5 mm powder fraction.
- Initial concentrations of copper and other elements were determined by ICP-MS method (Table 1).
- The leaching process is carried out in a periodic chemical reactor using various acids - sulphuric(VI), nitric(V), acetic, citric, and ascorbic.
- Influence of different parameters on leaching have been studied - a wide range of acid concentrations (0.1-18M H_2SO_4, 0.001-14M HNO_3, 0.1-10 CH_3COOH, 0.1-1M citric, 0.5-1.4M ascorbic); different leaching time (up to 48h) and temperature (RT or 45°C). Radiotracer techniques based on nuclear activation analysis (NAA) have been used for process optimization.
- The samples of the material were activated in neutron flux at MARIA Reactor and mixed with leached materials (Fig.4).
- Cu-64 signals were collected using a spectrometer equipped with a NaI detector (size 3x3")

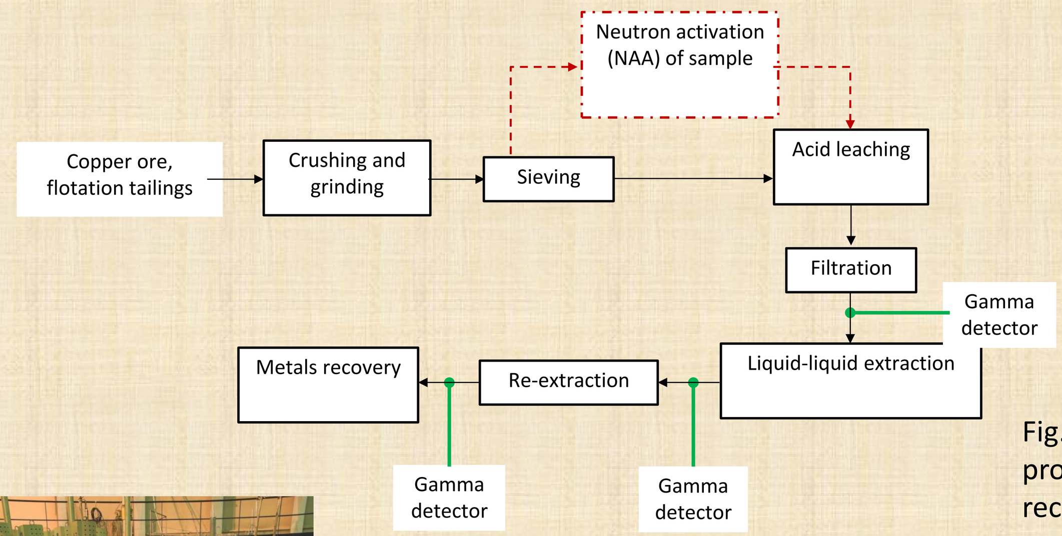
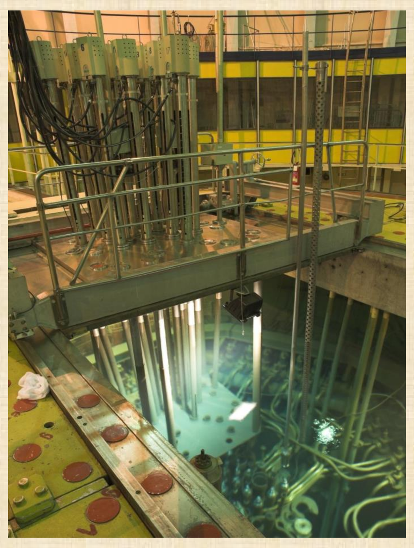


Fig.3 General scheme of processes for the metals recovery



Plastic containers with 1g sample of raw material

Neutron flux $1{\cdot}10^{14}$ n/cm²·s

Irradiation time 15 - 50 minutes

^{64}Cu ($t_{1/2}$ = 12.8 h)

in ore sample: 89 MBq

in flotation tailings: 22 MBq

Fig.4 Neutron activation process of samples, MARIA Research Reactor in Świerk (Poland).

Results

- The copper concentration, as a main metal, was at 4% level in the ore and less than 1% in the flotation tailings (Table 1).
- Type of acid, its concentration and leaching time are the main factors responsible for the degree of metal recovery (Figs 5-8).
- Optimal conditions of metal leaching require the use of medium acid concentrations and 4-6 hours of process. Longer time sometimes leads to decreased metal concentration.
- Under studied conditions, silver was the metal of the poorest leaching.
- Because of the interference for manganese, its recovery often exceeded 100%. Therefore, the graphs show no results for Mn.
- Metal leaching kinetics is different for ore and waste samples.
- The quantitative analysis of leached copper is consistent in ICP-MS and radiotracer method (^{64}Cu) (Fig.10).

Element	Copper ore (ppm)	Flotation tailings (ppm)
Co	397	124
Ni	375	70
Zn	393	524
Mo	334	35
Ag	201	61
Cd	2	3
Sb	5	4
U	18	6
Th	5	4
LREE - La, Ce, Pr, Nd, Sm, Eu	104	56
HREE - Gd, Tb,Dy, Ho, Er, Tm,Yb, Lu	14	9
V	1358	137
Cu	39403	10687
Mn	1335	1239
Fe	23977	8880
Pb	26200	3088

Tab.1 ICP-MS anaylsis of copper ore and flotation waste samples. LREE, HREE - Light and Heavy Rare Earth Elements.

Fig.5 Recovery of metals from copper ore by using H_2SO_4

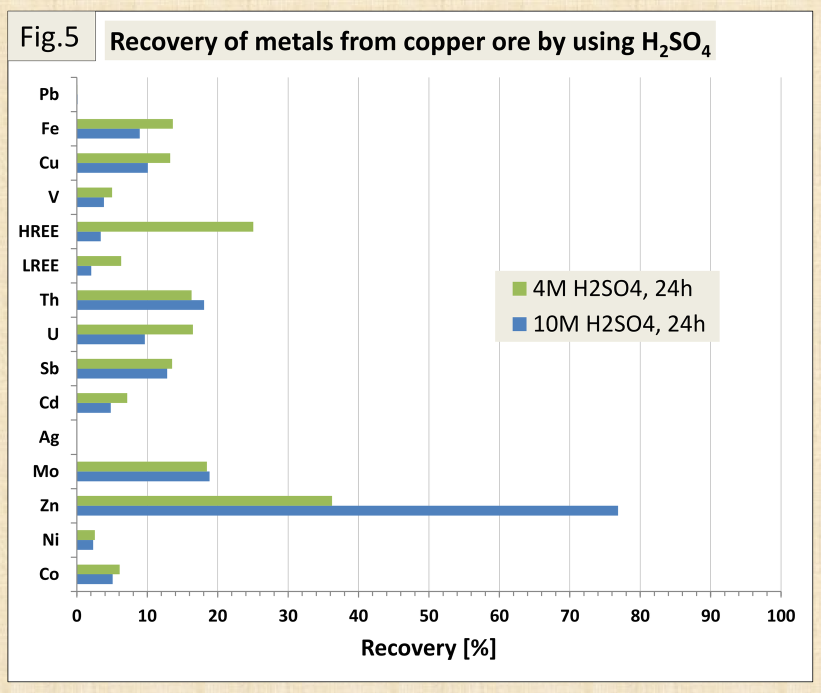


Fig.6 Recovery of metals from copper ore by using different acids and conditions

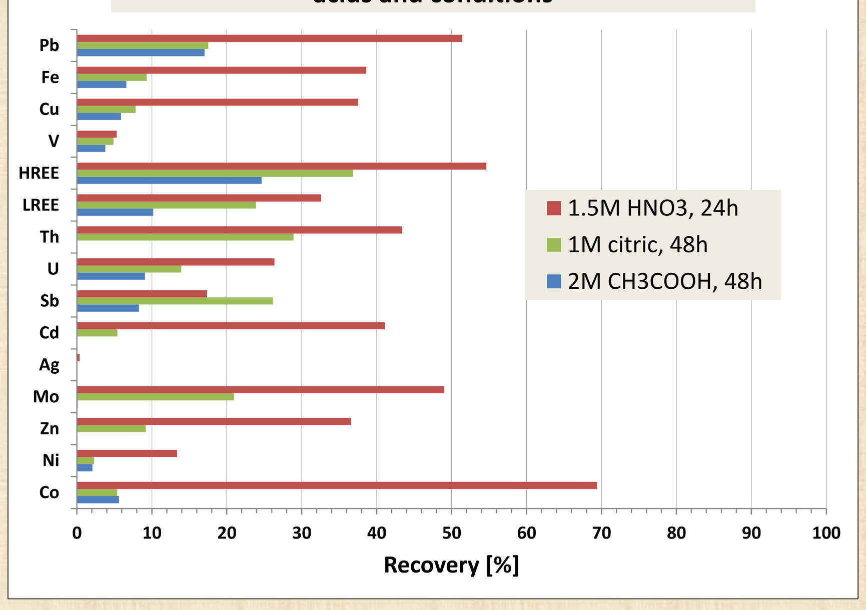


Fig.7 Recovery of metals from flotation tailings by using H_2SO_4

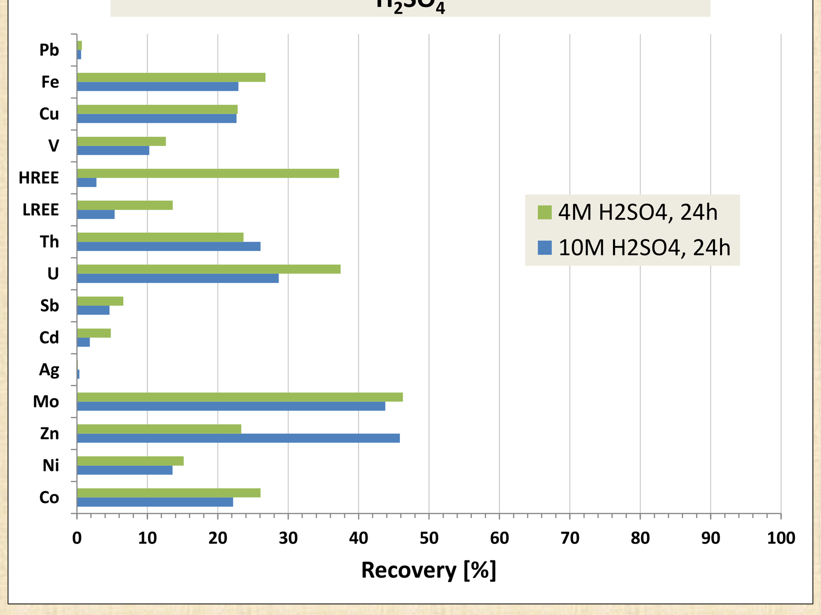
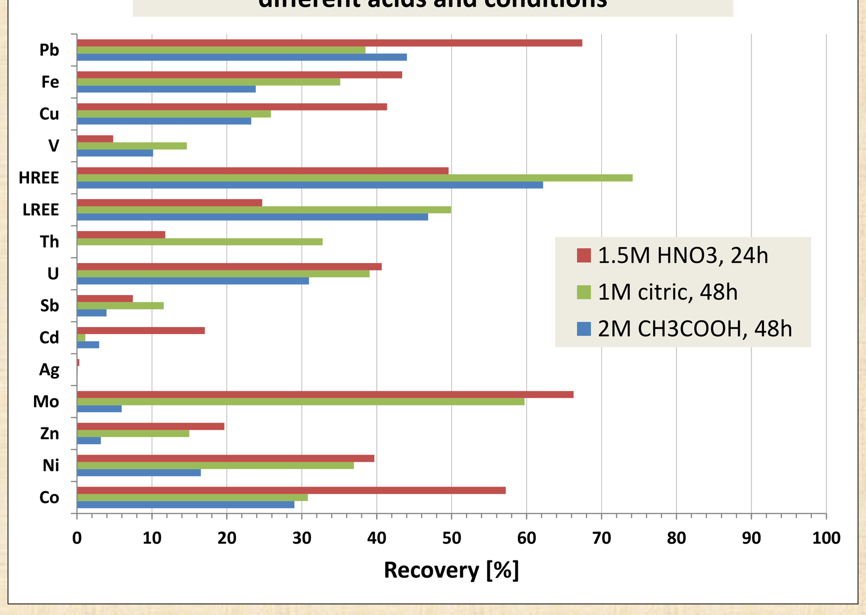


Fig.8 Recovery of metals from flotation tailings by using different acids and conditions



Figs 5-8 Exemplary results of leaching process under different conditions

Fig.9 Leaching of Cu-radiotracer using 0.5M H_2SO_4

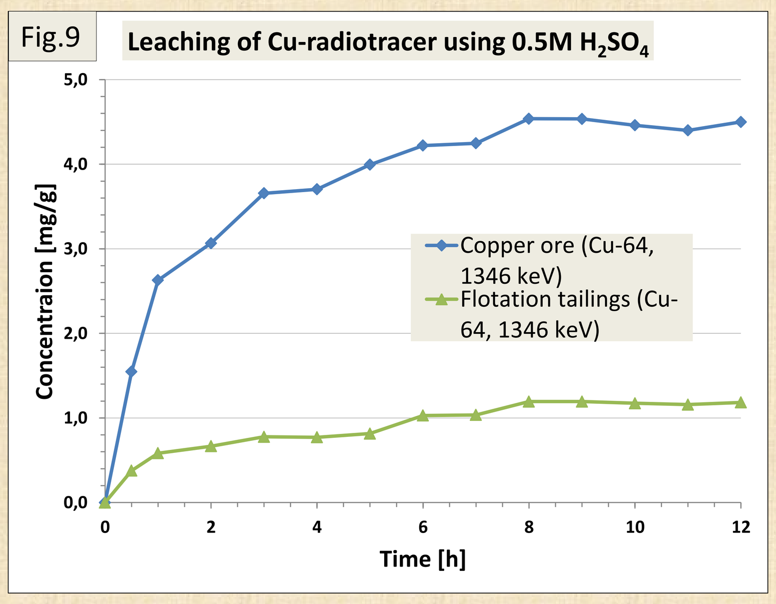
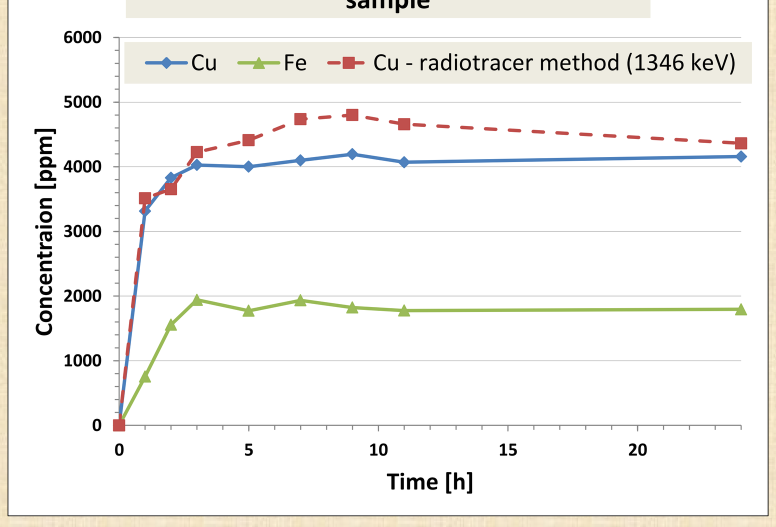


Fig.10 Leaching of ore by 2M H_2SO_4 with activated sample



Figs 9-10 Exemplary results of leaching process using radiotracers

Acknowledgments
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