



**MINING AND METALLURGY
INSTITUTE BOR**

and



**TEHNICAL FACULTY BOR,
UNIVERSITY OF BELGRADE**



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**International October
Conference**

**55th International October Conference
on Mining and Metallurgy**

PROCEEDINGS

**Editor:
Ana Kostov**

**15 – 17 October 2024
Hotel “Đerdap” Kladovo, Serbia**



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PILOT PLANT FOR AGITATION LEACHING OF THE FLOTATION TAILINGS

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Abstract

The flotation concentration plant in the RTB Bor started working at the industrial scale in 1933 and terminated in 2003. During those seventy years of copper ore processing, the flotation plant had disposed a huge amount of solid waste in the old flotation tailing dump. Chemical analysis had shown that an average concentration of targeted metals in tailings is: 0.23 % Cu, 0.4 g/t Au and 2.0 g/t Ag. The leaching degrees of analyzed elements, achieved after leaching the composite sample of flotation tailings in the pilot plant were: 54.35% Cu, 15.35% Fe, 3.75% Ag and 3.75 % Au.

Keywords: leaching, flotation tailings, pilot plant.

1. INTRODUCTION

During more than a century of mining and production of copper, gold and silver in the Mining and Smelting Plant in Bor, the landfills were formed, which due to a low content of useful components, could not be treated economically in a given period of time. These are the disposal sites for overburden from the "old" open pit, flotation tailings, residual ore in the pit, and similar [1,2]. Due to the increased exploitation of copper ore and discovery the low-quality deposits, it can be expected that more tailings will be present in the coming years, which could cause more environmental problems and challenges to solve them [3].

Disposal of flotation tailings in the Bor flotation from 1933 to 1987 was carried out in the valley of the Bor River. In the phase of exploitation the tailing dump, it is spatially divided into three fields separated from each other by cyclone sand dams. The Field III is filled with overburden from the open pit and ash from the Thermal Power Plant, so that the Fields I and II of the flotation tailing dumps remain available for possible additional revaluation of useful components.

The tailing dump itself is located on the border of the urban and industrial part of the city, and below it there is a city wastewater collector. Due to its close proximity to the city center, the old Bor flotation tailing dump is also one of the sources of negative environmental impact, which is reflected in the spreading of fine dust into the environment during windy periods and runoff of acidified water [4].



This paper contains a systematized review of physical characteristics and grain-size analysis of a representative sample of flotation tailings composite, which is acid leached at atmospheric pressure on an enlarged scale - at a pilot plant.

2. EXPERIMENTAL

In this paper, composite samples of flotation tailings with the following designations were used for the planned experimental tests of the leaching process of copper, gold and silver from tailings of the Old Flotation Tailing Dump:

The composite II was formed from samples from the part of tailing dump that includes the Field 2 with an estimated total amount of tailings of 9,924,717 t, which represents about 40% of the total amount of tailings. The estimated metal content is: 22,827 t Cu + 4.0 t Au + 20.0 t Ag.

3. RESULTS AND DISCUSSION

3.1 Physical-Chemical Characterization of Samples

Physical characteristics of representative samples of the flotation tailings composites include determination the sample density, bulk density and sample pH. The results of physical characterization the representative samples of flotation tailings composites are shown in Table 1.

Table 1. Physical characterization of representative composite samples of flotation tailings

Sample	Density (g/cm ³)	Bulk mass (kg/m ³)	pH
COMPOSITE II	2.765	1176.0	2.82

Table 2 presents the chemical characterization of representative sample of flotation tailings.

Table 2. Chemical composition of representative sample of flotation tailings composite II

Element	Unit	Content	Analytical method*	Element
Cuuk	%	0.23	AAS	Cuuk
Cuox	%	0.12	AAS	Cuox
Fe	%	8.9	ICP-AES	Fe
Ca	%	0.74	ICP-AES	Ca
K	%	0.59	ICP-AES	K
Na	%	0.19	ICP-AES	Na
S	%	12.38	ACS	S
SiO ₂	%	49.88	G	SiO ₂
Al ₂ O ₃	%	11.0	ICP-AES	Al ₂ O ₃
Au	ppm	0.4	FA/AAS	Au
Ag	ppm	2.00	FA/AAS	Ag



Sr	ppm	642	ICP-AES	Sr
As	ppm	166	ICP-AES	As
Zn	ppm	49.1	ICP-AES	Zn

* AAS - Atomic Absorption Spectrophotometer

ICP-AES - Inductively Coupled Plasma Atomic Emission Spectrometry

ACS - Carbon and Sulfur Analyzer

G - Gravimetry

FA - Flame Analysis of precious metals (cupellation)

Based on the copper analysis, shown in Table 2, it can be stated that the share of oxide copper in relation to the total copper for the studied composite samples is as follows:

$$\text{COMPOSITE II: Cu oxide/Cu total} = 0.12/0.23 = 0.52 \text{ (52\%)}$$

3.2 Copper Leaching from the Composite II Sample

In a reactor, made of poly-propylene, with a volume of 50 L, the leaching experiment of a composite sample of flotation tailings COMPOSIT II in the amount of 8 kg was carried out, under the optimal conditions previously defined by the laboratory tests (particle size: $-75 \mu\text{m}$, without the addition of oxidants, temperature: ambient, ratio of solid and liquid phase: 1:4, time: 4h, pH of the suspension: pH=1. To correct the pH value from pH 2.7 to pH 1, 200 ml of concentrated H_2SO_4 was added which represents the consumption of concentrated sulfuric acid of 44 kg per ton of tailings.

After the leaching process was completed, the suspension was filtered on a plan filter, and the solid residue was washed with water that was mixed with the alkaline solution. The volume of alkaline solution and rinse water was 47 L.

The solid residue was dried in a dryer to a constant mass of 7 kg and sampled. Its physico-chemical characterization was performed (Table 3 and Table 4), as well as its grain-size distribution. The results are shown in Table 5.

Table 3. Results of physical characterization of solid residue

Sample		Unit	Value
T-SFJ-PILOT	Sample mass	kg	7
	Moisture	%	0.33
	Bulk mass	kg/m ³	1355
	Density	kg/m ³	2850
	pH	/	2.88

Table 4. Results of chemical analysis of solid residue after copper leaching from the composite sample COMPOSIT II

Element	Cu (%)	Fe (%)	Ag (g/t)	Au (g/t)
Content	0.12	8.61	2.2	0.44



Table 5. Grain-size distribution of the solid residue after leaching the composite sample COMPOSITE II

d (mm)	m (%)	R (%)	D (%)
-0.425+0.300	2.00	2.00	100.00
-0.300+0.212	4.50	6.50	98.00
-0.212+0.150	6.00	12.50	93.50
-0.150+0.106	8.00	20.50	87.50
-0.106+0.075	8.50	29.00	79.50
-0.075+0.053	7.00	36.00	71.00
-0.053+0.038	7.50	43.50	64.00
-0.038+0.020	9.00	52.50	56.50
-0.020+0.00	47.50	100.00	47.50

Based on the results of chemical analyses of the solid residue, the leaching degrees of analyzed elements, achieved after leaching the composite sample of flotation tailings II at the pilot plant, were recalculated and are: 54.35% Cu, 15.35% Fe, 3.75% Ag and 3.75 % Au, what is in agreement with the results obtained at the laboratory level. Considering that the content of oxide copper in the composite sample of flotation tailings II is 52% (based on the data shown in Table 2), it can be stated that the copper, present in the oxide form, was completely leached in the sulfuric acid solution without heating, in a time of 4h and at the ratio of solid and liquid phase 1:4.

Based on the obtained results of the grain-size analysis, it can be concluded that 79.5% of the solid residue sample, obtained after agitation leaching of the composite sample of flotation tailings COMPOSITE II at the pilot plant, consists of particles smaller than -75 μm .

4. CONCLUSION

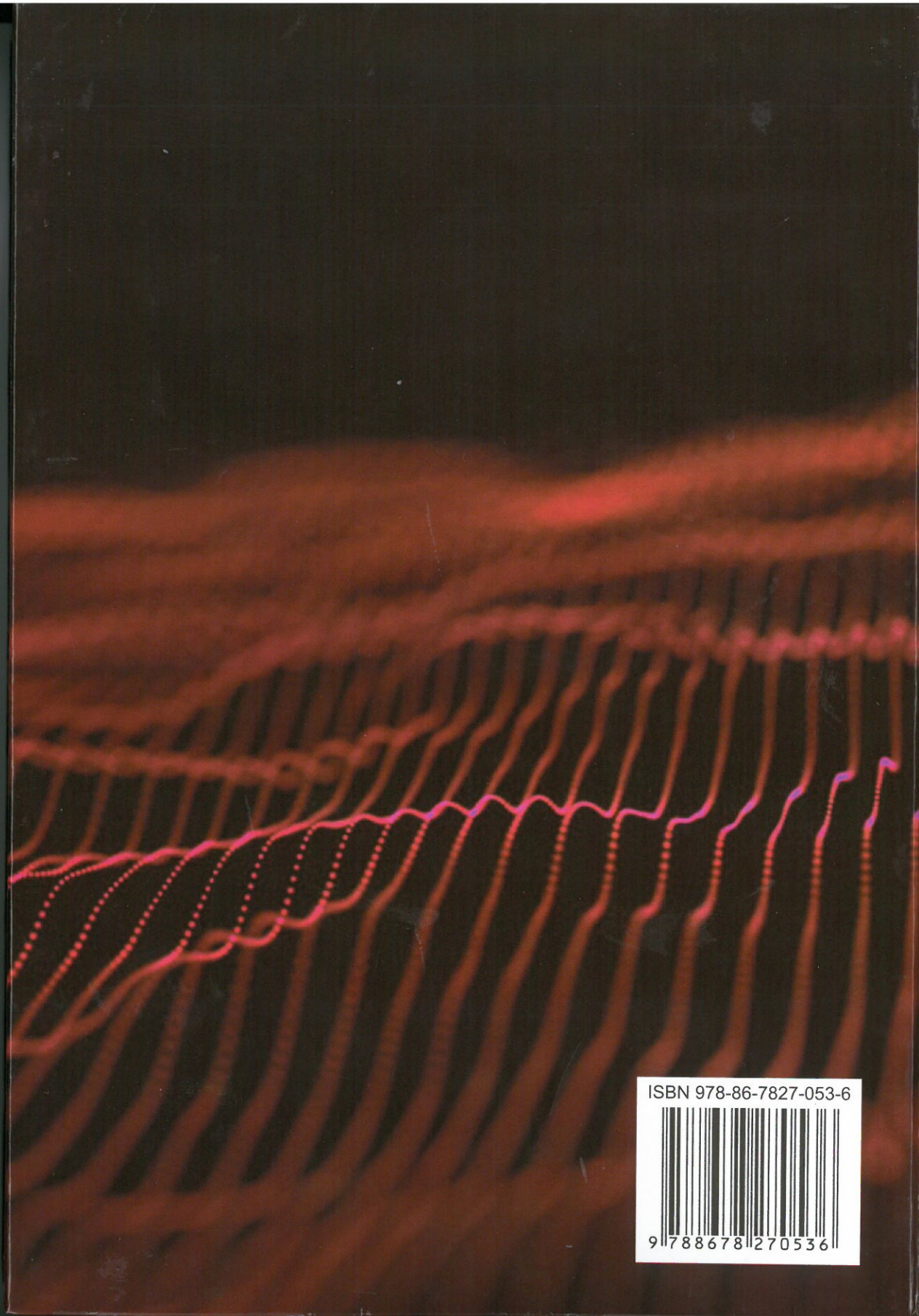
This paper presents the results of copper agitation acid leaching with sulfuric acid at atmospheric pressure for 4 hours, with a ratio of solid to liquid phase 1:4 at ambient temperature. Leaching was carried out at the pilot plant, during which 8 kg of flotation tailings were leached. The results showed that under these conditions the percentage of Cu leaching was over 54%.

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