

Review paper

INFLUENCE OF THE UNDERGROUND MINING WASTE ON THE ENVIRONMENTAL TAILINGS AND WASTEWATER CHARACTERIZATION

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Abstract: In presented paper influence of the underground mining waste on the environmental was investigated. From that point tailings and wastewater characterization was performed on samples taken from lead and zinc mine Grot, Serbia. In order to obtain experiments necessary for characterization, representative samples were taken from three different parts of the tailings: outlet pipe of the flotation facility (JOF), hydrocyclone overflow (JHC) and crest of dam (JKB). Characterization of the tailing samples include: thermal (differential thermal analysis and thermogravimetric analysis (DTA/TGA) and infrared analysis (FTIR), determination of the chemical composition and content of the heavy metals and qualitative roentgen analysis (XRPD). Also, wastewater samples have been taken from the tailings and concentrations of heavy metals in the taken samples were determined by using inductively coupled plasma mass spectrometry (ICP-MS).

Keywords: tailings; wastewater; lead and zinc mine Grot; characterization; heavy metals;

1 INTRODUCTION

The materials which remain after mining or technological processing of ore represents an industrial waste. In general, industrial waste, due to its characteristics, may be hazardous or non-hazardous. The waste which is obtained due to mining activities, and is disposed on the landfill is named tailing (Stevanović et al., 2003). Unfortunately, tailings are often located in environments which have cultural, historical and very often touristic potential. Also, the tailings may have an influence on the agricultural production, contaminate water (ground and underground sources) as well as air and consequently tailings may have an influence on human and animal health. Tailings, especially those obtained from mines which are active for a long time are very often located near water sources, so very easily the water sources may be contaminated and polluted.

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Mine Grot is located on the southeast slope of the mountain Besna kobila, in southeastern part of Serbia in the municipality of Bosilegrad. This part of the Republic, administratively is named a basin of South Morava, while the locals named it Krajište. Near tailings of the mine is located small town Kriva Feja.

The environment of the tailings and mine Grot is characterized with very beautiful nature with a high potential for tourism and there are located numerous protected natural areas: in the southeastern part of tailings is a monument of nature-black pine tree in Crnoštica, eastern from the tailings is Jarešnik-Special Nature Reserve and northern Vlasina range which is in the protection process (Institute for Nature Conservation of Serbia, 2005).

From aspect important for mining, it is good to know that the first geological data of this area is found in the Boue-a (1836) and Toula-e (1883) researchings. These researchers found that in the north of the Kriva Feja (Mountain-Crna Trava-Trn) was located phyllite, quartzite and micas.

Vankov (1900) noted that the oldest shales lie in the field Crnooka and registered presence of the granite in Topli Dol, Donja Lisina, Bosilegrad, Ljubatska Reka, Dukat, Jarešnik and Bucalovu. The same researcher found young volcanic rocks and tuffs in Karamanica area and Besna kobila, and first described presence of the mineral raw materials (Pb, and Zn) in Blagodol in Talamine and Resn; magnetite in Božica and gold in the neogen near Bosilegrad. With these studies started first organized mining activities in the wider region of Blagodol.

Cvijić (1911) described a lake terraces between the Vranjska Banja and Suvojnica, and Dinić (1923) sediments in Pčinja and Surdulica. Petković (1937) indicated Pb-Zn occurrences in Karamanici. Ilić (1939, 1940, 1950, 1954) explored the petrochemical composition of Surdulica massif, volcanic companion, crystalline schists and surroundings and the occurrence of mineral deposits within the massif. According to the same author, the pluton is imprinted between the Cretaceous and Tertiary.

Djordjević (1962) investigated the occurrence of magnetite in crystalline schists in wider area of Vlasina.

Pavlović (1957) in its mineralogical-petrological studies noted that massive of Surdulica embedded in two phases, where the first was given the "gneiss-granite" under the influence of simultaneous granitization, weld and alkalization of gneiss, while the second crushing gneiss-granite which led to the formation of granite with hornblende.

The first commercial research and organized exploitation of these areas started in 1903, when the Italian Mining Company "Societe Comercial d'Oriente" conducts research and exploitation of the outcrops in „Djavalja vodenica“ and Kula. These activities lasted until the beginning of II World War. In this period around 10,000t of lead and zinc ore was exploited (Mijatović, 2006).

Exploration and exploitation in 1914 were suspended because of the effects of war. After this, at the Krasnodolska into Crna reka remained deposited mine tailings and flotation treated material (Đokić, 2007). Mining activities concerning mineral field Blagodot were suspended between two World War period.

In time period from 1958.-1972. the ore field Blagodot was investigated by geological, geochemical and geophysical methods. The result of researchings leads the opening of the mine. At the point where it is located today, in 1963. the facility in which it is carried flotation Pb-Zn ore was built. Reserves of Pb and Zn ore in deposit were certified in 1969. Amount of mineral reserves of A + B + C1 categories are 4,766.241 t with medium content of 4.16 % of Pb and 4.24 % Zn.

Between 1984 and 1991. started production of detailed geological maps in ratio 1: 25,000, and continuation of the detailed geological plan 1: 1,000 of Blagodot ore deposit.

Tailing obtained due to mining company Grot activities is located at the highest altitude in Serbia. The highest part of the top dam is 1,178 m, medium height of thee central plateau is 1,172 m and altitude of the central collector is 1,099 m (Đokić, 2007). In the tailings is located about 5.5 million tons floated tailing materials, mainly in the state of biological vacuum.

The main task of this paper was to determine whether the tailings of the flotation facility of the lead and zinc mine Grot, Serbia potentially dangerous for the nature and environmental. For that purpose, on samples taken from tailings, characterisation was performed and include: thermal (differential thermal analysis and thermogravimetric analysis –DTA/TGA) and infrared analysis (FTIR), determination of the chemical composition and content of the heavy metals and qualitative roentgen analysis (XRPD). Also, wastewater samples have been taken from the tailings and concentrations of heavy metals in the taken samples were determined.

2 EXPERIMENTAL

In order to obtain experiments necessary for characterization experiments, representative samples were taken from three different parts of the tailings of the mine Grot: outlet pipe of the flotation facility (JOF), hydrocyclone overflow (JHC) and crest of dam (JKB).

The chemical composition of the tailing was determined by the classical chemical analysis of the aluminosilicates (Voinovitch, 1966). The concentrations of investigated heavy metals were determined by atomic absorption spectrometry (AAS) by using “Analytic Jena Spekol 300” instrument.

Thermal analysis, (DTA/TGA) was performed on a Netzsch STA 409 EP instrument. Samples were heated from 25 to 1000°C in an air atmosphere with a heating rate of 10°C/min.

Structural properties of the samples were determined by infrared spectroscopy. The Fourier transform infrared (FTIR) spectroscopic analyses of tailings samples were performed using a Thermo Scientific “Nicolet iS50” spectrometer with diamond attenuated total reflectance (ATR) smart accessory at spectrum resolution of 2 cm⁻¹ and 64 scans over a range of 4000-400 cm⁻¹. After recording the spectra, two corrections were performed: automatic correction of the base line and atmospheric suppression.

The mineralogical analysis of samples, JOF, JKB and JPH was performed by X-ray Powder Diffraction (XRPD) analysis. All samples were characterized at room temperature by using Ultima IV Rigaku diffractometer, equipped with Cu K α _{1,2} radiation, using a generator voltage (40.0 kV) and current (40.0 mA), without monochromator. The range of 2 θ 10°–90° was used for all powders in a continuous scan mode with a scanning step size of 0.02° and at a scan rate of 2° min⁻¹. Data for structural refinement were taken in the 2 θ range 10°–90°, with a scanning step size of 0.02° and at a scan rate of 0.5° min⁻¹.

Wastewater samples have been taken from the outlet pipe of the flotation facility (OF) and hydrocyclone overflow (PHC) in accordance with standard procedure (SRPS ISO 5667-10:2007, Water quality. Taking of sample. Part 10: Guidance on waste waters sampling). Collected samples were kept in the capped container and left at room temperature in order to separate liquid from solid phase. After few days, liquid phase was decanted and filtered through qualitative filter paper in order to remove large particles and impurities. Then, concentrations of heavy metals in the wastewaters were determined by using inductively coupled plasma mass spectrometry.

3 RESULTS AND DISCUSSION

3.1 Chemical analysis

The results obtained by classical chemical analysis of the samples taken from different areas of the tailings - flotation facility (JOF), hydrocyclone overflow (JHC) and crest of dam (JKB) are given in Tables 1 and 2.

Table 1 Chemical composition of the tailings of the flotation facility of the mine Grot

	JHC	JKB	JOJ
SiO ₂ , %	48.61 (22.68 % Si)	40.09 (18.71 % Si)	53.62 (25.02 % Si)
Al ₂ O ₃ , %	12.94 (6.85 % Al)	8.68 (4.60 % Al)	10.52 (5.57 % Al)
CaO, %	9.33 (6.66 % Ca)	9.08 (6.48 % Ca)	8.73 (6.24 % Ca)
MgO, %	2.74 (1.65 % Mg)	1.86 (1.12 % Mg)	2.15 (1.30 % Mg)
Fe ₂ O ₃ , %	11.8 (8.26 % Fe)	16.46 (11.52 % Fe)	10.42 (7.29 % Fe)
Na ₂ O, %	0.98 (0.73 % Na)	0.75 (0.56 % Na)	0.97 (0.72 % Na)
K ₂ O, %	2.10 (1.74 % K)	1.46 (1.21 % K)	1.94 (1.61 % K)
TiO ₂ , %	1.01 (0.61 % Ti)	1.01 (0.61 % Ti)	0.84 (0.50 % Ti)
Mn, %	1.14	1.05	1.17
S, %	1.52	8.07	2.14
Loss on ignition, %	7.23	10.67	6.91

Table 2 The content of heavy metals in tailings of the flotation facility of the mine Grot

	JHC	JKB	JOJ	Ref. value
Cd, mg/kg	18	14	12	1
Pb, mg/kg	2800	6700	2100	10
Cr, mg/kg	94	61	74	10
Ni, mg/kg	60	70	55	10
Cu, mg/kg	120	73	55	50
Zn, mg/kg	2700	2200	2000	-
Sb, mg/kg	100	70	55	0.7
Ba, mg/kg	<D.L.	<D.L.	<D.L.	100

Results presented in Table 1 showed that all samples mainly consist silica (~23, ~19 and ~25 % for JHC, JKB, JOJ, respectively), while the content of alumina was about 7, 6 and 5 % for JHC, JKB, JOJ, respectively. In addition to these elements, all three samples contain relatively high amounts of calcium (~9 %), while the content of magnesium, potassium and sodium, as well as manganese and titanium was much lower. According to results presented in Table 1, the main difference between these three samples was in the content of iron which was very high and was about 8, 12 and 7 % for JHC, JKB and JOJ, respectively. Also, in all three samples sulphur was detected. The content of sulphur in JKB (8.07 %) was about fourth time higher in comparison with JPH and JOJ (1.52 and 2.14 %, respectively), indicating presence of higher amounts of sulphide minerals in the JKB.

By using chemical analysis of tailings materials it was also determined the content of heavy metals in investigated samples and results are presented in Table 2. If the content of heavy metals is compared, it may be concluded that the content of iron in all three investigated samples was much higher than concentration of other heavy metals. Even

more, the amount of iron for all three samples was much higher (>80 %) than total amount of all other heavy metals (14-18 %) in the tailings (Figure 1).

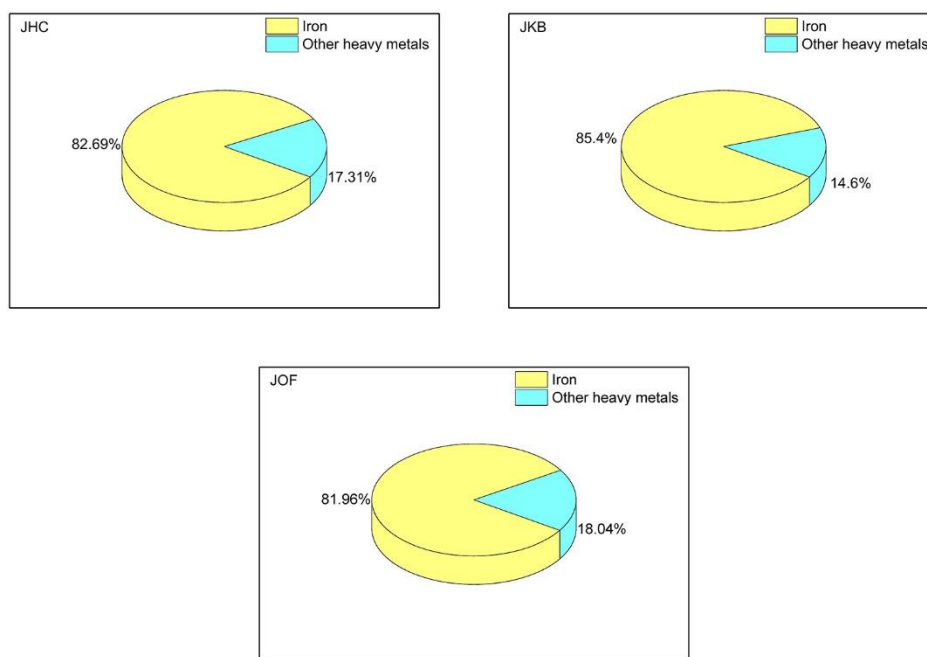


Figure 1 Ratio between the content of iron and other heavy metals in samples taken from three different parts of tailings from flotation facility of lead and zinc mine Grot, Serbia.

Also, as it can be seen from Table 2, the concentrations of all heavy metals (Cd, Pb, Cr, Ni, Cu and Sb) except Ba were much higher than referent values prescribed by the laws of Republic of Serbia (“Uverenje o utvrđivanju karaktera otpada, 2007”, Table 2). Consequently, according to the law of the Republic of Serbia (“Sluzbeni glasnik Republic of Serbia, 12/95”), investigated tailings samples may be classified as a dangerous waste.

3.2 Thermal analysis

The results obtained of thermal treatment of the samples taken from different areas of tailings are given in Figure 2 and Table 3.

As it can be seen from Figure 2 and Table 3 there is no huge difference in thermal properties between JOF and JPH, while slightly different behaviour was obtained for JKB. The TGA curves of all three samples showed non-continual trends in investigated temperature range. Very small weight losses (0.07 % for JOF, 0.21 % for JKB and 0.64 % for JPH) obtained in the first temperature area (25-400°C) are mainly due to moisture

losses. However, since the amount of the released moisture was very small, the characteristic DTA peaks were not observed, and DTA curves were practically unchanged. In second temperature region (400-650°C), one exothermic peak with maximum at 478°C was obtained by differential thermal analyses of the JOF and JPH, while weight losses of 1.39 (JOF) and 2.17 % (JPH) were obtained by TG analyses. On the other side, two exothermic peaks with much higher intensities in comparison with JOF and JPH were obtained for JKB. The peaks maximums were at 493 and 535°C, while in this temperature region, mass loss for the sample JKB was 3.92%.

Sulphide lead and zinc ores are always associated with other waste minerals known as 'gangue', usually calcite (CaCO_3), pyrite (FeS_2) or barytes (BaSO_4). Our results of chemical analysis showed ~8, ~12 and ~7 % of iron in JPH, JKB and JOF, respectively, as well as ~2 % of sulphur for JPH and JOF and about 8% for JKB. Since ratio between contents of iron and sulphur is not like in pyrite ($\text{Fe/S}=0.88$), and for all three samples the content of iron was much higher than amount necessary for pyrite which may be obtained from registered amount of sulphur in samples, these results suggest that beside presence in form of pyrite iron is also present in some of other forms, probably in form of oxide, chalcopyrite etc... Also, this is additionally supported with the fact that the sulphur is beside pyrite partly in the form of other minerals with Pb, Zn, Ni, Cu, etc. which may be presented in lead and zinc mine tailings.

In DTA curves (Figure 2) of all three samples, due to much smaller amounts of other heavy metals in comparison with iron (Figure 1), peaks characteristic for their minerals (PbS , ZnS , NiS , CuS) were not detected. Accordingly, regarding to shape and position of DTA peaks in second temperature interval, it may be concluded that DTA peaks with maximums at 478°C for JOF and JPH are due to presence of pyrite and its decomposition. On the other side, two exothermic peaks with maximums at 493 and 535°C obtained in DTA curve of the sample JKB, may be an indication that beside pyrite (peak at 493°C) iron was also presented in form of oxide (Fe_2O_3) (peak at 535°C)(MacKenzie, 1970).

In the third temperature range (650-1000°C) for all three samples an endothermic peaks with minimums at 796, 812 and 775°C were obtained at DTA curves of JOF, JKB and JPH, respectively. These peaks are characteristic for oxidation of carbonates and in all samples probably come from siderite (FeCO_3) and calcite (CaCO_3), which also were detected by XRPD analyses of samples (Figure 4). The decomposition of carbonates was followed with weight loss of 5.66, 6.41 and 6.03% for JOF, JKB and JPH (Table 3).

Table 3 Mass loss for investigated samples in different temperature regions

	Temperature, °C			
	25-400	400-650	650-1000	25-1000
JOF	0.07	1.39	5.66	7.12
JKB	0.21	3.92	6.41	10.54
JPH	0.64	2.17	6.03	8.84

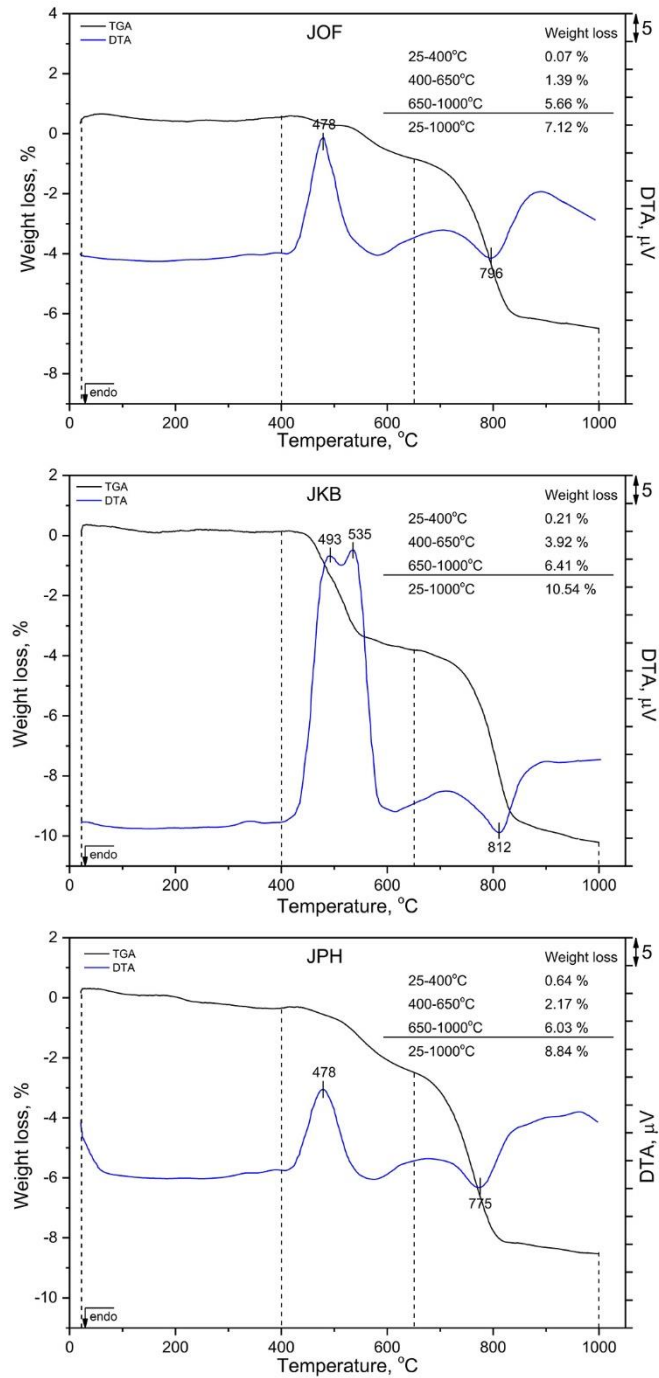


Figure 2 Thermal analysis of the JOF, JKB and JPH

3.3 Infrared spectroscopic analysis (FTIR)

Structural properties of the samples were determined by infrared spectroscopy and obtained results are presented in Figure 3.

As it may be seen from Figure 3, infrared spectra of all three samples are very similar each other and identical spectral bands appear in the spectra without significant changes in positions. That is in agreement with results of XRPD analysis of samples where almost the same and identical qualitative mineral composition of samples was observed. The spectrum of each sample is a resulting spectrum of all minerals which are included in the composition of a given sample. Thus, due to partial or complete overlapping of spectral bands, it was not possible to identify every individual mineral and determine exact composition of every sample. However, in all spectra it was possible to identify spectral bands and to assign their wave numbers. The band centred at $\sim 1420\text{ cm}^{-1}$ is due to the asymmetric internal stretching mode ν_3 of the CO_3 group which is characteristically broad for many carbonates. The measured value represents a composite of the transverse and longitudinal components of this vibration. The band at $\sim 870\text{ cm}^{-1}$ arise from the out-of-plane bending mode, ν_2 of the CO_3 . Existing of these two spectral bands confirmed presence of the calcite or siderite in all three samples (Samanta et al., 2016; Dubrawski and Channon, 1989).

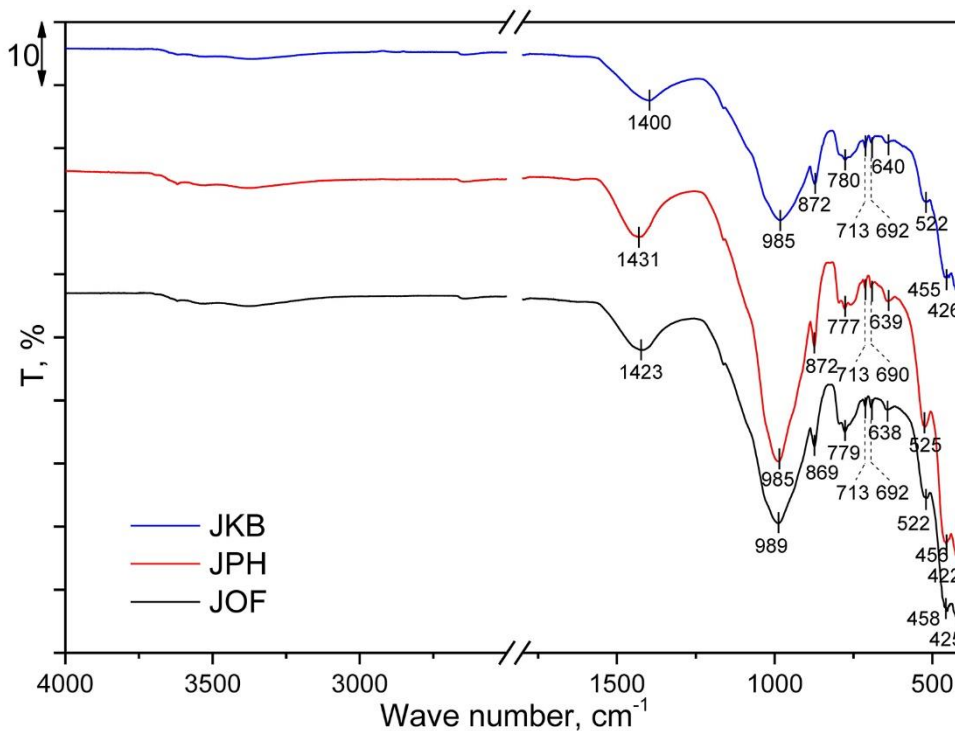


Figure 3 FTIR spectra of the JOF, JKB and JPH.

Spectral bands characteristic for iron oxide are not visible in spectra of JOF, JKB and JHC, probably due to overlapping them with bands originating from other groups. On the other side, two spectral bands of very low intensities at 713 and $\sim 692\text{ cm}^{-1}$ which are characteristic for pyrite suggest presence of the FeS_2 in all three samples (RRUFF Project, 2017). Other spectral bands are characteristic for aluminosilicate minerals (Marković et al., 2017) The strongest vibration band at $\sim 985\text{ cm}^{-1}$ is assigned to asymmetric Si–O–Si and Si–O–Al stretching vibrations. In the region from 400 to $\sim 640\text{ cm}^{-1}$ are bands that are assigned to Si–O and Al–O bending vibration modes. Band at 775 cm^{-1} is due to symmetric Si–O–Si and probably originated from quartz (Kocak, 2013).

3.4 Roendgen analysis

The mineralogical analysis of samples, JOF, JKB and JPH was performed by X–ray Powder Diffraction (XRPD) analysis. The obtained results are given in Figure 4 a-c.

As it can be seen from Figure 4 there are no huge difference between roentgen diffractograms of JOF, JKB and JPH. According to the obtained x-ray diffraction patterns of polycrystalline samples it was obtained that all three samples contain minerals quartz, clinocllore, calcite, phlogopite, siderite, iron oxide and anorthoclase.

Identification of the present phases was made based on the FullProf computer program and JCPDS Cards (Card No. 00-033-1161 for quartz, 00-029-0701 for clinocllore, 1010962 for calcite, 01-089-4212 for phlogopite, 00-002-0837 for siderite, 00-054-0489 for iron oxide, and 00-009-0478 for anorthoclase).

Finally, the microscopic analysis of investigated samples was performed. For that purpose, a polarisation microscope Carl Zeiss-Jena JENAPOL with measuring equipment and computer software Carl Zeiss AxioVision SE64 Rel. 4.9, module Multiphase and camera AxioCam 105 color was used. The mineralogical composition of the samples was determined by immerse method (as immersion xylene was used) with qualitative identification of present minerals. Lens zoom was 10x (Obtained results are not shown).

According to obtained results it was concluded that all three samples contain minerals: quartz, chlorite, minerals form carbonate group-calcite, feldspar group of minerals - orthoclase and clays group of minerals. The most abundant mineral in the samples is quartz, chlorite then carbonates and feldspar (K-feldspar, plagioclase and), while micas are side minerals. Also, in all samples, it was pronounced crystallinity of main phases. Results also showed that particle size was the highest for sample JKB, and lowest for the JPH.

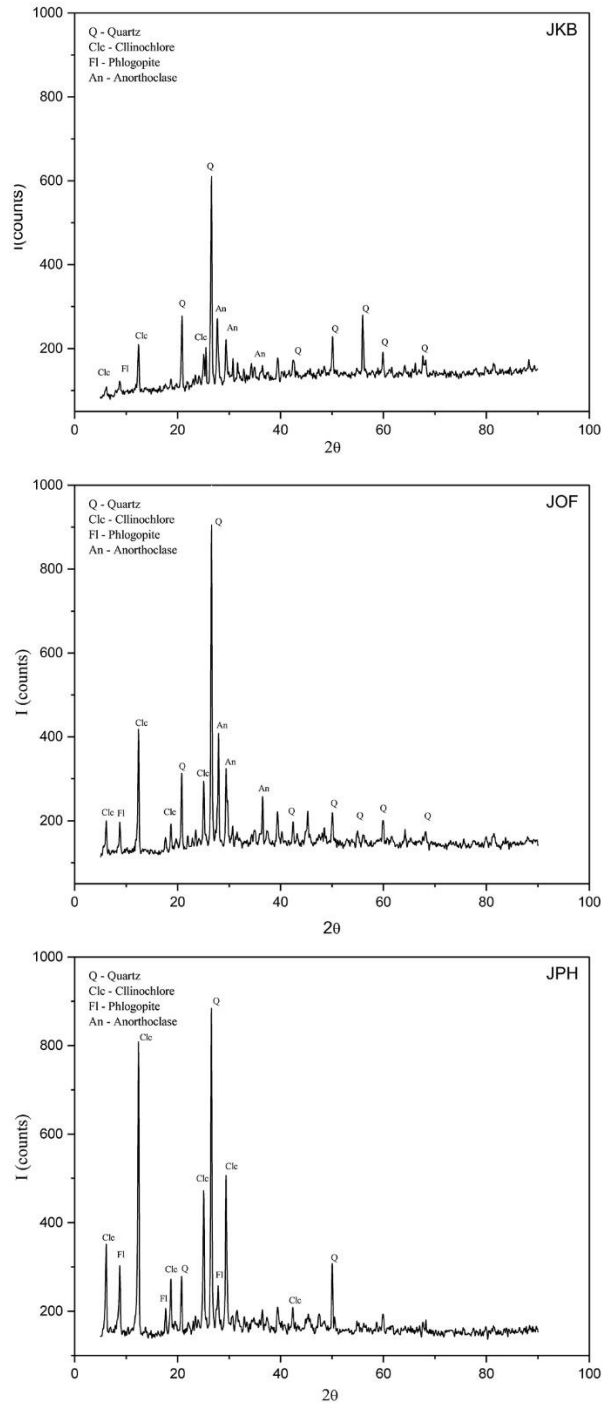


Figure 4 XRPD diffraction patterns of JKB, JOF and JPH

3.5 Tailing wastewaters

The above results clearly demonstrated that tailings from flotation facility of lead and zinc mine Grot, Serbia according to its composition may be classified as a dangerous waste. This is also supported by the fact that until now, on the tailings is deposited more than 5.5 million tons of tailing materials. Since the complete isolation of the tailings from the environment is not possible, its influence on the nature, including humans, animals and plants may be hazardous and with a serious consequences for health. In the environmental, hazardous constituents of the tailings could enter in different ways: 1) by scattering-through air, whereby by inhalation or secondary contamination of the soil or surface waters or plants may result in serious health problems for humans or animals; 2) by penetration into the deeper layers of soil and groundwater contamination and 3) through wastewaters which leave tailings.

In this paper a special attention was paid to wastewaters which leave tailings. Namely, wastewaters continuously leave the tailings in the amount of 100-200 m³/h depending on the level of production of ore in flotation facility. These wastewaters over streams "Seliški potok", "Soboštica", "Klisurska reka" and "Korbevačka reka" flows into rivers "Južna Morava" and over "Velika Morava" finally flows into "Danube". For that reason it was of interest to investigate quality of water which is produced at tailings. For that purpose, wastewater samples have been taken from the outlet pipe of the flotation facility (OF) and hydrocyclone overflow (PHC) in accordance with standard procedure (SRPS ISO 5667-10:2007, Water quality. Taking of sample. Part 10: Guidance on waste waters sampling). Collected samples were kept in the capped container and left at room temperature in order to separate liquid from solid phase. After few days, liquid phase was decanted and filtered through qualitative filter paper in order to remove large particles and impurities. Then, concentrations of heavy metals in the wastewaters were determined by using inductively coupled plasma mass spectrometry. Results are shown at Table 4.

As may be seen from Table 4 the concentrations of Zn, Hg, Mn, Pb, Ni, Cr are higher, while concentrations of other investigated elements are below maximal allowed amount (MDK) according to listed standards. The concentrations of lead, mercury and manganese were very high and for mercury it was more than 2000 time higher than allowed amount, while for lead and manganese the concentrations were 10 and 40-60 times higher, respectively. The pH of taken samples was about 7.2 indicating that heavy metals are mainly present in less mobile and dangerous - hydroxide form (REF). However, the pH downstream from the tailings in rivers is more acidic (in "Južna Morava" pH is about 6.5), meaning that more dangerous, cationic forms, of heavy metals is present. In contrast to the most of the organic pollutants, heavy metals are difficult to degrade in the nature and are easily accumulated in living organisms, thereby causing various diseases and disorders (Wang et al., 2017). It is known that heavy metals damage the kidney, liver, reproductive system, basic cellular processes, may

irritate the mucous membranes, leading to hepatic and renal damage, widespread capillary damage, central nervous system or problems with brain functions (Gaetke and Chow, 2003; Larous, 2005; Hao et al., 2015). For that reason it may be concluded that water obtained from this tailings is dangerous and it should be treated from aspect of environmental as well as for human or animal health protection.

Table 4 The content of heavy metals in ppm in wastewaters obtained from tailings

	PHC (Kragović et al., 2017)	OF	MDK1*	MDK2**
Zn	0.338	0.269	0.2	0.024-0.8
Hg	2.568	1.304	0.001	0.00001-0.0003
Mn	3.069	2.568	0.1	-
Cd	<0.045	<0.045	0.005	0.00006-0.006
Fe	0.075	0.179	0.3	-
Ba	<0.007	<0.007	-	-
Be	<0.004	<0.004	-	-
Cu	<0.017	<0.017	0.1	0.0013-0.075
Al	0.065	0.023	0.2	-
Mg	8.105	7.631	50	-
Ca	98.859	117.983	200	-
Si	3.221	3.668	-	-
Pb	0.611	0.402	0.05	0.0017-0.075
Ni	0.068	0.072	0.05	0.0021-0.075
Cr	0.093	0.169	0.1	0.0025-0.03
Sr	0.604	0.496	-	-

*MDK (maximum allowed amount) according to law of the Republic of Serbia, Regulations for Hazardous Substances in Waters, "Službeni glasnik SRS 31/82" and "Službeni list SRJ 42/98".

**Target values and soil remediation intervention values and background concentrations soil/sediment and groundwater for metals. Dutch Target and Intervention Values, 2000 (the New Dutch List)

4 CONCLUSION

In presented paper are shown results of tailings and tailing wastewater characterization. Results obtained by classical chemical analysis showed that the main difference between three investigated samples was in the content of iron which was very high and much higher than content of other constituents, and was about 8, 12 and 7 % for JHC, JKB and JOF, respectively. Also, in all three samples sulphur was detected. The content of sulphur in JKB (8.07 %) was about fourth time higher in comparison with JPH and JOF (1.52 and 2.14 %, respectively), indicating presence of higher amounts of sulphide minerals in the JKB. Also, the concentrations of heavy metals Cd, Pb, Cr, Ni, Cu and Sb except Ba were much higher than referent values prescribed by the laws of Republic of Serbia. Consequently, according to the law of the Republic of Serbia investigated tailings samples may be classified as a dangerous waste.

Results of thermal analysis indicate presence pyrite in JOF and JPH sample. On the other side, from DTA curve of the sample JKB, it was indicated that beside pyrite (peak at 493°C) iron was also presented in form of oxide (Fe_2O_3) (peak at 535°C). Infrared spectra of all three samples are very similar each other and identical spectral bands appear in the spectra without significant changes in positions. Also, presence spectral bands at $\sim 1420 \text{ cm}^{-1}$ and $\sim 870 \text{ cm}^{-1}$ confirmed presence of the calcite or siderite in all three samples. Results of roentgen analysis showed that there are no huge difference between roentgen diffractograms of JOF, JKB and JPH. According to the obtained x-ray diffraction patterns of polycrystalline samples it was obtained that all three samples contain minerals quartz, clinocllore, calcite, phlogopite, siderite, iron oxide and anorthoclase. Results of determining content of heavy metal cations in the tailings wastewater showed that concentrations of lead, mercury and manganese were very high and for mercury it was more than 2000 time higher than allowed amount, while for lead and manganese the concentrations were 10 and 40-60 times higher in comparison with maximal allowed amounts.

Finally, it may be concluded that tailings as well as tailings wastewater from mine Grot are dangerous for environment and may have a negative impact on human, animals and plant health. From that point, additional activities are needed.

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