Optimization and Standardization of Xanthate Derivatives Consumption in Lead Mine during Floatation Process: An Environmental Assessment

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Abstract

Mining and minerals extraction and purification are critical in today's world. However, these processes may have negative consequences on the environment. Xanthates which are essential in the floatation process are found to be significant polluting chemicals. In this manuscript, the effect of different parameters on the recovery of lead from Nakhlak lead mine was investigated considering the impact of used chemicals on the surrounding environment including air, soil and native plant species. The reason for this investigation was to achieve the optimal conditions for the minimum consumption of xanthates and other chemicals. The optimal recovery was obtained in the presence of xanthate (1 kg/t) and sodium silicate (0.4 kg/t). In addition, MIBC showed to be more efficient in the floatation process. Furthermore, it was observed that higher xanthate contents are required for the floatation of large particles. Therefore, smaller particles of feed can decrease xanthate consumption. A particle size of 100 µm showed the best floatation recovery with the least xanthate requirement.

1. Introduction

Freshwater is a limited precious resource and distributed unevenly on Earth such that nearly 80% of the world population is now experiencing the risk of water scarcity [1]. Mining and mineral processing industries are highly dependent on water resources through all their stages from exploration to closure. They are also a major source of water and soil contamination due to their heavy reliance on mining-related chemicals [2, 3-5] and their heavy reliance on mining-related chemicals [6-8]. Flotation is a common process for extracting valuable minerals from ore in the mining industry. In this process, the attachment of a suitable collector to a target mineral by chemisorption, van der Waals forces, or electrostatic bonds causes to become the surface of that mineral hydrophobic [9]. Nowadays, due to the depletion of mineral resources, the need to

develop more efficient collectors that have less environmental risks increases [10]. Xanthates are extensively used as a collector with strong collection effect, in the flotation process of a variety of sulfide and oxide minerals [9]. Xanthates are most often obtained by the reaction of alcohol, sodium hydroxide and carbon disulfide (CS2) [11]. Xanthates can also be obtaine by the reaction of alkoxide, which is obtained by the reaction of alcohol and hydroxide, alcohol and alkali metal, ether and hydroxide with carbon disulfide [9]. These compounds are salts of the O-esters of dithiocarbonates containing sodium or potassium as a counter ion in their structure [12-15]. As mentioned above, Xanthates act as collectors in the ore purification due to their strong potential to bind with metal ions. Despite their significant role in mining, xanthates are toxic

compounds causing significant water and soil pollution [16, 17]. However, they are unstable thermally and can be decomposed to carbon disulfide. To date, significant research efforts have been carried out on their consumption optimization or decomposition mechanisms [18, 19]. Particularly, several methods have been proposed to reduce the polluting effects of xanthates such as xanthate flotation in the presence of dextrin [12] and hydroxamate [13] and under different pH values [20] and water quality [21] levels. In an attempt, *Tornero and Hanke* [22] showed that the flotation agents such as xanthates are toxic to aquatic organisms. However, slightly is known about their impacts on marine wildlife. In a research, *Ma et al.* [11] emphasized that the xanthate production process suffers from low yield, low productivity, long reaction time and environmental problems. Therefore, extracting the xanthates used in the flotation process and removing them from the process water minimizes the problems caused by water and soil pollution. *Zhu et al.* [23] found that the initial pH of 6.5, agitating time of 90 min and settling time of 120 min are the optimum condition to the removal of nearly 100% of the watewater sodium isobutyl xanthates present in the flocculation process. In a lead-zinc mine, *Rostad et al.* [24] developed techniques to extract and analyze xanthates resulted from the mining floatation process.

Few research studies of the impact of Nakhlak mine on the environment, especially on the soil have been conducted. *Moore et al.* [25] conducted a comprehensive assessment of soil quality in the Nakhlak mining area with special focus on potentially toxic metals. To analyze geochemical data, geostatistical methods, correlation matrix, pollution indices and chemical fractionation measurements were used to evaluate soil contamination by potentially toxic metals as one of the major environmental problems in mining environments. The results showed that the soil of the region is contaminated with Ag, As, Cd, Mo, Cu, Pb, Sb and Zn elements. These researchers considered the origin of this pollution to be mineralized veins and mining operations. *Izadi and Montazeri* [26] believed that occupational exposure is the most common source of Lead poisoning in adults of Nakhlak lead mine. They performed a hair analysis by determining the concentration of lead in miners' hair to assess chronic lead toxicity. The lead concentration of hair samples was measured using flame atomic absorption spectroscopy. The results showed that

the mean concentration of lead in the hair of lead mine workers was 52.43±27.7 μg/g.

Allahkarami et al. [27] investigated the effect of galvanic interaction between galena from Nakhlak mine and pyrite and its influence on their floatability. Pyrite flotation was carried out alone and mixed with galena in the presence of nitrogen or air. In galvanic combination between galena and pyrite, pyrite served as a cathode and galena served as anode dueto the fact that galena is electrochemically more active than pyrite [28]. The results showed that the floatability of pyrite increases in galena-pyrite mixture, especially when nitrogen was present. This was due to galvanic interaction on the formation of hydrophilic/hydrophobic product. However, the flotation recovery of galena decreased. The increase in pyrite flotation recovery was possibly the result of the anodic dissolution of galena with the release of Pb^{2+} ions into the solution which adsorbed onto the pyrite surface and activated it to increase the absorption of the collector. Although the effect of galvanic interaction between galena and pyrite on xanthate collector consumption has not been investigated in this research, it seems that this phenomenon may lead to a decrease in collector consumption which needs more investigation. *Qin et al.* [28] showed that butyl xanthate uptake increased on the galena surface and was affected by a combination of pyrite−galena mixtures and conditioning time.

The optimization of the experimental method such as the selection of the appropriate particle size brings the best floatation recovery with the least xanthate requirement and this present research is an attempt to achieve this goal to minimize the environmental problems caused by xanthates. Literature review shows that many efforts have been made for the environmental investigation of lead mines. In addition, the environmental problems of using the xanthate collector have been recognized and efforts have been made to minimize the problems caused by the presence of xanthate in the flotation effluent. However, regarding the optimization of flotation conditions in order to reduce xanthate consumption, more research is needed, and this article is an attempt in this direction. Therefore, this research aimed to standardize and optimize the consumption of xanthate derivatives in the mining process of the Nakhlak Lead mine to address the concerns associated with its flotation wastewater.

2. Site description
2.1. The Study Area

Nakhlak lead mine is located at the Nakhlak mountain**,** 55 km northeast of Anarak town, Nain county, Isfahan province, the central part of Iran (Figure 1). The Anarak region is one of the richest areas with high mineral resource potential in Iran, and mining in this region has been of interest for a long time. Nakhlak lead mine contains 7 million tons of galena-barite ore with an average grade of 8.33% lead, 0.38% zinc and 72 ppm silver. The galena concentrate contains elevated amounts of Ag (932 ppm), Sb (342 ppm), Cu (422 ppm), As (91 ppm), and Zn (296 ppm) [29]. Examining this issue is crucial from an environmental point of view. Because the release of these trace elements into water and soil sources causes their pollution.

Anarak is located at an altitude of 1575.97 meters above sea level. The annual average temperature of this region is 20.12 degrees Celsius, which is 1.69% higher than the average temperature of Iran. The annual rainfall of Anarak is about 8.46 mm. Anarak has a Mid-latitude steppe climate. The Anarak lead mine is located in an arid and semi-arid region.
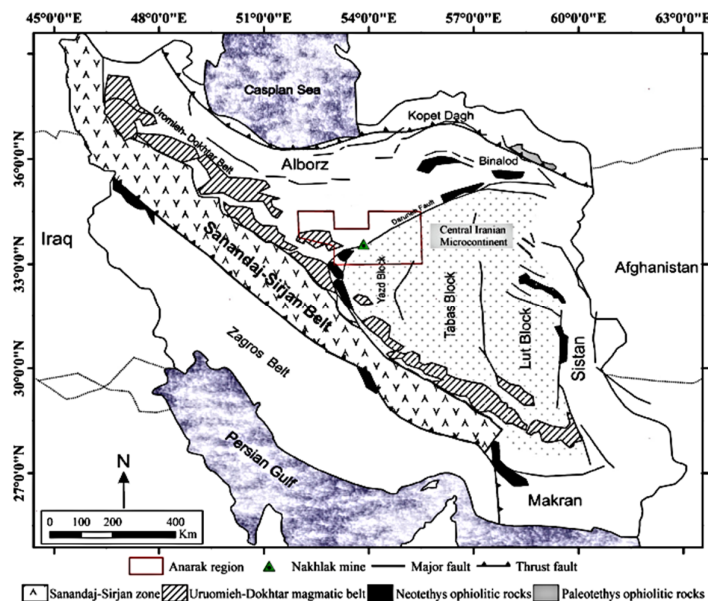

Figure 1. Geographical situation of the Nakhlak Pb-Ag mine (green triangle), Anarak region, Isfahan, Iran [30].

2.2 Mineralogy of the Study Area

From mineralogical view point, galena and barite are the major primary minerals and cerussite is the main secondary mineral. Sphalerite, pyrite, chalcopyrite, tetrahedrite-tennantite and acanthite occur as minor and trace mineral inclusions in galena. Secondary minerals are anglesite, plattnerite, wulfenite and malachite. In the host rock, the process of dolomitization has occurred. The analysis of galena samples shows the presence of several rare elements in galena. Among them, silver is significant [29].

2.3 Geological Setting

The Nakhlak Pb-Ag mine is situated in the northwest corner of the central Iranian structural zone. This zone is dominated by Precambrian to Miocene sedimentary rocks, Palaeozoic to Cenozoic ultramafic-acid igneous rocks, and Palaeozoic to Mesozoic metamorphic rocks [31]. The study area is located in the northern margin of the Yazd block and in the area of Anark-Khur massif in the metallogenic zone of Anarak (Figure 2). Anarak-Khur massif is characterized by ophiolites and blocks that were folded during the Alpine orogeny. Nakhlak Pb-Ag mine is located on the eastern edge of Nakhlak mountain. This mountain is located in the south of the Daruneh fault and the south of the Great Kavir Desert [30].
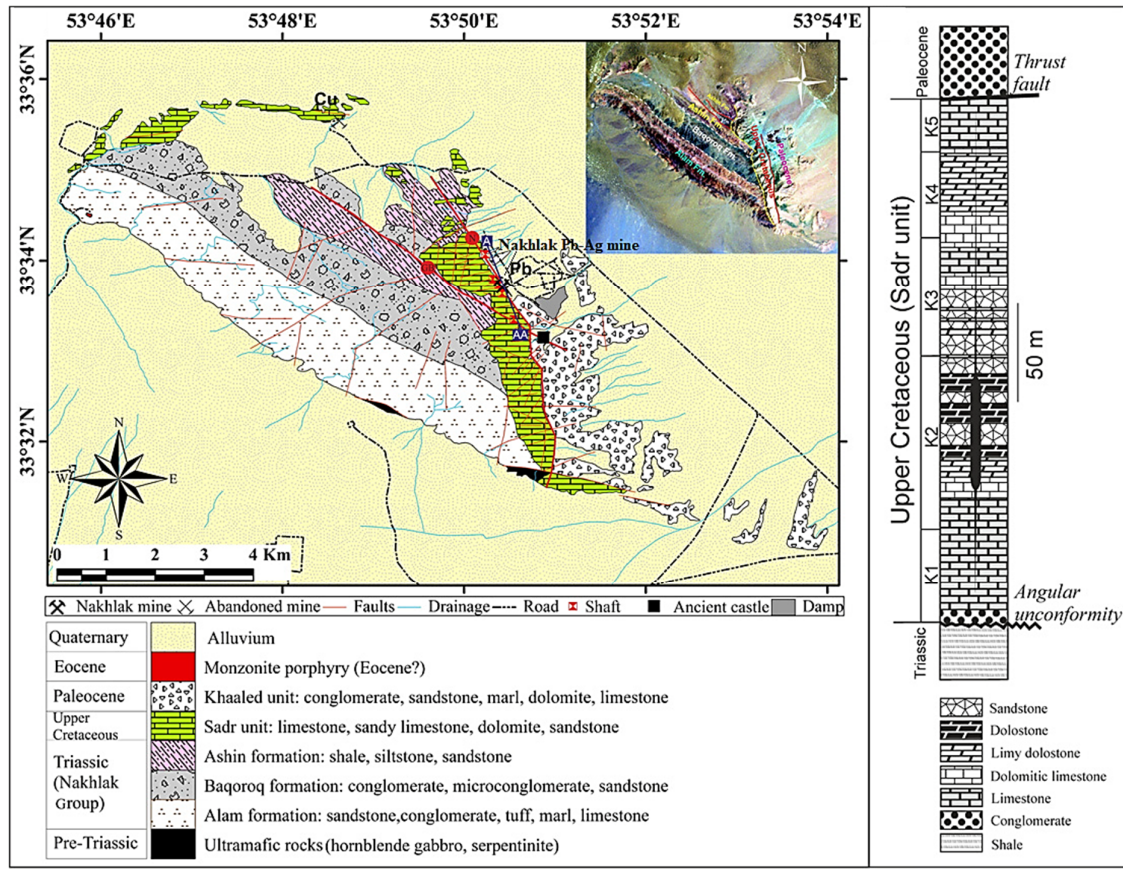
Figure 2. Geological map of the Nakhlak Pb-Ag mine [30, 32].

3. Material and Methods
3.1. Sampling and Analyzing

Optimization of the process is performed based on the samples from the Nakhlak lead mine. It produces a monthly average of 200 tons of concentrate and its proved reserve is estimated at 850,000 tons with a grade limit of 9%. Galena is the most abundant ore in this mine, followed by gangue minerals including barite, calcite, dolomite and quartz.

Samples were collected from the feed, concentrate, and waste. Water samples were collected before and after the flotation process. Soil samples were collected from the waste water storage pool and from the mine area that may contain heavy metal pollutants. Plants samples were collected from all native species grown around the mine area. Finally, air pollution was studied by evaluating the Carbon disulfide (CS_2) content in the air. Carbon disulfide can be made from coke, C(s), and sulfur dioxide. The overall reaction is as follows:

$$5C(s) + 2SO_2(g) \rightarrow CS_2(g) + 4CO(g) \qquad (1)$$
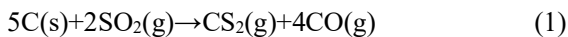
Soil samples were dried in a vacuum oven and ground to a particle sizes smaller than 3.3 mm. Plant samples were washed with distilled water, cut into small pieces and dried in an oven at 60 ºC. 1 g of the samples were digested at 80 ºC in a mixture of HNO_3 (70%), $HClO_4$ (65%), and H_2SO_4 (70%) in a volume ratio of 1:1:5. The distilled water (50 mL) was then added to the solution and the metal content was analyzed by the atomic absorption spectroscopy (AAS). The following parameters were constant in the research experiments: pH = 8.5-9.5; foaming agent (g/1000kg): 40-50; time (min): 5; mixing rate (rpm): 1100; solid amount (%): 30; water weight (g): 930 and solid (g): 400. In the floatation stage, the amounts of sodium silicate, sodium sulfide, and potassium amyl xanthate were 300, 1000, and 300 g/1000kg, respectively.

Ethylenediaminetetraacetic acid (EDTA) titration was used to investigate the bioavailability of heavy metal ions in the samples. For this purpose, the soil samples were added to 0.05M EDTA in 1:10 ratio and shacked for 1h. The solid was filtered off and the solution was used for the determination of the heavy metals content. For the

mineralogical studies, X-ray diffraction (XRD) patterns were recorded on a Bruker D8 Advance X-Ray diffractometer with a Cu Kα anode (λ = 0.1542 nm) operating at 40 kV and 30 mA. Furthermore, a Spectro Xepos X-ray fluorescence (XRF) spectrometer was used to determine the elemental composition of the samples. A Zeiss Axioplan 2 polarizing microscope was applied to determine the microstructure of the minerals. The metal content was determined using Shimadzu 1400 series atomic absorption spectrophotometer (AAS).

4. Study Results and Discussion

X–ray diffraction (XRD) analysis allows direct identification of mineral composition of the rock samples. The results of XRD analysis of the processing feed samples revealed that quartz, calcite, and dolomite are the major mineral constituents. Furthermore, other minerals comprising cerussite, barite and galena were also present.

Microscopic method was used to evaluate the mineral contents. The results showed that quartz, calcite and dolomite are the most abundant minerals in the feed and their amounts were above 10%. Barite and cerussite are present in the feed sample in the content of 2-10%. Other minerals including galena, clay and iron oxides and hydroxides were present in less than 2% of the feed samples. Various different materials including sodium sulfide, potassium amyl xanthate, sodium silicate and MIBC were used as the activator, collector, dispersant and foaming agent, respectively.

Mineralogical studies conducted by *Jazi et al.* [30] and *Jazi et al.* [33] proved the presence of above minerals as well as other minerals such as sphalerite, pyrite, chalcopyrite and fahlor group (tetrahedrite-tennantite) as minor in the samples of Nakhlek deposit (Figure 3).
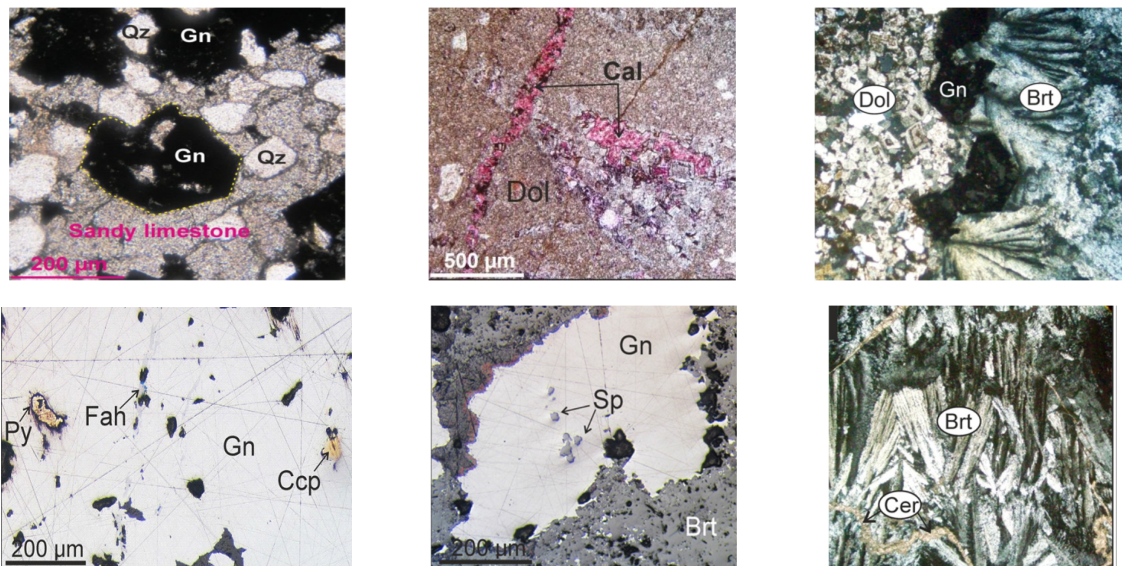

Figure 3. Photomicrographs of minerals identified in the Nakhlak Pb–Ag deposit; Qz: quartz, Cal: calcite, Dol: dolomite, Brt: barite, Gn: galena, Cer: cerussite, Sp: sphalerite, Py: pyrite, Ccp: chalcopyrite, Fah: fahlor group (tetrahedrite-tennantite) [30, 33].

The samples were further characterized by the XRF method. The XRF results are presented in Table 1. As shown well in Table 1, CaO and SiO$_2$ are the most abundant inorganic compounds found in the feed samples by 31.43% and 22.16%, respectively. MgO, Al$_2$O$_3$, and BaO were other common materials in the feed samples. PbO was present in the sample with a content of 6.05%.

Table 1. Results of XRF analysis of the feed samples

Compound	Content (%)	Compound	Content (%)	Compound	Content (%)
SiO$_2$	22.16	P$_2$O$_5$	0.1 >	PbO	6.05
Al$_2$O$_3$	3.73	SO$_3$	1.69	SrO	0.35
CaO	31.43	K$_2$O	0.54	ZnO	0.86
MgO	4.47	BaO	2.72	ZrO	0.1 >
Fe$_2$O$_3$	1.34	Cl	0.1 >	L.O.I	24.66

The size of the feed is a significant parameter affecting floatation process. By decreasing the size of the feed, the floatation efficiency increased. The results showed that, decreasing particle size from 19% to 36% in the size of below 38μm increased the recovery of the lead from 35% to 95%. Moreover, the purity of the water had a significant effect on the recovery efficiency. The results showed that increasing time of exposure to sodium sulfide from 5 min to 8 min decreased the recovery of Pb by 3%. In addition, decreasing content of the xanthate derivative from 300 to 150 g/1000kG decreased the recovery of the lead from 84% to 59%. A decrease in the time of exposure to the collector from 5 min to 8 min reduced the efficiency of the Pb recovery by 11%.

Simultaneous investigation of the effect of chemical additives and the exposure time on the purity and the recovery of lead was also evaluated. The results showed that the increase of sodium sulfide from 1000 to 2000 g/1000kg of the sample led to an increase in the purity of the produced lead from 45 to 49%. However, the recovery of the lead decreased by 6%. Therefore, the amount of the sodium sulfide additive showed to be the best at 1000 g/1000kg of the sample. On the other hand, changing the amount of the collector (potassium amyl xanthate) from 300 to 400 g/1000kg of the sample increased the recovery of the lead up to 89%. This sharp increase in the recovery of lead shows the more intense effect of the collector on the recovery of lead. Moreover, the effect of the amount of the activator (sodium silicate) on the efficiency of the floatation was optimized. By increasing the activator amount from 400 to 1000 g/1000kg of the samples, the recovery of lead increased from 30 to 39%. Based on these results, the use of such high activator content seems not to be suitable, while a higher recovery was desired.

The effect of the additive amounts on the grading of the recovered samples was analyzed by dynamic light scattering (DLS). DLS measures the Brownian motion of molecules and particles to find out size and size distributions. The results are presented in Figure 4. Based on the results, changing the additive amount can result in the particles with different sizes to be recovered. Using 400 g/1000kg of activator led to an increase in the size of the recovered sampled from 38 to 56 μm. Therefore, larger particles with higher lead minerals content were recovered.
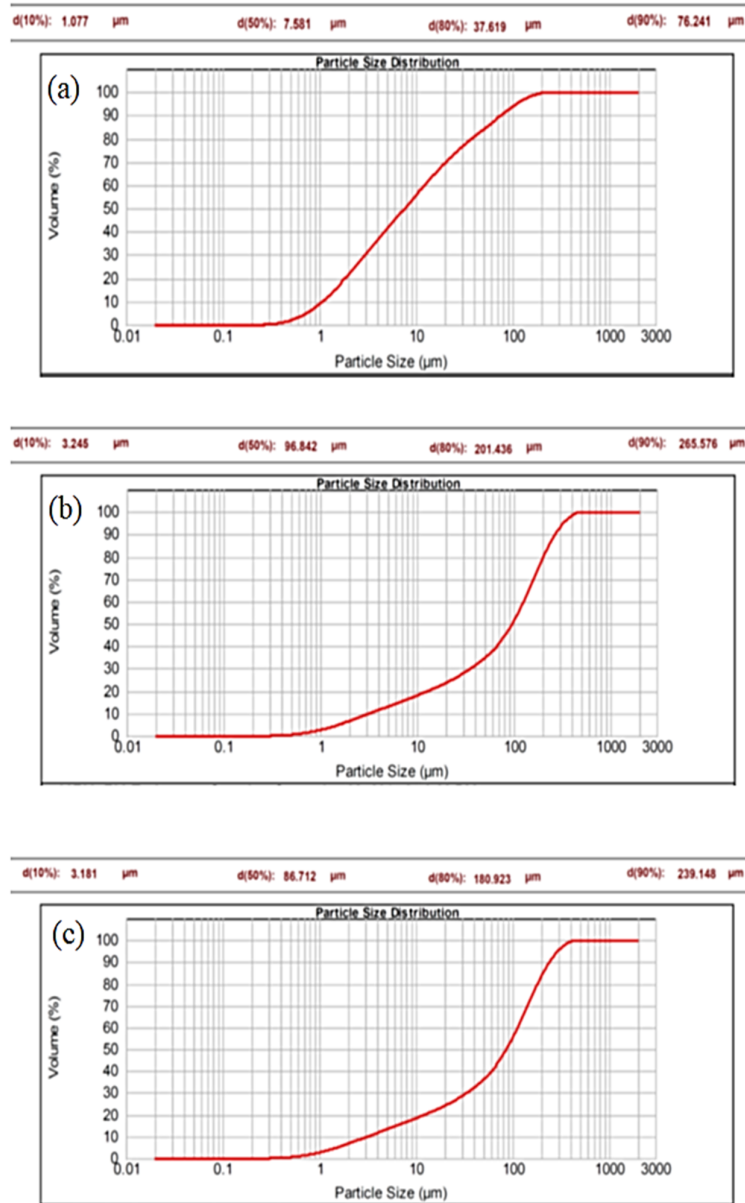
Figure 4. Effect of the amount of activator on the particle size of the recovered samples. The amount of sodium silicate was (a) 400; (b) 700; and (c) 1000 g/1000kg of the samples.

Changing the amount of MIBC from 50 to 75 g/1000kg of the samples increased the recovery by 2%. Using pine oil as a floating agent decreased the recovery by 12%. Decreasing the amount of the collector from 150 to 100 g/1000kg led to a decrease in the recovery by 23%. Therefore, the amount of the collector was optimal at 150 g/1000kg of the samples. On the other hand, decreasing the amount of the activator from 500 to 400 g/1000kg did not show a negative effect of the recovery efficiency. More increase to 300 g/1000kg decreased the recovery by 3%.

Therefore, the optimized amount of the activator showed to be 400 g/1000kg of the samples.

The feed particle sizes of 75, 100 and 150 µm were used to investigate theie effect on the recovery process. The results showed that by recreating the particle sizes from 150 to 100 µm, the recovery increased from 65 to 76%. More decrease in the particle size to 75 µm did not affect the recovery but improved the purity of the products. Therefore, the particle size of 100 µm was selected as an optimized condition.

The presence of xanthate derivative in waste water was further investigated. The results

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showed that about 10% of the added xanthate found in the waste water and about 90% of that exists in the solid particles. Therefore, using feed with less particle size could lead to a decrease in xanthate consumption. It should be noted that xanthate is a critical part of the floatation process. The effect of the amount of xanthate on recovery is shown in Figure 5.
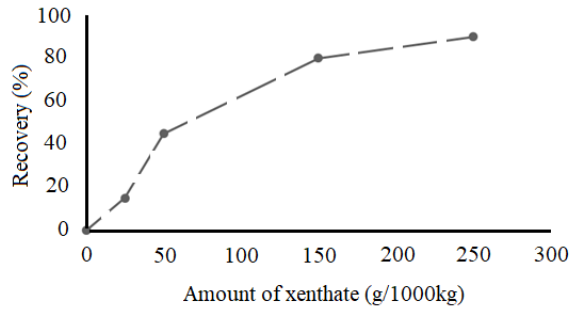

Figure 5. Effect of the amount of xanthate on the recovery of lead ore.

The content of trace element in plant samples of the Nakhlak mine area was evaluated to measure the environmental impact of the pollutants on the plants. The results are presented in Figure 6. Based on the results, strontium was present in *Alhagi* plant shoot especially in plant leaves with the most content. In addition, the presence of lead in the plants leaves was proved. Arsenic, cadmium and silver were present in the plants leaves samples in lower contents. In the plants roots, lead was the most abundant pollutant. Although not given here by details, studying the heavy metals content in the soil samples proved soil contamination in the Nakhlak mine area. The average concentration of lead, zinc, cadmium, silver and arsenic both in the mining area and in the tailings site is much higher than their average values in the earth's crust and can represent soil contamination with these metals. However, the values obtained for these metals in the tailings site are higher than in the mine area.
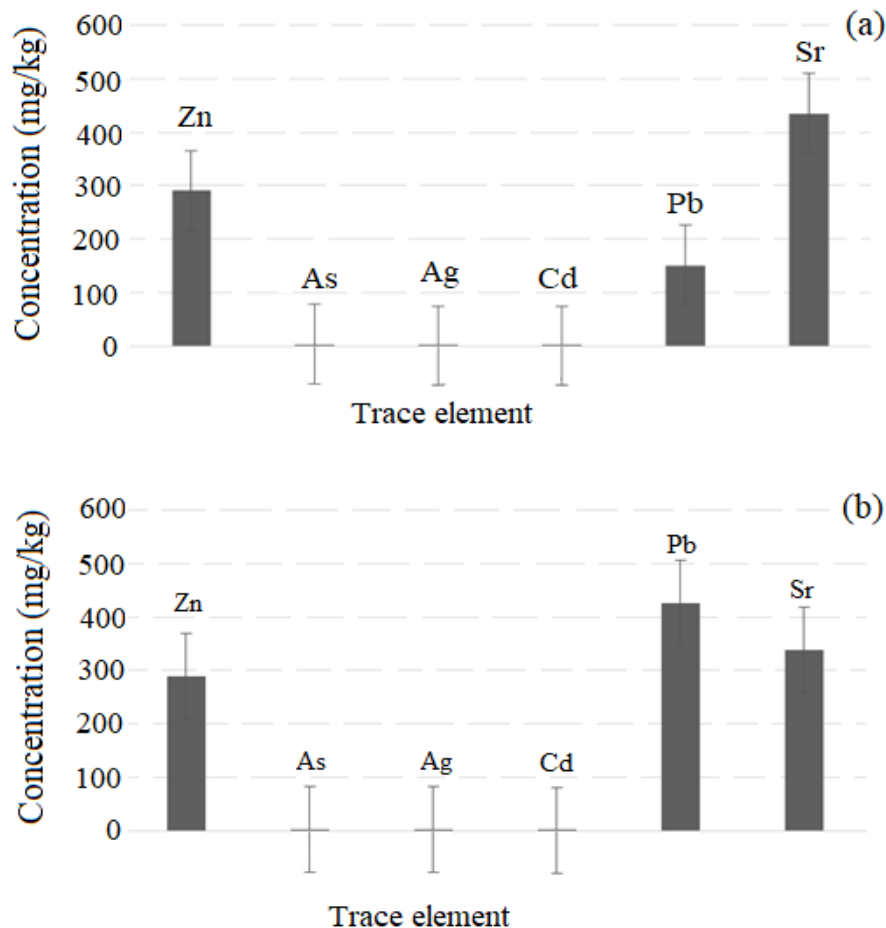

Figure 6. The amount of trace elements in (a) *Alhagi* plant shoots and (b) *Alhagi* plants roots in the mine area.

4.1. Methods of Pollution Assessment of Heavy Metals

To assess and compare the heavy metal uptake values of the native plant species in the study area, the bioconcentration factor (BCF) and the translocation factor (TF) were computed. The translocation factor is an index comparing the metal concentration in plant roots against that in plant shoots. A shoot-to-root metal concentration ratio of more than 1 can be considered to characterize hyperaccumulators [34].

- **Bioconcentration factor (BCF)**

The bioconcentration factor (BCF) was used to evaluate the ability of plants to accumulate metals from contaminated soils. BCF is defined as the ratio of heavy metal concentration in the plant (both root and shoot) to heavy metal concentration in the contaminated soil [35].

$$BCF = \frac{C_{Plant}}{C_{Soil}} \qquad (2)$$

where, both concentrations C_{Plant} and C_{Soil} are in mg/kg of dry weight.

- **Translocation Factor (TF)**

The TF index was defined for measuring a plant's capability to translocate metals from the roots to the shoots. The TF is defined as the ratio of metal concentration in the aerial part of the plant to the metal concentration in the plant's root [36].

$$TF = \frac{C_{Aerial}}{C_{Root}} \qquad (3)$$

where, C_{Aerial} represents the concentration in the aerial part, and C_{Root} is the heavy metal concentration in plant roots

The concentrations are in mg/kg of dry weight. The TF index evaluates the ability of plants to transfer heavy metals from soil to the respiratory parts. A TF value of lower than 1 shows that the heavy metal concentration is in the root, whereas a TF value greater than 1 indicates that the concentration is in the respiratory parts [37].

In Table 2, the concentration of some metals in the shoots, roots and soil of *Alhagi* plant in the study area is presented in comparison with the international standards.

Table 2. Metal concentration in *Alhagi* plant (shoots and roots) and soils with world standard limitations

Concentration (mg/kg)					Metal
Ag	As	Cd	Pb	Zn	
9.8-11	26-32.4	4.4-15.4	4950-7532	1357-2077	The average concentration in soil of the study area [25, 38]
-	0.1–15	0.01–2	15–30	50–100	The average concentration in soil [39]
0.3	5	0.36	20	70	
0.05	4	3	147	291	Metal concentration in the plant shoots
1	5	4	415	280	Metal concentration in the plant roots

The BCF helps to evaluate the plant's ability to translocate heavy metals from soils to plant organs. Table 3 gives the BCF values for the plant species.

Table 3. The bioavailability index of *Alhagi* plant for different elements

Bioconcentration factor (BCF)					Metal
Ag	As	Cd	Pb	Zn	
0.1	0.31	0.7	0.09	0.33	*Alhagi* plant

Alhagi has the highest ability to accumulate Cd through the roots, followed by Zn and As. It should be noted that the BCF value for all metals is less than 1.

The TF index is used to evaluate the ability of metals to translocate from roots to shoots. Table 4 presents the computed TF values of *Alhagi* plant species for different elements. As shown, *Alhagi* has the highest TF value for Zn followed by Cd. Moreover, the TF value for Zn is higher than 1.

Table 4. The TF values of *Alhagi* plant for different elements

Translocation factor (TF)					Metal
Ag	As	Cd	Pb	Zn	
0.05	0.8	0.75	0.35	1.04	*Alhagi* plant

The TF values calculated for different elements show that except for Zn, other elements are mostly in *Alhagi* plant roots.

In order to assess soil contamination by heavy metals, a series of indices including contamination factor (CF), degree of contamination (Cd), modified degree of contamination (mCd) and pollution load index (PLI) were calculated. The concentration of five potentially toxic metals (Ag, As, Cd, Pb, and Zn) in 7 soil samples of the Nakhlak lead mining area and tailings site are presented in Table 5.

Table 5. Concentration of metals in surface soils and plants of Nakhlak lead mine

No.	Sample	Ag	As	Cd	Pb	Zn
		Concentration (mg/kg)				
1	Mine 1	19.78	38.43	5.8	11120	2161
2	Mine 2	12.80	31.10	2.6	17420	517
3	Tailings 1	50.70	41.30	32.5	53420	2784
4	Tailings 2	82.40	59.20	33.9	23030	5290
5	Tailings 3	12.50	24.70	60.7	7389	2060
6	Mine ave	9.80	32.40	4.4	7532	1357
7	Tailings ave	20.40	27.0	63.3	10245	7500

The results are presented in Table 6. As shown in Table 6, the soil samples of the mining area and tailings site are in the condition of very highly contaminated to ultra high degree of contamination.

Table 6. Pollution index values of soil samples in the study area

Background value (mg/kg)	0.3	4.8	0.09	17	67	Pollution index		
Sample\Metal	Ag	As	Cd	Pb	Zn	Cdeg	PLI	mCdeg
Mine 1	>6	>6	>6	>6	>6	>32	>5	>32
Mine 2	>6	>6	>6	>6	>6	>32	>5	>32
Tailings 1	>6	>6	>6	>6	>6	>32	>5	>32
Tailings 2	>6	>6	>6	>6	>6	>32	>5	>32
Tailings 3	>6	5.1	>6	>6	>6	>32	>5	>32
Mine ave.	>6	>6	>6	>6	>6	>32	>5	>32
Tailings ave.	>6	5.6	>6	>6	>6	>32	>5	>32
Pollution index	CF							

CF>6; Very high contamination [40]
Cdeg>32; Very high degree of contamination [41]
PLI>5, Very highly contaminated [42]
mCdeg >32; Ultra high degree of contamination [43]

5. Conclusions

The results show that xanthate is a critical component for the recovery of lead from its ore in the mining industry and no lead recovery was observed without this compound. Sodium silicate and MIBC improved the recovery. The optimal recovery was obtained in the presence of xanthate (1000 g/1000kg) and sodium silicate (400 g/1000kg). In addition, MIBC showed to be more efficient in the floatation process. Besides, it was observed that more xanthates are required for the floatation of large particle sizes. Therefore, smaller particles of feed can lead to a decrease in xanthate consumption . The particle size of 100 μm showed the best floatation recovery with the least amount of xanthate. Evaluating the amounts of heavy metals in the plant species and soil samples proved the pollution in the studied samples. The bioconcentration factor (BCF) and the translocation factor (TF) were used to assess heavy metal uptake values of the native plant species in the study area. Alhagi was found to have the highest ability to accumulate cadmium through roots. Alhagi showed the highest TF value for zinc followed by cadmium. The TF values further show that except for Zn, other elements are more abundant in the root of the plant. The application of the various pollution indices show that the soil samples of the mining area and tailings site are in the condition of very

highly contaminated to ultra high degree of contamination. Hence, an immediate reclamation and rehabilitation process is required for the decontamination of the polluted sites by applying appropriate remediation strategies such as phytoremediation and phytostabilization technologies. The results obtained from this study show that by the use of the optimized floatation conditions with less toxic chemicals, the environmental pollution can be considerably reduced.

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بهینه‌سازی و استانداردسازی مصرف مشتقات زانتات در معدنکاری سرب در طی فرآیند شناورسازی: یک ارزیابی زیست محیطی

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چکیده:

استخراج معادن و استحصال مواد معدنی در دنیای امروز حیاتی است. با این حال، این فرآیندها ممکن است پیامدهای منفـی بـر محیط زیسـت داشـته باشـند. زانتات‌ها که در فرآیند شناورسازی ضروری هستند، آلاینده‌های شیمیایی مهمی هستند. در این مقاله، تأثیر پارامترهای مختلف بر بازیافت سرب از معدن سرب نخلک با توجه به تأثیر مواد شیمیایی مصرفی بر محیط زیست اطراف از جمله هوا، خاک و گونه‌های گیاهی بومی بررسی شده است. دلیل این تحقیق دستیابی به شرایط بهینه برای حداقل مصرف زانتات‌ها و سایر مواد شیمیایی بود. بازیابی بهینه در حضور زانتات (۱ کیلوگرم بر تن) و سیلیکات سدیم (۰/۴ کیلوگرم در تن) به دست آمد. علاوه بر این، MIBC در فرآیند شناورسازی کارآمدتر نشان داد. علاوه بر این، مشاهده شد که محتوای زانتات بالاتری برای شناورسازی ذرات بزرگ مورد نیاز است. بنابراین، ذرات کوچکتر خوراک می‌تواند مصرف زانتات را کاهش دهد. اندازه ذرات ۱۰۰ میکرومتر بهترین بازیابی شناور را با کمترین نیاز زانتات نشان داد.

کلمات کلیدی: فرآوری مواد معدنی. سولفید سدیم، دی سولفید کربن، زانتات، معدن سرب نخلک، آلودگی زیست‌محیطی، شاخص‌هـای آلـودگی، فـاکتور غلظت زیستی، فاکتور انتقال.