Pollution 2022, 8(1): 1-14
DOI: 10.22059/POLL.2021.320134.1029

RESEARCH PAPER

Geotechnical Investigation of Tailings Disposal Site for Tailings Storage of zinc Processing Factory

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Received: 07.03.2021, Revised: 10.10.2021, Accepted: 24.11.2021

ABSTRACT
The present study aims at determining the geotechnical properties of the tailings and the natural bed at Iran Mineral Processing Company, Sites 1 and 5. It qualitatively studies the subsurface layers of the company's tailings storage site. After drilling different boreholes and conducting in-situ tests, it has made laboratory analyses in the form of field exploration to determine the geotechnical parameters of the extracted samples. Results from the analyses show the permeability coefficient of the subsurface layer of Site No. 1 and 5 to be very small, in the range of 10^{-7} cm/sec. Considering the conformity of permeability coefficient, percentage of fine grains (98% to 99%), plasticity index (28.5-29.5), and clay content of different layers of Sites 1 and 5 (68%-80%), based on the compacted clay liner criteria, it can be concluded that by nature, the subsurface layers of the mentioned sites are sealed with no need for any compacted clay liner. The tailings for storage Site 5 are fine-grained (80-88<75μm), basically in ML range according to USCS system, with a permeability coefficient of about 10^{-6} cm/sec. Therefore, the tailings themselves act as a relatively primary sealing layer against the infiltration of hazardous leachates into the natural bed. The method, used in the process of site selection of tailings storage facilities (TSF), can cut the construction time as well as the expenditures, thus reducing the production costs in the long run.
Keywords: Tailings Properties, Permeability, Filter Cake, Site Selection

INTRODUCTION

The exploitation of mineral resources, while promoting the development of economy and society, will generate massive waste/tailings that may cause issues such as heavy environmental pollution and land and resource wastage (Shreekant et al 2016, Meng et al., 2020). Some non-ferrous metal enterprises have been forced to halt production since they were unable to build new tailing dams (Zhang et al., 2006).

In the mining industry, the two predominant mine waste types that require short and long-term management include waste rocks, or mine waste rocks, and tailings, the former discarded from mining operations (quarrying overburden and unwanted rock during the extraction of minerals) and the latter produced during ore extraction processes (Robert & Sarsby, 2013; Shreekant, 2016; Blight, 2010, Carmo et al. 2020). Tailings are typically fine-grained with high water contents (low solids contents), whereas waste rocks are generally gravel- to cobble-sized material with sand and fines, and have been shown to have moisture retention characteristics comparable to naturally occurring fine sand, silt, and clay (Aubertin et al., 1998, Williams et al., 2003, Tayebi-Khorami et al. 2019).

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INTRODUCTION

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The tailings-to-concentrate ratio is commonly very high, around 200:1 (Lottermoser, 2007); in Australia, the average Cu grade dropped from 10% in 1885 to 1% in 2005, and in Canada, the average Ni grade from around 5% in 1885 to 1.5% in 2005 (Giurco, 2010). This trend was driven by the high demand for metals in the period 2005–2008; the consequent sharp increase in their prices, in turn, led to the extraction of even lower grade ores with high tailings-to-concentrate ratios (Blas & Bream, 2008).

In recent years, the low-grade tailings (uneconomical for reprocessing) have substituted construction materials, considerably reducing waste management costs, avoiding wastage of primary resources, and freeing areas dedicated to tailings disposal. As such, the reuse of tailings reduces the overall cost of construction projects. Due to their physical and mechanical properties, tailings have been able to supersede various construction materials. Recycling of tailings and their use as construction materials can be classified into two main types depending on the presence of pozzolanic properties:

In road construction, copper slag lacking pozzolanic properties can be used only as a substitute aggregate for base and subbase materials (Shirdam et al. 2014). Among the tailings, slags such as steel slag (Tran et al. 2014; Mohammed et al. 2016; Padmapriya et al. 2016) and copper slag (Dolatabad & Tarqi, 2017, Raj et al., 2018), lack pozzolanic properties due to the formation of crystalline (non-amorphous) structures, and therefore, can only be used as a replacement for concrete aggregates.

Tailings enjoying pozzolanic properties, such as Grand Granulated Blast Furnace Slag (GGBFS) (Saafan et al., 2020, Shirdam et al. 2020; Duan et al. 2013; Sharmila and Dhinakaran, 2016), copper slag (with pozzolanic properties) (Brindha, and Nagan, 2011; Shirdam et al. 2019a, Kumar and Naik, 2015), copper mine tailing (Esmaeili and Aslani 2019, Zhihua et al. 2003)**,** red mud from aluminum bauxite processing (Pujar And Prakash, 2014; Ribeiro et al. 2011) and Cement Kiln Dust (CKD) (Stevulova et al., 2021, Al-Jabri et al. 2006) also known as Cement By-Pass Dust (CBPD), can be used as a substitute for a percentage of cement in concrete. However, in situations where it is not possible to use the tailings as construction materials, they can be chemically stabilized using various additives before being disposed in landfills (Shirdam et al., 2019b).

However, the following two conditions necessitate depositing and storing tailings in the required, appropriate places: A) situations where the reprocessing of low-grade waste via existing technologies is not economically justified and at the same time, it is not possible to recycle them because of their physical and mechanical properties (in such situations, permanent disposal is required), and B) situations where a temporary depot is required prior to reprocessing the tailings.

Adequate site selection is the primary step in establishing storage for mine waste, which should pursue the following objectives (Blight, 2010):

- to ensure that the site is appropriately located, of adequate size, and technically feasible to develop for waste storage with acceptable safety margins;
- to ensure feasibly achievable acceptability in terms of cost, environmental, and social impacts.

Based on the said objectives, several location criteria have been previously studied, but this article focuses merely on the geotechnical study of the tailings' storage bed, and aims to determine the sealing degree (the behavior of the bed layers of the site concerning the infiltration of contaminants from tailings into groundwater). For these tailings, which contain various metal elements, the management and engineering are important in terms of the hazard they pose. To minimize the spread of pollution of these tailings to the surrounding environment, it is necessary to store these wastes in places where zero leakage from the bed of the depot is guaranteed. Therefore, in case of the poor performance of the depot's structural components, especially lack of sealing of the bed (lack of impermeability of the bed), tailings dams or surface disposal area can cause additional problems such as groundwater pollution. One of the important elements in the design of Tailing Storage Facilities (TSF) is the design of the required liner to seal the bed of the disposal site (with minimal permeability) to prevent the spread of leachate of tailings to groundwater. Parameters affecting the permeability coefficient of used clay soils in liners are grain size, plasticity index (PI), relative density (D_r), dry unit weight (γ_d), and moisture (w).

According to USEPA, 1993, the criteria of a suitable clay liner include permeability coefficient, percentage of fine particles (smaller than sieve number 200), plasticity index, and particles no larger than 3 inches (USEPA, 1989). Obviously, if the natural bed of the selected sites for storing tailings (whether the bed of tailings dams or the bed of the surface disposal area) can meet the criteria set by USEPA, 1993, there is practically no need to apply a clay liner to seal the bed. If a clay liner is not required, it will certainly be economically important and preferable for the owners of the mineral processing industry since it means reduced production costs.

MATERIAL AND METHODS

Iran Mineral Processing Company (IMPC) is one of the industrial centers in Iran Zinc Mines Development Company (IZMDC), its main activity being minerals processing to produce zinc concentrate and zinc ingots. According to the site plan map shown in Figure 1, this plant is located in Dandi City of Zanjan Province, 90 km from Zanjan City in Iran.

Fig 1. Location of IMPC near Dandi City in Zanjan Province

IMPC produces three types of tailings according to the zinc processing flow diagram shown in Figure 2. These three types of tailings are leach filter cake, nickel filter cake, and cobalt filter cake, which are stored in disposal Sites 1 to 3, respectively (Figure 3). In this company, the BZS plant, with two cake washing plants, produces 20%-grade hydroxide using Basic Zinc Sulfate (BZS) technology to supply the required feed for the zinc factory (50,000 tons per year). The process of cake washing in the two plants requires 16 tons of high-grade leach filter cake from Site 1 to produce each ton of hydroxide (Figure 2); for the annual production of hydroxide, 800,000 tons of filter cake per year, already stored in Site 1 (in the zone of high-grade filter cake), is used. The filter cakes leaving the cake washing plants are stored in the low-grade leach filter cake zone on Site 1 (Figure 2). The topography of Site 1 makes it difficult, or in some cases impossible, to transport tailings in wet seasons from Site 1 to 2 cake washing plants. Therefore, disposal Site 5, next to Site 1 (Figure 3), is intended for the temporary storage of high-grade leach filter cake of Site 1. In other words, it was decided that the high-grade tailings of Site 1 be transferred to and stored in Site 5 during dry seasons so that it can be used in cake washing plants during the wet seasons.

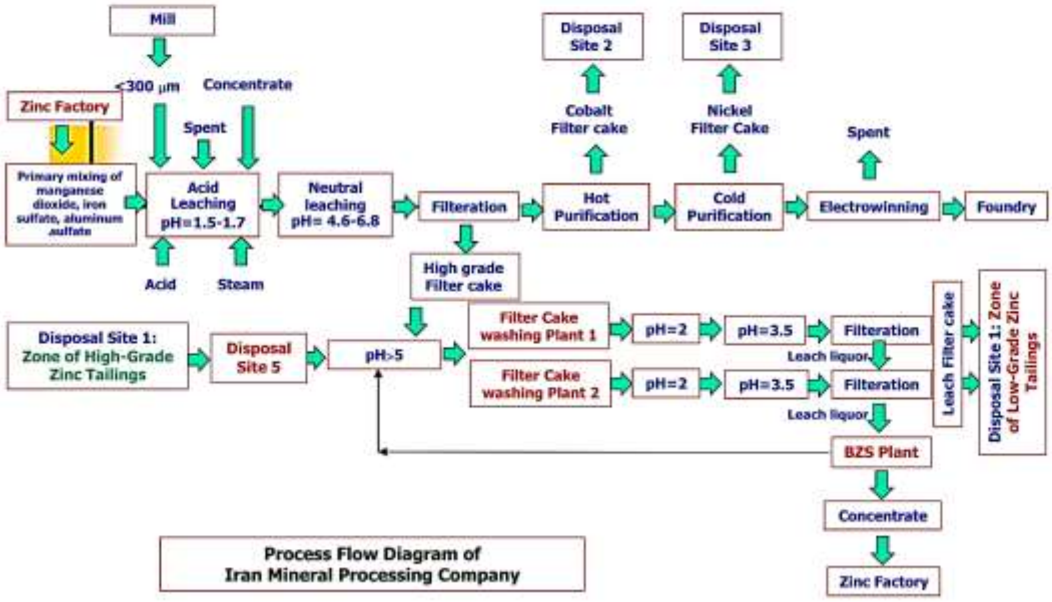

Fig 2. Zinc processing flow diagram in Iran Mineral Processing Company (IMPC)

Quantitative and qualitative identification of the leach filter cake oxides (which are to be stored in Site 5) was performed via the XRF test using SIEMENS SRS3000 at the laboratory of Research and Engineering Company for Non-Ferrous Metals (RECo.). For the measurement of heavy metals in leach filter cake, the samples were first digested according to USEPA3050B-1986 and then analyzed via USEPA 6010D, 2018 using an ICP-OES (ICP-7900, AGILENT) in the laboratory of Zarazma. Each extraction was performed three times, and average values were reported to ensure data repeatability. The results of all the performed analyses in this section are presented in Table 1. The chemical properties of leach cake filters stored at Site 5 show the amounts of some heavy metals measured to be higher than the threshold limit set by the quality standards of Iranian soil resources (2016). Therefore, considering the risk of leakage of pollutants into the region's aquifers, the technical specifications of the said sites were examined. For this purpose, the geotechnical parameters of Sites 5 and 1 were measured via subsurface exploration and laboratory tests.

In order to identify the nature of surface and subsurface layers and measure the geotechnical properties, especially the permeability of tailings stored in Site 1 and the natural substrate of Sites 1 and 5, a borehole in Site 1 and three test pits in Site 5 were drilled. It is worth noting that Site 1 is adjacent to Site 5. The location of the borehole at Site 1 was decided to be adjacent to Site 5 so that its geotechnical properties would be virtually representative of those of Site 5. Together, these site investigations can determine the likelihood of leakage of contamination from the leach filter cake deposited at these two sites into the aquifer.

Drilling operations of the BH borehole, as the first step, was carried out in the tailings layers of the leach filter cake and the natural substrate of Site 1 via rotational drilling method using a D750 skate drilling machine at a depth of 14 meters with BH code (Figure 4). During the drilling of this borehole, different undisturbed samples were taken from depths of 3-4, 5-6, 9-10 and 13-14 meters to be sent to the laboratory for analysis and determination of geotechnical characteristics (Figure 5). Also, 3 test pits were drilled to a depth of 3 meters in the natural bed of Site 5 by an excavator with the codes TP1, TP2, and TP3. Since the soil layer characteristics were the same at all depths of 3 m in all three test pits, sampling was performed only at depths of 0 to 0.5 m and 0.5 m to 1 m from the TP1 borehole. The mentioned samples were sent to the laboratory for analysis to determine the geotechnical properties of the layers.

During TP1 test pit at Site 5, in-situ density measurements of soils were performed using a sand cone apparatus following ASTM D 1556-00 at depths of 0-0.5 and 0.5-1.0 meters, and then, the obtained samples of the two depths were taken for laboratory analysis.

Laboratory tests were conducted on samples extracted from the BH borehole (at Site 1) and the TP1 test pits (at Site 5) in a Tak Azma laboratory. Water content was determined according to ASTM D 2216-92 and Gs was measured according to ASTM D 854-92. The grain size was analyzed via sieving and hydrometry according to ASTM D 422-90, and Atherberg limits in accordance to ASTM D 4318-95 1998. And the permeability was measured in a laboratory through a falling head test following N188-2000. Also, in-place density of soil (or tailings) was determined by the drive-cylinder in the BH borehole following ASTM D 2937-94. The results of all performed experiments and tests are presented in Tables 3 and 4. It is worth mentioning that the dry density and water content of samples in the permeability test cell were determined according to the in-situ density and water content measured on site.

Table 1. The Physicochemical properties of the leach filter cake

Heavy metal (total)		**Oxides (%)**		**Other parameters**	
Cu (ppm)	120	SO_3	24.16	pH	5.9
Mn (%)	0.15	SiO_2	17.8	w (%)	36
Fe (%)	4.12	CaO	16.61	(%) < 5µm	12-17
Pb (%)	4.5	Al_2O_3	5.158	(% silt) 5µm - 75µm	68-71
Cd (ppm)	320	Na_2O	3.71	(% fine) < 75µm	80-88
Co (ppm)	153	MgO	3.041	75µm - 4.75mm (Sand)	8-17
Ni (ppm)	10	ZnO	1.57	γ (KN/m^3)	15.4-15.7
Zn (%)	3.19	K_2O	0.91	[1]USCS	ML
Mg (%)	0.625	TiO_2	0.46	[2]USDA	SILT
Cr (ppm)	99	P_2O_5	0.042		
Ag	48				

[1]Unified Soil Classification System [2]United States Department of Agriculture

Fig 3. Site plan of Iran Minerals Processing Company and location of tailings disposal Sites 1 to 5

RESULTS AND DISCUSSION

The tailings and soil profiles of the BH borehole, along with relevant soil layering profile, are presented in Table 2. This profile shows tailings (leach filter cake) from the surface to a depth of 9 meters, the starting level of the earth's natural bed, and then from 9 meters to 14 meters (and even more) which represents a layer of natural soil. Field observations inside the trench created during excavation operations of TP1, TP2, TP3 test pits, at a depth of 2 meters in the natural bed of Site 5 showed that the soil profiles are the same at all depths, with a completely clay nature.

Fig 4. Drilling of in the tailings and natural substrate of Site 1 with a skate drill D750

Fig 5. Undisturbed samples extracted by Shelby sampler during BH borehole drilling

The results of on-site and laboratory tests performed on BH borehole and TP1 test pit samples are presented in Tables 3 and 4 and Figure 6 and 7.

The results of tests performed on BH borehole samples show that the bed of Site 1 constitutes the tailings layer from 0-9 meters and natural soil from 9 to 14 meters (and more). There is a significant difference between the materials of the tailings layers and the natural soil layer in terms of the particle size distribution (the percentage of grains finer than No. 200 sieve, and percentage of clay), LL, USCS symbol, soil density, and finally, their coefficient of permeability. The particle size distribution of the BH borehole samples (Figure 6) shows that the percentage of grains finer than No. 200 sieve for tailings at depths of 3-4 meters and 5-6 meters are 80% to 88%, respectively, which corresponds to tailing particle size distribution obtained by Vick 1990, Qiu and Sego 2001 and Yilmaz et al., 2009. It can be stated that both samples have a completely fine-grained texture, and also, according to the analysis of the Atterberg limits, the plasticity of the tailings is low (LL<50). These tailings are classified in the range of silty (ML) soils with low plasticity according to USCS system (ASTM D2487-17e1, 2017) and A-7-6 following AASHTO System (AASHT, 2002). For natural soil samples at depths of 9-10 meters and 13-14 meters (and more), the percentage of sieve-200 grains is 98 to 99, and the soil can be said to have a very fine texture. According to the two criteria of gradation and plasticity, the above-mentioned soil samples are classified CH following USCS system, and A-7-6 according to AASHTO system. The results of measuring the in-place density in different layers show that the whole tailings layer (0-9 m) has a similar density of 1.54 to 1.57 g/cm^3 but the density of natural bed soil (9-14 Meters) is equivalent to 1.55 to 1.75 g/cm^3. The results of measuring the permeability coefficient by the falling head method show that the average permeability coefficient of the tailings layer (0-9 m) is 10^{-6} cm/sec.

As can be seen from the results, k values of tailings layer (0-9m) fall within the range of 2×10^{-6} to 7.9×10^{-6} cm/sec. These tailings are considered to have very low permeability typical of silty clay. The measured k values are within the same range as those reported for similar tailings in the literature: 10^{-4} – 10^{-6} cm/s for coarse and fine lead-zinc tailings respectively (Quille and Kielly, 2010), 10^{-4} to 10^{-6} cm/sec for homogenized tailings (Aubertin et al., 1996), 2×10^{-4} to 10^{-6} cm/sec for coarse and fine iron tailings respectively (Hu et al., 2017), and 10^{-4} to 10^{-6}cm/sec for copper tailings (Volpe 1979).

Also, the measured permeability coefficient of the natural bed clay layer (9-14 m) ranged from 1.5E-07 to 6.4E-07 cm/s. These results correspond to the determined typical values of Sarsby (2013) for the permeability coefficient of clay (10^{-6} – 10^{-9} cm/s).

In this regard, the permeability coefficient of the natural bed well satisfies the permeability criterion for compacted clay liners.

Since Site 5 is adjacent to Site 1, the geotechnical properties of the TP1 test pit specimens are similar to the geotechnical properties of the BH borehole specimens (Figure 7) In other words, in terms of fine-grained content, clay percentage, Atterberg limits, permeability coefficient and soil symbol, TP1 test pit soils have a profile similar to that of the BH borehole soils.

The geotechnical properties of the bed soil of Sites 1 and 5 obtained during various experiments show that the bed soil of these sites, according to USEPA, 1993 and USEPA 1989, meet the criteria of a suitable compacted clay liner. These criteria include a permeability coefficient of 10^{-7} cm/s, at least 20-30% of clay-sized particles, a plasticity index between 10% and 30% (USEPA, 1993) or 10% and 40% (USEPA 1989), and lack of particles larger than 3 inches. It is worth noting that if the soil of the surface layers of Site 5 is compacted using rollers with a moisture content of 1% to 7% higher than the optimum moisture content (USEPA, 1989), a lower permeability coefficient can be obtained to increase the in-situ density. It is worth noting that Athensopoulos et al. (2009) considered a range of 10^{-7} – 10^{-6} cm/s as a suitable permeability coefficient for compacted clay liner. Therefore, considering the criteria for a compacted clay liner, it can be concluded that for Site 5, there is practically no need to implement a compacted clay liner, and the natural bed soil, as a natural liner, displays a satisfactory performance.

For heterogeneous reactions (in metal extraction and processing), the migration rate of reactive molecules from one phase to another must be relevant to the interface area, and as a result, fine particles react faster than coarse particles because of their larger surface area (Ruan et al., 2019). Tailings' grain size is not generalizable due to its high variability which is determined based on specific process requirements. However, Sarsby (2000) defined tailings particle sizes as mainly gravel-free and clay-free, with a combination of sand and silt.

The results of previous studies and research show that an increase in grain size reduces zinc extraction rate due to reduced surface contact area of larger grains (Hurşit et al., 2009; Santos et al., 2010, Koohestani et al., 2019). For this reason, in IMPC factory, before importing mineral soils to the acid leaching process, the grain size of all mineral soil is reduced to less than 300 microns by ball mills in the crushing unit (Figure 2), which practically raises the proportion of silt (5-75 μm) to 68% to 71% (Table 4). This grain size range was determined in Iran Mineral Processing Company through the optimal process conditions obtained in previous research (Chen at al., 2009, He et al., 2010, Li et al., 2010, Xu et al., 2010) to achieve maximum zinc extraction from the mineral. This reduction in grain size in the milling process of IMPC causes the zinc plant tailings (the tailings to be stored at Site 5) to be essentially fine-grained and in the ML soil group, with a permeability coefficient of approximately 7.9E-06 to 2.0E-06 cm/s (Table 3). Therefore, in addition to the impermeability of the bed of Site 5, the tailings stored in Site 5 (leach filter cake) with a low permeability coefficient serve as an initial (partial) sealing layer which stops the infiltration of hazardous leachate of tailings from reaching the natural bed layer. Thus, they prevent the penetration of hazardous compounds into the natural substrate layers. Due to the fact that the bulk density within tailings increases with depth due to compaction and gradual drainage of moisture (Sarsby, 2000), the dry density of the tested tailings increases from 1.54 to 1.57 g/cm^3 with the increase in depth from 3 meters to 5 meters, which reduces the permeability coefficient from 7.9E-06 to 2.0E-06 cm/s.

Table 2. Profiles of tailings and natural soil substrate in BH borehole at Site 1

Depth (m)	Graphic Log	USCS Description	Material Description	LL	PI	ρ_d (g/cm^3)	ω (%)	GWL	Permeability (cm/s)
1 2									
3 4		ML	Silt with sand	44.5	16	1.54	36		7.9E-06
5 6		ML	Silt with sand	45	18	1.57	36		2.0E-06
7 8									
9 10		Up to 9 meters of fine tailings CH	Fat Clay	58	28.5	1.65	20		5.3E-07
11 12									
13 14		CH	Fat Clay	59.5	29.5	1.55	29		7.9E-07
End of Boring in 14.0 m									

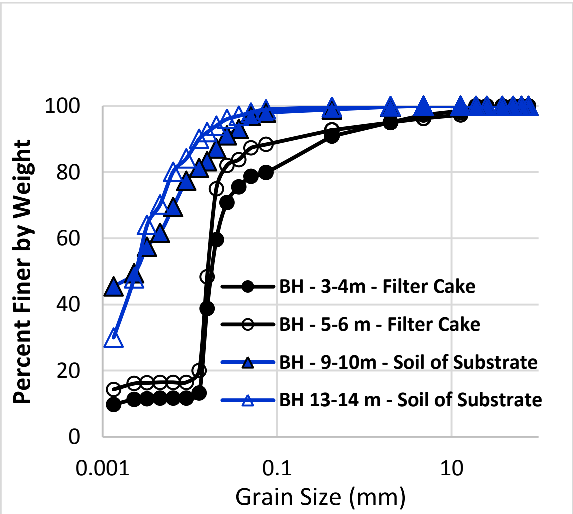

Fig 6. The particle size distribution of 4 samples extracted from BH borehole at Site 1

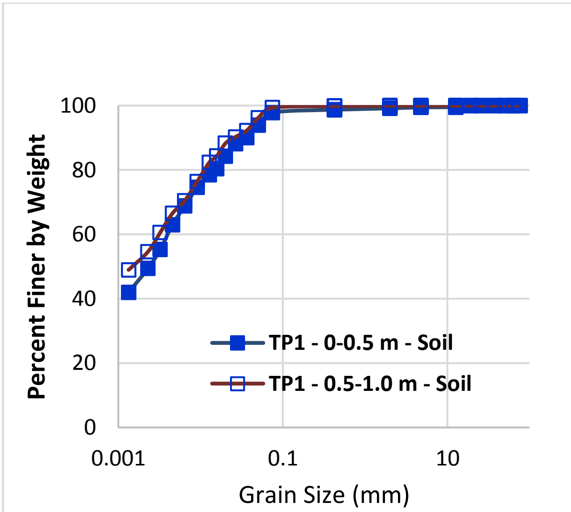

Fig 7. The particle size distribution of 2 samples extracted from TP1 test pit at Site 5.

Table 3. Results of geotechnical parameters measurement in tailings and natural bed layers of Sites 1 and 5.

K (cm/s)	Gs	ρ_d (g/cm^3)	ϖ (%)	AASHTO**	USCS*	PI (%)	LL (%)	Material description	Depth (m)	Borehole & test pit Name
7.9E-06	2.65	1.54	36.3	A-7-6	ML	16	44.5	Tailings	3-4	BH Next to the site 5
2.0E-06	2.64	1.57	36	A-7-6	ML	18	45.0	Tailings	5-6	
5.3E-07	2.63	1.65	20.4	A-7-6	CH	28.5	58	Natural bed soil	9-10	
7.9E-07	2.63	1.55	22	A-7-6	CH	29.5	59.5	Natural bed soil	13-14	
6.4E-07	2.70	1.56	16.4	A-7-6	CL	29	57	Natural bed soil	0-0.5	TP1 Site 5
1.5E-07	2.66	1.56	14.0	A-7-6	CL	27.5	56	Natural bed soil	0.5-1	

* Unified Soil Classification System

** American Association of State Highway and Transportation Official

Table 4. Grading parameters of tailings and natural bed soil of Sites 1 and 5.

* Silt (%)	Sand (%)	Gravel (%)	<5μm (%)	<75μm (%)	<#40	<#10	<#4	Material	Depth (m)	Borehole & test pit Name
68	17	3	12	80	91	95	97	Tailings	3-4	
71	8	4	17	88	93	95	96	Tailings	5-6	BH
30	2	0	68	98	99	100	100	Natural bed soil	9-10	(Site 1)
19	1	0	80	99	100	100	100	Natural bed soil	13-14	
30	2	0	68	98	99	99	100	Natural bed soil	0-0.5	TP1
29	1	0	70	99	100	100	100	Natural bed soil	0.5-1	(Site 5)

* The percentage of silt is expressed according to AASHTO and ASTM systems.

CONCLUSION

The experiments of this study were conducted using BH borehole drilling and three test pits, TP1 to TP3, to determine if the compacted clay liner is needed at Site 5. In general, this type of study plays an important role in site selection for tailings storage facilities (TSF) as well as in reducing the associated operating costs. The following includes the conclusion that can be drawn from the findings of this study.

The results of measuring the permeability coefficient of natural bed soil of Sites 1 and 5 through the falling head method showed a low permeability coefficient in the range of 1.5E-07 to 7.9E-07 cm per second. Considering the compliance of permeability coefficient, fine percentage, plasticity index and clay content of adjacent Sites 5 and 1 with the values of compacted clay liner criteria in the relevant standards, it can be stated that disposal and storage of tailings at Site 5 do not necessitate the implementation of a compacted clay liner. Besides, in the implementation phase of this project, compacting the surface layer of the site with sheepfoot rollers can increase the dry density of natural bed soil from 1.57 to 1.65 g/cm^3, which in turn reduces the permeability coefficient even more.

Reducing the size of mineral soil in the milling process brings the produced tailings mainly into the range of fine-grained soils and in the ML silty fine-grained soil group. This significantly reduces the permeability of the tailings (leach cake filter) to small values of about 2.0E-06 cm/s to 7.9E-06. Therefore, in addition to the natural permeability of the natural bed soil of Site 5, the permeability coefficient of the tailings stored at Site 5 acts as a partial, primary sealing layer. In fact, before the hazardous leachate reaches the natural bed layer, the compacted tailings on the ground bed partially restrict the infiltration of hazardous tailings leachate into the natural bed soil. On the other hand, in terms of hydraulic behavior of these tailings over time, it can be stated that the load on the lower layers of tailings increases with the increase in the depth of the tailings. Over time, with gradual drainage and leachate discharge from the tailings, a higher density of the lower tailings is achieved. Obviously, this phenomenon, in turn, can further decrease the permeability of tailings.

The methodology presented in this paper, via the site selection process of tailings dams or other tailings storage facilities (TSF), can financially reduce their implementation costs, meaning lower ultimate production costs. Moreover, reducing the construction costs of such facilities can encourage industry-owners to implement environmental projects and consequently preserve the quality of the environmental around the plant.

ACKNOWLEDGEMENTS

The author sincerely thank the Iran Mineral Processing Company (IMPC), all the managers and experts, for their kind help and support during several visits and testing.

GRANT SUPPORT DETAILS

Partial financial support was received from Iran Mineral Processing Company.

CONFLICT OF INTEREST

The author declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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