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FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería de Minas

Tesis

Evaluation of the Efficiency of Silica Removal in Effluents with (Zea Mays Var. Saccharata) in the Santa Rosa 94-1 Mining Concession in C.C. Llocllapampa, Jauja, Peru

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Para optar el Título Profesional de
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Huancayo, 2024

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Evaluation of the Efficiency of Silica Removal in Effluents with *(Zea Mays Var. Saccharata)* in the Santa Rosa 94-1 Mining Concession in C.C Llocllapampa, Jauja-Peru

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Abstract. In recent years in Peru, there are few non-metallic mining companies, one of the main ones being the Santa Rosa 94-1 mining concession, which is located in the community of Llocllapampa Jauja - Peru, where the main resource is silica sand that is used in this place, although it also generates a negative impact on the siliceous sand washing operation process since it modifies the conditions of the surface water since they do not have a treatment system. The objective of the research is to determine the efficiency and the amount of organic coagulant (Zea mays var. saccharata) for the removal of silica from the effluent in the mining concession. The characterization of the silica was carried out through petrographic analysis to know its composition, the effluent of the Total Suspended Solids (TSS) parameter was characterized, then it was designed factorially for 8 treatments with variation of the organic amendment, volume and time, which was applied to removal processes. After the analysis, they gave as a result that the non-metallic mining effluent generates a negative environmental impact on the ecosystem, comprising 15010 mg/L of TSS which exceeds the Maximum Permissible Limits, the combinations of organic amendment, effluent and time were developed, where in treatment 8 an average removal of 5,999 g/ml was obtained, which represents 88%, being the most efficient for silica removal.

Keywords: removal, silica, effluent, and organic reagent

1 Introduction

SiO2, known as quartz, is the main constituent of silica sand, rocks that can be intrusive, extrusive and sedimentary; this sand has several industrial applications. It is given because of its chemical and physical stability, the only detrital mineral that is chemically pure, so it can be 100% SiO2, consisting of 46.7% of Silica and 53.3% of Oxygen [1],

for the extraction requires investments in large quantities, necessarily for the machinery and equipment that will be needed to move the sand, as well as to achieve degrees of purity and quality. Silica can be found in three main forms: pure, unconsolidated areas and consolidated rocks [1]. Silica is a non-metallic mineral that is extracted from the rocks where it is found in open-pit mining, being processed to the point of crushing to obtain a higher concentration of silica.

Globally, China is the largest producer of silica in 2021 with 6 million metric tons, followed by Russia [2]. Which, until today silica has been very important for each country, specifically in Peru, non-metallic mining has been growing gradually, being the department of Junin in the month of June in the year 2021 and 2022 there is a percentage of variance 202.2% [3]. Peru is a country of ancient mining tradition that has a geological potential, the presence of the Andes Mountains throughout the territory, constitutes our main source of mineral resources (MINEM) [4], besides having a great potential in non-metallic minerals also known as Industrial Minerals, such as silica, marble, diatomite (first producer in South America) and borates. Peru is considered one of the few countries in the world where large deposits of these minerals can be found.

The activities in the town of Llocllapampa are extremely important because it has caused problems to the natural environment due to the irrational exploitation of the quarry, which is affected day by day, increasing the problems and generating a great impact not only socially but also environmentally; specifically, in the operation of washing the silica sand, it modifies the surface water conditions because it flows through the Poncijalo stream, discharging its waters into the Mantaro River. On the other hand, it also affects the living beings that consume it, because the effluents of the Santa Rosa 94-1 Mining Company do not have a treatment area where the substances it contains can be eliminated to continue the cycle, so alternative solutions were established to reduce the high concentration of silica in the effluents, starting with project management, planning, execution, follow-up, control and closure, also the development of the engineering of the project with its respective stages, within which is the recognition of the area, sampling, laboratory analysis, implementation of technology based on organic reagents at various scales, performance monitoring and data processing, using factorial experimental designs, obtaining a true result of each process in execution, which benefits the community of Llocllapampa. Therefore, the objective is to determine the efficiency and the amount of organic reagent for the removal of silica from the effluent in the Santa Rosa 94-1 mining concession.

2 Materials and Methods

2.1 Materials

The following materials were used to determine the efficiency of organic coagulant removal (see Table 1).

Table 1. Materials used in the laboratory

Material	Quantity
Corn starch *(Zea mays var. saccharata)*	2400 g
Effluent (wastewater with silica)	1L

A. Organic coagulant (corn starch)

It is an organic compound of biological origin, the main ones being starch, cellulose, vegetable extracts, alginates, among others. Being an alternative with great potential because they are biodegradable and do not cause any harm to the environment [5].

B. Effluent from Santa Rosa mining concession 94-1

The effluents from the Santa Rosa 94-1 mining concession are the mixture of water with nonmetallic mineral (silica) that is usually generated in a mining production process, which in many cases affects the environment in which it is developed.

2.2 Methodology

Location and Site Description. The "Santa Rosa 94-1" mining concession is owned by the farming community of Llocllapampa. The Santa Rosa 94-1 quarry is located in the community of Llocllapampa at 3496 masl, located in the central Andes of Peru, 52 km from the city of Huancayo. According to the mining rights summary of the Instituto Geológico, Minero y Metalúrgico (INGEMMENT), the concession covers an area of 300 hectares. In the Geological and Mining Cadastral Information System (GEOCATMIN) the Status of Right code is 020003094 mentioned in its Concession File [6] (see Fig. 1).

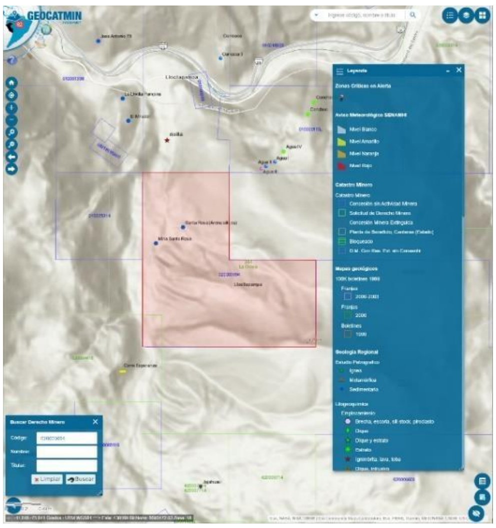


Fig. 1. Concesión Minera Santa Rosa 94-1

Source*: [6]*

The study area is located by geographic coordinates [7] (see Table 2). Politically, it is located in Ajocucho, Llocllapampa district, province of Jauja in the department of Junín (see Fig. 2). The Llocllapampa community has a diverse climate; from October to May there is rainfall (8° - 20°) with precipitation and from May to September there is an absence of rain. The predominant crops are tubers, forage oats, and ichu in the higher elevations, and the surrounding population raises cattle [8].

Table 2. UTM coordinates PSAD

Vertex	North	East
1	8,692,000.00	434,000.00
2	8,691,000.00	434,000.00
3	8,691,000.00	432,000.00
4	8,693,000.00	432,000.00
5	8,693,000.00	433,000.00
6	8,692,000.00	433,000.00

Source: INGEMMET, 2022 [7]

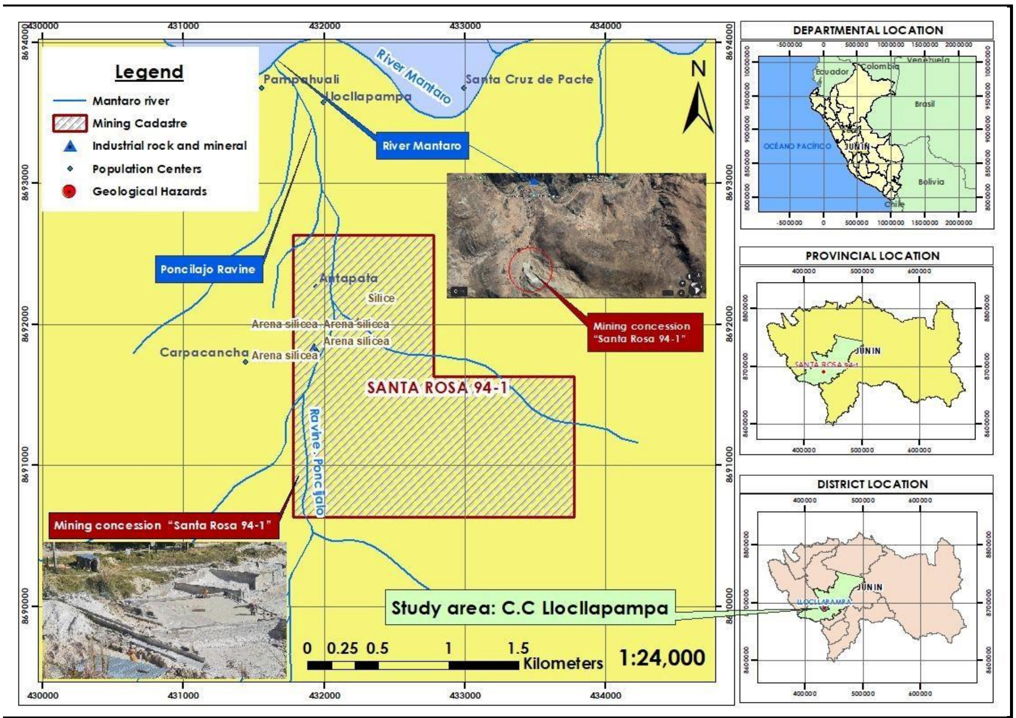


Fig.2. Location of the study area: "Santa 94-1" Mining Concession.

The Santa Rosa 94-1 mine consists of a process in which 50 people work in rotating shifts, the first process being drilling and blasting, which has a 10-minute water dragging, which reaches the classification plant by granulometry of 1 ½ mm, 1 mm, ¼ mm, the latter is used for construction, then it goes through double washing of silica ⅛ mm, and finally goes through a 1/16 mm washing process, to pass through drying ponds, where the effluent process does not have a treatment plant which comes to form a stream, which comes to flow into the Mantaro River directly contaminated (see Fig.3).

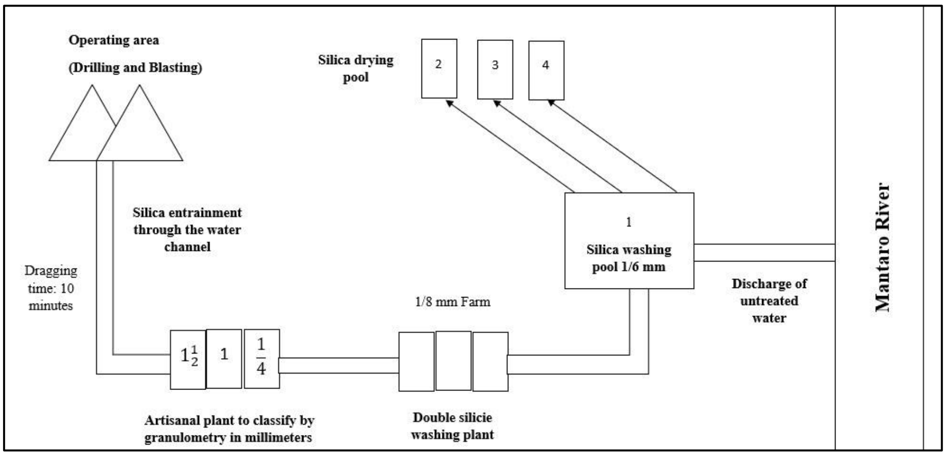
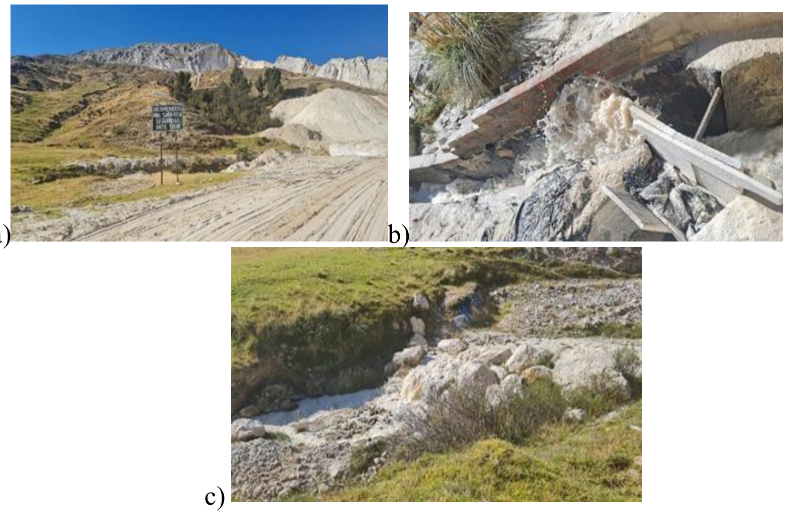


Fig. 3. Silica processing in the mining concession

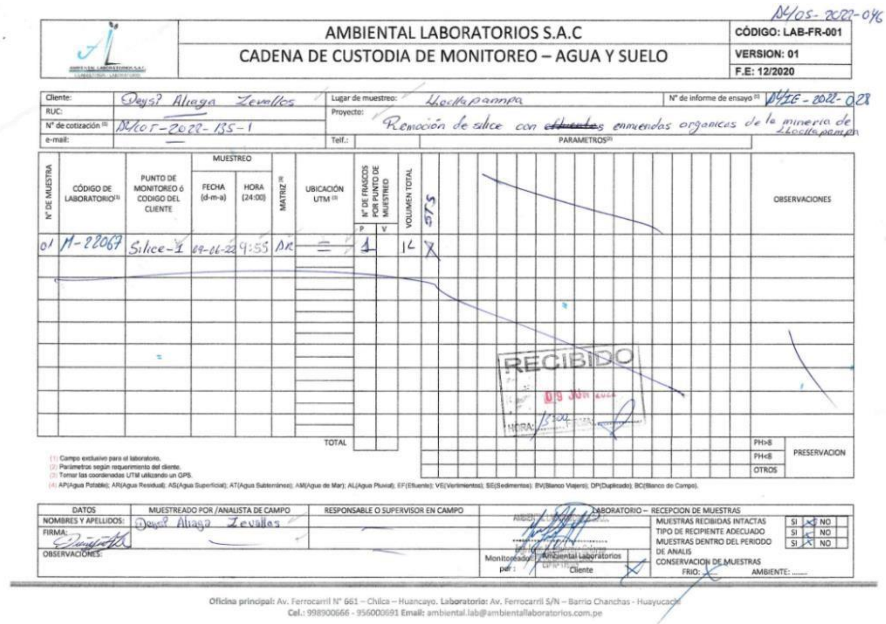
Silica Characterization. Silicon dioxide, commonly known as silica, is a silicon oxide with formula SiO2 that is commonly found in nature as quartz. Due to its chemical and physical stability, it is the most abundant detrital mineral [1]. The silica extraction process in the Santa Rosa 94-1 mining concession is carried out with an open pit in the form of quarries, with benches of heights greater than 40 m and a mining platform (fig. 4a). During the whole process the hydraulic force of water is used, which is supplied by channels coming from the "Poncijalo" stream, so that the granulated material deposited by gravity on the lower loading platform is driven through the channels to wash the broken material (fig. 4b) [8], later the effluent, not having a treatment plant, comes to form a stream until it flows into the Mantaro river (fig. 4c).



a) b) c)

Fig.4. During the visit to the Santa Rosa 94 - 1 mining concession in 2022, the silica deposit and the open pit activity were observed (a), also the path of the effluent was observed before entering the drying lagoon 1 for silica concentration (b) and finally the path of the effluent was observed (c).

Silica Characterization. To perform the characterization was carried out with the receipt of materials or equipment by the laboratory Environmental Laboratories S.A.C which provided us with the Chain of Custody of Water, where after it was collected a single sample "Silica 1", with a volume of 1L of effluent that was taken at 11°49'59. 0 "S 75°37'27.2 "W, being a simple sampling at 9:55 a.m. being generated by the Santa Rosa 94-1 Mining Concession (see fig. 5).



AMBIENTAL LABORATORIOS S.A.C

CADENA DE CUSTODIA DE MONITOREO – AGUA Y SUELO

CÓDIGO: LAB-FR-001

VERSION: 01

F.E: 12/2020

AL/OS-2022-046

Cliente: Deysi Aliaga Zevallos

Lugar de muestreo: Llocllapampa

N° de informe de ensayo (1): AL/IE-2022-028

RUC:

Proyecto: Remoción de sílice con ~~efluentes~~ enmiendas organicas de la mineria de Llocllapampa

N° de cotización (1): AL/COT-2022-135-1

e-mail:

Telf.:

N° DE MUESTRA	CÓDIGO DE LABORATORIO (1)	PUNTO DE MONITOREO ó CODIGO DEL CLIENTE	MUESTREO FECHA (d-m-a)	MUESTREO HORA (24:00)	MATRIZ (4)	UBICACIÓN UTM (3)	N° DE FRASCOS POR PUNTO DE MUESTREO P	V	VOLUMEN TOTAL	PARAMETROS (2): STS	OBSERVACIONES
01	M-22067	Silice-1	09-06-22	9:55	AR	–	1		1L	X	
						TOTAL					

PH>8 / PH<8 / OTROS — PRESERVACION

(1) Campo exclusivo para el laboratorio.
(2) Parámetros según requerimiento del cliente.
(3) Tomar las coordenadas UTM utilizando un GPS.
(4) AP(Agua Potable); AR(Agua Residual); AS(Agua Superficial); AT(Agua Subterránea); AM(Agua de Mar); AL(Agua Pluvial); EF(Efluente); VE(Vertimientos); SE(Sedimentos); BV(Blanco Viajero); DP(Duplicado); BC(Blanco de Campo).

RECIBIDO 09 JUN 2022 HORA: 15:20

DATOS	MUESTREADO POR /ANALISTA DE CAMPO	RESPONSABLE O SUPERVISOR EN CAMPO
NOMBRES Y APELLIDOS:	Deysi Aliaga Zevallos	
FIRMA:		
OBSERVACIONES:		

Monitoreado por: Ambiental Laboratorios / Cliente X

LABORATORIO – RECEPCION DE MUESTRAS

MUESTRAS RECIBIDAS INTACTAS	SI X	NO
TIPO DE RECIPIENTE ADECUADO	SI X	NO
MUESTRAS DENTRO DEL PERIODO DE ANALIS	SI X	NO

CONSERVACION DE MUESTRAS FRIO: X AMBIENTE: ......

Oficina principal: Av. Ferrocarril N° 661 – Chilca – Huancayo. Laboratorio: Av. Ferrocarril S/N – Barrio Chanchas - Huayucachi
Cel.: 998900666 - 956000691 Email: ambiental.lab@ambientallaboratorios.com.pe

Fig.5. Chain of custody for effluent monitoring
Source: Ambiental Laboratorios S.A.C

Silica Characterization

Wastewater Analysis. It was given through a SINGLE OR SPOT SAMPLE, according to the ANA (2016), this type of sample is also called discrete [9]. Which consisted of taking a portion of water in the area of 11°49'59.0 "S 75°37'27.2 "W of the Santa Rosa 94-1 mining, with the volume of 1L of wastewater, which was analyzed the parameter of suspended solids in the laboratory˝Ambiental Laboratorios S.A.C˝˝, with the SMEWW-APHA-AWWA-WEF Part 2540 D, 23 rd Ed. 2017 method whose description is Solids. Total Suspended Solids Dried at 103-105°C (see fig.6).

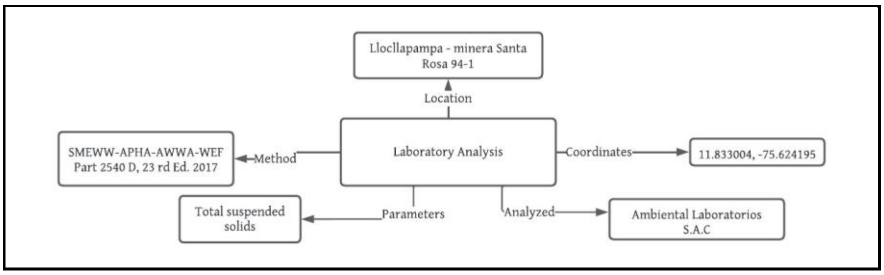


Fig. 6. Wastewater analysis process

Petrographic Analysis. Petrographic analysis helps us to describe and classify the composition of a sample with the main objective of analyzing the nature and origin of the sample by determining the type of rock, as well as the minerals and the degree of weathering [10].

a) Lithology

The Santa Rosa 94-1 mine is characterized by presenting a silica deposit, which is represented with a sequence of sedimentary and volcanic rocks, which is between the Neogene - Quaternary (NQ) period series. The white to gray silica is interbedded with the opaque yellow to dark orange sandstones due to the different sedimentary faces on which they were deposited (see Table 3).

Table 3. Prospecting for Industrial Rock and Mineral Resources in the Junín Region

Chronostratigraphic Column - Industrial Rocks and Minerals Resources In The Junín Region				
Er-	**System**	**Series**	**Symbology Alto Condoroma - atema**	**Caylloma, Western Cordillera and Eastern Cordillera Lithostratigraphic Unit**
Cenozoic	CUATERNARIO	HOLOCENE	Q	Residual Deposit
				Biogenic Deposit
				Colluvial Deposit
				Alluvial Deposit
				Fluvial Deposit
				Chemical deposit, travertine
				Moraine deposits
		PLEISTOCENE		Glacial deposit
				Fluviglacial deposit
				Alluvial deposit
	NEOGEN	PLIOCENE	NQ	La Merced Formation
				Jauja Group-Mataula Formation
				Pacococha Formation
		MYOCENE		Ushno Formation
				Ipururo Formation
				Incahuasi Formation
				Millotingo Formation
				Yanacancha Formation
				Caudalosa Formation

Source: Chronostratigraphic column (Ingemmet, 2018) [11].

Factorial design:

For the analysis of silica removal will be performed with 8 experimental treatments.

$$2^3 = 8$$

A: Amount of coagulant/flocculant (reagent)	t1: 30g t2: 60g
B: Sample volum	v1: 200 mL v2: 400 mL
C: Sedimentation time	t1: 1h t2: 2h

Table 4 shows the operationalization variables, where it is divided into 3 dimensions, being the quantity (c) to be used of 30 grams and 60 grams, in addition to the effluent volume (v) of 200 and 400 milliliters, and the sedimentation time (t) in a range of 1 and 2 hours, which will be used for the combination of treatments. **Table 4.** Variables and operationalization.

Variables	Dimension	Indicators	Items
Organic Reagent	Quantity (g) Sample volume	Amount of organic reagent dosed:	
Sample		Amount of reagent c1: 30 g to decrease the sil- c2:60 g ica concentration Sample volume in a certain sample v1: 200 ml volume to XX%. v2:400 ml	
Sedimentation	Sedimentation time		Sedimentation time t1:1h t2:2h

Table 5 shows the experimental execution which consists of 8 treatments, which is made up of the amount of coagulant (c), volume of effluent used (v) and the time taken (t).

Table 5. Combinations of treatments

Experimental run	Combination of treatments
1	c1v1t1
2	c2v1t1
3	c1v2t1
4	c2v2t1
5	c1v1t2

6	c2v1t2
7	c1v2t2
8	c2v2t2

3 Results

3.1 Parameters Evaluated with Respect to Water Quality

The parameter to evaluate the effluent is total suspended solids.

Total Suspended Solids. The results obtained by performing the analysis through the laboratory "Ambiental Laboratorios S.A.C", with the suspended solids parameter with the SMEWW-APHA-AWWA-WEF Part 2540 D, 23 rd Ed. 2017 method whose description is Solids. Total Suspended Solids Dried at 103-105°C.

As established in the Supreme Decree 010-2010 of the Ministry of Environment [12], the results of the effluent in the **laboratory** exceed the maximum allowable limits of the effluent evaluated in the laboratory (see Table 6 and Table 7).
The Maximum Permissible Limit for the effluent from the Santa Rosa 94-1 mining concession is the concentration of substances in the liquid effluent from the activities carried out, which when exceeded causes damage to the health of the people living near the site and, above all, affects the ecosystem.

Table 6. Maximum permissible limits for the discharge of liquid effluents from mining and metallurgical activities.

PARAMETER	UNIT	Anytime Limit	Limit for Annual Average
pH		6-9	6-9
Total Suspended Solids	mg/L	50	25

Source: [12]

Table 7. Effluent Laboratory Results

Código	Ensayo	Resultado	Unidad
Sílice 1	Sólidos Totales en Suspensión	15010	mg/L

3.2 Laboratory Analysis Results

Amount of Silica. The results are presented from the laboratory analysis. This table shows the initial silica concentration without addition of organic reagents (see Table 8).

Table 8. Amount of initial silica

Initial Silica Quantity (0.017 g/mL)	
Sample Volume	Silica Mass
200 mL	3.4085g
400 mL	6.817g

Silica Removal Analysis. This table shows the combinations performed and the average silica removal for each of them (see Table 9).

Table 9. Repeat treatments

Combination	Repetitions 1	2	3	4	Average g/ml
c1v1t1	1.701	1.750	1.634	1.715	1.700
c2v1t1	2.322	2.325	2.306	2.328	2.320
c1v2t1	3.409	3.405	3.400	3.418	3.408
c2v2t1	4.635	4.634	4.624	4.645	4.634
c1v1t2	2.405	2.405	2.410	2.404	2.406
c2v1t2	2.999	2.985	3.100	2.910	2.999
c1v2t2	4.781	4.785	4.785	4.770	4.780
c2v2t2	5.999	5.950	5.840	6.208	5.999

For the experimentation, disinfected and regulated laboratory equipment was used (see fig.7.a) in addition 8 different repetitions were performed (see fig.7b) as a result we obtained samples with removed silica (see fig.7c).

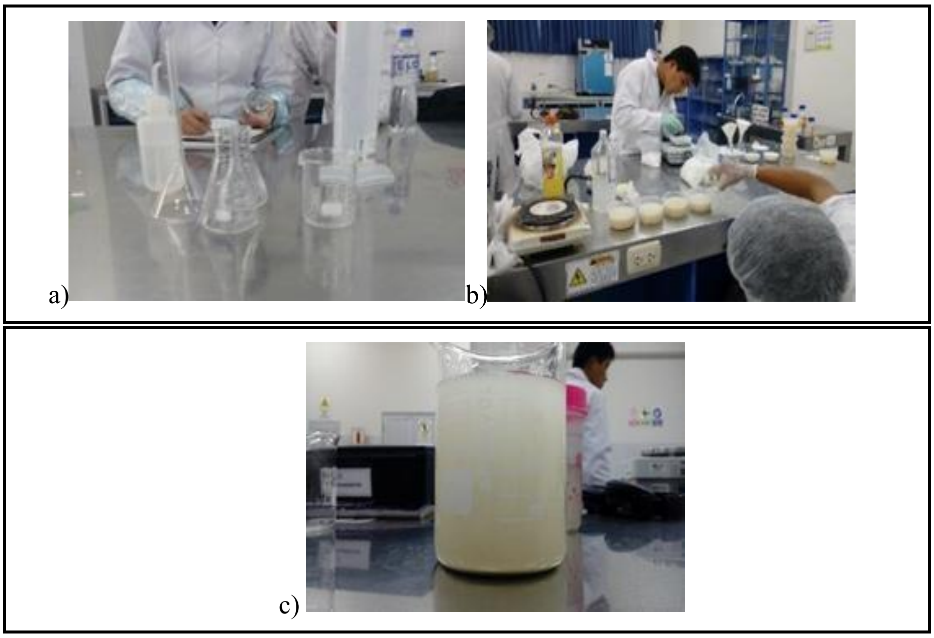


Fig.7. The experimental process was observed in the laboratory, where materials were used for the testing process (a), the 8 treatments were prepared (b) and finally the silica removal results were observed (c).

This table shows the percentage removal for each treatment combination. The higher the corn starch additive over a longer period of time, the higher the percentage removal of silica, with 88% removal efficiency in the treatments of 60g in 200 ml with a time of 2 hours and 60g in 400 milliliters with a time of 2 hours (see Table 10).

Table 10. This table shows the combinations carried out and the average silica removal for each of them.

Experimental run	Combination of treatments	Amount of silica	Amount of removal g/ml	% Removal
1	c1v1t1/ 30g-200ml-1h	3.4085g	1.700	50%
2	c2v1t1/ 60g-200ml-1h	3.4085g	2.320	68%
3	c1v2t1/ 30g-400ml-1h	6.817g	3.408	50%
4	c2v2t1/ 60g-400ml-1h	6.817g	4.634	68%
5	c1v1t2/ 30g-200ml-2h	3.4085g	2.406	70%
6	c2v1t2/ 60g-200ml-2h	3.4085g	2.999	88%

7	c1v2t2/ 30g-400ml-2h	6.817g	4.780	70%
8	c2v2t2/ 60g-400ml-2h	6.817g	5.999	88%

4 Discussion

4.1 **Organic Amendment and Fuculant -Flocculant Obtained from Nopal Cactus**

The study was carried out using organic coagulant (corn starch) where eight trials of 30 g and 60 g of coagulant were carried out, with a time of 1h and 2h in volumes of 100ml and 200ml, obtaining a removal efficiency of 50%, 68%, 70% and 88%, this experiment was conducted in the laboratory of the Continental University, where the test system was used in beakers to simulate the coagulation process, being where the maximum removal of 5. 999 g/ml with test eight, where 60 gr of coagulant was added in 400 ml with a time of 2h having a percentage of 88% in the total removal, being the most optimal treatment for the removal of silica to the test carried out of suspended solids in Minera Santa Rosa 94-1, Thus, the use of "Opuntia ficus-indica" mucilage should be implemented for a better efficiency, since it presents a great effectiveness of 80% as treatment in the effluent of the mine belonging to the concessions of Compañía Minera Colquirrumi S. A.[13]

5 Conclusion

• The wastewater effluent from the Santa Rosa 94-1 non-metallic mining company was analyzed because it does not have a treatment system for its effluents discharged into the receiving body (Mantaro River), as evidenced in the laboratory results, exceeding the Maximum Permissible Limits for the discharge of liquid effluents from miningmetallurgical activities, which generates a negative environmental impact and affects the ecosystem.
• After performing the 8 treatments with different combinations of organic amendment, amount of effluent and time, it was observed that after the repetitions of each treatment, in this case 4, the most optimal was treatment 8 (c2v2t2), where 60 grams of amendment were used in a volume of 400 milliliters with a time of 2 hours, obtaining as a result an average removal of 5.999 g/ml.
• It was observed that after the tests carried out for treatments 6 (60 grams of amendment in 200 ml with a time of 2 hours) and 8 (60 grams of amendment in 400 milliliters with a time of 2 hours), the results obtained for silica removal were 88%, being the most optimal in the Santa Rosa 94-1 mining concession.
• The application of the natural flocculant in the samples showed that corn starch is efficient in the removal of silica in the effluent of the non-metallic mining company.

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