EVALUATION OF ROCK POWDER USE FOR PRIMARY WASTEWATER TREATMENT - AUXIPÓ

Rodrigo Augusto Franco de Oliveira Zawadzki
Serviço Nacional de Aprendizagem Industrial (SENAI), Parana (Unidade CIC), Brazil
Rua Senador Accioly Filho, 298 – CIC – Curitiba, PR
rodrigo.zawadzki@pr.senai.br

Alessandra Rosa Vieira
Serviço Nacional de Aprendizagem Industrial (SENAI), Parana (Unidade CIC), Brazil
Rua Senador Accioly Filho, 298 – CIC – Curitiba, PR
alessandrarv@hotmail.com

Francisco Soveral Zanella
Serviço Nacional de Aprendizagem Industrial (SENAI), Parana (Unidade CIC), Brazil
Rua Senador Accioly Filho, 298 – CIC – Curitiba, PR
fszanella@uol.com.br

Patricia Barbosa dos Santos
Serviço Nacional de Aprendizagem Industrial (SENAI), Parana (Unidade CIC), Brazil
Rua Senador Accioly Filho, 298 – CIC – Curitiba, PR
patricia17_bsantos@hotmail.com

1) ABSTRACT

The formation of rock powder in suction fan bag filters in mining industries produces large amounts of solid wastes with low aggregated value and usually disposed as an asphaltic compound or in industrial landfills. However, this waste comprises high aluminum and silica levels in its chemical composition, therefore suggesting that it can attain a nobler use as an auxiliary coagulant in primary wastewater treatment. The laboratory tests developed at SENAI CIC (Curitiba, PR) showed that this powder improves color and turbidity removal rates in an average of 50% when applied to three different wastewaters. This technology named AUXIPÓ was developed aiming at a more sustainable disposal for this rock powder and at increasing primary wastewater treatment efficiency in industries.

2) KEY WORDS

Rock powder, AUXIPÓ, mining industries, primary wastewater treatment.

3) INTRODUCTION

Mining industries produces large amounts of dust, causing air pollution and unsafe work conditions (IBRAM 2012). The use of suction fan bag filters generally is the solution to this problem, however, generates a solid refuse that is removed from the bags and demands an appropriate destination. That refuse usually is co-processes with raw asphaltic matter, although, sometimes industrial landfill disposal are necessary (CETESB, 1990).

On the other hand, chemical characterization of this rock powder shows nobler uses for this refuse, such as a coagulant auxiliary, since silica and alumina are common substances in some rocks. For example, bentonite and activated silica are extensively used as coagulant auxiliaries in water and wastewater treatment plants all over the world. (DI BERNARDO *et al.* 2005)

The use of rock powder in wastewater treatment gives a new possibility to increase the value of this mining refuse, allowing also a more sustainable disposal to the waste. (VIEIRA *et al.* 2012).

Therefore, the objective of the present work is to evaluate the use of rock powder as a coagulant auxiliary in the primary wastewater treatment.

4) MATERIALS AND METHODS

This work was developed in SENAI CIC lab (Curitiba, Parana State, Brazil). The rock powder, formed after the mechanical disaggregation processes, was obtained from a mining industry in Candeias do Jamari (Rondonia State, Brazil). This powder was collected in the outlet of suction fans bag filters, using a polyethylene flask. The methods applied in the present work were as it follows.

4.1 Rock powder characterization

The rock powder was characterized in the Minerals and Rocks Analysis Laboratory of UFPR (Federal University of Parana), using X-ray diffractometry (Philips PW 1830) and X-ray fluorescence (Philips PW 2400).

4.2 Wastewater Jar Tests

The use of the rock powder in primary wastewater treatment was evaluated with Jar Tests assays. In those assays, color and turbidity removal rate was monitored, using a UV-Vis spectrophotometer, by comparing color and turbidity removal in tests with rock powder as a coagulant auxiliary and in tests without using rock powder. Settling rate was also taken using Imhoff's cone and a chronometer. Three different wastewaters was undertaken for the Jar Tests assays, provide by a beverage industry, textile industry and a decorative wallpapers industry.

4.3 Dissemination proposal of rock powder use in wastewater treatment

The dissemination for the use of rock powder as a coagulant auxiliary in wastewater treatment was realized by a partnership with the marketing department of SENAI Parana. Logistic and financial analysis were also made to evaluate the possibility to offer the rock powder as a coagulant auxiliary in industrial scale, using as calculation basis a mining in Candeias do Jamari (Brazil).

For this analysis, it was consider the payment cost of an production worker to bagging the rock powder (W), the mass that the worker can bag per hour (M), transportation cost of the rock powder to Curitiba (Brazil), and the selling price of the powder as a coagulant auxiliary (SP). Table 1 shows the equations used for those analyses.

Two price quotations were made for financial analysis. The first one aimed the selling price of the rock powder, and was realized in five different suppliers of bentonite and activated silica for wastewater treatment in Curitiba (Brazil).

The second one aimed the rock powder value increasing capacity, and was taken in three different mining industries in the state of Rondonia (Brazil).

Table1. Equations used for financial analysis of rock powder use as a coagulant auxiliary.

Parameter	**Equation**
Cost for bagging the rock powder in R$/kg (CB)	$CB = W/M$
Total cost for bagging and transportation of the rock powder in R$/kg (CBT)	$CBT = CB + CT$
Profit in R$/kg ($P_{R\$}$)	$P_{R\$} = SP - CBT$
Percentual profit ($P_{\%}$)	$P_{\%} = (P_{R\$}/SP) \times 100$

5) RESULTS AND DISCUSSIONS

5.1) Characterization of the rock powder

The rock powder analyzed showed a mineral composition of alkaline feldspar, plagioclase and mica, with a 200 mesh gradation (smaller than 0,074 mm). Table 2 shows the chemical composition of the powder.

Table 2. Chemical composition of the rock powder collected in the outlet of the suction fan bag filter.

	Chemical Composition*							
Compound	SiO_2	Al_2O_3	K_2O	Fe_2O_3	Na_2O	CaO	TiO_2	MgO
Concentration in %	63.3	13.6	5.9	3.9	3.3	2.9	0.9	0.6
Compound	P_2O_5	BaO	MnO	SO_3	ZrO_2	Rb_2O	SrO	F.L**
Concentration in %	0.4	0.2	0.1	0.1	0.1	<0.1	<0.1	0.60

* Results normalized to 100%.
** F.L (Fire Loss).

In Table 2 it's evident a high silica and alumina concentration, and also insignificant levels of potential toxic metals, such as chrome, nickel and cadmium, among others.

According to Di Bernardo (2005) and Metcalf & Eddy (2003), the use of rock powders as coagulant auxiliaries depends on how elevated the silica and alumina levels are in the original rock. Therefore, Table 2 shows innocuous characteristics that guaranties such use. Absence of toxic metals are very important for wastewater treatment, because the products add along the treatment can not cause toxicity or even dangerous chemical characteristics to the sludge formed after coagulation and flocculation.

Low calcium and magnesium levels shown in Table 2 also gives interesting features to use rock powder as a coagulant auxiliary, because wouldn't cause any hardness problems to the treated wastewater. Hardness can causes incrustation problems in any industrial equipment that uses water, such as boilers, heat exchangers and cooling towers. Therefore, the absence of significant hardness allows more proper water reuse strategies for the clarified wastewater.

However, its useful to mention that not all kinds of rocks are appropriate to be used as a coagulant auxiliary, because they can cause excessive floc bulking, due to inadequate gradation, add color or turbidity to the clarified, due to high solubility, add toxic metals in the treated wastewater, or, simply doesn't do nothing that increases the quality of the treatment.

5.2) Use of rock powder in primary wastewater treatment

The use of rock powder as a coagulant auxiliary, shown in Table 3, was able to increase the color removal rate up to 35 to 58% in the clarified wastewater, and 40 to 50% increase in turbidity removal rate. The Jar tests describe in Table 3 was made with three different wastewaters.

Those results show that this rock powder has appropriate chemistry characteristics that can be used as a coagulant auxiliary. The increases rates achieved in Table 3 are due to the ability of the rock powder to act in the mass center of stable colloids particles, allowing then to be more easily removed by flocculation and settling.

During Jar tests with the textile wastewater, it was noted an increase in the settling rate up to 1.7, confirming the mass increase that the colloids and flocs

experiments when the rock powder it's add in the raw wastewater. The increase in settling rate was also able to give a more compact sludge. At last, along all jar tests with all three wastewaters, no volume increase in sludge formation was noted.

Having achieved those results, a patent request was made in Brazilian Patent Office (INPI – Instituto Nacional de Patentes Industriais), under the registration number BR 10 2013 012017 0, aiming to protect the process developed in the preset study.

Table 3. Color and turbidity removal rate along Jar tests in three different wastewaters.

	Removal rate to the raw wastewater		**Increase in the removal rate to the clarified wastewater by adding rock powder.**	
Wastewater origin	**Color removal (%)**	**Turbidity removal (%)**	**Color removal (%)**	**Turbidity removal (%)**
Beverage industry	87.0	74.0	35.0	40.0
Paper industry	99.8	99.4	57.8	50.2
Textile industry	95.7	96.4	57.2	42.2

5.3) AUXIPÓ Technology

The process developed in the present study has been given a commercial name of AUXIPÓ, and the logo show in Figure 1 was developed to marketing purpose, aiming to disseminate the technology of using rock powder as a coagulant auxiliary to industries and every other potential client. This logo it's also under patent protection, by document number BR 10 2013 012017 0.

Figure 1. Logo developed to disseminate AUXIPÓ technology.

5.3.1) Financial Analysis of AUXIPÓ Technology

To establishes the costs necessary to operationalization of AUXIPÓ, and also to set the selling price of the technology, an financial analyze was made, as it's shown in Table 4. Given the simplicity in obtaining the rock powder in the mining industries, Table 4 shows only bagging and transportation costs that are related to the process. Energy or equipment costs are not undertaken for this analysis, since they are not necessary to obtaining the rock powder, as it will be discussed in section 5.3.3.

Thereby, the rock powder selling price it was set at 0.50 R$/kg, considering the selling market in Curitiba (Brazil). This value its set bellow 1.11 R$/kg, that is the common price of most coagulant auxiliaries that are commercialized in Brazil (bentonite and activated silica).

Table 4. Production costs, selling price and profit in commercialization of rock powder to AUXIPÓ's technology.

Parameter	**Value**
Payment cost of an production worker to bagging the rock powder in R$/h (W)	3.80
Mass (in kg) that the worker can bag in 1 hour. (M)	600.00
Cost for bagging the rock poder in R$/kg (CB)	0.00633
Transportation cost of the rock powder from Candeias do Jamari (Rondonia State) to Curitiba (Parana State), including on board costs and transportation licenses required in R$/kg (CT)	0.20
Overall cost to bagging and transport the rock powder, in R$/kg, adding 0.10 R$ per plastic bag required. (CBT)	0.306
Selling price of the rock powder in R$/kg (SP)	0.50
Raw profit in R$/kg ($P_{R\$}$)	0.194
Raw profit in em % ($P_{\%}$)	38.73

5.3.2) Value increasing of the rock powder

Nowadays the selling price of the rock powder in mining industries in Brazil is in average 0.05 R$/kg, and the biggest purchasers are the asphalt manufactures. To achieve financial viability in the transportation of the rock powder, trucks carry the minimum weight of 15 ton. Therefore, without taxes, a mining is able to raise R$ 750.00 in each cargo selling. However, the high demand that asphaltic manufactures exerts to mining industries, allows a large amount of rock powder destination to that purpose, creating also interesting profits to the sellers.

Although, some rock formations, as describes in section 5.1, show a nobler use than the co-processing wit asphalt, adding a more competitive feature to selling the rock powder refuse. Therefore, the present study suggest a selling price of any rock powder that can be used as a coagulant auxiliary of 0.50 R$/kg, ten times higher than the value practice to asphalt manufactures. However, two facts must be taken in consideration.

In first place, the quantities of rock powder that can be selling to AUXIPÓ's technology are lower than the quantities that can be selling to asphalt manufactures. This is due to small dosages that are required in coagulation process.

At second place, dissemination of AUXIPÓ's technology to Brazilian industries can allow that a mining that has a rock formation according to the necessary characteristics to use the rock powder as a coagulant auxiliary, can choose to sell its rock powder only to AUXIPÓ's technology, that is a more profit selling then asphaltic co-process. Since there are a few rocks formations in the Brazilian territory that provides rock powder with proper chemical characteristics to be used in AUXIPÓ's technology, that feature shows to be financial interesting to the mining industry. In that case, this mining will be one in a few that can offer that product, creating a high demand for it.

5.3.3) Transportation and stoking of rock powder

In Brazil, the transportation of the rock powder can be made by state or federal highways. There are no special licenses required for that transportation, as Federal Police or Army licenses, since the rock powder it's a completely harmless and not flammable or explosive product.

Stocking of the rock powder in the industries that start to use the AUXIPÓ's technology it's also simple, and requires a cover area with a roof without leaking, concrete floor and pallets to pile the bags up. However, the rock powder needs to be proper bag in 5 to 50 kg plastic bags or 1 ton big bags.

That way, there are some investments needs to the mining to allow the proper bagging of the rock powder. However investments in bagging machines or

any other analogous equipment are not necessary. The rock powder it's removed of the bag filter suction fan by opening a valve located at the bottom of the filter, requiring only that a worker place the plastic bag under the exit valve.

6) CONCLUSIONS

The use of rock powder as a coagulant auxiliary it's an innovative process that shows to be highly competitive to the current alternatives to primary wastewater treatment, since it has shown increase in the color and turbidity removal rate in three different wastewaters without increasing the sludge formation.

By increasing the selling value of rock powder refuse in mining industries, and also allowing a more nobler destination to the refuse, AUXIPÓ's technology shown to be both economic and environmental sustainable.

At last, the possibility to offer a product with a lower price than the current commercialized coagulant auxiliaries sets AUXIPÓ in a high competitive place, with high profits potentials.

7) REFERENCES

CETESB - Companhia de Tecnologia de Saneamento Ambiental. Tecnologia de controle de poluição por material particulado. São Paulo/SP, 1990.

DI BERNARDO, L; DANTAS, A. DI BERNARDO. Métodos e Técnicas de Tratamento de Água. 2ª ed. 2v. Rima, São Carlos, SP, 2005.

IBRAM, Instituto Brasileiro de Mineração. 2012. Disponível em: <www.ibram.org.br>. Access in june of 2012.

METCALF & EDDY. Ingeniería Sanitaria: tratamiento, evacuación y reutilización de aguas residuales. Metcalf & Eddy Inc. 4ª ed. 2003.

VIEIRA, A.R; ZANELLA, F.S; SANTOS, P.B.; ZAWADZKI, R.A.F.O. Aplicação de Pó de Rocha como Auxiliar de Coagulação em Efluentes Industriais. Environmental Technician Conclusion Paper, SENAI CIC, Curitiba, PR. 2012.