Combined Treatment of Acid Mine Drainage and Sewage in the State of Santa Catarina – Brazil

Roberto Romano Neto[1], Michael S. Crocetta[1], Maria Gisele R. Souza[1], Edilane Rocha[1], Márcio Zanuz[1], Cleber J. B. Gomes[2]

[1]SATC – Associação Beneficente da Indústria Carbonífera de Santa Catarina, CTCL – Centro Tecnológico de Carvão Limpo, Rua Pascoal Meller,73. Universitário. Criciúma/SC. CEP 88805—380, roberto.romano@satc.edu.br

[2]SIECESC – Sindicato da Indústria de Extração de Carvão do Estado de Santa Catarina, Rua: Pascoal Meller 73, Bairro. Criciúma/SC. CEP 88805—380, cleber.gomes@satc.edu.br

Abstract Abandoned mines are the main sources of rivers pollution in coal basin of Santa Catarina due to acid mine drainage (AMD) generation. In addition to contaminants from AMD, rivers have been polluted with sewage which has been discharged into the rivers without any prior treatment. Clean Coal Research Center (CTCL) has been developing laboratory studies of AMD and sewage treatment in combined way. Effluents were collected in Criciuma, south region of Santa Catarina. Studies have shown that combined treatment of AMD and sewage can eliminate pathogens, organic matter and meaningfully reduce metals, sulfates, P and N contents.

Key Words acid mine drainage, sewage, combined treatment, Fenton reaction.

Introduction

Rivers pollution in the city of Criciuma, located in the southern of Santa Catarina (fig. 1) state, Brazil, originates from AMD and untreated sewage discharges. Coal has been mining in this region for 120 years and several mines were abandoned without environmental reclamation. These areas have been the source of acid mine drainage (AMD) which causes contamination of soil and surface and groundwater with high metals and sulfate contents. Acid drainage results from the oxidation and hydrolysis of sulfide minerals (pyrite and marcasite) constituents of coal and enclosing rock layers. Besides the acid mine drainage, the environmental quality of water resources have been also impacted by sewage that has been released directly into rivers, polluting the water with high levels of organic matter, nitrogen, phosphorus and pathogens.

According to Campos (2007), 5.96% of Criciuma area (1407 hectares) are occupied with abandoned open pit coal mines and tailing deposits. In addition, there are hundreds of drift galleries with underground discharge of AMD (Brasil 2009).

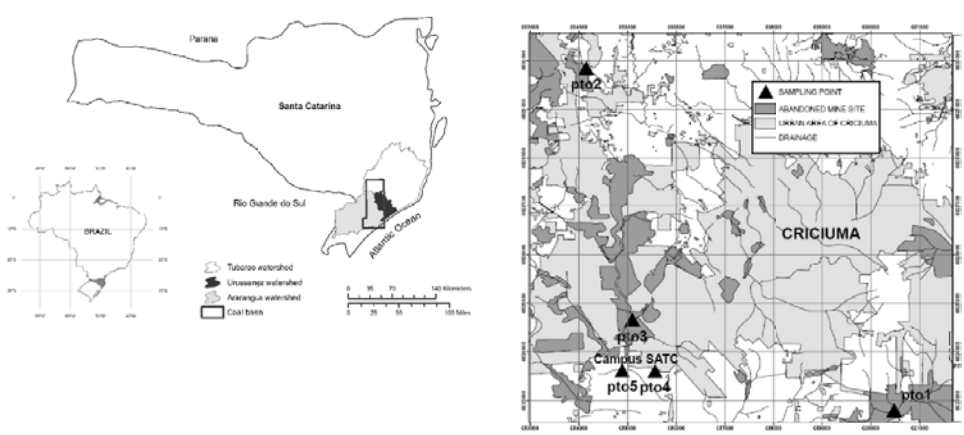

Figure 1 *Location maps*

Most of the sewage in the city of Criciuma (185,000 inhabitants) is not subjected to any kind of treatment, being released directly into the rivers. Despite, the government is expanding the sewage system, at present it has been treated in insignificantly amounts.

A court decision published in 2000 demanded the coal mining companies to reclaim water resources impacted by abandoned mines from coal mining activity. Ever since, Association of the Coal Mining Industry of the State of Santa Catarina – SIECESC and Research Center of Clean Coal (CTCL) what is a branch of Benefit Association of the Coal Industry of Santa Catarina State – SATC has been conducting a comprehensive environmental reclamation project, covering all coal basin, including the construction of a pilot plant for combined treatment of AMD and sewage.

Combined treatment of AMD and sewage aims to reduce the environmental impact on water resources. These studies have shown that the blend of effluents decreases acidity, metal contents and causes precipitation of the organic matter. These studies have been conducted since December 2008 through a technical cooperation agreement between SATC and FAPESC Foundation to Support Scientific and Technological Research in the state of Santa Catarina.

Methodology

Methodology is based on laboratory tests with samples of AMD and sewage collected at five points located in Criciuma which were performed from February to November 2009. The sampling points 1, 2 and 3 are located within of tailings deposits and points 4 and 5 are drill holes with AMD discharge. These samples were analysed for physical and chemical parameters (pH, acidity, sulfate, conductivity, total dissolved solids, suspended solids, OBD, Al, Fe, Mn, P and N) at SATC laboratory, and for ecotoxicological and bacteriological (coliform) at the University of South of Santa Catarina – UNESC laboratory. Characterization analysis were performed with samples of AMD, sewage and blends of effluents in the ratios of 1:1, 1:2, 1:3, 1:4 with the goal to evaluate which of the blends present the best results for reducing chemical and organic pollutants.

Samples blended in 1:1 ratio were subjected to Fenton's reaction that consists in addition of hydrogen peroxide into the blend of AMD and sewage with the purpose to oxidize organic matter. In this reaction the Fe^{+2} concentration of the blend runs as catalyzing agent which is also known as Fenton's catalyst. Tests were done with addition of 8 mL per liter of hydrogen peroxide and with the pH around 3.5. Amount of hydrogen peroxide was determined by the concentration of Fe^{+2} in AMD, following the indications described by Schneider (2009). After one hour of reaction, the samples were filtered and sent to the laboratory for analyses. In the laboratory tests were spent U$ 0.03/liter for combined treatment of AMD and sewage with addition of hydrogen peroxide and NaOH.

Results and discussions

Tests results presented in table 1 represent average values of physical and chemical analyses performed with six samples of AMD and sewage collected at point 1 from February to December 2009. They have shown that AMD carries high concentrations of metals, sulphate and acidity and sewage high concentration of organic matter, nitrogen, phosphorus and pathogens.

Tests with the 1:1 ratio blend was found a 95% of decrease in the concentration of acidity and metals with reductions ranging from 17% for Fe and 38% for Mn considering concentrations found in AMD. Sewage alkalinity promoted reduction of metals concentration by dilution and by partial neutralization of acidity.

High concentration of dissolved metals and acidity of AMD account for 53% of reduction in organic matter, 47% of N, 43% of P concentrations and the complete elimination of pathogens of sewage.

It was added NaOH to precipitate metals of blend, reaching levels below those set by environmental regulations after the pH be reached to 6.6 in average. In those tests, the organic matter was completely oxidized, however the concentrations of N and P, although significantly reduced by 47% and 89% compared to concentrations found in blends, will require a greater number of tests, as they had not fit within the limits set by environmental regulations. These tests will be conducted at a pilot plant which will be constructed for effluents treatment in 2010.

It is worth pointing out that the contaminants reduction obtained by combined treatment were greater than that achieved in the sewage treatment station maintained by the state government.

Table 1 Average results of analysis from samples collected in point # 1

PARAMETERS	AMD (1)	SEWAGE (2)	BLEND (1 + 2)	BLEND TREATED	LAW LIMITS
pH	2.6	6.9	2.8	6.6	5 to 9
Acidity (mg/L $CaCO_3$)	1615.6	34.3		65.6	
Alcalinity Total (mg/L $CaCO_3$)	0	286.5			
Oxygem biochemical demand	3.1	247.8	115	**NOT DETECTED**	10
Condutivity (uS/cm)	1930	726.2			
N (mg/L)	4	99.6	53	28	13
P (mg/L)	0.8	15.8	8.9	1	0.15
Sulfate (mg/L)	1550.3	25.2	964.7	480.4	
Discharge (m^3/h)	49.6	26.6			
Dissolved solids (mg/L)	2070.6	411.8			
Dissolved oxygen (mg/L)	6.1	1			
Al (mg/L)	94.7	1.8			
Fe (mg/L)	218.9	1.9	179.8	2.42	15
Mn (mg/L)	1.94	0.05	1.19	0.22	1
Pathogens (Number/100mL)	0	>1,6E+06	0	0	
Ecotoxicity	64	3	12		1

Conclusions

Combined treatment of acid mine drainage and sewage was based on the results of physical, chemical, biological and ecotoxicological analysis performed with samples collected in the urban region of Criciuma.

Studies objectives were achieved, allowing the evaluation of the advantages and limitations of AMD and sewage treatment, as well as the directions for a pilot scale treatment plant design.

Tests have shown that there are high concentration of contaminants in both AMD (Fe, Al, Mn and sulfate) and sewage (N, P, organic matter, fecal coliforms).

Blend of effluents in 1:1 ratio has reduced the concentration of metallic contaminants (Mn and Fe) in 17% and around 50% of organic matter.

Mechanisms involved in reducing the concentration of metallic and organic contaminants of blends are related to coagulation, dilution and neutralization. Coagulation process results from the increase of positive charge promoted by acid drainage that eliminates the repulsion of the colloids and promotes sedimentation.

Adding of sewage with acid drainage reduces metals and acidity by dilution and by neutralization. These processes efficiency depends on sewage alkalinity content.

Pathogens concentration reduction depends on the acidity of the AMD, being completely eliminated, when acidity is greater than or equal to 1,000 ppm.

Blend of acid drainage and sewage in a 1:1 ratio along with the addition of hydrogen peroxide has eliminated organic matter and pathogens completely, and have reduced metals contents below the limits set by environmental regulations.

Tests performed with hydrogen peroxide addition have proved more efficient in removing organic matter and in reducing the concentrations of N and P than the conventional treatment performed by state company of water supplying.

References

Apha (1995). Standard Methods for the Examination of Water and Wastewater. Washington D.C.: APHA-AWWA- WEF.

Brasil (2009) Justiça Federal. 1ª Vara Federal de Criciúma, SC. Processo nº 2000.72.04.002543—9. Autor: Ministério Público Federal. Réu: Nova Próspera Mineração S.A. e outros. Recuperação dos passivos ambientais decorrentes da mineração de carvão no sul do Estado de Santa Catarina. Terceiro relatório de monitoramento dos indicadores ambientais. Criciúma, 246 p.

Campos, Jonathan J.(2007) A Importância da Integração de Dados Minerários com a Gestão Urbana: Estudo de Caso na Região Metropolitana Carbonífera de Santa Catarina. Dissertação (Mestrado em Engenharia Civil) – Programa de Pós-Graduação em Engenharia Civil, Universidade Federal de Santa Catarina.

Fenton, H.J.H. (1984) Oxidation of tartaric acid in presence of iron. Journal of Chemical Society, v.65, p.899—910.

Jordão, E.P.; Pessoa, C.A. (1995) Tratamento de Esgotos Domésticos. Rio de Janeiro: ABES.
Kontopoulos, A. (1998) Acid mine drainage control. In: Effluent Treatment in the Mining Industry. Castro, S.H.; Vergara, F.; Sánchez, M.A.; (Eds.). University of Concepción.
Mello, J.W.V; Abrahão, W.A.P. (1998) Geoquímica da drenagem ácida. In: Recuperação das áreas degradadas. Viçosa, p. 45—57.
Metcalf, L.; Eddy, H.E. (2003) Wastewater Engineering: Treatment and Reuse. Boston: McGraw-Hill, 4th Edition.
Schneider, I. A. H; Eickter, A. (2009) Tratamento de Lodo de Fossa Séptica com Drenagem Ácida de Mina. UFRGS – Universidade Federal do rio Grande do Sul em parceria com a Carbonífera Criciúma S/A.