Qualitative and Quantitative Representation of the Coal Mining Impact in the Rivers of Santa Catarina State, Brazil

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Abstract A huge environmental reclamation project has been executed in the southern region of Brazil and its main environmental impact is the acid mine drainage (AMD). A monitoring program has been in progress in three watersheds, which data is used to identify the main AMD generation areas. The need for a quicker mapping production demanded an automation of acidity evaluation. A GIS algorithm is able to integrate monitoring data along with the cartographic basis. The results have shown that roughly 5% of the water resources in the three watersheds are polluted by AMD. A modeling calibration work will be performed.

Key Words monitoring, AMD, water resources, geographic database

Introduction

This study aims to present an information processing methodology for an environmental database organized in a Geographic Information System (GIS) in order to evaluate the impact of coal mining in the water resources in three watersheds where the Santa Catarina Coal Basin Environmental Reclamation Project (CETEM 2001) has been developed: Araranguá, Urussanga and Tubarão (fig. 1). This project covers roughly 1,950 km^2 (752 mi^2). The cartographic products generated with this methodology, as well the results presented here, were integrated to the Third Environmental Parameters Monitoring Report (Brazil 2009). This report must be provided to the federal court every year and the responsible for the environmental monitoring data is the Clean Coal Research Center of the Coal Industry Beneficent Association of Santa Catarina State (CTCL/SATC). Initially, the rivers' pollution had been represented through handmade colour-scaled maps (Gomes 2003).

Methods

Features concerning water resources in the area of study were based on both Brazilian Institute of Geography and Statistics maps (IBGE 1999) and Brazilian National Department of Mineral Pro-

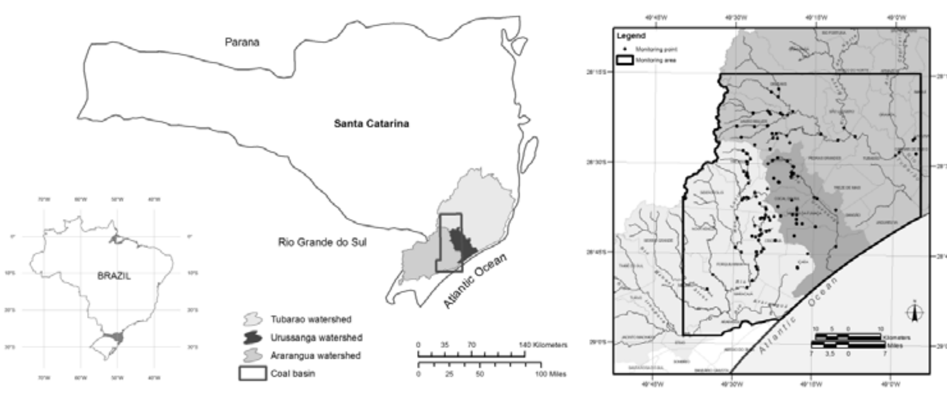

Figure 1 *Area of study*

Figure 2 *Stream tracing correction*

duction orthophotos (DNPM 2002). Besides the good quality of those bases, some correction had to be done in order to adjust the water resource features, especially the streams tracing (fig. 2).

After cartographic adjustment, all monitoring points were analyzed as well and, for each one, was defined an influence area. The monitoring point influence area was based on the terrain numeric modeling of each watershed combined with a near-monitoring point surface polluted area analysis (fig. 3). Features concerning rivers and monitoring points could then be related with each other in ArcGIS® using some common key attributes for both features.

Table 1 *Analysed classes of pH and acidity*

Parameter	**Range of values**
Acidity [mg/L]	acidity < 16
	16 ≤ acidity < 120
	120 ≤ acidity < 600
	acidity ≥ 600

Figure 3 *Monitoring point influence area definition*

Following the geographic features organization and relationships, some routines in the GIS software were performed in order to quantify and classify the monitoring data. The parameter acidity was chosen because of its direct relationship with AMD pollution. Furthermore, both hydrography and monitoring results attribute tables were related with each other. Feature properties were customized using the query builder tool to set up in the map an appropriate acidity range of values (tab. 1).

As a result of this methodology, maps representing the parameter acidity could be produced as well the identification and quantification of the stretches of polluted rivers by AMD (fig. 4). Finally, the monitored river segment length was summarized according to the analyzed parameter. The results obtained are shown in the table 2. Besides the results have shown a reasonable proportion among pH and acidity classes, a calibration strategy should be performed in the next monitoring campaigns. The idea is to analyse water in several points in a river stream that is modeled as well. Then, it will be possible to compare the predicted and the sampled results and see what calibration will be necessary or even possible.

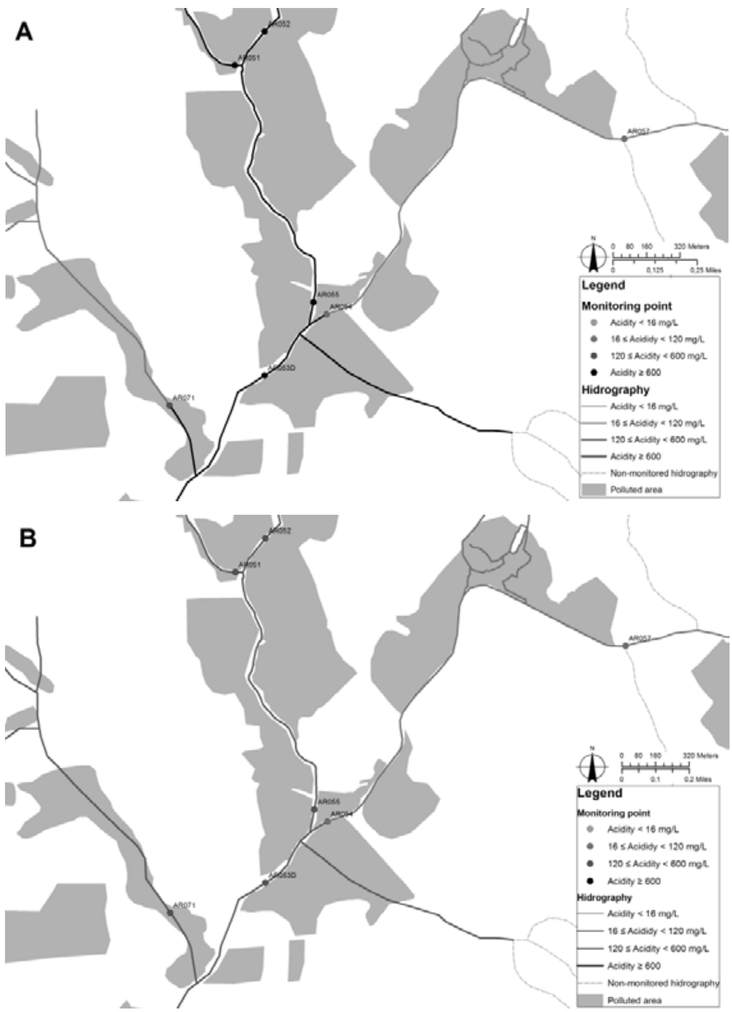

***Figure 4** Cartographic representation of the results of the 13th (A) and 20th (B) monitoring campaigns for the parameter acidity in a river length of Ararangua watershed*

Table 2 *Total AMD polluted river lengths after the 20th surface water monitoring campaign*

Acidity classes (mg/L)	Total river length [km]				
	Ararangua	**Urussanga**	**Tubarao**	**Total**	**Percentage**
acidity ≥ 600	52	58	21	131	0.6%
120 ≤ acidity < 600	232	50	216	498	2.5%
16 ≤ acidity < 120	179	112	147	438	2.2%
acidity < 16	44	57	124	225	1.1%
Non-monitored	5,257	1,299	12,366	18,922	93.6%
Total	**5,764**	**1,575**	**12,874**	**20,214**	**100.0%**
Total length of polluted rivers [km]*	**463**	**219**	**384**	**1,067**	**5.3%**

* *(acidity > 16 mg/L)*

Conclusions

Although Urussanga is the smallest monitored area in this reclamation program (709 km^2) it is proportionally the most AMD polluted watershed (14% of total river length). In another hand, Tubarao watershed, that has 5,960 km^2, shows only 3% of its total river length polluted. Ararangua (3,025 km^2) has 8% of its total river length polluted.

Only 6% of total river length, in the three watersheds, has been monitored, and roughly 5% (1,067 km) is polluted by AMD. Besides acidity, other parameters can be represented through thematic maps.

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