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SPECIALIZED MONITORING OF THE QUALITY OF ARTESIAN WELLS WATER IN THE MUNICIPALITY OF RIO AZUL

Gabriela Diedrichs Barbosa[a], Paulo Costa de Oliveira Filho[a], Carlos Magno de Sousa Vidal[a], Grasiele Soares Cavallini[a]

[a] **Centro-Oeste State University/PR**

Abstract

Currently, new methodologies have been created to improve analysis of the interactions of society with the environment and quality of life. Therefore, we seek to acquire complementary technologies that allow the acquisition of complementary and additional information regarding these interactions, mainly those that enable the spatial information obtained, making the necessary analyzes and assessment more efficient. This paper proposes a specialization in terms of the monitoring of the water of artesian wells quality for the municipality of Rio Azul, Paraná, in a geographic information system environment, in order to facilitate understanding for possible contamination, as well as support the decision making of managers responsible for quality control of the water used by the population.

Keywords: Environmental Management, Geoprocessing, Water Quality Parameters

1. INTRODUCTION

Environmental problems related to the use of natural resources have received increasing attention. According to Vasco *et al*. (2007), water is the resource that causes the most noticeable, the most immediate and most serious impacts to the population. Limitations related to water availability in terms of quantity and quality greatly affect the quality of life of people.

Sperling (2005) mentions that water quality requirements are established according to the intended use. Thus, for the use in the domestic water supply, the quality required must be greater than, for example, the quality for the industrial or recreational and leisure supplies. Thus, the household water must be free of chemical substances and organisms that are harmful to health; it should be adequate for domestic services, low aggressiveness and toughness and aesthetically pleasing. The same author states that the main pollutants of water are suspended solids, biodegradable organic matter and non-biodegradable, nutrients, pathogenic organisms, metals and dissolved inorganic solids.

The quality of water required for human consumption is defined as potable. According to FUNASA (2006), the water potability standards have the maximum permissible values with which harmful elements or unpleasant features such as bacteriological, organoleptic, physical and chemical can be present in water without offering risks to human health.

Also according to FUNASA (2006), only 0.29% of water on the planet is found in underground sources; they are called aquifers. Silva *et al*. (2007) define aquifer as a rock mass that water accumulates in large amount because of high porosity and permeability of the soil. Martinez (2010) explains that an aquifer acts as a water reservoir fed by rain infiltrating the underground, providing water to wells and springs and serving as sources of supply. The author cites the important roles that aquifers play in nature, keeping the surface water courses stable and preventing water excesses through absorption. As Zimbres (2011) reports, when the aquifer is under a higher pressure than the atmosphere, is called “artesian”. The artesian aquifer is characterized for being among relatively impervious confining layers.

According to Casarini (2011), the subterranean reservoirs generally have very clean water, because of the natural filtering it undergoes when draining away by the porous soil. Silva (2002) states the artesian aquifers are protected from contamination by humans, and it often dispenses

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treatment. However, Colvara *et al*. (2009) reported that until the 1970s, it was believed that the groundwater was naturally protected from contamination by layers of soil and rocks, and as Zimbres (2011) explains that , in the cities, the quality of the water in the aquifers is quite impaired due to lack of sewerage, disposal of industrial effluents into water bodies or directly in the ground and even the presence of garbage dumps and cemeteries, as quotes Almeida *et al*. (2003), and also in the field, due to the use of pesticides (Figure 1).

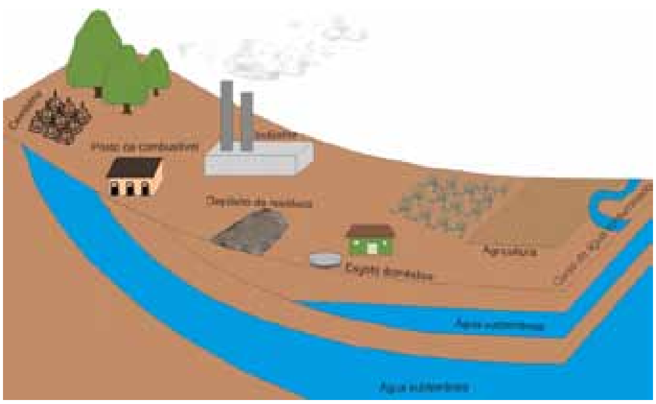

Figure 1. Sources of contamination of groundwater
Source: Silva (2007)

In the Paraná Health Code, the paragraphs 2 and 3 of article 180 refer to the opening of wells and use of sources for water supply for human consumption. This water must be in accordance with the potability standards defined in legislation. The wells should follow some rules, such as being, at least, 15 meters away from sources of contamination and be suitably protected in order to prevent contamination.

The indications of contamination in aquifers are not always readily evident, as they are a few meters deep. According to Pilati (2008), this evidence may take the form of gases, depending on the contaminant, concentrated in garages and underground power and phone boxes, registering a potential risk of explosions. Another form of evidence is the presence of contaminants in rivers and lakes, transported by the groundwater until those water bodies. In this case, contamination is of major proportions and can reach large areas.

Pilati (2008) reports that, when the risk of these types of contamination is visible, such problems involving simple subsoil recognition and monitoring programs should be avoided. The Environmental KW companies (2011) and Portal de Postos (2011) report that this is done through the installation of monitoring wells (efficient method for detecting and measuring contamination), and its drilling follows the norm NBR 13895 - Construction of monitoring and sampling wells.

According to Reis (2001), environmental monitoring consists in carrying out specific measurements and observations, addressed to a few indicators and benchmarks, in order to determine whether certain environmental impacts are occurring; in this case its magnitude can be scaled and its efficiency regarding any adopted preventive measures can be assessed. Santos (2009) mentions that the monitoring wells are drilled without the use of any potentially contaminating fluids, installed with geomechanical coatings to allow the sampling at water level without the occurrence of direct contamination by the well or by the process.

Sperling (2005) mentions that, when requesting water analysis, you must select the parameters to be investigated by the analysis, where the knowledge of the peculiarities of each situation is what should defines the parameters to be included in the analysis. In the case of underground, raw or treated water, the most commonly associated parameters are color, turbidity, taste and odor, temperature, pH, alkalinity, acidity, hardness, iron and manganese, chlorides, nitrogen, micro-pollutants and indicator organisms.

According to Ordinance No. 2914 of December 12, 2011 of the Ministry of Health, "all water intended for human consumption, collectively distributed by a system or alternative collective solution of water supply, should be subject to control and surveillance of water quality" and it is also "the responsibility of the person in charge of the system or alternative collective solution of water supply for human consumption to exert control over the water quality". The Ordinance presents the patterns of drinking water quality, in which there must be no Escherichia coli and total coliform, turbidity of 1.0 uT at most, maximum fluoride concentration of 1.5 mg/L and 5 mg/L maximum concentration of chlorine, and these quality monitoring parameters of the most important water to be analyzed, according to the Health Surveillance of Paraná State.

The information obtained through the analysis of samples can be spatialized through Geographic Information Systems (GIS), which for Azevedo *et al*. (2001), is a tool increasingly employed in environmental monitoring processes. According to Silva (2004), a Geographic Information System (GIS) is a collection of integrated software, methods, data, and users, enabling the development of an application capable of collecting, storing and processing georeferenced data. The use of GIS has taken a very large proportion, it is possible to improve the management of information and evolve in decision-making processes in the areas of transport, environmental protection, and municipal, state and federal planning.

According to Francisco (2007), multiple transactions presented by a GIS are differentiated according to the purpose for which they are intended. The geographic database ma-

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nagement is the storage, integration and retrieval of data from different sources, formats and themes, arranged in a single database. Spatial analysis occur when, from a geographic database, crossings and combinations of data are made through geometric and topological operations, which results in the generation of new data.

The author also mentions that in a GIS, spatial data are structured in information plans, also called layers. The layers, when geographically referenced (to the terrestrial coordinates system), can be superimposed and represent real-world model. Thus, the data obtained have been spatialized with the analysis, where its function is to monitor the evolution of the phenomena analyzed by comparing successive mappings in time.

The objective of this study is to present a spatialized monitoring of the proposed artesian wells of water quality for the city of Rio Azul, Paraná, in geographic information system environment to visualize the spatial distribution of artesian wells monitored by the Department of Health of the municipality, and map the results for possible contamination, as well as support the decision making of managers responsible for quality control of the water used by the population.

2. MATERIALS AND METHODS

Rio Azul was defined as the project coverage area (Figure 1). The city has 14,000 inhabitants, including 5,000 in urban areas and 9,000 in rural areas. Nearly 1800 buildings are served by the water supply of the Paraná Sanitation Company (Sanepar, 2010), indicating that much of the water consumed still comes from alternative sources.

In the initial phase of the project the implementation of the data model was performed using the SPRING software, version 5.2, entering the geographical boundaries of Rio Azul and the water collection points for monitoring the artesian wells network in the municipality.

Thus, with the assistance of the Health Department of the Municipal Government of Rio Azul through working in the field, they started the processes for obtaining the geographic coordinates of artesian wells and other points of water supply through GPS navigation receiver (GARMIN eTrex Vista H model) and collection of water samples from artesian wells in different locations and dates.

The geographical coordinates of the location of the artesian wells, water collection points, along with county data (such as geographic boundary) were obtained and spatialized in Geographic Information System (GIS).

The water samples were monthly submitted to the Environmental Sanitation and Water Quality Laboratory of the Department of Environmental Engineering of UNICENTRO, Campus Irati, where they were analyzed according to the quality parameters required by the health monitoring of the state of Paraná (chlorine, fluoride, turbidity, total coliforms and E. coli).

During the process of analyzing the water, it was observed that some parameters had higher values than the required under health surveillance. Thus, in order to discover which factors were damaging water quality in the communities, there were visits to points of water collection, where the field work to verify the situation of the wells and their surroundings was conducted, observing possible sources of contamination and features relevant.

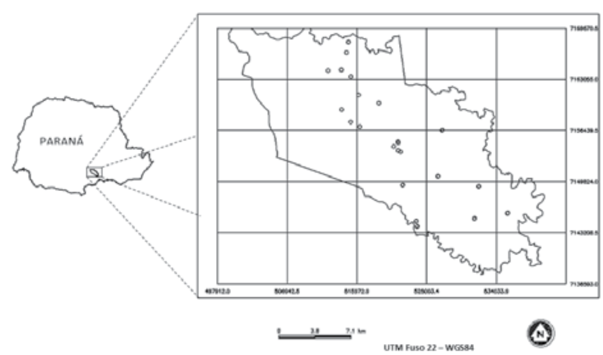

Figure 2. Study area containing the spatial distribution of artesian wells

Some rural communities have their own supply systems, such as the Rio Vinagre community, which belongs to the rural municipality studied. Figure 03 shows a photograph of artesian wells used to supply the population living in the community. This is just one of which, according to the Municipal Sanitation Basic Plan of Rio Azul-PR (2012), has its water supply system operated and maintained directly by the local community with the support of the municipality, but without the intervention of service providers. The treatment of water is performed directly on the output of the well by disinfection with sodium hypochlorite. The treated water is conveyed by pipes to the tank (Figure 4).

The database used by the GIS received alphanumeric information, such as the community name in which each well is located, the geographical location of the collection point and the water quality parameters (chlorine, fluoride, turbidity, total coliform, E. coli and the occurrence of rain in the last 48 hours). They were associated with each point of water collection represented. However, the data varying each month were placed on the “non-spatial” tables, that is, as information not directly associated to the water collection points.

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Figure 3. Artesian well in Rio Vinagre community, in Rio Azul/PR

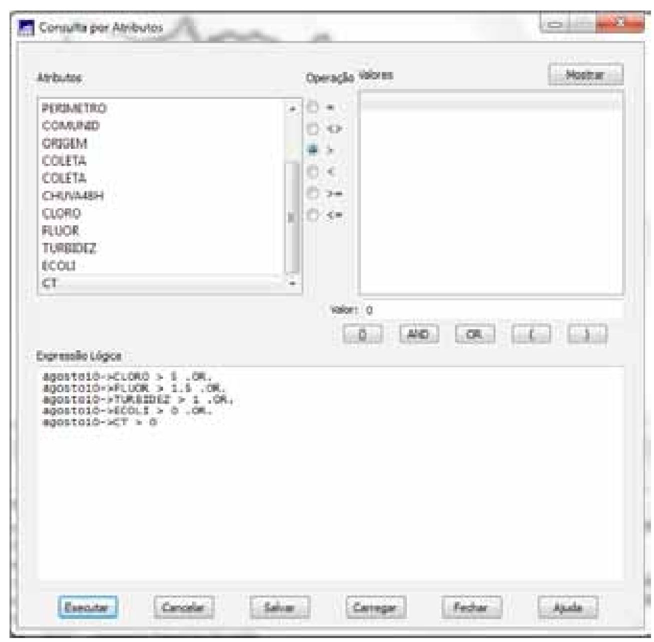
Figure 4. Water Reservoir of Rio Vinagre community, in Rio Azul/PR

The data were organized according to the type of information through the tables "object" and "non- spatial". Information such as the community to which the well or collection point belongs to were stored in a main table and were directly linked to the geo-objects, which are the graphical entities used for the representation of wells or collection points. However, the data that are added to each new analysis of the collection points water were stored in tables organized monthly, as collections are made. Thus, the information can be retrieved spatially on a monthly basis, as well as the monitoring work of the artesian wells of Rio Azul is performed.

Using the GIS through binding the geo-object tables (spatial) and non- spatial, the main table is connected to the monthly tables. Once connected, it was possible to develop various consultations on changes in the analyzed water quality parameters, obtaining a response in real time and spatialized in relation to collection points/ artesian wells regarding the analyzed or desired characteristics.

3. RESULTS E DISCUSSION

Through a logical expression of Figure 3, which involves the limits of the analyzed water potability parameters, the values for each parameter analyzed may not exceed those quality parameters required by the sanitary surveillance of the state of Paraná. As displayed in Figure 5, the consultations carried out in the system indicated the collection points that presented some parameter that were nonstandard for the considered months.



Logic Expression of the Consultation
(Comments)
August10 -> CHLORINE > 5 .OR.
Select the wells with residual chlorine above 5 mg/L in August 2010 table, or
August10 -> FLUORINE > 1.5 .OR.
that a fluoride concentration above 1.5 mg/L has been detected, or
August10 -> TURBIDITY > 1 .OR.
that an amount above 1 uT has been detected, or
August10 -> ECOLI > 0 .OR.
that an amount above 0 mg/L of Escherichia coli has been detected, or
August10 ->CT > 0 .OR.
that a quantity above 0 mg/L of total coliforms has been detected

Figure 5. Application screen in the query module for attributes showing the logical expression for the month water potability parameters of August 2010

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Regarding the parameters chlorine and fluoride, all analyzes performed are in compliance with the current legislation, Decree No. 2914 of the Ministry of Health, as they did not show concentrations above 5 mg/L and 1.5 mg/L, respectively.

The parameters of fecal contamination show high concentrations in some analyzes, and they are in disagreement with the legislation. The Escherichia coli parameter showed values greater than 0 mg/L at two points of water collection (in the months of August and October 2010, December 2011 and February 2012) and the parameter total coliforms showed values greater than 0 mg/L in five points of water collection (in the months of August, October and November 2010, April, May, November and December 2011 and February 2012). Regarding the turbidity parameter, there were sharp values, above 1uT at different collection points in all analyzed months, in violation of the law.

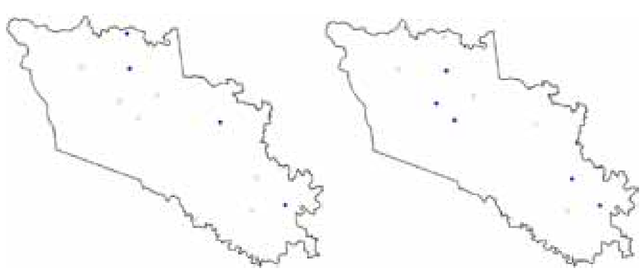

Figure 6. Collection points outside the limits of potability in August 2010 (a), August (b), October (c), and December (d). Rio Azul, 2011.

The implementation of the geographic information system for the management of the monitoring of the network water quality of the artesian wells of Rio Azul municipality showed satisfactory results due to the use of the research that has achieved fast specialized query results on screen. Information such as location of landfills, cemeteries, industries and other potential pollution sources can also be integrated into the system to serve as an analysis information base.

4. CONCLUSION

The results showed the usefulness of spatialized monitoring through a geographic information system as a complementary and efficient tool to analyze and provide spatial information in terms of the monitoring of the water quality of the artesian wells in the municipality concerned.

Among the five parameters analyzed the indicators of fecal contamination and turbidity presented results in violation of the law. Turbidity happens by the presence of suspended solids, such as sand, silt, clay and organic and inorganic materials of industrial waste and sanitary sewer. These suspended solids may harbor microorganisms that are not affected by the applied disinfectant action (chloride), resulting in a high concentration of Escherichia coli and total coliform parameters.

In addition, the neglect of some individuals responsible for the dosing of chlorine in the communities that fail to operate the chlorine metering pump and do not take the minimum care for maintaining the artesian well was observed. In the artesian well of one of the communities, it was noted the improper use of poison to kill unwanted plants around the construction of the well uptake. It was also found that, of the total 12 points for collecting water analyzed, nine of them featured, in at least one month, some parameter outside the limits of potability. Only two collection points had all parameters in accordance with Ordinance No. 2914 in the months analyzed.

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