

Evaluation of the surface water quality in the Itapicuru river basin – State of Bahia, Brazil

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Abstract

The Itapicuru River basin is located in the northeast of the State of Bahia, Brazil. It is a large basin with variable conditions in terms of soil, climate, topography, natural vegetation, and economy. About 80% of the total area is subjected to severe drought periods. Poor cropping systems and lack of adequate systems for disposing wastewater from the urban areas determine the water quality along the basin. This proposal aims to carry out a study on the actual situation of the surface water resources, including diagnostic and prognostic actions. The study presents a spatial analysis of the surface water quality using hydro chemical data of the water and sediments from 30 stations along the river and the tributaries, including points in the reservoirs of the dam and estuary region. The main processes related with the water quality are: erosion, concentrations of salt and nutrients, punctual contamination of metals and bacteria. The spatial distribution of the parameters in the different points is illustrated in maps. Zones showing higher values of coliforms, nitrogen, phosphor, chloride, conductivity and nitrates are in the high and medium part of the river, where there is low rainfall, higher demographic density and expressive social-economic dynamics. Closer to the chromium mines the concentration of iron and chromium in the sediments is above the limits. The results are associated with the environmental quality in order to have a characterization of the hydro chemical and social-economic elements, in different scales. Also critical areas are defined in detailed studies to help implement corrective actions to minimize or eliminate the contamination problems. It is expected that the results and achievements of this project will be useful in order to support the development of state and federal programs on the sustainability of water resources in the region.

Keywords: water quality, environmental quality, Itapicuru river basin.



1 Introduction

The Itapicuru river basin occupies a total area of 36,440 km², with an estimated population of 1,300,000 inhabitants. The environmental impact associated to the farming, mining, industrial, tourist activities and the disordered growth of the cities with inadequate infrastructure of sewers threaten the water quality. The basin is subdivided into four sectors with differentiated characteristics, as shown in table 1.

Table 1: Characteristics of the main sectors of the Itapicuru River Basin (SRH [1], PRODETAB [2]).

	Upper Sector (I)	Middle Upper Sector (II)	Middle Lower Sector (III)	Lower Sector (IV)
Annual Mean Rainfall	727.61 mm	500.29 mm	682.27mm	1,182.71 mm
Area	11,968.97 km ²	10,106.57 km ²	12,232.01 km ²	2,131.45 km ²
Hydrological Environment	High declivity terrain. The water from the rock fractures influences the permanent flow of the river. Many dams.	Crystalline rocks with discrete hydro potentiality. More saline waters. Rivers flow in the rainy period.	Ground that favors infiltration. Rivers are intermittent. The underground hydro potential is high.	Deeper ground. The greatest rainfall rates assures the permanent flow of the small and medium sized rivers
Physical Vulnerability	High and medium. Risk of erosion	Medium. High on some points.	Low. Medium and high on some points.	High. Risk of flooding.

The basin's volume of average annual precipitation is estimated to be 24,631.38 x 10⁶m³ and the total flow 1,269.96 x 10⁶m³. The superficial hydro potentiality is considered low (0.76 l/s/km²). Around 80% of the area is in the conditions of semi-arid climate. The fluvial regimen in the sectors is a reflex of the regional variation of rainfall: from the middle lower sector of the river to the



lower the flow is permanent; otherwise, at the upper and the middle upper sectors the river and its tributaries are intermittent. The state of hydro deficit has stimulated the construction of dams and the perforation of wells, to increase the availability of water in the period of greater demand.

Regionally, we don't see a control in the use of the ground and of the water and situations of aggression to the environment can be noticed, like: indiscriminant removal of the vegetation coverage; the absence of or deficient control of the activities of mining and of the launching of solid and liquid residues in the water courses; and the construction of dams without the correct management or prior study.

This work discusses the results of studies for the environmental diagnosis associated to the quality of the basin's superficial water, with the objective of guiding planning programs of its water resources and sustainable development. The research integrates the Investigation Project PRODETAB/EMBRAPA 055-01/01, under the auspices of the World Bank.

2 Methodological aspects

The Itapicuru River is formed mainly by the confluence of the Itapicuru, Itapicuru Açu and Itapicuru Mirim rivers, and the contribution of several tributaries. To characterize the quality of the water, was established a sample grid of 30 points for water collection and 20 points for sediments. The territorial extent of the basin is large, and although the number of points is limited, the sample contemplates the sections of the main course of the river and its tributaries (R1, R2,..., R23), including the reservoirs (B1, B2,..., B7). Two stages of fieldwork were carried out in distinct seasons: August 2005 (greater indices of rainfall) and January of 2006 (less rainfall). The standards recommended by APHA [3] were used as techniques for the samples collection and analyses. For each point the following variables were investigated: conductivity, chlorides, total nitrogen and phosphor, nitrates, thermo-tolerant coliforms, Trophic State Index – TSI introduced by Carlson [4], Water Quality Index – WQI National Sanitation Foundation - U.S.A., and the level of metal in the sediments.

In order to illustrate the information obtained, geoprocessing techniques were used to permit a spatial reading of the territory using maps in the regional scale (1:1,000,000). The final approach includes an analysis of the environmental quality of the basin, integrating other specifics information available in the scope of the Project PRODETAB/EMPRAPA.

3 Results and discussion

The basin of the river Itapicuru covers diverse climatic, geologic, geomorphologic environments and distinct ecosystems. The comprehension of the social-environmental dynamics, which influences the quality of the water resources, demands the integration of the variable information. As a methodological basis for the construction of the basin's diagnostics and prognostics associated to the quality of the superficial water, the physical



vulnerability of the units of landscape were evaluated and integrated to the aspects of socioeconomic dynamics, including the concession of rights to its use. The results are discussed as follows.

3.1 Evaluation of the water quality

The largest concentration of metals found in the water was of manganese (0.06–13.42 mg/l), iron (>0.3 mg/l) and chromium in the points R20 (0.05 mg/l) and B3 (0.08 mg/l).

The hydro chemical parameters at each study point, fig. 1, show that, in general, the tributaries have water with less quality. Improper values of thermo-tolerant coliforms appear in the stations: R15 (5320 col/100mL), close to the sewers of the city of Queimadas; R18 (13600 col/100ml), downstream of the city of Jacobina; R22 (3200 col/100mL), a river tributary that receives effluents from Campo Formoso; and B7 (6300 col/100mL), at the Cariacá dam. The total nitrogen proportions are higher close to populated areas (>25,000 inhabitants), as in the cities of Tucano, Jacobina and Senhor do Bonfim.

The results suggest that the water quality reflects the natural and anthropogenic conditions. The main alterations can be related to the following processes:

- **Siltation:** the average depth varies in the stations of the river between periods 1 (0.8m) and 2 (0.4m) of the collection sample;
- **Eutrophication:** the water has an elevated concentration of total phosphor (0.07– 23.95 mg/l), the highest values (>1500 mg/l) are in the points closest to the cities of greater population of sector I (Senhor do Bonfim and Jacobina);

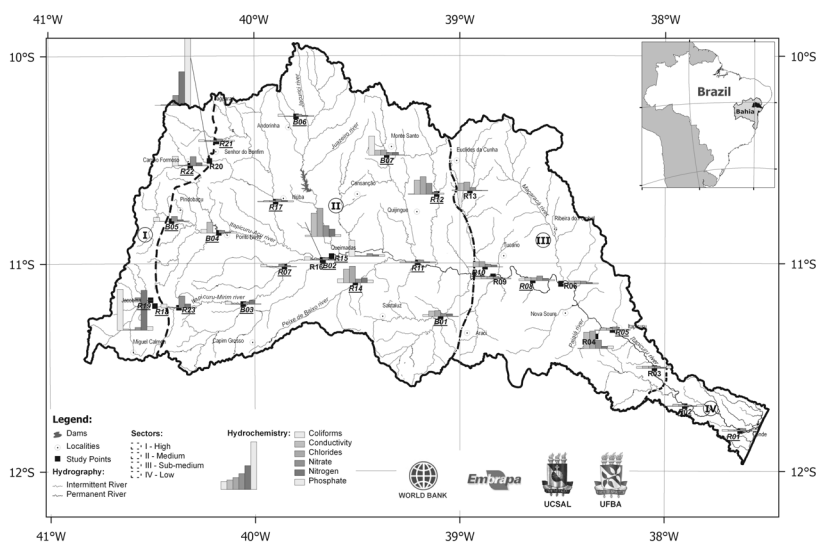


Figure 1: Maximum concentration of parameters in the sample points.



- Salinization: the points in the middle Itapicuru, where the precipitation is low, show greater values of conductivity (>600 $\mu\text{S}/\text{cm}$) and of chlorides (>300 mg/l);
- Chemical contamination: in the high Itapicuru, where there are more chrome mining activities, the concentration of metals in the sediments is higher.

3.2 Socio-environmental subsidies for the evaluation of the environmental quality

The integrated analysis of the physical environmental components of the territory (geology, terrain morphology, drainage density, soils, etc) resulted in the delimiting of homogeneous units of landscape, for which levels of physical vulnerability to the anthropogenic impacts were identified, based on the analysis of the intrinsic sensitivity and resilience of the systems.

The greater vulnerability zones (19% of the basin's area), fig. 2, are distributed preferably on the northern portion of the basin and on the areas of the coastal plain or estuary region. They are areas with an average precipitation of 1,100 mm and of high risk of erosion. In sector I are the springs of the main courses of water to the north and in sector IV the sensitive ecosystems.

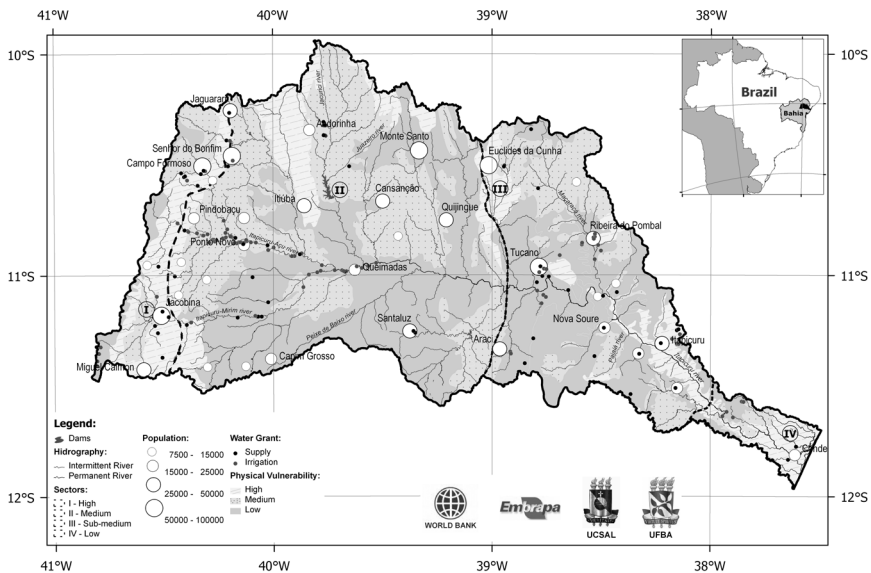


Figure 2: Map of the physical vulnerability associated to the population and water rights grant distribution in the Itapicuru basin.

The zones of medium and low vulnerability occupy, respectively, 35 and 46% of the basin's area. The areas of greater demographic density are the same as



those of greater register in water rights grant or predominant use of the water resources (SRH [5]). Around 75% of the water rights grants are for irrigation and concentrated in the upper and in the middle lower sectors of the Itapicuru, respectively, sectors I and III.

Aiming at conjugating elements to mark the results of the environmental components was tried to understand the level of anthropogenic pressure associated to the economic activities of the basin. From this viewpoint, six homogeneous socio-economic units were delimited and mapped, fig. 3, identified from the analysis of socio-economic indicators, such as: urban population, GDP (Gross Domestic Product), farming activities, areas of mining and industry. The results indicate the low economic dynamism of the basin and confirm the scenery of the quality of superficial waters depicted in this study.

3.3 Environmental diagnosis and prognosis associated to the quality of the surface water

Comprehending the environmental quality of a certain territory is always a great challenge, for there are many involved variables and very often the methods used are not sufficient to produce a reading compatible to the scale and object analyzed. As a methodological procedure for the validation of the environmental quality of the Itapicuru basin, were used the indicators related to the environment, productive activities and water quality.

For water quality the indicators TSI and WQI - empirical indices aggregate values of various parameters in a sole numeric indicator. The TSI groups the results of total phosphor and chlorophyll *a*, and the WQI the following parameters: temperature, pH, dissolved oxygen, biochemical demand for oxygen - DBO, coliforms, nitrogen and total phosphor, total solids and turbidness. The metal concentration in the sediment for each point was evaluated for the three levels of standards of the National Oceanographic and Atmospheric Administration - NOAA (Buchman [6]):

TEL - Threshold Effects Levels - Concentration below which adverse effects seldom occur;

PEL - Probable Effects Levels - concentration above which is expected that the adverse effects occur; and

UET Upper Effects Threshold - concentration above which the adverse biological impacts would be expected for a certain bioindicator.

The results, fig. 3, show that in a good part of the points the TSI indicates the states of mesotrophy and eutrophy or, respectively, with intermediate or high productivity, associated to the areas agriculture and urban sewers. The hipertrophy state is identified in some points of sector I. According to WQI the water quality is good in most part of the basin, especially, in the middle and lower sectors. In sector I the values are of acceptable quality, with only point of improper quality, close to Senhor do Bonfim. The same happens for the TSI.



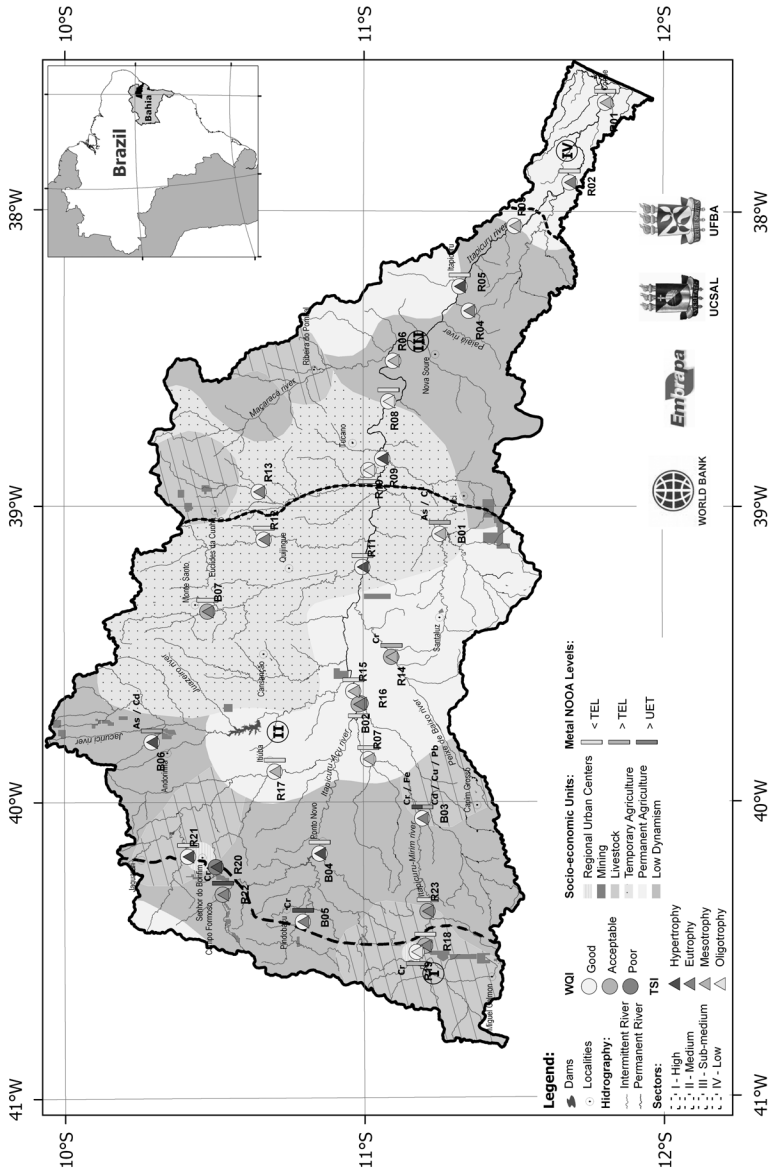


Figure 3: The zoning of the socioeconomic units on the Itapicuru basin, associated to the values of TSI and WQI in the water, and to the metals in the sediments of the sample points.

The unsuitability of the water is evident in areas of greater population, due to the sewers (residential, commercial, butchery, etc.). Mineral activity is also reflected in punctual results. In most part, the sediments bring metals with values below the TEL level, suggesting the good environmental quality of the basin. Chromium is over the UET level (95 ppm) is found in the dams B3 and B5 and on the point R22, areas with chrome mining activities.

The results lead to the diagnosis that the Itapicuru basin does have a satisfactory environmental quality, especially, related to low economic dynamism. The activities associated to agriculture and livestock have little effect on the GDP of the region and relative influence on the environmental impact on the water. The mineral activity gave dynamism to the economy and concentrated populations in the urban centers of average sizes in the past; today it doesn't promote the region's economic growth. The passive and active environmental impacts associated to the areas with mining activities are also reflected in the quality of the sediments.

4 Conclusions and recommendations

The results indicate that the quality of the basin is satisfactory. The productive activities have low polluting potential, and do not generate wealth, a factor that explains the unexpressive GDP per capita of the basin's population. The homogeneous socio-environmental units indicate the large areas where productive activities compatible with the environment's fragility can be implanted. Many areas are in zones of low economic dynamism and demographic density, indicating that there are no governmental actions to promote their sustainable development. The largest population concentrations are located in regional urban centers, given dynamism by the mineral industry that is in decadence. The economic stagnation, in most of the cities of the basin, contributes to soothe the impacts over the water resources.

The evaluation of the quality of the superficial water of the rivers, evaluated in this study shows satisfactory results, in terms of the quality indices defined by many legislation and international organisms. Then, despite the conditions imposed by the semiarid evidenced in the middle section, in general, the quality of the natural resources in the basin is good. However the economy is stagnated and the poverty rates are high. It's expected that the results and achievements of this study or the entire project will be useful to support the development of a management program on the sustainability of water resources, mainly, in order to increasing the economy in the Itapicuru basin.

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