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PRELIMINARY ANALYSIS ON DEFORESTATION AND SELECTED SURFACE WATER QUALITY PARAMETERS OF THE PURUS RIVER BASIN, AMAZONAS STATE, BRAZIL

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ABSTRACT

The Amazon, that presents different characteristics from the other Brazilian hydrographic areas, is one of the world's regions containing the most of the usable water resources. The Purus basin is classified into the basin group that still is in a great conservation status in the Brazilian Amazon. However, the next wave of frontier expansion will take place mainly in this area that has been so far spared from heavy logging and deforestation due to lack of access. In that way, the advance of the agricultural frontier mainly for soybean production and the associated deforestation constitute a threat for the aquatic ecosystems. This paper aims to diagnose changes in the water quality at the main channel of the Purus river and to relate them with deforestation in the basin. The higher deforestation rates were observed in sites with larger total deforested areas. No relation was found between deforestation rates and the water quality variables at the four sites. We observed a clear trend on physical and chemical properties of water from upstream to downstream of the Purus river: decrease of pH, Electrical Conductivity; and an increase of Turbidity. The pH was the water quality variable that presented more influence of the Accumulated Total Deforestation (ATD). Therefore, despite of the good conservation status of the most part of the Purus river basin, impacts on water quality caused by human activities are evident, especially close to urban areas and on a local scale. Therefore, actions to control the deforestation in this basin would need to be taken to maintain its conservation status, and this may be seeing as a warning on the negative effects of deforestation on water quality.

Keywords: Amazonia, deforestation, Purus, water basin, water quality.

1 INTRODUCTION AND METHODS

Considering the population increase and the reduction of the water sources in the world, the water is seen today as an invaluable wealth for the future. In this context, the Amazon, that presents different characteristics from the other Brazilian hydrographic areas, is one of the world's regions containing the most of the usable water resources. This water potential presents privileged place in the vision of development. Expressions such as "the Amazon is the Largest Basin of the World" and "we have a World of Water" constitute the speech about the need to rationally exploit this vast potential that Amazon offers.

Water chemistry provides important parameters for quantifying biogeochemical cycles and determines management options in river systems and wetlands. The first scientific classification of Amazonian rivers was elaborated by Sioli (1956a; 1956b). He used water color, transparency, pH and electrical conductivity to explain limnological characteristics of the large Amazonian rivers and correlated these characteristics to the geological properties of the river catchments, a landscape ecology approach. Whitewater rivers (such as the Amazon, Juruá, Purus and Madeira) are turbid and have their origins in the Andes, from which they transport large amounts of nutrient-rich sediments. Their waters have near neutral pH and relatively high concentrations of dissolved solids indicated by the electric conductivity that varies between 40–140 $\mu S\ cm^{-1}$. Blackwater rivers (such as the Negro River) drain the Precambrian Guiana shield, which is characterized by large areas of white sands (podzols), their waters show low quantities of suspended matter but high amounts of humic acids that give the water a brownish-reddish color. The pH values of such rivers are in the range of 4–5 and their electrical conductivity is $<20\ \mu S\ cm^{-1}$. Clearwater rivers (such as the Tapajós and Xingu Rivers) have their upper catchments in the cerrado region of the Central Brazilian archaic shield. The transparency of their greenish waters is above 1.5 m, with low amounts of sediments and dissolved solids, electrical conductivity that is in the range of 10-20 $\mu S\ cm^{-1}$, and pH that varies between 6 and 7 in large rivers (Junk et al. 2011).

The Purus basin is classified into the basin group that still is in a great conservation status in the Brazilian Amazon. However, the next wave of frontier expansion will take place mainly in this area that has been so far spared from heavy logging and deforestation due to lack of access (Carvalho et al. 2002). In that way the advance of the agricultural frontier mainly for soybean production and the associated deforestation constitute a threat for the aquatic ecosystems.

The human impacts on the forest for agriculture, cattle ranching or urban expansion cause changes on water resources. According to Souza et al. (2003) few data are available in the scientific literature about the effects on the hydrological micro scale, and fewer still, about the cumulative effect of those human activities on the regional water resources, that could promote changes in water distribution and water quality at a local level.

In this context, it is possible to evaluate the impact of land use through the monitoring of the surface and subsurface water quality in a watershed since surface and subsurface water quality are good indicators, respectively, of the trend and condition of a watershed (Leonardo 2003).

This paper aims to diagnose changes in the water quality at the main channel of Purus River and to relate them with deforestation rates in the Basin. The Purus River is one of the chief tributaries of the Amazon River. It is one of the longest rivers in South America, rising in the eastern lowlands of Peru and flowing 2100 miles (3380 kilometers) before entering in the Amazon River at the northwestern Brazil (Fig. 1).

Figure 1. A section of the middle/lower Purus River (photograph of Moulaert, 2007)

Time series of water quality variables (Temperature, pH, Electrical Conductivity, Turbidity), reported by the Brazilian National Agency of Water (ANA), were examined for four monitoring stations along the main channel of the Purus River in the period from 1998 to 2006 (Table 1). These time series are constituted by the results of, at least, three samplings per year in each monitoring station. These data were related to deforestation rates of the municipal district where each monitoring station is located from Brazilian National Institute of Spatial Research (INPE) data during the period from 2001 to 2006.

2 RESULTS AND DISCUSSION

The Table 1 shows the identification of the four water quality monitoring stations of the ANA, whose records were used in this paper.

Table 1. Water quality monitoring stations of the ANA in the Purus River basin (HIDROWEB, 2007)

Station Number	Station Name	Geographic Coordinates		Municipal District
		Latitude (South)	Longitude (West)	
1	Seringal Caridade	09°02’06’’	68°34’06’’	Boca do Acre
2	Seringal Fortaleza	07°43’02’’	66°59’05’’	Pauini
3	Lábrea	07°15’08’’	64°48’00’’	Lábrea
4	Arumã	04°44’04’’	62°09’02’’	Beruri

The Electrical Conductivity decreases from upstream to downstream of the river (Fig. 2), which could be explained because of the increase of activities associated with the use of land, such as deforestation, cattle breeding and agriculture, concentrated in the Municipalities of Boca do Acre and Lábrea, which are located in the Amazonas State. It happens because there are four deforestation fronts, corresponding to migratory processes, proceeding from the neighboring States (Acre and Rondônia), the ones which are stimulated by the agriculture expansion and wood predatory exploration (Sanches et al. 2007). However, it was observed an increase in Turbidity from upstream to downstream that could be explained due to soil loss and sediments transport from all the contributing areas along the basin (Leonardo 2003). This could be responsible too for the light decrease on the Dissolved Oxygen from upstream to downstream. The pH-value decreases from upstream to downstream (Fig. 3).

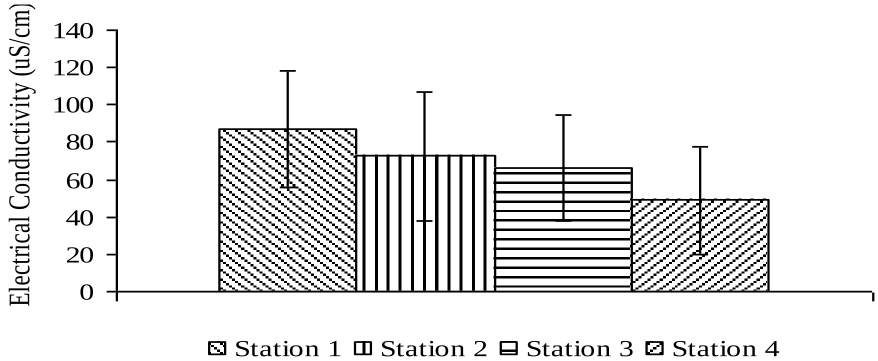

Figure 2. Average Electrical Conductivity (μS/cm) values for each water quality monitoring station (1998 to 2006)

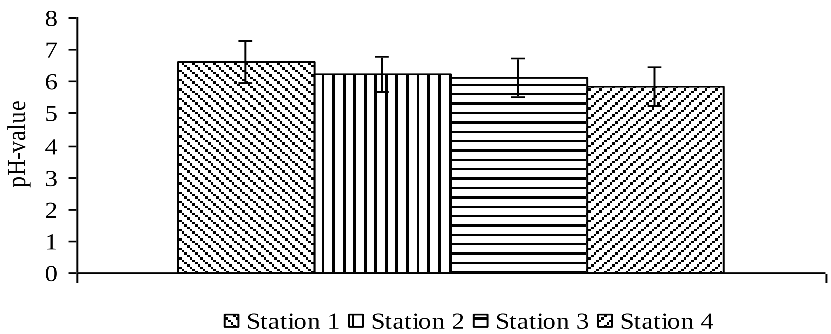

Figure 3. Average pH values for each water quality monitoring station (1998 to 2006)

The higher deforestation rates were observed in Boca do Acre and Lábrea with larger total deforested areas probably related with the access by road to the floodplain areas. The lower rates were observed in Pauini and Arumã where the access to the floodplain forest by road is almost inexistent (Fig. 4 and Table 2). No relation was found among deforestation rates – DR (km^2/year) and the water quality variable values at the four sites. On the other hand, Accumulated Total Deforestation – ATD (km^2) influences water quality mainly in station 3 (Lábrea) where the larger ATD was observed. The ATD correlates with changes in Temperature in the stations 2 and 3, with Total Suspended Solids in the station 4, Dissolved Oxygen in the station 3, pH-value in the stations 1, 2, 3, 4 and Turbidity in the station 3. We observed a clear trend in changes of physic and chemical water properties from upstream to downstream of the Purus River: decrease of pH-value, Dissolved Oxygen, Electrical Conductivity, Total Suspended Solids and, an increase of Turbidity. The pH was the water quality variable that presented more influence of the Accumulated Total Deforestation (ATD), but the Deforestation Rate (DR) did not present any relation concerning the water quality variables analyzed in the monitored stations.

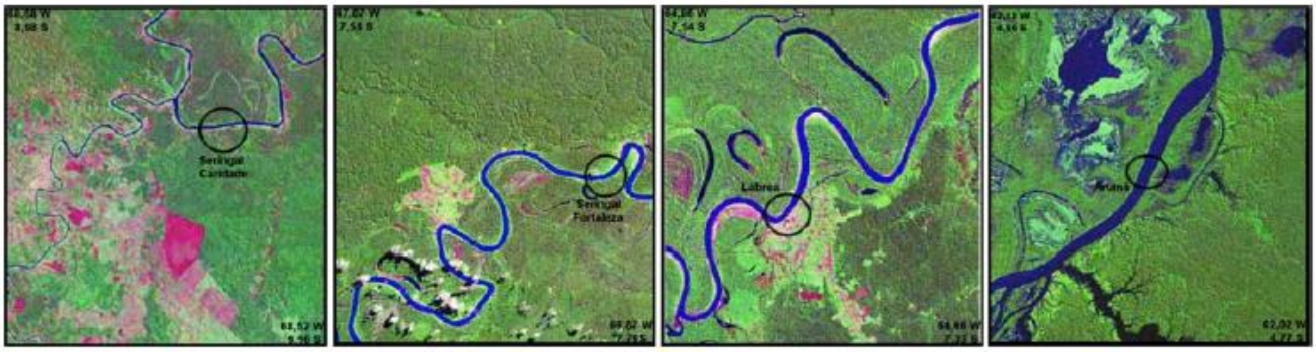

Figure 4. Land covering and use of the soil in the area where the water quality monitoring stations are located (Silva et al. 2007)

Table 2. Deforestation for the municipal districts of the study (PRODES, 2007)

Year	Boca do Acre		Pauini		Lábrea		Beruri	
	ATD[a]	DR[b]	ATD	DR	ATD	DR	ATD	DR
2000	1165.9	-	146.8	-	1245.1	-	181.4	-
2002	1319.8	103.6	164.8	10.1	1625.9	206.1	191.7	2.5
2004	1693.7	123.1	184.5	7.0	2449.5	366.0	200.2	3.0
2006	1831.9	84.6	201.1	7.6	2910.5	279.2	203.3	2.4

[a]ATD: Accumulated Total Deforestation (km^2)
[b]DR: Deforestation rate (km^2/year)

It was estimated more than 50% increase of deforested areas. In the Purus river basin the highest percentage of the area is represented by forested land since it covers more than 80% of the basin area and for this reason some authors have considered that this basin is located within an almost intact forest area (Fig. 5). However the basin suffered a relative intense process of land use and cover compositional changes. The most significant estimated alteration is the increase of deforested areas that have reached an extent of 20610 km^2 in 2007 while the forests lost roughly 5967 km^2. Another important aspect of the identified changes is that secondary forests (forest in regeneration process) lost approximately 555 km^2. The reasons for the land degradation are mainly the expansion of cattle ranching and farming lands. During this decade the urban areas (where the municipality seat cities are located) also presented a considerable 14 km^2 increase. The area covered by water showed a significant 857 km^2 decrease. The areas with presence of aquatic macrophytes have been reduced approximately 40% from their initial extent, but this would be due to the effects of the seasonal periods on the rivers and lakes's water level (Junk et al. 1989; Junk and Wantzen 2004).

3 CONCLUSIONS

According to the spatial sequence showed by the data, the deforestation rates are increasing further at the municipal districts located at south and southeast of the Amazon region. In this sense, the greater deforested areas along the basin are concentrated surrounding urban areas of the municipal districts of Rio Branco, Sena Madureira, Plácido de Castro and Senador Guiomard, in the Acre state, and Lábrea and Boca do Acre, in the Amazonas state. Even so, it was showed that the deforestation levels do not yet cause a large effect on the water quality. The water quality variables were influenced by factors such as river discharge and level, excepting pH-value and dissolved oxygen. The rainfalls determined the water quality mainly in basin' upstream areas. Therefore, despite of the good conservation status of the most part of the Purus River basin, impacts on water quality caused by human activities are evident, especially close to urban areas, at a local scale. Thus, actions to control the deforestation in this basin would need to be taken to maintain its conservation status. Since similar attributes are common in other basins of the white water systems of the Brazilian Amazon, this may be seeing as a warning on the negative effects of deforestation in larger areas than that of our study sites.

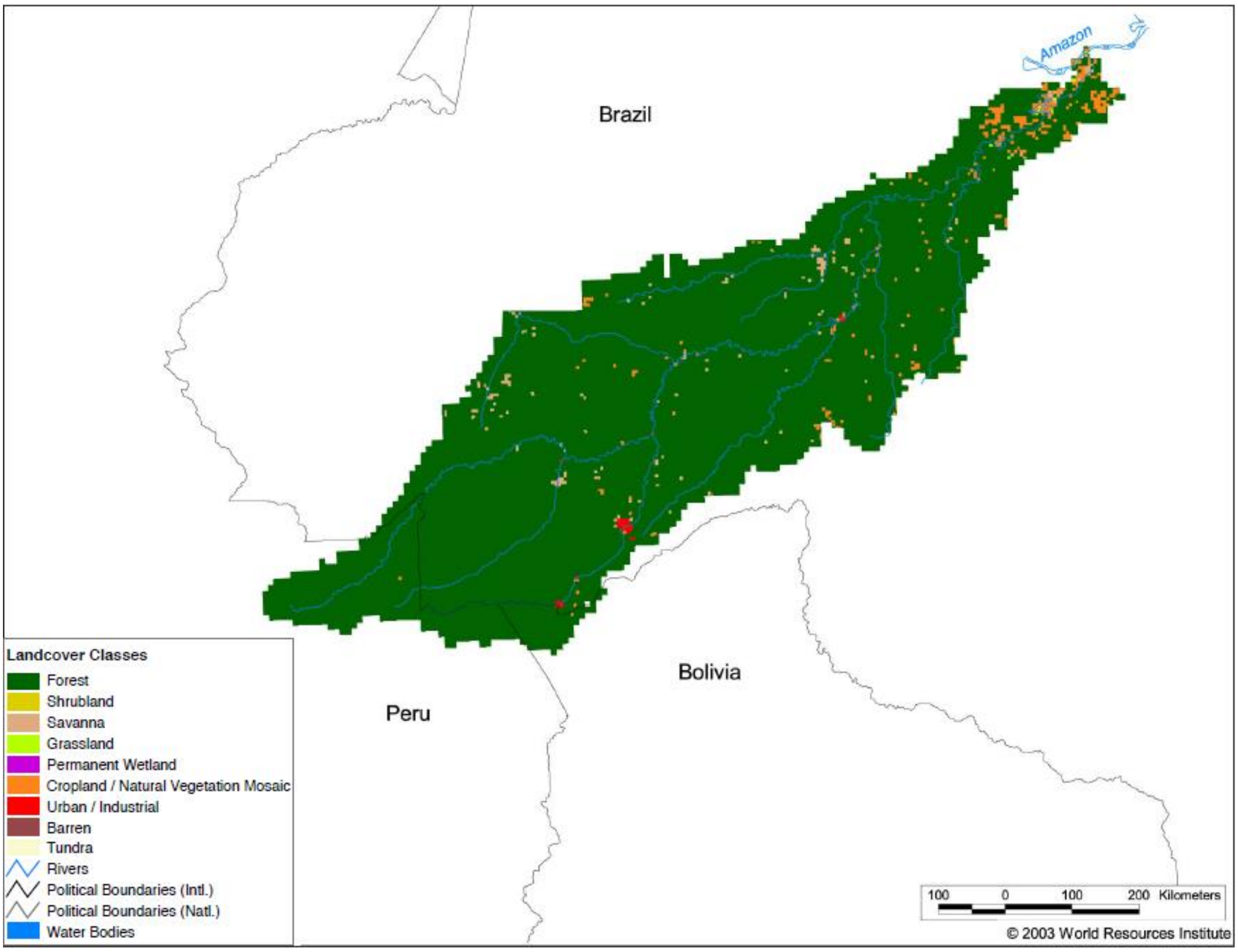

Figure 5. Land cover and use variables on the Purus Watershed **(**Water Resources eAtlas 2003)

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