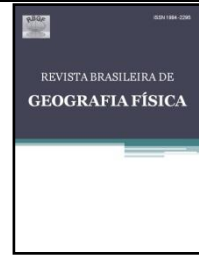




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## Environmental Quality of the Monapo River Basin in Mozambique - A Report of Experience

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### ABSTRACT

The environmental quality of a river basin is directly related to activities such as the use and occupation of its lands. Thus, the main objective of this work was to demonstrate to Mozambican researchers how to verify the environmental quality of the Monapo River Basin, in the province of Nampula in Mozambique-Africa. The methodologies used included: identification of the main physical characteristics; implementation of the Rapid Assessment Protocol (RAPs) and flow calculation. As a result, it was verified that flow measurement was only possible at points close to the mouth of the Monapo river, due to the presence of water current. Accordingly, RAP data in the section between points 6 and 8 of the basin can be classified as impacted. Through this experience report, it was possible to conclude that the river basin presents environmental impacts from local anthropic activities, and that for better results, new fields of analysis and adequacy of RAP are required.

Key words: Hydrographic basin, environmental quality, anthropic activities.

### Introduction

Water is the most precious commodity for life on earth, its absence retards the natural development of species and hinders human activities. The quality of water in river basins has been discussed at conferences, meetings and university researches around the world, having as one of the main objectives, to obtain knowledge of the process that changes and weakens the aquatic environment.

Anthropogenic activities such as minings, industrialization, effluent releases in general and deforestation are the main factors responsible for most unnatural changes in water, and when in high quantities, it exceeds the capacity for self-purification, thereby resulting in the process of eutrophication (Andrade, 2010).

The quality of the water sources and aquatic biodiversity have been significantly hampered by these activities, thereby disrupting the physical environment and the natural dynamics (Goulart and Callisto, 2003). With this, over time, the level of drinking water quality has suffered a decline, reinforcing the need to discuss and deepen the analysis of environmental quality.

Habitat fragmentation enables changes in ecological and climatic conditions by altering natural biodiversity; therefore, environmental studies are indispensable, helping to guide the correct management and appropriate use of the environment (Bezerra et al., 2016).

Vargas and Ferreira (2012) emphasized that, in the present time, environments that are in preserved conditions are rare; also, the use and occupation of the lands of the hydrographic basins in general provide modifications in the physical-chemical and biological characteristics of the waters and the surroundings of its banks, and need to be monitored.

In this context, it is worth mentioning that the application of Rapid River Assessment Protocols (RAPs), make it possible to measure environmental quality and consider the integrated analysis of the lotic ecosystem through its simple and precise application (Rodrigues et al., 2008). Callisto et al. (2001) explained that RAPs allow evaluation of river sections by the present levels of impacts, serving as an effective tool for environmental monitoring programs.

The use of protocols contributes to environmental management and conservation, so

that visual parameter analysis replace the traditional physical-chemical and bacteriological analysis of the waters, and supports evaluation of the structure and functioning of the ecosystems in focus (Callisto et al., 2002; Vargas and Ferreira, 2012).

In this sense, the main objective of this work was to demonstrate to researchers from Mozambique, how to verify the environmental quality of the Monapo River Basin, in the province of Nampula in Mozambique-Africa, through an experience report.

## Materials and methods

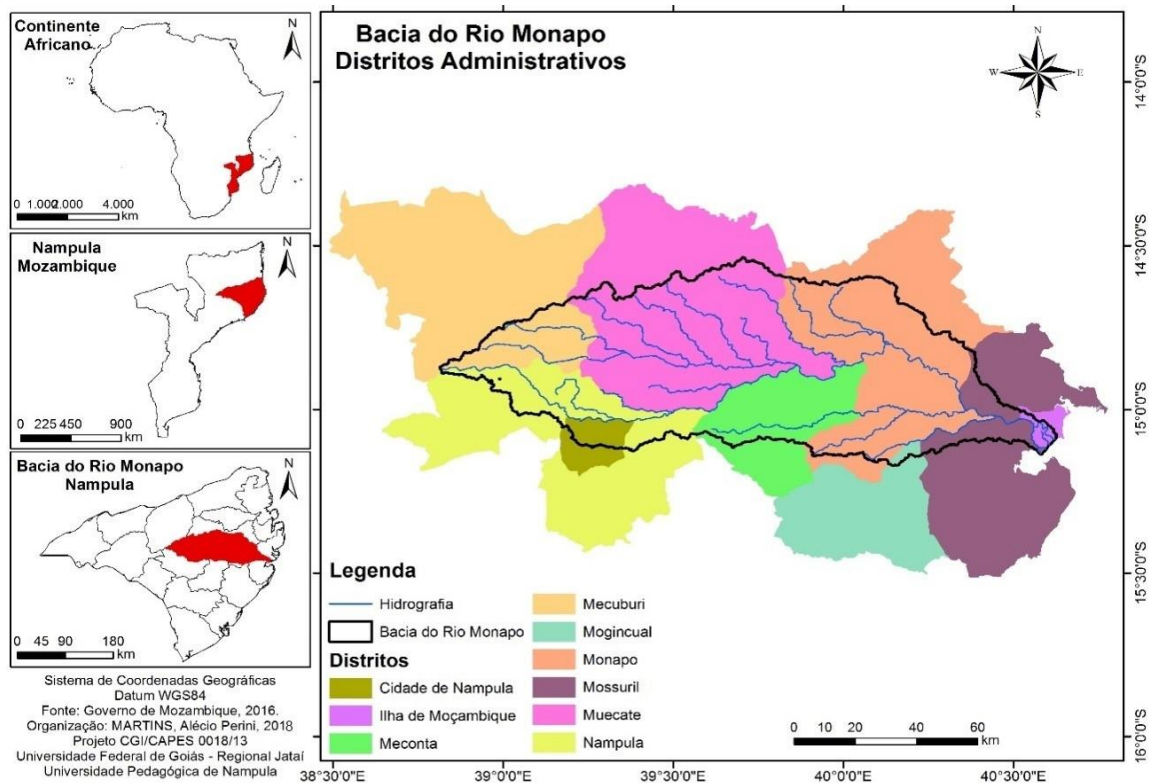


Figure 1. Location of the Monapo river basin, Mozambique - Africa. **Source:** Authors' production (2018).

The Monapo River Basin covers the districts of Nampula City, Mozambique Island, Meconta, Mecuburi, Mogincual, Monapo, Mossuril, Muecate, and Nampula.

The total altitude variation in the basin is 1600 m (maximum), considering mountainous areas of granite outcrops, and has altimetric variation of 575 m, from the springs in the district of Mecubúri to the mouth in the Indian Ocean.

The main channel of the basin, has 235 km in length represented by the river Monapo in a predominantly flat terrain with an average slope of 2%. These lands have crystalline basement (gneisses) and vegetation of open low forest and wooded prairie (with open savanna formations,

## Description of the physical characteristics of the study area

The research was carried out in the hydrographic river basin of the Monapo river, located in the province of Nampula -Mozambique (Figure 1).

The study area presents two well defined climatic seasons, being from October to March with the presence of rains, relatively high temperature and humidity, and another one between the months of April to September, less rainy (dry) season, with characteristics similar to those found in the Brazilian Cerrado (Arroz, 2016).

similar to a typical Brazilian cerrado) (EMBRAPA, 2011).

The predominantly perennial basins are the Monapo and Muecate (main), Marrimúé, Cataca, Moetaze, Ximacute, Mesica, Ampoense, Muimite, and Messimite. It is important to emphasize that these are the most extensive rivers of the basin, and even then they have intermittent stretches during critical periods of drought. The basin drains an area of 8,047 km<sup>2</sup>, and rainfall is the main source of water in this area. The average rainfall ranges from 650 to 900mm per year (EMBRAPA, 2011).

The basin consists predominantly of chromic fersalic soils, of quartziferous crystalline rocks (Luvisols). The mouth is delta-shaped, at sea level, flowing into the Indian Ocean. It presents

alluvial and lacustrine soils, and is associated with the same type of soil found in the springs. The geology is represented by sandbars on tide, fine to medium grain sands as well as salt marshes and mangrove swamps. The vegetation at the mouth is represented by mangroves and areas of agriculture (EMBRAPA, 2011).

*Collection points*

Initially, a course was given demonstrating the objectives of the research to students and teachers of the Pedagogical University of Mozambique Delegation of Nampula, after eight points of analysis were defined for the environmental quality of the Monapo River Basin (Figure 2). This analysis occurred in November 2016, a period that is around the dry season, with almost total absence of rain.

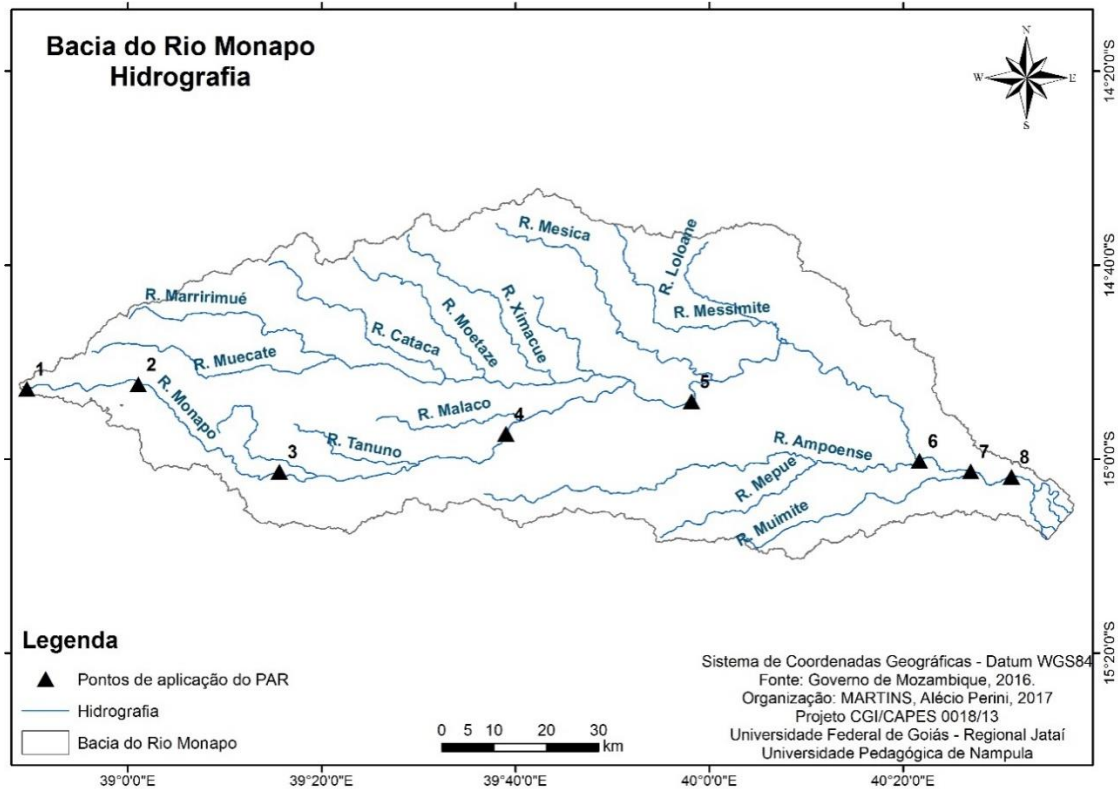


Figure 2. Location of the analyzed points of the Monapo river. Source: Authors' production (2018).

The collection points were georeferenced with GNSS (Table 1) and selected to cover the greatest amount of information from the research area such as vegetation, land use, and land use

relief consistent with the parameters proposed in the RAP, from the source until the mouth.

Table 1. Geographical coordinates of the points analyzed by the RAP.

Sample points	Latitude (X)	Longitude (Y)	Altitude (m)
1	-14° 52' 46"	+38° 49' 36"	565
2	-14° 52' 19"	+39° 01' 06"	469
3	-15° 01' 19"	+39° 15' 37"	352
4	-14° 57' 24"	+39° 39' 00"	225
5	-14° 54' 06"	+39° 58' 11"	153
6	-15° 00' 12"	+40° 21' 39"	38
7	-15° 01' 17"	+40° 26' 59"	35
8	-15° 01' 59"	+40° 31' 10"	19

Source: Authors' production (2018).

*Rapid assessment protocol for rivers (RAPs)*

The rapid assessment protocol is composed of two parts (Table 1), comprised of 22

environmental parameters that are classified into categories. In the first part, they are scored from 0 to 4 following the one designated by the Ohio Environmental Protection Agency (USA) (EPA,

1987). The second part is from 0 to 5 as described by Callisto et al. (2002), modified from Hannaford et al. (1997).

Table 1. Rapid Assessment Protocol for rivers, applied in stretches of river basins.

Location:				
Date of collection:		Time of collection:		
Time (situation of the day):				
Collection mode (collector):				
Type of environment: ( ) stream ( ) river				
Width:				
Depth:				
Water temperature:				
<b>SCORE</b>				
<b>PARAMETERS</b>	<b>4 points</b>	<b>2 points</b>	<b>0 points</b>	
1. Type of occupation in the banks of the watercourse (main activity)	Natural vegetation	Field of pastures/ agriculture /monoculture/ reforestation	Residential/commercial/ industrial	
2. Proximity of erosion to the banks of the river with silting on its bed	Absent	Moderate	Accentuated	
3. Anthropogenic changes	Absent	Alterations of domestic origin (sewage, garbage)	Changes of origin industrial / urban (factories, steelworks, plumbing, reuse of the course of the river)	
4. Plant cover in the bed	Partial	Total	Absent	
5. Odor in water	None	Sewage (rotten egg)	Oil/ industrial	
<b>SCORE</b>				
<b>PARAMETERS</b>	<b>4 points</b>	<b>2 points</b>	<b>0 point</b>	
6. Oiliness of the water	Absent	Moderate	Abundant	
7. Water transparency	Transparent	Blurry / strong tea color	Dull or colored	
8. Odor of sediment (background)	None	Sewage (rotten egg)	Oil / industrial	
9. Oiliness of the background	Absent	Moderate	Abundant	
10. Type of background	Stone / concrete	Mud / sand	Cement / channeled	
	<b>5 points</b>	<b>3 points</b>	<b>2 points</b>	<b>0 point</b>
11. Types of background	More than 50% with Diversified habitats: pieces of submerged logs; gravel or other stable habitats	30 to 50% of diversified habitats: suitable habitats for the maintenance of populations of aquatic organisms	10 to 30% of diversified habitats: insufficient habitat availability; substrates often modified	Less than 10% of habitats diversified: absence of obvious habitats: unstable rocky substratum for organism fixation
12. Extension of rapids	Well-developed rapids: rapids as wide as the river and with a length equal to twice the width of the river	Rapids with a width equal to that of the river but less than twice the width of the river	Rapid stretches may be absent: rapids not as wide as the river having length less than twice the width of the river	Rapids or nonexistent rapids

13. Frequency of rapids	Relatively frequent rapids; distances between backwaters divided by the width of the river between 5 and 7	Non-frequent rapids; distances between backwaters divided by the width of the river between 7 and 15	Fast or occasional rapids; habitats formed by the contours of the background; distance between backwaters divided by the width of the river between 15 and 25	Usually with "smooth" water depth or with rapid of shallow habitat; distance between rapids divided by the width of river > 25
14. Types of substrate	Abundant pebbles (mainly in river springs)	Abundant pebbles; common gravel	Background Predominantly formed by gravel; some pebbles	Rocky background; pebbles or muddy
15. Mud Deposition	Between 0 and 25% of the bottom is covered by mud (silt and clay)	Between 25 and 50% of the bottom is covered by mud	Between 50 and 75% of the bottom is covered by mud	More than 75% of the bottom is covered by mud
16. Sedimentary deposits	Less than 5% of the background with mud deposition; absence of deposition in the backwaters. Probably the current drags all the fine material	Some evidence of background modification, mainly increase in gravel, sand or mud; 5 to 30% of background affected, smooth deposition in backwaters	Moderate deposition of new gravel, sand or mud on the banks; between 30 and 50% of the affected background; moderate deposition in the backwaters	Large deposits of mud, silted banks; more than 50% of the modified background; absence of backwaters due to the deposition of sediments
17. Changes in the river channel	Plumbing (rectification) or absence or minimal dredging; river with normal pattern	Presence of some pipeline, usually close to the construction of bridges; evidence of modification for more than 20 years.	Any modification present on the two banks; 40 to 80% of the modified river	Cemented banks; above 80% of the modified river
18. Characteristics of the water flow	Relatively equal flow across the width of the river; minimum amount of exposed substrate	Water depth above 75% of the river channel; or less than 25% of the exposed substrate	Water depth between 25 and 75% of the river channel, and / or most of the substrate in the exposed rapids	Low water depth and only present in backwaters
19. Presence of the riparian forest	Above 90% with native riparian vegetation, including trees, shrubs or macrophytes, minimal evidence of deforestation; all plants reaching "normal" height	Between 70 and 90% with native riparian vegetation; evident deforestation, but not affecting the development of vegetation; most plants reaching "normal" height	Between 50 and 70% with native riparian vegetation; obvious deforestation, exposed soil or vegetation removed; less than half of the plants reaching "normal"	Less than 50% of native riparian vegetation; very pronounced deforestation

20. Stability of the margins/banks	Stable margins; evidence of minimal or absent erosion; potential for future problems. Less than 5% of margin affected	Moderately stable; small areas of frequent erosion. Between 5 and 30% of margin with erosion	Moderately unstable; between 30 and 60% of the erosion margin. High risk of erosion during floods	Unstable; many areas with erosion, frequent areas discovered in the river curves; obvious erosion between 60 and 100% of the margin
21. Extension of the ciliary forest	Riparian vegetation width greater than 18m; without influence of anthropic activities (agriculture, roads, etc)	Riparian vegetation width between 12 and 18m; minimal anthropogenic influence	Width of riparian vegetation between 6 and 12m; intense anthropogenic influence	Width of riparian vegetation less than 6m; restricted vegetation or absent due to anthropogenic activity
22. Presence of aquatic plants	Small aquatic macrophytes and / or mosses distributed through the bed	Aquatic macrophytes or filamentous algae or mosses distributed in the river, substrate with periphyton	Filamentous or macrophyte algae in a few rocks or some backwaters, periphyton and biofilm	Absence of aquatic vegetation in the river bed or large macrophyte banks (eg water hyacinth)

**Source:** Callisto et al. (2002) modified from the protocol of the Ohio Environmental Protection Agency (USA) (EPA, 1987).

In the first part of the protocol, the characteristics of sections of river drainage and the level of environmental impact offered by anthropic activities are evaluated, aiming at highlighting the water qualities and the bottom sediment, attributing importance to erosion and vegetation cover. In the second part, the evaluator focused on characteristics of the habitat and its conservation, concentrating on the water flow and the type of sediment for the development of the biota, and less importance of the occupation around the margins (Vargas and Ferreira, 2012).

The first part classifies the parameters from 0 to 4, which is equivalent to 40% of the total score

of this protocol item. The second stage, which corresponds to a score of 0 to 5 points, represents 60%. As a final evaluation, the values attributed to each of the parameters are summed up, and it reflects the level of preservation of each analyzed section of the river, and when combined with the classification of these stretches, it gives the general environmental condition of the river.

The scoring interval for each environmental situation can be visualized in Table 2. The results were tabulated and analyzed by the score of each evaluated parameter, and classified according to the proposal of Calliston et al. (2002).

Table 2. Score ranges for each environmental situation.

Score	Environmental situation
61 – 100 points	Natural
41 – 60 points	Changed
0 – 40 points	Impacted

Source: Rapid Assessment Protocol proposed by Callisto et al. (2002).

#### Flow Measurement

In addition to the application of RAP, the flow measurement was carried out according to the proposal of Ramos (2003) and Palhares (2007) from the flow method. Two cross sections were chosen in each section where the river was rectilinear and uniform.

A millimeter ruler and measuring tape were used to measure the depths of each cross section with a linear distance of 30cm, and a distance between the downstream and upstream section of 10m, seeking to compose the geometric figures (triangle and trapezoid) to calculate the area of the section and flood.

The determination of water velocity was performed ten consecutive times, for this, a floating device composed of 2/3 water in bottle was released at the beginning of the upstream and timed section with manual stopwatch support until the end of the downstream section.

The final flow calculation followed the one proposed by Palhares (2007), corresponding to:

$$Q = A \times V \times C$$

where:

Q = Flow ( $m^3 s^{-1}$ );

A = Area of the average section ( $m^2$ );

V = velocity of water ( $\Delta s / \Delta t$ ) (m/s);

$\Delta s$  = distance in meters;

$\Delta t$  = average time in seconds for determining water velocity;

C = coefficient of roughness (0.7 for background with vegetation, 0.8 for rocky background and 0.9 for muddy background).

The evaluated points did not have adequate conditions, the application of RAP and flow measurement were not performed, these being points 1 to 5.

## Results and discussion

### Experience report

In order to reach the objectives, a course was initially given regarding the activity proposals, and methodologies to be carried out in the Monapo River Basin, for four students and seven teachers from the Pedagogical University of Mozambique

Delegation of Nampula, courses were taken in Geography and Environmental Management and Community Development (GADEC). The locations of the eight points of analysis have been defined (Figure 2).

In order to apply the proposed methodology, two field days were designated, on the first day, five points of analysis did not allow the application of RAPs and the flow measurement, because these stretches did not have water current during the evaluated period. With this, the main physical characteristics of these sites were verified, by means of photos and the testimony of the riverside residents.

At the three points covered on the second day, the water body provided the feasibility of the RAPs application and the flow measurement, in addition to observing the main physical characteristics.

After the field, a conversation wheel was used for the calculation and tabulation of results.

### Physical characteristics of points 1 to 4

Collection point 1 is closest to the source of the Monapo river. It has, for the most part, sparse vegetation, very sandy soil, with human occupation including subsistence farming houses and activities such as goat breeding, as well as sugar cane and cassava planting. The collection of mango and cashew is also a common activity in this area. Some of the physical characteristics of the region near the source can be observed in Figure 3 A-B.



Figure 3. A - Presence of houses, vegetation and burnings; B - Presence of animals on sandy soil with scarce pasture. Source: Authors' production (2018).

In the period of the research, the source was without water presence, making the

application of RAPs and flow measurement impossible. In the basin, the rocky basement is

represented by gneisses and predominantly flat relief, resulting in areas of sandy soils with small potential for surface runoff.

The areas with burn can be seen in Figure 3. These were carried out by the local residents because there was no other way to dispose of garbage, and also due to the need to use the forest areas for goat farming.

The second point of analysis is located approximately 22 km from the source, where water pools were verified, but without current. As shown in Figure 4, the site contains exposed soil (Figure 4 - A), providing high water turbidity, with presence of sludge (Figure 4 - B). The vegetation of the banks is composed of forage plants and small trees typical of the savanna domain (Figure 4 - C).



Figure 4. Physical characteristics of point 02 analyzed. Source: Authors' production (2018).

The population of the region uses these waters for domestic purposes, recreation and animal watering. Some residents reported that in about eight months, the Monapo River has no water current, and it is necessary to use potable water for cooking and drinking. The largest volumes of water are recorded between the months of December and March.

The district of Nampula has the Monapo River reservoir of water for public supply, and this particular location serves as the third point of analysis, approximately 58km away from the springs.

According to the Truth Journal (2017), Nampula receives on average 20 liters of water per day per person, well below the average volume of countries like Brazil, where each person uses 165.3 liters per day (SNIS, 2015). Public supply, whether in relation to the availability of water, or even to the collection and distribution of this resource to

the population, represents one of the most serious social and environmental problems in the province of Nampula.

On the day of the visit, the reservoir was below the level of the bus (Figure 5 - A and B), since it was used in water mode because the water reservoir has smaller dimensions. Some characteristics of the water body can be seen in Figure 5 - C, showing the small width and quantity of water in the Monapo river, as well as the geological structure of the rocks, constituted by granite outcrops, representing the highest points and with greater slopes of the basin.

The presence of aquatic macrophytes occurred (Figure 5 - D), a feature that may indicate eutrophication or increase of nutrient loads to the reservoir, resulting from domestic sewage, and agricultural products used in small plantations near the reservoir (Conselho de Ministros, 2007).

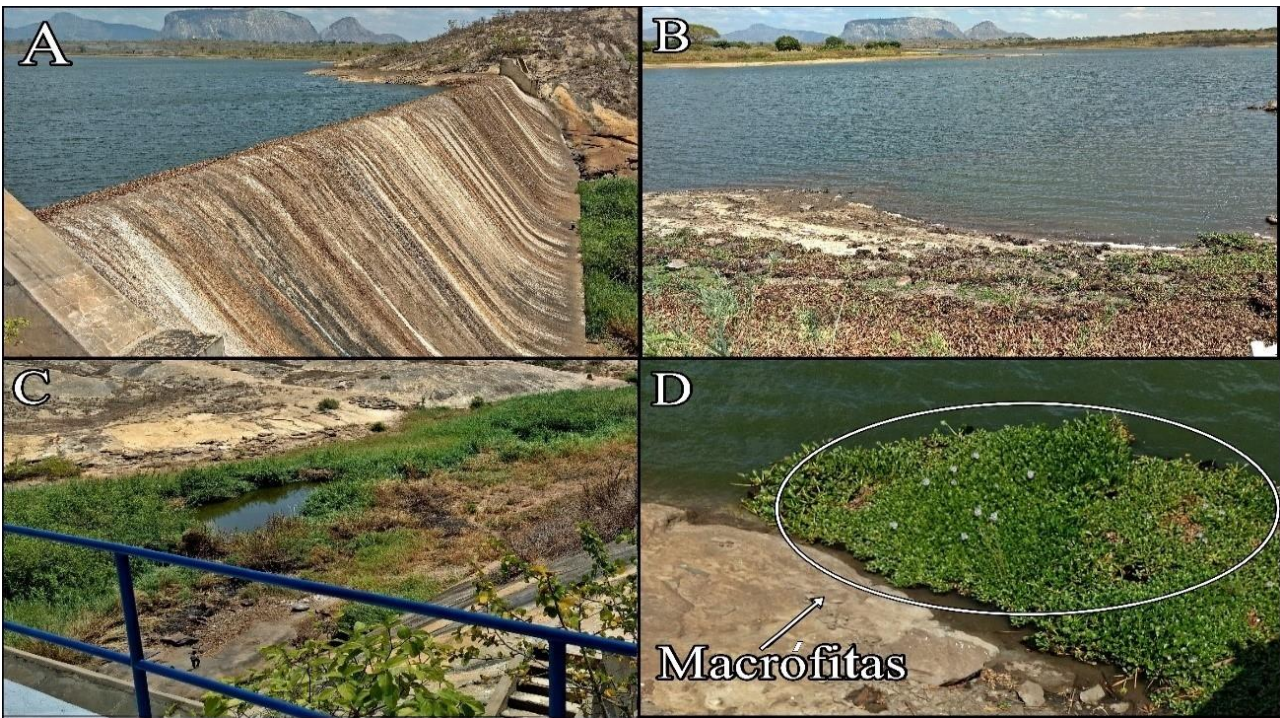


Figure 5. Characteristics of the Monapo river reservoir in Nampula district. Source: Authors' production (2018).

Following the direction of the Monapo river downstream, the district of Muecate was the place determined for the fourth point of analysis. The vegetation is composed of forage plants typical of savannas, the soil is sandy, facilitating the formation of erosions on the slopes.

The presence of people with digging activities, markings of animals in the river bed and visible erosions of the slopes (Figure 6 - A), are indicative of the increase of sediments to the water body, providing siltation and alteration of the natural properties of the aquatic environment.

In this section of the Monapo river, the anthropic activities are present in the vicinity of its banks, by the inhabitants of the district of Muecate. Figure 6 - B shows burn marks and straw ranch in the deforested area. In the background, an outcrop of granite is observed, which together with the gneisses represent the geological base of the region, which confers a low potential for water storage in the drainage network of the basin. The relief is predominantly flat in areas near the watercourse and steep on the slopes.



Figure 6. Physical characteristics of point 04 analyzed. Source: Authors' production (2018).

As shown in Figure 6 - A, this stretch of river water has no current, being approximately 102 kilometers from the source. It is possible to

observe some perforations in the river bed, where the locals seek to obtain water for domestic use.

The main agricultural activities verified in point 05 are plantations of banana and corn,

developed in the flood area of the river (Figure 7 A). The riparian areas do not have riparian forest protection, or contour, which is made possible through fluvial and / or wind transport, all types of products were used in the cultivation of the water body. The section of the river shown in Figure 7 (B), is the point of analysis denominated as 05, and is located in the district of Namialo.

In this place, the vegetation is composed of forage plants and dry trees near the houses (Figure

7 - B). The locals usually set fire to any set of garbage, causing burning residues, which when leached from the rainwater, are taken to the bottom of the valley.

This section of Monapo River has no current, only water which the inhabitants of the region use for domestic activities. The residents reported that they use sand from the river bed to build houses, for this they make sand banks as shown in Figure 7 - C.

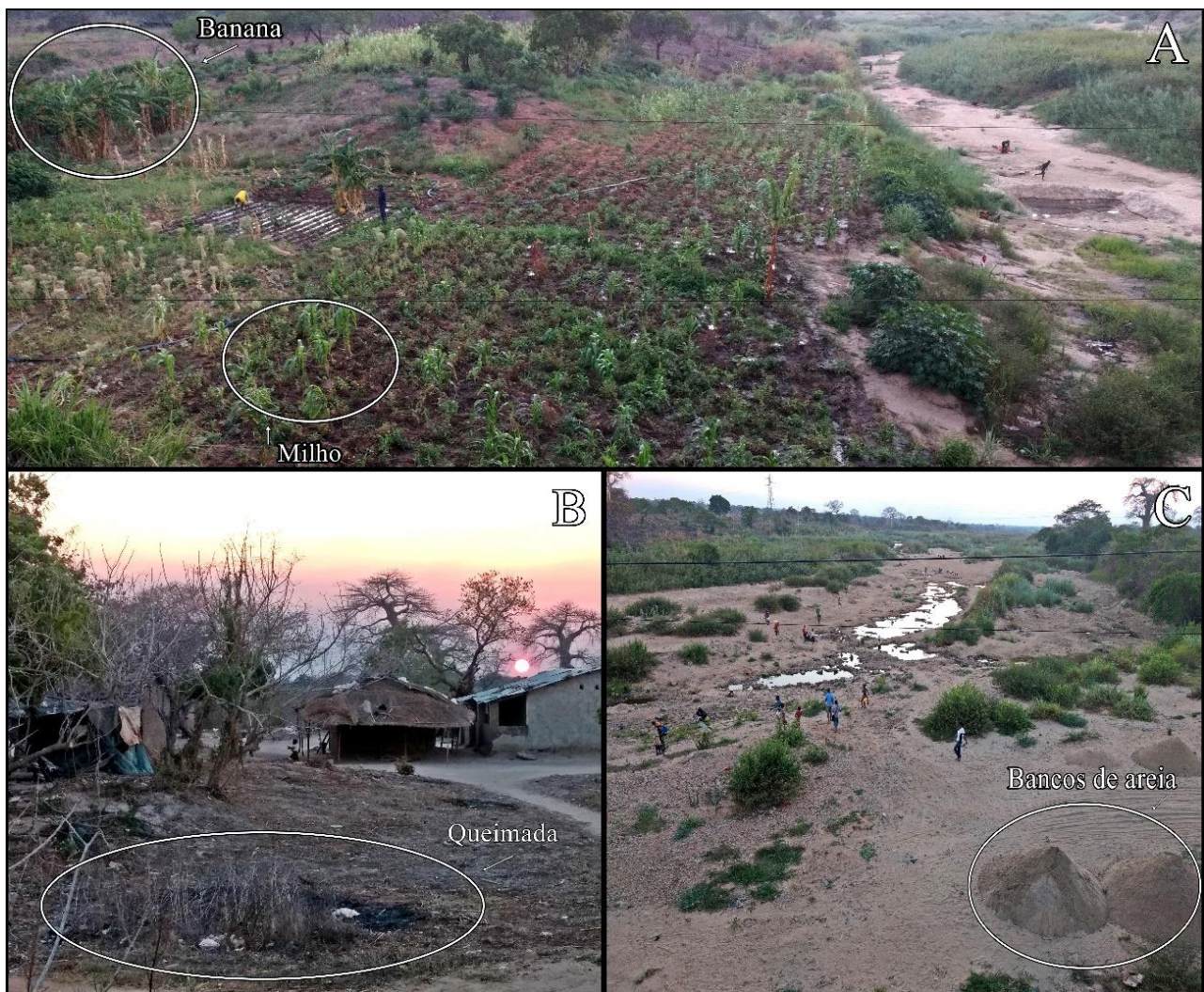


Figure 7. Agricultural systems, and characteristics of the use and occupation of lands close to point 7 analyzed. Source: Authors' production (2018).

At the points of analysis 6, 7 and 8 it was possible to apply the Rapid Assessment Protocol (RAPs) and the flow measurement. In these stretches, there was the presence of water current, but in small amount compared to the extent and importance of the Monapo river to the region. The river drains an area consisting of 09 of the 21 districts of Nampula province.

The score obtained for each parameter of points 6, 7 and 8 are presented in Table 3, and the final classification of each point and the general

environmental condition of the Monapo river, as proposed by Calliston et al. (2002) is shown in Table 4.

Point 06 is located below the confluence of the Monapo River with the Ampoense River (Figure 2). The characteristics of this stretch have the presence of sandy soil, lack of riparian forest due to the strong practice of deforestation, riverbank erosion, litter on the slopes and bed sedimentation (Figure 8A - B - C), making the natural habitat severely modified, significantly degrading the environment. The final result of the

RAP for this section of the river was 24 points, which was classified as impacted.

Table 3. Score achieved by the application of RAPs.

<b>PARAMETERS</b>	<b>P6</b>	<b>P7</b>	<b>P8</b>
1. Type of occupation at the banks of the water body (main activity)	4	2	2
2. Near erosion and / or river banks and silting in its bed	0	0	0
3. Antropic alterations	2	2	2
4. Vegetable cover in bed	4	4	0
5. Water odor	2	2	2
6. Oiliness of water	2	2	2
7. Transparency of water	2	2	2
8. Odor of sediment	2	2	2
9. Oiliness of background	2	2	2
10. Type of background	2	2	2
11. Types of background	0	0	0
12. Extension of rapids	0	0	0
13. Frequency of rapids	0	0	0
14. Types of substrate	0	0	0
15. Deposition of mud	2	2	0
16. Sedimentary deposits	0	0	0
17. Changes in the river channel	0	0	0
18. Characteristics of water flow	0	0	0
19. Presence of riparian forest	0	0	0
20. Stability of the margins	0	0	0
21. Extension of ciliary forest	0	0	0
22. Presence of aquatic plants	0	0	0

Source: Authors' production (2018).

Table 4. Final result of the application of RAP.

Collection points	Score of RAP	Environmental Condition
6	24	Impacted
7	22	Impacted
8	16	Impacted

Final classification of the environmental condition of the Monapo river: IMPACTED

Source: Authors' production (2018).



Figure 8. Physical characteristics and anthropic desires (garbage) of point 06. Source: Authors' production (2018).

The result of the flow in the period evaluated in point 6 was 0.172 liters per second ( $m^3/s$ ). The place chosen to collect the necessary

information for the calculation was straight. Some characteristics of the bed and materials used to perform the flow can be seen in Figure 9.



Figure 9. Application of the methodology for the calculation of the flow in point 06. Source: Authors' production (2018).

The silting of the river bed can provide changes in the natural development of aquatic species, as it changes the temperature and the level of oxygen present in the water. Suspended particles hamper the penetration of the sun's rays, and the physico-chemical reactions required to maintain aquatic life (Esteves and Barbosa, 1986).

This large amount of sediment exists due to the physical characteristics of the basin, such as sandy soil, but also, it is mainly because there are

no conservation measures and the rains are concentrated only in a few months of the year.

It should be noted that a volume of 0.172  $m^3/s$ , in a river with 235 km of length and a basin of more than 8 thousand square kilometers, can be considered very low when compared to other rivers of the world with great volume of water and length. However, for the reality of the region, geological factors can be considered compatible, and there is a real need for conservation actions on the water

course, in order to try to minimally guarantee the needs of the population.

The application of RAP in point 07 confirms that this section does not present preserved natural conditions. This point is located below the confluence of the Muimite River with the Monapo River (Figure 2), and received environmental classification as impacted with the value of 22 points. A decline was observed in the characteristic, "type of occupation around the banks of the body of water (main activity), compared to point 6, because in this place dairy

activities were recorded with the rearing of goats near the bed.

The result for the calculation of the flow of this section was  $0.52 \text{ m}^3/\text{s}$  lower than the previous stretch upstream of the Monapo river, totaling  $0.120 \text{ m}^3/\text{s}$ . This can be explained by the manual deviations made by the riverside population, upstream of point 7, since the inhabitants of the region rely only on these waters for domestic activities. Part of this characteristic has been recorded in Figure 10.



Figure 10. Manual deviation of the Monapo river, upstream of point 7 analyzed. Source: Authors' production (2018).

Vieira (2009) explained that anthropic activities such as agriculture, removal of natural vegetation, diversion of springs, generate loss of biodiversity and contamination of rivers, by the accelerated process of environmental degradation.

Point 8 was the last analyzed on the Monapo River, located 15 km from the mouth in the Indian Ocean. In this place, the RAP evaluation reached 16 points, being classified as impacted. Habitat properties were observed falling with

emphasis on the parameters: type of occupation of the banks of the body of water (main activity), vegetation cover of the bed, deposition of mud.

The anthropic activities of this region are strongly indicative of the alteration of these habitats, directly compromising the environmental quality. The vegetation cover is composed of small numbers of forage plants, distant from the water body, with no presence of riparian forest on the slopes of the bed, in some regions with sisal plantations (Figure 11).



Figure 11. Sisal plantation near the water body. Source: Authors' production (2018).

The Journal Online of 2014 talks about the importance of sisals for the population of the province of Nampula, for the generation of employment and family support. Part of the fiber collected is destined for export to the European

market, and part of it is used by factories in the region, offering income and a better quality of life for workers. This study noted the practice of burning near riverside houses, and domestic activity, such as washing clothes in the water body (Figure 12 A-B).



Figure 12. Physical characteristics and domestic activities in the Monapo river. Source: Authors' production (2018).

In the study by Bezerra et al. (2016) in the catchment area of Córrego da Onça (Mato Grosso do Sul, Brazil), the authors obtained, as a result of the application of the Rapid Assessment Protocol, the lowest results in the river that counted on the presence of anthropic activities similar to the Monapo River. The authors stated that land use and occupation are primarily responsible for altering environmental quality.

The river flow at point 8 was 206 l/s, in this area the altitude was 19m, which is the closest place to the delta, with fairly flat lands. In times of flood, the inhabitants use the fluvial transport to carry out the fishing activities.

The final classification of the application of the RAP to the Monapo river basin constituted only one class, and it was "impacted", reaffirming the levels of degradation in all the analyzed sections of the basin.

### Conclusion

Through this work, it was possible to report on the experiences acquired in the environmental analysis of the Monapo River Basin in Mozambique - Africa.

The research concluded that:

1 –The environmental diagnosis through the application of RAPs requires adjustments, in river basins with the same characteristics as the present research. The absence of water current in most of the analyzed riverbeds, makes it impossible to apply RAPs and flow measurement, leaving open the analysis parameters to be evaluated in these stretches.

2 –The physical description and observation of the eight points of analysis, including the result of the application of the RAP and flow measurement in the three points where it was possible, shows that there was an environmental disturbance in the river basin.

3 –The recorded photos present a modification of the natural structure in the banks and the bed, the disordered use of the lands by the burning, plantations, animal husbandry, and garbage near the water body, in which they offer high amounts of organic matter, sediment and contaminants to the river bed, contributing to sediment deposition and sedimentation.

4 –For a better environmental diagnosis of the river basin in question, it is necessary to carry out new fields of analysis, which can be carried out by the students and teachers of the Pedagogical University of Mozambique. With this, it is possible to monitor the development and progression of anthropic activities in relation to the physical characteristics of the basin, as well as the adequacy of the RAPs used, or even the use of new research methodologies.

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