PRESSURES–IMPACT ANALYSIS OF THE PACORA RIVER, PANAMA

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ABSTRACT

The Pacora River is one of the priority basins of the Republic of Panama since it provides water for human consumption therefore its conservation is of great importance; the country has laws that protect the integrity of the basins from their ecological nature to that for use for economic activities. This basin has great potential not only for agricultural activities but also a buffer for population development in the urban area of the country. This study was carried out in the middle and lower upper parts of the Pacora River during the wet, dry and transitional season, the data obtained was used to calculate the water quality index and the fluvial habitat index and the elaboration of an impact–pressure matrix, in order to evaluate the levels of influence that anthropogenic activities have in the area, based on established laws regulating water quality levels and forest legislation. The results obtained indicate that the Pacora River are among the ranges of little polluted, acceptable and uncontaminated for the water quality index and for the habitat fluvial index in the range of not reaching very good, good and very good. Regarding the analysis of pressures and impacts, the values are between probable impact, checked and non-apparent impact and medium to high risk. These data indicate a shift in the use of native forest land to industrial, agricultural and urban activities.
Keywords: pressures–impacts analysis, water quality index (WQI), fluvial habitat index (FHI), Pacora River, Panama.

1 INTRODUCTION

Water is a liquid of vital importance for the maintenance of life in the environment, although the quality of water has deteriorated over time, both in surface and groundwater, due to natural and human activities [1]. Atmospheric, hydrological, climatic, lithological and topographical factors are mentioned as natural factors that interfere with the quality of the waters [2], on the other hand, the activities of anthropogenic origin that go from the rural landscape to the urban, such as livestock, agriculture, mining, industries, residential areas and the disposal of liquids such as solids, in addition to the loss of green areas replaced by cement, increase runoff, considering that problems of sedimentation, erosion, presence of heavy metals, fecal coliforms, agrochemicals, among others [3], [4], and contamination limits the use of water for recreational activities [5]. In addition, it must be considered that the pollution that arrives through the waters that flow through rivers and streams reaches the sea (it has been estimated that 90% of these pollutants are transported to the sea via rivers), entailing a series of consequences negative effects on estuaries and on the other living resources that inhabit these ecosystems [6]. According to UNEP [7], water pollution has worsened since the 1990s in most rivers in Latin America. Global concern about water availability and quality has been increasing, with demand for water estimated to increase by 20–30% by 2050 [8].

A successful tool to verify and determine contamination is through the water quality index (WQI), which represents a valuable and unique qualification to show the general state of

water quality that is useful for the selection of the technique that mitigates with the use of an appropriate treatment to resolve or improve water quality [9], [10].

2 MATERIALS AND METHODS

2.1 Study area

The Pacora River is located on the Pacific slope of the Republic of Panama at the coordinates 8°00' and 8°20' north latitude and 79°15' and 79°30' west longitude. Its extension is 388 km^2 and the drainage area is 364 km^2. It is bordered on the north by the Chagres River, on the south by the Bay of Panama, on the east by the Bayano River and on the west by the Juan Diaz River. The basin is represented in three life zones: very humid premontane forest, premontane humid forest and tropical humid forest. This river provides water for human consumption and therefore is considered one of the priority basins in the country [11].
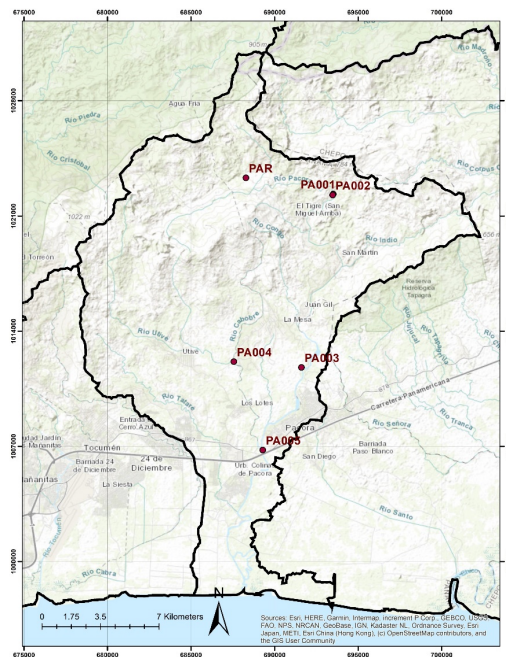

Figure 1: Location of the study sites.

2.2 Pressure impact analysis

For the development of this analysis, an adaptation was made to the manual prepared by the General Directorate of Water of the Ministry of the Environment of Spain IMPRESS (2004), whose objective is to identify the risks of surface water bodies for compliance with the Water Framework Directive 2000/60/EC [12].

The pressure–impact assessment was carried out at a qualitative level considering the results obtained from the water quality index and the fluvial habitat index, with these data it was classified in impacts: probable, checked and no apparent impact, and according to risk:

high, medium, low and non-risk, based on established laws regulating water quality levels and forest legislation.

3 RESULTS AND DISCUSSION

3.1 Pressure impact analysis

3.1.1 PA001
The point PA001WE had a value of 76 and 83 for PA001DR in the water quality index whose rating is acceptable, however, these scores decrease in the parameters established in Executive Decree No. 75 (of June 4, 2008) "By which the primary standard of environmental quality and quality levels for inland waters for recreational use with and without direct contact is dictated", in its Article 12 [13]. The point PA001TR with a value of 92 whose rating is uncontaminated; these values are due to the population settlements in the area.

Regarding the river habitat index its value was 72 whose rating is very good however its score decreases in the percentage of shade in the channel therefore does not fully comply with Law 1 of February 3, 1994, Chapter III of the Forest Protection "In the rivers and streams the width of the channel will be taken into consideration and the width of it will be left to both sides but in no case will it be less than (10) meters; a strip of forest of not less than ten (10) meters may also be left as a distance" [14]. Therefore, PA001 has a probable impact and a medium risk according to the values of WQI and HFI.

3.1.2 PA002
The point PA002WE had a value of 74, PA002DR 75 and PA002 TR 75 in the water quality index whose rating is acceptable, however, these scores decrease in the parameters established in Executive Decree No. 75 (of June 4, 2008) "By which the primary standard of environmental quality and quality levels for inland waters for recreational use with and without direct contact is dictated", in its Article 12 [13]. The point, these values are due to the population settlements in the area.

Regarding the river habitat index its value was 58 for the points PA002WE, PA002DR AND PA002TR whose rating is good however its score decreases in the percentage of shade in the channel therefore does not fully comply with Law 1 of February 3, 1994, Chapter III of the Forest Protection "In rivers and streams, the width of the channel will be taken into consideration and the width of the same will be left on both sides but in no case will it be less than (10) meters; a strip of forest of not less than ten (10) meters may also be left as a distance" [14]. Therefore, PA002 has a probable impact and a medium risk according to the values of WQI and HFI.

3.1.3 PA003
The point PA003WE had a value of 73, PA003DR 77 and PA003TR 73 in the water quality index whose rating is acceptable, however, these scores decrease in the parameters established in Executive Decree No. 75 (of June 4, 2008) "By which the primary standard of environmental quality and quality levels for inland waters for recreational use with and without direct contact is dictated", in its Article 12 [13]. The point, these values are due to the population settlements in the area.

Regarding the river habitat index its value was 54 for the points PA003WE, PA003DR and 67 PA003TR whose rating is good however its score decreases in the percentage of shade in the channel therefore does not fully comply with Law 1 of February 3, 1994, Chapter III of the Forest Protection "In rivers and streams, the width of the channel will be taken into

consideration and the width of the same will be left on both sides but in no case will it be less than (10) meters; a strip of forest of not less than ten (10) meters may also be left as a distance" [14]. Therefore, PA003 has a likely impact and a high risk according to the values of WQI and HFI.

3.1.4 PA004

The point PA004WE had a value of 73, PA004DR 79 and PA004TR 77 in the water quality index whose rating is acceptable, however, these scores decrease in the parameters established in Executive Decree No. 75 (of June 4, 2008) "By which the primary standard of environmental quality and quality levels for inland waters for recreational use with and without direct contact is dictated", in its Article 12 [13]. The point, these values are due to the population settlements in the area.

Regarding the river habitat index its value was 61 for points PA004WE, PA004DR and 64 PA004TR whose rating is good however its score decreases in the percentage of shade in the channel therefore does not fully comply with Law 1 of February 3, 1994, Chapter III of the Forest Protection "In rivers and streams, the width of the channel will be taken into consideration and the width of the same will be left on both sides but in no case will it be less than (10) meters; a strip of forest of not less than ten (10) meters may also be left as a distance" [14]. Therefore, PA004 has a likely impact and a high risk according to the values of WQI and

3.1.5 PA005

The point PA005WE had a value of 68, rating of little contaminated, PA005DR 78 and PA005TR 76 is acceptable, in the water quality index, however, these scores decrease in the parameters established in Executive Decree No. 75 (of June 4, 2008) "By which the primary standard of environmental quality and quality levels for inland waters of recreational use with and without direct contact is dictated", in its Article 12 [13]. The point, these values are due to the population settlements in the area.

Regarding the river habitat index, its value was 50 for points PA005WE and PA005DR whose rating does not reach good and 57 PA005TR whose rating is good however its score decreases in the percentage of shade in the channel therefore does not fully comply with Law 1 of February 3, 1994, Chapter III of the Forest Protection "In the rivers and streams the width of the channel will be taken into consideration and the width of the same will be left on both sides but in no case will it be less than (10) meters; a strip of forest of not less than ten (10) meters may also be left as a distance" [14]. Therefore, PA005 has a checked impact and a high risk according to the values of WQI and FHI.

3.1.6 PAR

This point is the reference site, represents the ideal conditions, had a value of 91, rating of uncontaminated, in the Water Quality index, however, these scores decrease in the parameters established in Executive Decree No. 75 (of June 4, 2008) "By which the primary standard of environmental quality and quality levels for inland waters for recreational use with and without direct contact is dictated", in its Article 12 [13]. The point, these values are due to the population settlements in the area.

Regarding the river habitat index its value was 86 whose rating is very good however its score decreases in the percentage of shade in the channel therefore does not fully comply with Law 1 of February 3, 1994, Chapter III of the Forest Protection "In the rivers and streams the width of the channel will be taken into consideration and the width of it will be left on both sides but in no case will it be less than (10) meters; a strip of forest of not less than ten

(10) meters may also be left as a distance" [14]. Therefore, PA005 has a non-apparent impact and an average risk according to the values of WQI and FHI.

Table 1:   WQI and FHI ratings of the monitored sites and impact–pressure matrix of the Pacora River.

COD	WQI	HFI	Impact	Risk	Site
PA001WE	76	72	Probable	Middle	
PA001DR	83	72	Probable	Middle	
PA001TR	92	72	Probable	Middle	
PA002WE	74	58	Probable	Middle	
PA002DR	75	58	Probable	Middle	
PA002TR	75	58	Probable	Middle	
PA003WE	73	54	Probable	High	
PA003DR	77	54	Probable	High	
PA003TR	73	67	Probable	High	
PA004WE	73	61	Probable	High	
PA004DR	79	61	Probable	High	
PA004TR	77	54	Probable	High	
PA005WE	68	50	Checked	High	
PA005DR	78	50	Checked	High	
PA005TR	76	57	Checked	High	
PAR	91	86	No apparent impact	Middle	

The Pacora River has experienced a population growth in its middle and lower parts, therefore a change of land focused on industrial and urban development. In the upper parts there is a change of native forest species due to the development of agricultural activity and also the extraction of minerals directly from the river [15].

The water quality index of the Pacora River is in the range of acceptable, suitable for recreational, industrial, agricultural activities, aquatic biodiversity and human consumption [11], [16].

Different authors agree that the review of water quality data over time is the best way to verify the behavior of surface water pollution that passes through different areas between agricultural, urban, whether residential or industrial, such as the case of the Yamuna River in India between the years 2000 and 2009 [17]; Juan Díaz River in Panama between the years 2002 and 2018 [18]; comparative studies between water bodies in the USA and Canada [19]; monitoring of the four main rivers of South Korea between the years 2007 and 2018 [20]. Although the results present a variability in the results depending on the location of the sampling station, in this sense the concept of water quality is not necessarily a state of purity of the water, but refers to the chemical, physical and biological characteristics that determine their different uses [21].

4 CONCLUSION

The results obtained in this research indicate that the Pacora River has a score of 73 to 92 with ratings of little contaminated, acceptable and uncontaminated in the Water Quality Index. For the river habitat index we find values from 50 to 86 with ratings of not reaching good, good and very good

The Pacora River for points PA001, PA002 has a probable impact and medium risk, for points PA003 and PA004 a probable impact and high risk, for point PA005 a checked impact and high irrigation and finally PAR the reference point non-apparent impact and medium risk.

These results show the change of native forest soil to the development of industrial, agricultural and urban activities.

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