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Evaluation of the Level of Air Pollution by Gases and Particulates at the Edge and in the Interior of a Conservation Unit: A Case Study in the FLONA of Restinga de Cabedelo, Paraíba, Brazil

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ABSTRACT
Air pollution has become one of the biggest problems and concerns worldwide, especially in large industrial cities, where the discharges of toxic substances together with the intense and growing traffic of vehicles are largely responsible for the emission of pollutants into the atmosphere. It is known that road infrastructure generates several environmental impacts during its implementation and operation. Thus, the present study seeks to describe the air quality in and around the Restinga de Cabedelo National Forest (Flona), a conservation unit located in the State of Paraíba, prior to the improvement work with expansion of the capacity and safety of the BR-230 Highway, through the measurement of PTS, PM10, SO2 and NO2.

Keywords: Air quality, Pollution, Protected area, Flona.

1 INTRODUCTION

The Conservation Units (UCs) are areas rich in biodiversity, with a relevant ecological function and protected by the government aiming at conservation. Through Law No. 9,985, of July 18, 2000, the National System of Nature Conservation Units (SNUC) was instituted and criteria and standards were established for the creation, implementation and management of conservation units (BRASIL, 2000). According to Barbosa et al (2021), "areas protected by law represent one of the strategies for biodiversity conservation, especially in regions under strong anthropogenic pressure."

Duarte et al (2019) highlighted the importance of the environmental services provided by conservation units, such as the development of tourism with income generation, protection of natural resources, production of cosmetics and pharmaceuticals, mitigation of greenhouse gas emissions, in addition to ecological functions. The aforementioned authors also listed numerous direct pressures suffered by conservation units, including roads.

In Brazil, highways represent the main means of transportation and circulation of cargo, goods and people in the country. The extensive Brazilian road network crosses the most diverse biomes and ends up interfering in numerous sensitive areas. In this sense, it is of fundamental importance to know how highways affect conservation units, in order to propose measures that minimize the impacts caused to these areas. The search for harmony between roads and protected areas must be constant because both represent important roles that involve, respectively, the economic development of the country, in addition to the right of locomotion guaranteed by the Federal Constitution and the protection of natural resources, with preservation of the ecological function.

Popularly known as AMEM Forest, the Restinga de Cabedelo National Forest is located at Km 11, on the banks of the BR-230/PB highway, in the municipalities of João Pessoa and Cabedelo, between the Renascer and Bessa neighborhoods, in the metropolitan region of João Pessoa. According to the Chico Mendes Institute for Biodiversity Conservation - ICMBio, the FLONA da Restinga de Cabedelo is one of the 320 Federal Conservation Units managed by ICMBio. Created in 2004, the Conservation Unit is the first National Forest located in an urban area in the country. The Restinga de Cabedelo National Forest has an area of 116.83 hectares, encompassing mangrove and restinga areas – typical ecosystems of the Atlantic Forest in coastal areas, a significant sample of the most threatened phytophysiognomy of the Atlantic Forest biome.

Air pollution has become one of the world's biggest problems and concerns, especially in large industrial cities, where the discharges of toxic substances together with the intense and growing traffic of vehicles are largely responsible for the emission of pollutants into the atmosphere. As a result of industrial processes and urban development, numerous environmental impacts have been observed, including the degradation of air quality, which, in turn, generates other socio-environmental impacts.

In view of the industrial urban growth and the compromise of air in cities, criteria were established for pollution control. In Brazil, the body that establishes the standards for monitoring and controlling air pollution is the National Council for the Environment (Conama), and Conama Resolution No. 491/2018 regulates air quality standards. According to this resolution, the pollutants considered indicators of air quality are: Total Particulate Matter (TSP), Particulate Matter (PM10, PM2.5), Sulfur Dioxide (SO2), Nitrogen Dioxide (NO2), Ozone (O3), Smoke, Carbon Monoxide (CO) and Lead (Pb5).

2 GOALS

The present work aims to portray the reality of atmospheric emissions regarding the concentration of Total Suspended Particles (TSP), Total Inhalable Particles (PM10), Sulfur Dioxide (SO2) and Nitrogen Dioxide (NO2) in the region of the Restinga de Cabedelo National Forest/PB, prior to the beginning of the construction of the BR 230 federal highway.

3 METHODOLOGY

This is a case study based on the environmental study "Assessment of the level of air pollution by gases and particulates at the edge and interior of the Restinga de Cabedelo National Forest" in 2020 by the National Department of Transport Infrastructure – DNIT, with technical support from the Brazil/Tecon Environment Consortium, due to the Improvement Works with Adequacy of Capacity and Safety on the BR-230/PB highway.

According to Ventura (2007), the case study as a research modality aims at the choice of a specific, well-defined object, subsidizing the detailed search for information. The author highlights several advantages of case studies, such as the stimulus to new discoveries, the emphasis on the multiplicity of dimensions of a problem, and the in-depth analysis of a given theme.

4 FINDINGS

The Restinga de Cabedelo National Forest, created in 2004, has an area of 116.83 hectares and is located at km 11, on the banks of the BR-230/PB highway, in the municipalities of João Pessoa and Cabedelo. According to the Management Plan, the Flona de Cabedelo is an essentially urban conservation unit and is home to one of the last fragments of restinga forest, a consequence of local real estate pressure (ICMBIO, 2016).

In the execution of the study in the Restinga de Cabedelo National Forest, for the measurement and correct analysis of the impacts of the activities surrounding the area in relation to the measurement of air pollutants, a single air quality monitoring campaign was carried out at three sampling points.

The first sampling point (P01) located near the edge of the forest with the BR-230 highway; the second sampling point (P02) located inside the flona with a distance of 250 linear meters from the edge; and the third sampling point (P03) located inside FLONA, with an approximate distance of 500 linear meters from the edge of the flona, as can be seen in Figure 01.

Figure 1: Map of the sampling points in the Cabedelo Flona. Source: DNIT / Consortium Ambiente Brasil/Tecon, 2020.

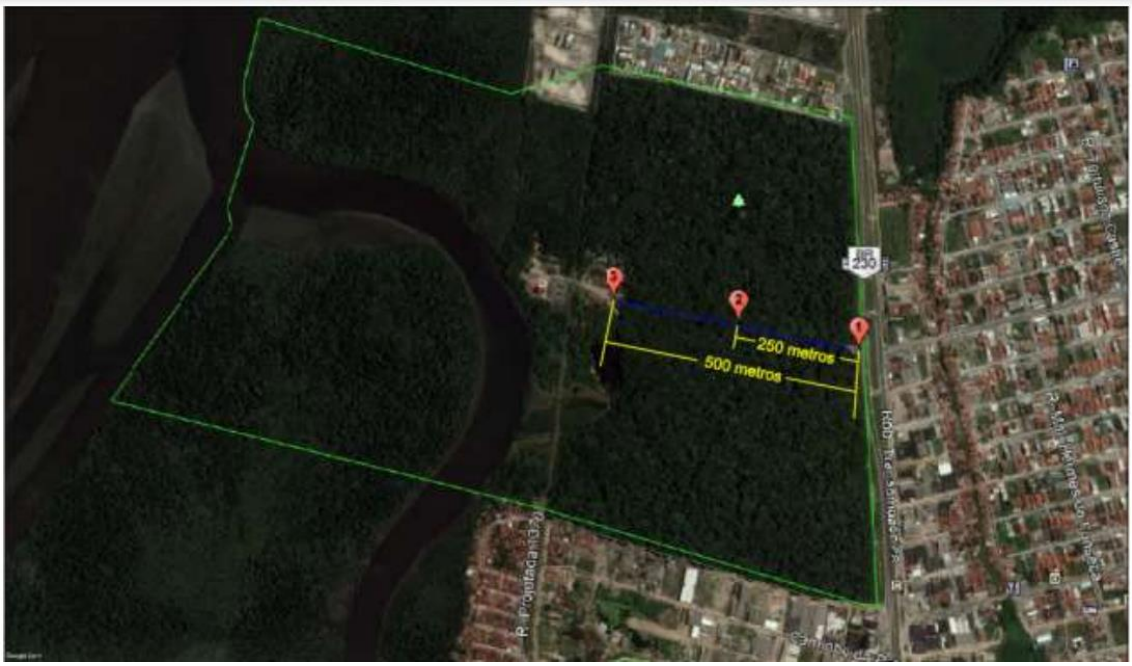

Table 01 presents the information describing the three sampling points in the Restinga de Cabedelo National Forest:

Table 01. Information about the three sampling points.

PONTOS DE AMOSTRAGEM	LONG. (E)	LAT. (N)	DESCRIÇÃO
P01	295595.00	9218710.00	Área imediata da portaria da entrada da Floresta Nacional da Restinga de Cabedelo, na borda da rodovia BR-230/PB.
P02	295342.00	9218753.00	Ponto localizado a 250 metros lineares da borda da rodovia BR-230/PB com a Flona, no meio da trilha interior da Flona, de acesso ao setor administrativo do ICMBio, Cemave e Associação Metropolitana de Erradicação da Mendicância (AMEM).
P03	295104.00	9218801.00	Ponto localizado a 500 metros lineares da borda da rodovia BR-230/PB, onde localiza-se o setor administrativo do ICMBio, Cemave e . Associação Metropolitana de Erradicação da Mendicância (AMEM).

For the execution of the study, primary data were collected at each sampling point, between July 13 and 16, 2020 by a technical team specialized in environmental consulting and environmental projects.

The distribution of pollutant concentrations in the atmosphere depends on emission conditions and weather conditions, and some pollutants can be transported over long distances before reaching ground level.

In this sense, the meteorological conditions directly influence the result of the measurements, becoming indispensable for the analyses. Thus, prior to the measurements, meteorological data were measured and the results obtained are as follows: The results obtained during the measurements that took place on 07/13, 07/14 and 07/15 are listed below in Table 02.

Table 02. Results of meteorological data, measured after installation of the equipment at the sampling points.

DADOS METEOROLÓGICOS			
DADOS COLETADOS	PONTOS DE AMOSTRAGEM		
	P01	P02	P03
Data de Aferição:	13/07/2020	15/07/2020	14/07/2020
Temperatura Ambiente (ºC):	28,4	27,5	28,1
Velocidade dos ventos (m/s):	1,2 - 1,4	0,1 – 0,3	1,1 – 1,3
Umidade Relativa (%UR):	61,3	74,2	68,9
Pressão Atmosférica (mmHg):	760,0	760,2	760,3
Direção dos Ventos (AZº):	009	334	358

After the analytical results of the laboratory analyses present in the reports of the test reports, it was possible to obtain the values related to the air pollutants of the present study, at each sampling point, presented in Table 03. The reference values of the air quality standards presented in Table 04 are in accordance with what is recommended in Annex I of CONAMA Resolution No. 491, of November 19, 2018.

Table 03. Results obtained with laboratory analysis of air pollutants by sampling point.

RESULTADOS ANALÍTICOS DOS POLUENTES ATMOSFÉRICOS				
Poluente Atmosférico	Referência CONAMA 491/2018	Pontos de Amostragem		
		P01	P02	P03
Partículas Totais em Suspensão - PTS (µg/m³)	240	70,8	31,99	47,20
Material Particulado - MP_{10} (µg/m³)	50	3,68	1,63	2,94
Dióxido de Enxofre – SO_2 (µg/m³)	20	<20	<20	<20
Dióxido de Nitrogênio – NO_2 (µg/m³)	200	<200	<200	<200

Obs.: Todas as referências são de um período de 24 horas, que foi o ocorrido nas medições realizadas.

Regarding the concentration of pollutants related to meteorological conditions, shown in Table 02, the results indicate that some of the parameters favor pollution indexes, such as: percentage of calm, light winds and thermal inversions at low altitudes.

The data indicate that the highest temperature recorded occurred on the first day of measurement (07/13/20) at sampling point 01, as well as the highest wind speed. As for relative humidity, the highest index was recorded on the third day of measurement (07/15/20), at sampling point P02, with 74.2%. The area of the P02 sampling point was located approximately 250 linear meters from the edge of the entrance to FLONA, with a greater presence of arboreal individuals in the vicinity of the point and lower rates of anthropogenic activities, along the access trail to the administrative sector of ICMBio, Cemave and AMEM Association. The highest atmospheric pressure indices recorded were 760.3 mmHg on the second day of measurement, at sampling point P03, which was located approximately 500 linear meters from the entrance to the Restinga de Cabedelo National Forest.

Regarding the results shown in Table 03, after the analysis of the data obtained, it can be concluded that point 01 (one), point 02 (two) and point 03 (three) are within the parameters required in the Reference values present in Annex I of CONAMA Resolution No. 491/2018, for the 24-hour sampling period.

As for the air pollutants "total suspended particles" (TSP), they can be defined in a simplified way as those whose aerodynamic diameter is less than or equal to 50 μm. Some of these particles are inhalable and can cause health problems, while another part can adversely affect the quality of life of the population, interfering with the aesthetic conditions of the environment and impairing the normal activities of the community.

Under this aspect, the highest TSP index was recorded at sampling point P01 of 70.8 μg/m³. This sampling point is the closest to the incidence of anthropogenic activities, such as the flow of vehicles on the BR-230/PB highway and the surrounding industrial activities. Even so, the value resulting from the laboratory analysis indicates that the atmospheric measurements of PTS are well below and in full compliance with the maximum allowed value of 240 μg/m³ of CONAMA Resolution No. 491/2018. In the decreasing sequence, the sampling point P03 showed a result of 47.20 μg/m³, followed by the sampling point P02 with 31.99 μg/m³.

The general denomination of Particulate Matter (PM10) encompasses a set of pollutants consisting of dust, fumes and all kinds of solid and liquid material that remains suspended in the atmosphere because of its small size, whose main sources of PM emission into the atmosphere are through motor vehicles, industrial processes, biomass burning, resuspension of ground dust, among others.

In the sampling results, the highest number of Particulate Matter was recorded at sampling point P01 with 3.68 µg/m³, followed by sampling point P03 with 2.94 µg/m³ and sampling point P02 with 1.63 µg/m³. Thus, all sampling points are in compliance with the legal reference parameters of 50 µg/m³ for a period of 24 hours.

The pollutant Sulfur Dioxide (SO2) results mainly from the burning of sulfur-containing fuels such as diesel fuel, industrial fuel oil, and gasoline. It is one of the main formers of acid rain. Sulfur dioxide can react with other substances present in the air to form sulfate particles that are responsible for reducing visibility in the atmosphere.

Regarding sulfur dioxide, results below 20 µg/m³, which is the maximum allowed value, were recorded at all sampling points (P01, P02 and P03) for a period of 24 hours; all of which are in compliance with the relevant environmental legislation on air emissions of this pollutant.

Nitrogen dioxide (NO2), on the other hand, is formed during combustion processes, and vehicles are usually primarily responsible for the emission of nitrogen oxides. NO, under the action of sunlight, is transformed into NO2, which plays an important role in the formation of photochemical oxidants such as ozone. Depending on the concentrations, NO2 can cause harm to health. However, the analytical results indicated that all sampling points (P01, P02 and P03) are in compliance with the legal environmental parameters, with values lower than 200 µg/m³, which is the maximum value allowed by CONAMA Resolution No. 491/2018.

5 CONCLUSIONS

In view of what was exposed through the evaluation of the results of the data measured in this report, it was possible to infer that the presence of dense vegetation in the Restinga de Cabedelo National Forest contributes positively to the positive result of the measurements, in accordance with the current environmental legislation. Added to this, the hot and humid climate, the high rainfall in July and the occurrence of winds throughout the year may also have influenced the decrease in the concentration of air pollutants recorded.

Thus, through the knowledge of the satisfactory analytical results of the concentrations of air pollutants and meteorological data, it is possible to understand that the monitoring of air quality is essential and extremely important for the conservation of the energy and ecosystem balance of the area in question, thus ensuring the maintenance of all forms of life.

According to the data presented in the Assessment of the level of air pollution by gases and particulates at the edge and interior of the Restinga de Cabedelo National Forest, it is observed that all points are considered COMPLIANT with regard to the parameters expressed by the CONAMA 491/2018 legislation.

Therefore, the results of the atmospheric measurements related to PTS, PM10, SO2 and NO2 in the area of the Restinga de Cabedelo National Forest/PB, prior to the beginning of the works to expand the capacity and safety of the BR-230/PB highway, are below the limits stipulated by the current environmental legislation.

As all parameters are in compliance, no direct or indirect environmental impacts are expected from the activities of the BR-230 highway that affect air quality in the Restinga de Cabedelo National Forest, and it is not necessary to present, so far, mitigation measures.

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