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Diagnosis of acid rain in a neighborhood of the city of recife: case study

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Abstract
The study of water quality is essential, both to characterize the consequences of a particular polluting activity, and to establish the means to satisfy a given water use. This work aimed to contribute to environmental agencies through analyzes of acid rain, to identify a possible presence of acidity in rainwater drained from buildings, as well as parameters related to impacts. The methodology used for the analysis of runoff water was the Standard Methods for the Examination of Water and Wastewater, 2012. The collections carried out in the fall pipes of the rainwater drainage in the Boa Vista neighborhood, had expressive pH values, in which for the drained water the highest value was 8.4 and the lowest 4.3. In the case of rainwater, the highest value was 9.35 and the lowest was 3.56. In the other studied locations, the pH values found were higher compared to the Boa Vista neighborhood, suggesting that it is a potentially polluting region.

Keywords: acid rain; precipitation; flow; water quality

Introduction

Acid rain is a theme that has been widespread and valued in recent years, due to the potential impacts that these can cause to the quality of life of society [1] guaranteed by [2] in its Art. 225. "Everyone has the right to an ecologically balanced environment, a common use of the people and essential to a healthy quality of life, imposing on the Public Power and the community the duty to defend and preserve it for present and future generations".

In Brazil, housing distribution is carried out without planning in most cities, among them, Recife. As a result, they suffer from the consequences of this poor planning, which can lead to such a phenomenon. Boa Vista, in the city of Recife, can be considered as a city that tends to acid rain, as it is considered one of the neighborhoods with the highest flow of cars (50,000 per day), in addition to being a neighborhood made up of large buildings, where the oldest ones use marble and sculptures in limestone [3]. It is known that about 90% of the air pollution in large cities is associated with the burning of fossil fuels generated by motor vehicles.

Factors such as air pollution, heat sources (combustion of fossil fuels by cars or factories) and reduced vegetation cover are triggers for this phenomenon [4]. The chemical composition of the atmosphere, altered by the emanation of gases from industries and vehicles, has been influencing the hydrological cycle, causing problems in the quantity and quality of rainwater that reaches the soil, surface waters and vegetation [5]. This rain, when it reaches a pH below 5.6, is considered acidic. The impacts of this rain vary from the alteration of the biota to the destruction of monuments. Although many different types of stone have been used in sculptures or buildings, the most vulnerable to attacks by acid rain are marble and limestone.

The soil can also be acidified by rain, but some types of soil are able to neutralize at least partially the acidity of the rain because of the presence of natural limestone and lime ($CaCO_3$ and CaO). Soils without limestone are more susceptible to acidification. The natural neutralization of rainwater by the soil minimizes the impact of water reaching the lakes through its slopes (leaching). Acid rain causes a greater spread of heavy metals from the soil to lakes and rivers, which can poison aquatic life [6].

Considering the Boa Vista District chosen for its high-volume vehicle characteristics, studies will be carried out on the possibility of acid rain incidence in the region based on analyzes of the quality of rainwater and its runoff, to verify possible changes in buildings and ecosystems in the region. A comparison of the analyzes of the neighborhoods of Boa Vista will also be made, with samples collected in the Metropolitan Region of Recife. Brazilian studies are practically punctual according to the study by [7]. These authors detected the presence of acid rain in the city of Rio Claro / SP, relating the change in pH and conductivity to the increasing industrial level and the vehicle emission.

The development of the project is of utmost importance, as more in-depth studies on the collected rainwater need to be carried out and the need to verify whether there is acidity in the rain according to its location: locally (Boa Vista neighborhood) or if it covers regionally.

The present work aims to contribute with the environmental agencies through the analysis of acid rain, with its possible impacts, having as a case study, the incidence about Boa Vista, located in the city of Recife-PE.

Materials and methods

The applied methodology will be divided into the following steps

Literature review

Through the analysis of literature data and more recent studies on acid rain, its problems and public policies adopted, it will be possible to understand it in the city of Recife.

Method

Study Region

The Boa Vista neighborhood is in the central region of Recife and is one of the neighborhoods with the highest concentrations of vehicle flow, for this reason it was chosen for the purposes of this study. Currently, in Bairro da Boa Vista, 15 thousand people reside, and as the Neighborhood is in a central region, it becomes the route of approximately 400 thousand people, among them tourists, workers, students, etc. As it is an "inevitable" route, many people end up participating in the neighborhood's problems.

It is in this plural space that one of the most vigorous urban expressions of the city of Recife is found: buildings of various architectural styles (limestone-based sculptures) and distinctive construction times, especially the oldest houses, with their lean and tall houses, which used marbles on their facades; and the new, with wide avenues and open spaces coexist with each other with great cultural "tolerance", forming a living example of this expression, which at the same time promotes and materializes the history of the city itself.

Analyze

The presence of acid rain is associated with the high concentration of sulfur dioxide and / or hydrogen sulphide generated by the burning of fossil fuels. Motor vehicles when using gasoline (because it is the most viable energy medium) tend to generate large amounts of these gases. It is also known that with it, due to the low pH, the possibility of the presence of heavy metals generated and emitted into the atmosphere through the wear and tear of vehicles and fossil fuel [8].

Sampling

Glass containers, sterilized before each collection, are being used to collect rainwater. The containers will be placed on supports of about 1 meter in height, with the surface of the site being completely open, without any type of vegetation such as trees, or close to roofs with gutters so that the quality of water collected is not influenced by the introduction of particles such as leaves and small stones. The collection is carried out only in the beginning of the precipitation, not being exposed to dry deposition. Fortnightly samples are collected at each of the chosen points. An observation method will be used in the Boa Vista neighborhood to choose the best position for the data and rainwater collection points. This observation consists of an analysis involving the mass of vehicles, people circulating the area and the type of building, which may be affected by the effects of the phenomena to be studied. Green density factors are also weighted to observe the greatest possible variation in temperature because of this factor and despite safety to keep the equipment installed and / or prevent possible damage. As soon as the points were duly chosen, the installation began, which, depending on the location, involves the participation and / or authorization of some establishment or residence. It is important to note that after observing and choosing the location of the equipment, the days to collect this data are selected according to the climatic situation of the city of Recife, that is, in different periods of climatic situations, if possible.

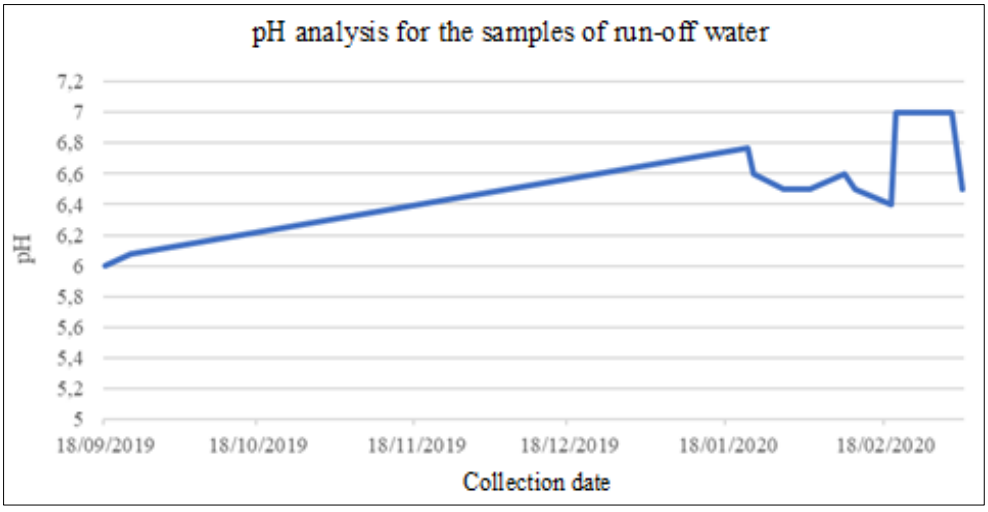
Results and discussion

It is noteworthy that, Seinfeld and Pandis (1998), assigned a pH value equal to 5.00, as a lower limit for rainwater acidified by substances of natural origin, and below this value as a contribution of anthropic origin.

The samples were collected between 21 \ 08 \ 2019 until 04 \ 03 \ 2020, totaling 94 samples, in which 43 samples were runoff and 51 rainwater. Where the pH values of rainwater runoff found ranged from 4.3 (minimum found in 26 \ 08 \ 2019) to 8.9 (maximum found in 26 \ 11 \ 2019). The numerical mean pH value of the 43 samples was 6.72814.

The pH values found for rainwater ranged from 3.56 (minimum found in 27 \ 11 \ 2019) to 9.35 (maximum found in 16 \ 08 \ 2019). The numerical mean pH value of the 51 samples was 6.739608.

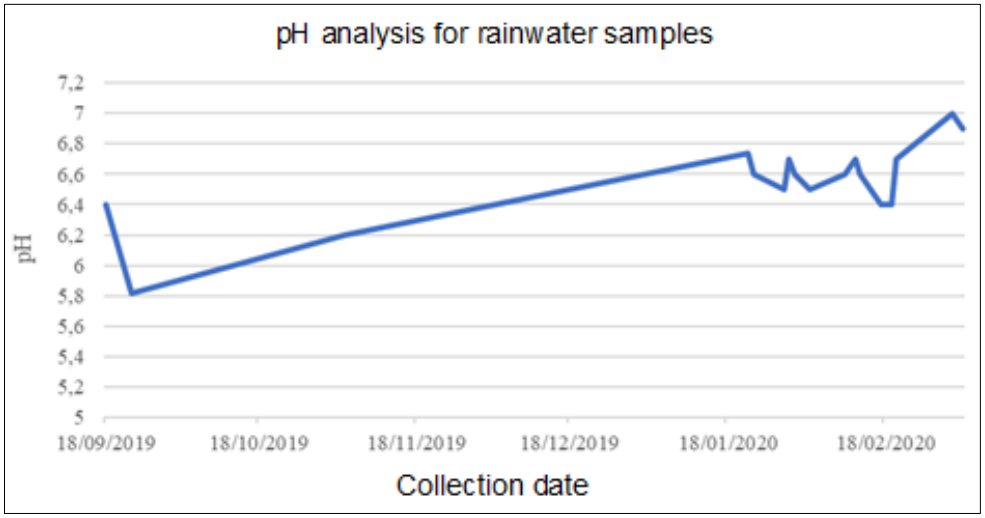
From the samples collected from both rainwater and drained water, Figures 1 and 2, which represent the pH variation line for different collection times, could be obtained, starting in September 2019, and ending in March 2020. It is noted that for rainwater the pH at the beginning was already below the neutral value, which is 7.0, and over the days it has become more acidic. Sometime later, this acidity characteristic decreased, until finally it remained close to the neutrality value, around 6.9. As for drained water, the initial pH was also below the neutral value, however, with the passing of days it became less acidic. After a few months, this characteristic remained, and compared to rainwater, it is further from the 7.0 reference value, remaining at 6.5.



Source: The Authors.

Fig 1: pH analysis for rainwater samples.

According to Gonzaga *et al*. (2014) [9], the formation of salt deposits in masonry and concrete occurs by the crystallization of salts from aqueous solutions, whose saturation can be reached because of solvent evaporation. Thus, it can be suggested that the speed of the winds that travel through the researched region is with a high percentage of gases emitted by vehicles and particulate materials from limestone derived from civil construction that, when in contact with water, result in the acidity of rain.



Source: The Authors.

Fig 2: pH analysis for drained water samples.

It was not possible to test the viability of the chloride samples, however, VACCARI *et al*., (2005) [10], COSTA *et al*., (2007) [11], JAQUES *et al*., (2006) [12] and Pinheiro *et al*., (2005) [13] reported that high levels of chlorides were not detected in the models.

As discussed in the paper, for rain to be considered acidic it is necessary that its pH is below the value of 5.6. According to the analysis period, the lowest value for rainwater was 5.82 and for drained water was 6.0. According to the literature, the values are not below 5.6 and according to the graphs above, it is noted, towards the end of the period of analysis that the values remained at 6.9 and 6.5, respectively. In a first conclusion, the analyzed samples do not constitute acid rain, however the values are not far from the limit considered for such statement. In parallel, there is the reality of the study site, which ranges from atmospheric pollution directly or indirectly, which can certainly contribute to the acidifying presence in rains from other periods.

Despite the values obtained from the samples collected, it is necessary that the monitoring and control of this situation be carried out, because although the rains for this location are not effectively acidic, they have a strong potential to become of this type, which could constitute serious environmental problems, such as altering the characteristics of the present ecosystems, social, such as respiratory diseases, skin corrosions, and cultural and economic, such as intensification of the corrosive process in historical monuments, building constructions, among others.

Conclusions

It is concluded that vast amounts of pollutant are entering the atmosphere, imposing threats to human health, degrading the environment, and possibly altering the Earth's climate. Historically, the air has been renewed through interaction with vegetation and oceans. Today, however, this process is threatened by the increased use of fossil fuels associated with the expansion of industrial production and the growing use of motor vehicles.

The physical-chemical analysis carried out cannot indicate a predominance of rain with high acidity in Bairro da Boa Vista, even though some results have shown slightly acid rains, however there is no evidence that confirms the frequent presence of this acidity in precipitations.

It was noticed a significant change in the ideal rainwater and the one observed in practice, this difference is possibly related to civil construction and high flow of vehicles present in the city of Recife more specifically about Boa Vista.

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