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Impacts of the Port Activities in Guarujá-SP, Brazil: Biological Monitoring as a Tool for the Assessment of Atmospheric Pollution

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ABSTRACT
Guarujá, a tourist city in Baixada Santista – SP that comprises the left bank of the Port of Santos, which plays a leading role as a lever for the country's economic development. However, because of its intense expansion, the city was surprised by an important logistical bottleneck for the flow of production, which generates intense congestion in the streets close to the port area. The lack of fluidity in traffic culminates in intense emission of gases and particulate matter (PM), resulting in increased of atmospheric pollution. Although the Environmental Company of the State of São Paulo (CETESB) is responsible for monitoring air quality, in Guarujá this monitoring is recent and has only one manual station. Vicente de Carvalho is the neighborhood where Porto is located and where, predominantly, its activities and negotiations take place. The population who lives in the place is around 150,000 inhabitants. Therefore, monitoring by CETESB is not representative of polluting activities. This research presents the concentrations of heavy metals that were determined, by an alternative method, which uses plants as bioindicators of pollution. Cadmium is a metal that is commonly present in the composition of diesel. Its concentrations in areas with intense movement of trucks were 155 times greater than those observed in regions without pollution. The diagnosis of pollution carried out in Guarujá has contributed to the understanding of the complexity of urban environmental problems, providing SEMAM with inputs for the formulation of public policies aimed at achieving fairer and more balanced socio-environmental conditions.

KEYWORDS: Guarujá – SP, Atmospheric Pollution, Biological Monitoring.

1 INTRODUCTION

The development of cities, although obviously necessary, has contributed to the intensification of anthropic activities with polluting potential, which results in the release of various chemical substances into the atmosphere, soil and water resources. Among these activities, the pollutants of the atmosphere that certainly stand out are the emissions from light and/or heavy motor vehicles, whose operations depend on fuels that present heterogeneity in their chemical composition and, consequently, emissions generated from contaminants in the environment (THEOPHILO et al., 2021). The contribution of vehicle emissions is quite pronounced in megalopolises and coastal cities, especially in those where port activities are being developed, as is the case of the municipalities of Baixada Santista, Santos and Guarujá, which include the facilities of the Port of Santos, the largest in America Latin (THEOPHILO et al., 2021).

Faced with the global concern about climate change, special attention has been given to evaluating some air quality parameters, since unplanned urban growth and the impacts of anthropogenic emissions have contributed to the increase of several diseases, such as respiratory, cardiovascular and allergic diseases (FERREIRA et al., 2017; MARTINS et al., 2021).

However, it is worth mentioning that the damage to air quality due to emissions from mobile sources was materialized in 1986, through the National Council for the Environment (CONAMA), which created the Air Pollution Control Program for Motor Vehicles - PROCONVE (Conama Resolution No. 18/1986). Among the main objectives of PROCONVE, the reduction and control of atmospheric contamination by vehicle emissions stand out. To this end, the program imposed certification of prototypes and vehicles, special authorization from the federal environmental agency for the use of alternative fuels, recall and repair of vehicles or engines found to be in non-compliance with production or design, and prohibited the sale of vehicle models. not homologated, according to criteria established by law (IBAMA, 2016).

Over the years, PROCONVE has been improved, encouraging innovation so that vehicles adapt to the most restrictive limits of emissions, a technical advance, both in relation to studies and laboratory tests, as well as in the part of vehicle production by automakers. Consequently, significant changes were observed in national technological standards, with investments of millions of dollars in research and technological development and technical training (IBAMA, 2016).

In 1993, PROCONVE's assumptions were reinforced with the enactment of Law No. 8723, whose main objective was to require the reduction of emission levels of atmospheric contaminants. The benefits of PROCONVE were estimated by Saldiva and André (2009), who indicated a 40% reduction in the concentration of pollutants between 1990 and 2005. In terms of quality of life, the authors state that the decrease, over the fifteen years, avoided 50,000 deaths, in monetary terms, savings of around US$ 4.5 billion in health expenses were observed, in addition to the reduction in energy consumption and the reduction of greenhouse gases (GHG).

Although there are no doubts about the positive impacts of PROCONVE after more than 30 years, the Ministry of the Environment - ME draws society's attention to some obstacles to the effective success of the proposal, which are verified on a local scale. City halls, municipal environmental departments and the Detrans face the difficult challenge of maintaining and improving the quality of the air breathed by the population, especially in cities with high levels of pollutants. For the ME, environmental agencies should implement perennial networks for the characterization and quantification of atmospheric contaminants from mobile and stationary sources, in addition to inspection/maintenance programs for vehicles and warnings of conditions compromising health. The ME also highlights the importance of investments to improve public transport and environmental awareness (IBAMA, 2016)

Among the country's environmental agencies, the Environmental Company of the State of São Paulo (CESTEB) stands out for its sophisticated "Air Quality Information System - QUALAR", with automatic and fixed networks, which guarantee the measurement of atmospheric conditions, in locations with different characteristics, so that the stations meet different monitoring needs, generating information about areas where high levels of pollutants are expected, the associated concentrations in places with higher population density, impacts on air quality due to anthropic sources, such as industries and vehicle fleet and average data on the concentration of pollutants in the atmosphere, considering the economic vocation and the regional characteristics of the physical space of the state's cities (CETESB, 2018).

The importance of QUALAR for urban and regional planning is clearly verified, especially in the Metropolitan Region of São Paulo (RMSP). In 2021, CETESB had 62 fixed automatic stations and one mobile station, which monitor 42 municipalities. Baixada Santista has 05 fixed monitors, 03 installed in the Industrial District of Cubatão and 02 in Santos. In the municipality of Guarujá, this monitoring is recent, it started in 2016, by means of only one manual station, which in 2021 registered an exceeding of the daily standard for PM_{10} (particulate matter fraction ≤ 10 μm); that is, it was above 120 $\mu g/m^3$. In this case, the concentration reached 153 $\mu g/m^3$ (CETESB, 2022).

On the other hand, one of the most important environmental bodies in the world, the United States Environmental Protection Agency (EPA), points out that air quality management systems are costly and sophisticated; therefore, in addition to a substantial budget, they require specialists trained in the use of sensors and data interpretation (SYNDER et al., 2013).

This implies that few cities in the world, especially those in underdeveloped or developing countries, will be able to maintain a robust monitoring network, where there is potentially polluting activity (RIBEIRO et al., 2017). As is the case of the municipalities of Baixada Santista, which despite having CETESB stations, these are not sufficient to monitor the levels of atmospheric contaminants from the fleet of heavy vehicles that serve the activities of the industrial center of Cubatão and the Port of Santos – the largest in Latin America, and are essential for transporting inputs to cargo terminals and other regions of the country (NEVES, 2015).

As an alternative to the lack of financial resources to establish an air quality program, since the beginning of the 2000s, the World Health Organization (WHO) considers biological monitoring as a low-cost and effective method to estimate the levels of contaminants in the air. air and its impacts on receptors. Living organisms such as plant leaves, lichens, mosses and tree bark are useful markers that allow relating to human exposure the risks caused by various air pollutants (WHO, 2012; FERREIRA et al., 2017).

Specifically in the case of Guarujá, the expressive participation in the Port of Santos, even though it directs significant financial resources to the city, culminated in impacts to the territorial organization, due to the congestion of trucks (Prefeitura Municipal de Guarujá, 2012). The intense flow of vehicles favors the enrichment of ozone precursors (O3) in the atmosphere, such as hydrocarbons (except methane), aldehydes, NO_x, $MP_{2,5}$ e MP_{10}. The latter, with high concentrations of heavy metals, such as cadmium – Cd, copper – Cu and lead – Pb; endangering the health of the population (CETESB, 2014). The panorama verified at the port/city interface reveals transformations in the urban space of Guarujá, which weaken the reach of planning and development guidelines foreseen in the Municipal Master Plan (Complementary Law 156/2013).

Faced with the intense contribution of vehicular emissions and the lack of a representative monitoring network for the area surrounding port activities, the main objective of this study was to determine, spatially, the levels of heavy metals in Vicente de Carvalho, the Guarujá neighborhood located on the left bank of the Port of Santos. For this proposal, the research made use of biological monitoring, with the bromeliad *Tillandsia usneoides* L., an aerial epiphyte species, which means that, with superficial roots, it can only support itself on tree trunks, to always reach the highest place, in an attempt to absorb all the nutrients it needs from the atmosphere. Therefore, in the same way as PM, T *usneoides* also retains pollutants that are present in the environment. In addition, its growth is slow and it does not have any contact with the soil; that is, in studies of quantification of chemical compounds, there is no doubt that they come from the atmosphere (CARDOSO-GUSTAVSON ET AL., 2016; THEOPHILO et al., 2021).

2 MATERIALS AND METHODS

2.1 Study Area

Guarujá – SP is part of the Metropolitan Region of Baixada Santista; it has an estimated population of 1.7 million people. On the national scene, Guarujá is certainly recognized for its tourist vocation, due to its natural beauties embedded in an island (with the shape of a dragon), with an area of 143 km² in extension, which houses 25 paradisiacal beaches. In addition, other cities in the Baixada have high tourist potential. As a result, the region, in periods of high season, which comprise the months of November to March, especially at the end of the year and Carnival, can have an increase of up to 50% over its total population.

This number becomes more worrying for the port cities, since there is a substantial increase in the vehicle fleet which, added to the already usual one that accesses the Port, means that, in the case of the Municipality of Guarujá, some premises of the Master Plan are neglected, namely: (ii) the economic development of the municipality and the socially fair and environmentally balanced use of its territory, in order to ensure the well-being of its inhabitants; (iii) the control or promotion of building density, considering the infrastructure capacity of each region and (iv) the guarantee of the quality of the urban environment with the preservation, protection and recovery of the natural and built environment, through effective monitoring and control pollution (air, water and soil) caused by human activities, among others (CITY HALL OF GUARUJÁ, 2012).

It is estimated that around 150,000 are directly affected by emissions from freight transport accessing the Port, whose left bank is entirely located in the Vicente de Carvalho District, a neighborhood of Guarujá where there is a predominance of residences and commercial activities. On the other hand, the local management itself emphasizes that the 10 port terminals and 08 port terminals generate about 5,000 job openings, for an estimated population of 324,977 inhabitants, in Guarujá - SP (IBGE, 2021).

Facing air pollution is a global challenge, which is why the engagement of local authorities is now seen as a primary task, as each municipality has its unique features. Accordingly, it is worth highlighting the role of urban treescape in minimizing the impacts of environmental pollution (NOWAK et al., 2018; MARTINS et al., 2021). However, a study pointed out by Benini and Godoy (2022) on the quality of urbanized public green areas - squares, gardens and urban parks - in contemporary cities, such as Cuiabá – MT, Brazil, revealed that the city lacks, not only in quantity, but also quality public spaces for leisure and recreation. This fact, according to the authors, denotes the absence of public policies aimed at urbanization and revitalization of existing green areas in the region.

On the contrary, the results of this research have already allowed the spatial mapping of contaminants, as well as associating them with the main emitting sources, and with future treatments of the results it will be possible to indicate the potential risks to the health of the population. Threfore, enabling the adoption, by SEMAM, of preventive measures with regard to the environmental control for the transport of inputs, through the strengthening of public policies in the form of sectoral agreements with the Port of Santos, through assemblies of the Municipal Council of Defense of the Environment, with an afforestation project in Vicente de Carvalho, which is already in progress (Process 0004731-98.2013.8.26.0223).

2.2 Biological Monitoring Stations in Guarujá - SP

As verified by the Secretariat for the Environment of Guarujá (SEMAM), for at least 07 years, the city has been suffering from the problem of cargo transport logistics. Congestion occurs on a daily basis, mainly on Rua Idalino Pines, Via Santos Dumont and Rodovia Cônego Domenico Rangoni (Figure 1). The problem intensified with the release of commercial vehicles to transport goods in the Port of Santos, in response to periods of super harvest.

The Cônego Domenico Rangoni Highway (or Piaçaguera-Guarujá) is one of the largest highways in the State of São Paulo. It starts at Rodovia dos Imigrantes; it is about 30 km long, allowing access from Guarujá to the Rio-Santos interchange; skirting the industrial center of Cubatão. It is also the main road on the left bank of the Port of Santos.

In the urban and residential perimeter, in Vicente de Carvalho, Rua Idalino Pines (better known as "Rua do Adubo") is the gateway for trucks to load or unload their inputs. Rua do Adubo is 1.5 km long. The so-called Ecoponto is located there, a patio with an area of 70,000 m², used as a stop so that trucks can be washed and can go to the supply terminals to transport the inputs to other regions of the country.

As Rua do Adubo is the main access to the port and the Ecoponto, most drivers who cannot find a space inside the courtyard end up parking in its surroundings, affecting vehicular traffic; for example, Avenida Santos Dumont, the main lane for urban traffic, which gives access to Avenida Perimetral on the left bank, with a length of 4 kilometers (HILSDORF and NOGUEIRA NETO, 2016). The impacts of the circulation of heavy vehicles are verified in the lack of mobility and in the well-being of the population that resides in Vicente de Carvalho (Figure 1).

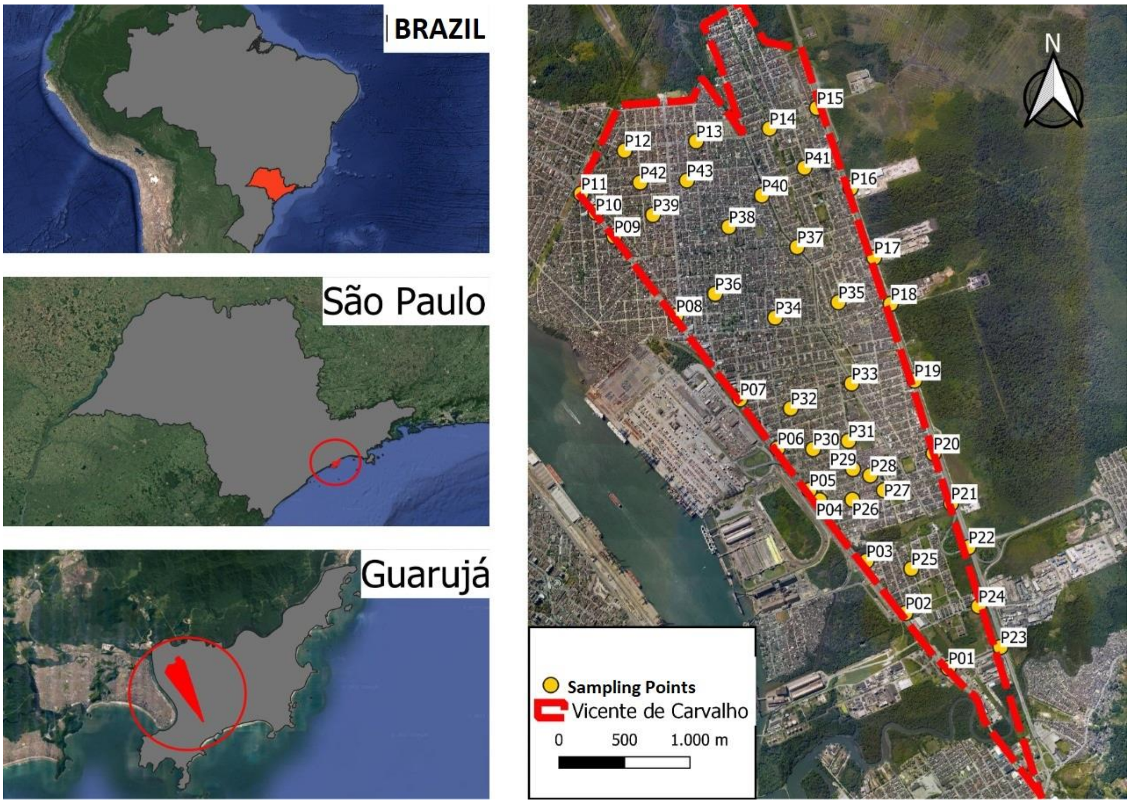
Figure 1 - Congestion caused by cargo transport in Vicente de Carvalho and around the left bank of the Port of Santos, Guarujá-SP.

Source: Images: google/Search (2019).

For biological monitoring in the Vicente de Carvalho District, plant samples were installed, throughout 2019, in strategic locations, whenever possible, maintaining homogeneous distances, totaling 43 sampling stations, each of them containing about 10 g of the bioindicator T. *usneoides* (the bromeliads were stored in nylon nets), arranged on tree branches, at a height of approximately three meters from the ground.

Each station had its coordinates recorded, using a GPS, using the Universal Transverse Mercartor System (UTM), Figure 2. The plant samples were exposed for up to two (being changed after this interval), considering dry periods and with greater rainfall index. As a control region (without pollution), the municipality of Cordeirópolis - SP was considered, where the plant nursery is located and there is no polluting activity.

Figure 2: Geographical location of the study area and bioindicator sampling stations.



Source: Authors (2022).

2.3 Chemical Analysis and Spatial Distribution of Pollutant Concentrations

The collected samples were stored in cellulose fiber packaging (cardboard) and transported to the Chemistry laboratory at UNINOVE, until preparation for quantification of the pollutants. In the next step, the samples were dried (until constant weight) in an oven with air circulation at 40°C, to prevent the loss of volatile elements. After this procedure, the samples were lyophilized without prior washing and ground in a vibrating mill until obtaining a fine and homogeneous powder.

0.6 g aliquots of Peach leaves bioindicators and reference materials, (SRM 1547) were accurately weighed into 15 mL centrifuge tubes, then transferred to teflon tubes and a mixture of nitric acid solution was added and hydrogen peroxide (10 mL de HNO_3 e 2 mL de H_2O_2). The samples were submitted to digestion in a digester block, according to protocol 3050 (USEPA, 1986). The clear and homogeneous solutions were analyzed using the Atomic Absorption Spectrometry (AAS) technique, on the Perkin-Elmer AAnalyst 800 equipment, belonging to the Neutron Activation Laboratory, Research Reactor Center, Institute for Energy Research and Nuclear (LAN/CRPq/IPEN).

In this work, the data obtained for the heavy metals Cd, Cu and Pb will be presented, considering the month of February (normally more humid) and July (normally drier), 2019. The choice of these elements is due to the fact that they are recognized tracers of vehicular pollution (FIGUEIREDO and RIBEIRO, 2015; CARDOSO-GUSTAVSON et al., 2016; THEOPHILO et al., 2021).

With the concentration database of each metal and the geographic coordinates of the sampling stations, spatial distribution maps can be prepared. The maps were generated in scale 1:1000, with Universal Transverse Mercator projection (UTM) and Datum SIRGAS 2000, 23S time zone in data processing in compliance with the official cartographic reference system (CHEN and LIU, 2012).

For a better visualization of the concentrations of the contaminants, the technique of interpolations by the inverse of the distance (IDW) was used, resource available in Q-Gis 3.20.3. This modeling allows estimating concentrations at unknown points from values at known points, generating a raster image in QGiS, with estimates made for all cells of this raster (CHEN and LIU, 2012).

3 RESULTS E DISCUSSION

Even being transplanted to areas with intense anthropic activity, the samples of T *usneoides* remained green and showed simple growth for the exposure period of one month. This quality is indicative that the plants maintained their physiological and metabolic characteristics to accumulate potentially toxic substances from the atmosphere, evidencing the ability to be used as a biomonitor (NOGUEIRA, 2006).

Table 1 shows the concentrations obtained for Cd, Cu and Pb. Data refer to samples exposed in January and collected in February, as well as exposed in June and collected in July (2019). The concentrations of heavy metals in the samples from Cordeirópolis (place without vehicle pollution) are also indicated.

Table 1 – Concentration intervals (minimum and maximum) obtained for Cd, Cu and Pb, considering the 43 sampling stations, in Vicente de Carvalho, Guarujá - SP, for the collections carried out in February and July 2019.

Collection Month	Interval	Cd (μg/kg)	Cu (mg/kg)	Pb (mg/kg)
	Minimum	44	6	1
02/2019	maximum	1.501	87	6
07/2019	Minimum	37	40	1
	maximum	5.430	118	18
Control Region (Cordeirópolis)		**35**	**45**	**0,5**

Source: Authors (2022)

The maximum concentration values determined in T *usneoides* indicate a significant enrichment of atmospheric contaminants, when compared with the levels in the control region, especially for Cd, whose levels were 155 times higher than those determined in Cordeirópolis.

Still referring to Cd, the samples exposed in February, the behavior in most collection points was consistent with places with significant contribution of vehicular and industrial emissions. The median for the data set (43 samples) was around 887 μg/kg. The observed content for the sample exposed at P28, located exactly at Ecoponto, represented the maximum value for the month; that is 1,501 μg/kg. The maximum concentrations observed for Cu (87 and 118 mg/kg) were observed at P35 and P25, respectively. In the analysis of the Cu dataset, for February the median was equal to 30 μg/kg; concentrations above 70 mg/kg were atypical and found, in addition to P35, only in P18. In July, the median indicated exactly twice the February concentration (60 mg/kg), with the highest concentrations (above 100 mg/kg), in addition to P25, only in P24. Regarding Pb, only P18 had a concentration above 10 mg/kg, as indicated in Table 1, for the month of July.

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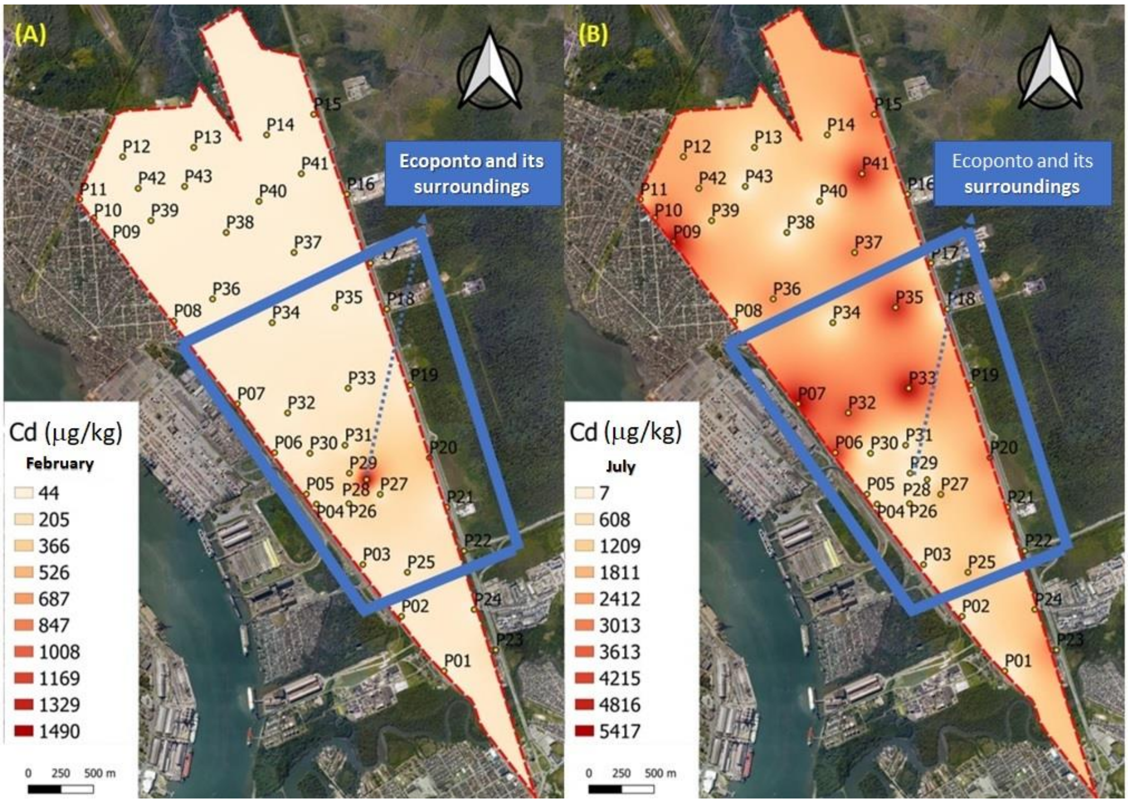
For a better visualization of the behavior of contaminants, in the representative area of Vicente de Carvalho, maps are presented with the spatial distribution of Cd, Cu and Pb concentrations, for February and July (Figures 3 to 5).

Figure 3 - Spatial distribution of Cd concentrations for exposed plants (Feb and Jul/2019) in Vicente de Carvalho, Guarujá-SP.



Source: Authors (2022).

Despite the minimum concentration of the metal in February being about 6.3 times greater than that of July; it is observed that at the collection points surrounding the Ecoponto (P28), the samples showed significant enrichment of the metal, regardless of whether the month was rainier (February) or dry (July), which, in a way, would explain the lower levels observed in Figure 3(A). Therefore, at most sampling stations Cd levels were above 350 μg/kg; that is, the bioindicator that in the Control Region presented a content of 35 μg/kg (Table 1), had a notable contribution as a source of the metal in the delimited area.

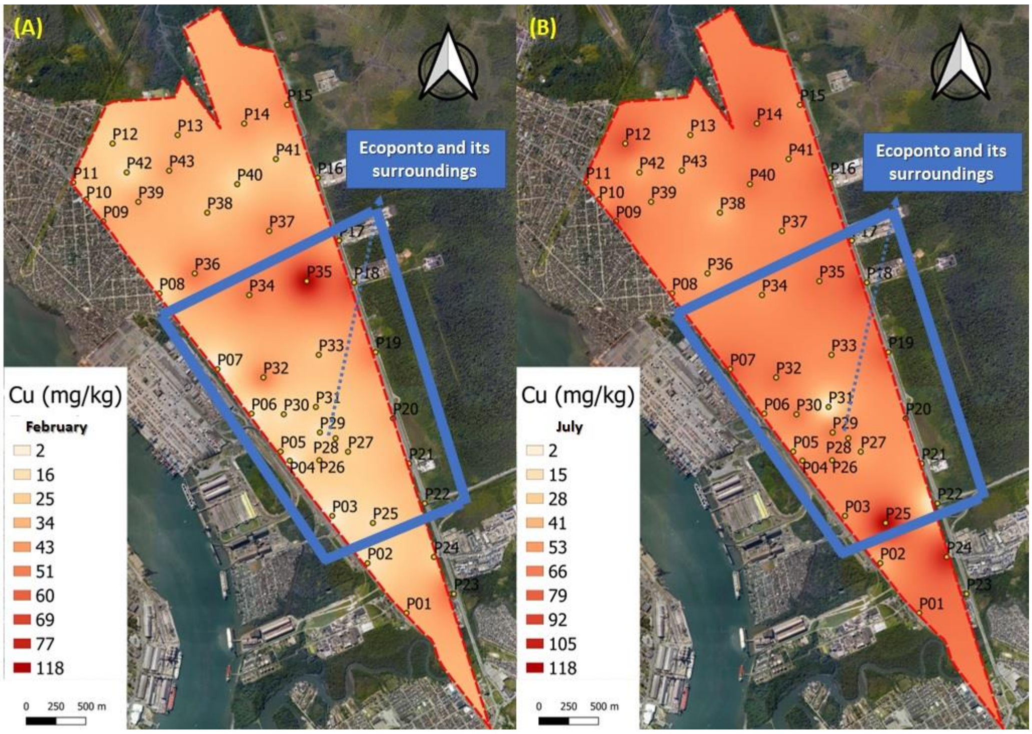
Although it is also part of the chemical composition of gasoline, according to Shukla et al. (2017) and Coufalík et al. (2019), Cd is a more efficient marker for diagnosing emissions from diesel engines, such as trucks and buses.

The results found for Cd draw attention because they exceed concentration values in previous studies, which also used T *usneiodes*, to assess air quality. Nogueira et al. (2006) reported values in the order of 1260 μg/kg in plant samples exposed on Avenida Marginal do Rio Pinheiros, where there is a predominance of heavy vehicle circulation. In studies by Viena et al. (2011), concentrations of around 800 μg/kg were determined in samples exposed in the neighborhood of Barra, in Salvador - BA and 230 μg/kg in the central region of Rio de Janeiro - RJ.

As already highlighted, Vicente de Carvalho is a residential neighborhood, with around 150,000 inhabitants and which, despite the presence of Porto, has commerce as its main economic vocation. Thus, the only polluting source to which the origin of the metal can be associated is the emission of PM by vehicles, essentially heavy vehicles. Therefore, the levels found up to 5.5 times higher (Figure 3B) than that verified by Nogueira (2006), in one of the most important avenues in the country, in a place that gives access to the southern section of the Rodoanel, must be analyzed by SEMAM as an alert to the health issues of the local population.

Regarding Cu, some authors indicate that the metal is one of the best vehicle emission tracers. It is present both in the chemical composition of gasoline (in greater quantity) and diesel (VIANNA et al., 2011; CARDOSO-GUSTAVSON et al., 2016). For this reason, although the metal has also shown a simple enrichment in its concentrations, when comparing the months of February (wetter) and July (drier), its spatial distribution is quite homogeneous, within the delimited area - the 43 sampling points of Vicente de Carvalho. Thus, what we observe in the Cu maps (Figure 4) does not allow us to distinguish the main source of PM contribution; that is, whether it comes from light vehicles (gasoline) or heavy transport (diesel), since the contribution of light vehicles is quite pronounced because it is a commercial district and that in its northern portion, located and the “Vincent de Carvalho Ferry”, which transfers light vehicles from Guarujá to the municipality of Santos.

Figure 4 - Spatial distribution of Cu concentrations for exposed plants (Feb and Jul/2019) in Vicente de Carvalho, Guarujá-SP.



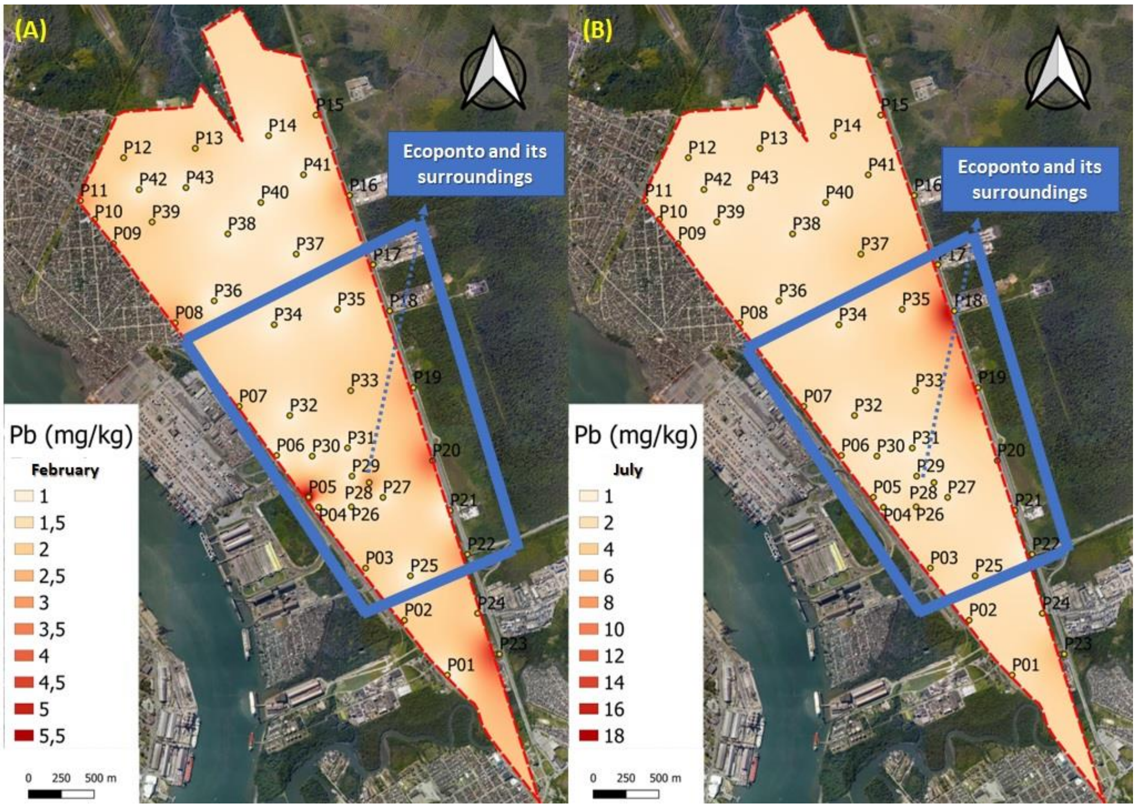
Source: Authors (2022).

In the case of Pb, as with Cu, a non-significant increase in its concentrations could be observed in the two months studied (Figure 4). It should be noted that among the most outstanding benefits of PROCONVE are the reduction of the sulfur (S) content in diesel oil and the removal of Pb from gasoline (SALDIVA AND ANDRÉ, 2009). According to Carvalho et al.

(2015), with the resurgence of the program over the years, vehicle emissions were reduced by 70%. On the other hand, perhaps such benefits are not felt in terms of air requalification, given that the number of motor vehicles has grown dramatically. For the specific case of trucks circulating in the RMSP, in 2006, there were around 1,500 units, in 2019, the fleet had around 5,000 units (RAKAUSKAS et al., 2020).

Although Pb is not used as a tracer for diagnosing pollution, the metal is usually quantified in studies on air quality, precisely as a way of corroborating the assumptions of PROCONVE; that is, concentrations above the values investigated in other studies of the same nature were not expected (CARDOSO-GUSTAVSON et al., 2016).

Figure 5 - Spatial distribution of Pb concentrations for exposed plants (Feb and Jul/2019) in Vicente de Carvalho, Guarujá-SP.



Fonte: Autores (2022).

4 CONCLUSIONS

From the quantification of airborne contaminants, as well as the geostatistical treatment of the data, it was possible to carry out an analysis on the spatial distribution of metals Cd, Cu and Pb, in the 43 sampling stations, arranged in the area of Vicente de Carvalho, a neighborhood belonging to Guarujá – SP, which houses - in its entirety - the left bank of the Port of Santos.

Pollution peaks – the highest concentrations of heavy metals – were observed in samples exposed at Ecoponto (P28) and its surroundings; that is, precisely on the streets where there is a predominance of heavy vehicle fleet. The quantification was done by means of an aerial bioindicator (*Tillandsia usneoides* L) that removes all its nutrients and water from the atmosphere. Like the PM, T *usneoides* maintains heavy metals from emissions from polluting activities in its composition. In the case of Vicente de Carvalho, the objective was to associate pollution with truck emissions and, consequently, with port activities.

For such findings, the study was based on the values of Cd concentration, considered a better tracer of emissions from diesel vehicles. Compared to the concentration of plants grown in Cordeirópolis - SP, the metal showed, especially around the Ecoponto, concentrations that were 43 times higher (in February) and 155 times higher (in July). In the control region, the average maximum concentration was 35 μg/kg.

O Cu que é reconhecidamente um ótimo traçador de emissões veiculares; contudo, para o propósito de nossa pesquisa, não se mostrou viável, dado que não permitiu a distinção entre a contribuição da poluição por veículos leves e a poluição por veículos pesados. Fato esperado, pois Vicente de Carvalho também conta com significativa emissões de veículos leves.

Cu, which is known to be a great tracer of vehicle emissions; however, for the purpose of our research, it was not feasible, as it did not allow the distinction between the contribution of pollution by light vehicles and pollution by heavy vehicles. An expected fact, as Vicente de Carvalho also has significant emissions from light vehicles.

The slight enrichment of Pb was consistent with the studies pointed out in the discussion; its determination is usually carried out with the aim of assessing whether the requirements determined by the premises of PROCONVE remain being fulfilled.

The diagnosis of pollution from freight transport carried out in Guarujá, more specifically in Vicente de Carvalho, has contributed to the understanding of the complexity of urban environmental problems, providing inputs to SEMAM for the formulation of public policies whose goal is to achieve socio-environmental conditions fairer and more balanced. That is, the quantitative data, together with the perception of the actors involved, such as the residents of the region, play the role of instruments to support the management and formulation of environmental public policies.

Since 2019, SEMAM has been planting trees throughout the City, in view of their importance for biodiversity, oxygen production and mitigation of the effects of atmospheric pollution. In addition, meetings are held with representatives of port companies, so that the sector is charged with social, environmental and economic responsibility. From this perspective, the scenarios for the creation of environmental public policies in Guarujá and the legitimation of the corresponding legislation must be constituted by conjunctural aspects between the Public Power and private actions. In the case of this study, it is expected that the Port of Santos contributes voluntarily, in partnership with SEMAM, for example, the execution of projects aimed at revitalizing public roads, which portray the municipal or even state political order, which constitutes an important object of reflection, since air pollution caused by motor vehicles is a challenge not only for Brazil, but for all countries around the world.

In addition to revitalization through the planting of trees, the survey also indicates other solutions that can be considered by SEMAM in improvement projects for Vicente de Carvalho, such as road reform to improve local traffic and, consequently, minimize pollution of the air in the region. Also relate the state of the art of public policies of environmental education, in private companies and public administration, and their challenges with the current trends of such policies, in a context beyond that presented here.

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