Brownfields in São Paulo City

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Abstract - Brownfields are a reality in the metropolis. Areas that have been contaminated by industrial activities, irregular waste deposits or toxic substances, are difficult to follow the changes in land use and occupation, familiar in the dynamics of society. Understanding the relationship between population shifts and use e occupation of urban land can help policymakers and planners ensure that cities remain economically productive and environmentally sustainable. Brownfields revitalization is an issue that has an essential role in The Sustainable Development Goal, as goal Sustainable Cities, and Communities. In this research, five districts on São Paulo city were chosen to analyse the contaminated areas and identify the percentage of revitalization e clean-up also considering the price of urban land and the number of the population residing in these districts. The results indicated that the process of revitalization and clean-up of contaminated land is happening in all five districts evaluated, in Santo Amaro the process is more evident. It is the same place where the price of the square meter is the most expensive and had the highest percentage of contaminated areas with confirmed risk. However, this revitalization process is different, given the essential factors of each district, as localization and zoning law. This difference means different answers on general public strategies to the revitalization of brownfields. So local studies can offer more instruments to policymakers.

Keywords: Brownfields, Revitalization, Urban Land Use, Sustainable Development.

1. Introduction

By 2015, nearly 4 billion people—54 percent of the world's population—lived in cities. That number is projected to reach 5 billion by 2030[1]. Rapid urbanization brings enormous challenges for the cities. When significant numbers of people move to urban areas, city boundaries typically expand to accommodate new inhabitants. Understanding the relationship between population shifts and use e occupation of urban land can help policymakers and planners ensure that cities remain economically productive and environmentally sustainable. Brownfields revitalization is an issue that has an essential role in The Sustainable Development Goal, more specifically in eleventh goal, Sustainable Cities, and Communities.

Discussions related to the identification of Brownfields, ways to manage them and revitalization they are contemporary themes and permeate the fields of environment, urban development, and public health. The term Brownfields is the antagonism to Greenfield. Brownfields are spaces, spots in the urban fabric as a result: contaminated by industrial activities, irregular waste disposal or storage of polluting substances and which, for these reasons, present difficulties in following changes in land use and occupation, as present in the modern dynamics of society. The term brownfield had its origin in a US law, the CERCLA (Comprehensive Environment Response, Compensation, and Liability Act), published in 1980, being conceptualized as "real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant"[2].

In Brazil, to refer to places where there is the presence of contaminating chemical substances, above the reference values previously established as safe, and due to anthropic activities in the soil, such as to limit the use of this environmental resource, either for current use or intended is used the denomination of contaminated area[3], [4].

The city of São Paulo, located in the southeast region of Brazil, in the state of São Paulo, has an area of 1,521.11 km² and a population of approximately 12,106,920 inhabitants with a population density of 7,398.26 hab/km² [5]. Of the 31 megacities in the world, that means cities with 10 million or more inhabitants, in 2016, 24 are located in less developed regions or in the "global south". In this ranking, the metropolitan region of São Paulo occupies the fifth position[6]. Currently the city has 2,148 contaminated areas. In 448 places, occurred or is planned the reuse of contaminated areas[7], this means a change of use trend in the occupation of deactivated areas, considering that these areas are, in the majority, destined to the construction of real estate projects. However, the way in which the revitalization happens around the city is not so evident.

The aim of this research is to understand the local revitalization and clean-up process connected to brownfields, so five districts in São Paulo, located in different regions, has analysed, about the total contaminated areas and the percentage of revitalization also considering the price of ground and the number of population residing in these districts.

2. Material and Methods

For this study, were chosen five districts by São Paulo city to analyse the contaminated areas and identify the percentage of revitalization e clean-up, using public data of the Report of Contaminated and Remediated areas in São Paulo state[8], published by Environmental Agency of São Paulo state (*Companhia Ambiental do Estado de São Paulo*-CETESB). Each district is located in a different region of the city. The districts selected were Santo Amaro (south region), Butantã (west side), Casa Verde (north region), Aricanduva (east side) and Cambuci (district central). The number of inhabitants per district was obtained by the Statistical Portal of the State of São Paulo, maintained by the government of the state of São Paulo[9]. As for the data of the total area of each district, the information of the prefecture of the city of São Paulo was used[10]. Concerning the average price of the square meter in the selected districts, the values were extracted from the FIPE ZAP Index of Prices of Real Estate Announced. Indicator with national coverage that accompanies the sale and lease prices of real estate in Brazil. The index is calculated by the Foundation for Economic Research (*Fundação Instituto de Pesquisas Econônimcas*- Fipe) based on data published in a portal of Real Estate and other Internet sources [11]. About zoning applied for studied places were used a framework with georeferencing data by prefecture on São Paulo[12]. To elaborate the images of the districts and the contaminated areas, the Paulista Environmental System, a tool with georeferenced data provided by the São Paulo State Government, was used[13].

3. Results and Discussion

The Table 1 then shows the located data of the size of districts, inhabitants, the price of the square meter, total of contaminated and remediate areas, total of clean-up areas, the percentage of clean-up for districts and number of the reutilized places or in process.

Table 1: Data of districts.

District	Inhabitants[9]	Area in Km²[10]	Price of m²[11]	Contaminated areas[8]	Clean-up areas[8]	Percentage of clean-up areas	Reuse places[8]
Aricanduva	86,501	6.60	R$ 4,718.00	16	4	25%	4
Butantã	53,970	12.50	R$ 5,965.00	26	7	26.92%	3
Cambuci	40,049	3.90	R$ 6,878.00	28	6	21.43%	11
Casa Verde	86,009	7.10	R$ 6,927.00	17	4	23,53%	3
Santo Amaro	74.139	15.60	R$ 8,242.00	80	26	32.50%	34
Total	340,668	45.70	R$6.546,00 (average)	167	47	28,14%	55

According to the results, it is possible to identify that revitalization process of brownfields is happening in all the districts analysed. However, specifically in Santo Amaro the process is more evident. Is the same place where the price of the square meter is the most expensive. This fact was observed in other study [14]. Another relevant data is the values of the last column of Table 1, these values represent places who have a different occupation than the cause of pollution. In some cases are not complete the remediation process, but exist a kind of occupation, like parking, trading or residences.

Figure 1 represents information about the type land use, which caused contamination in the districts analysed.

Polluter Activity x Number of Contaminate Land

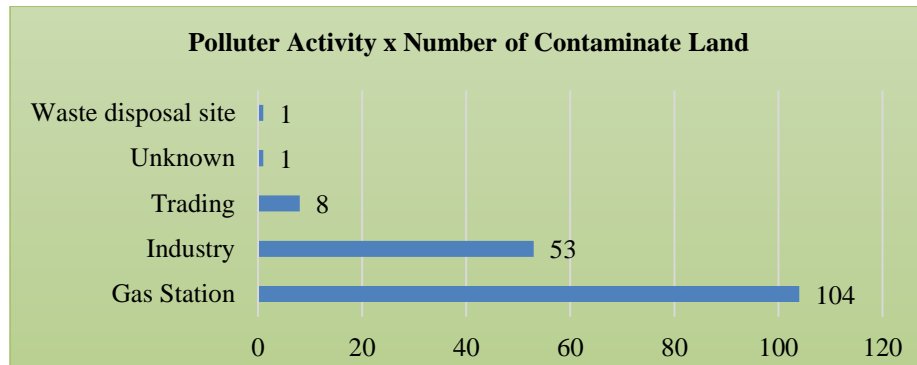| Polluter Activity	Number
Waste disposal site	1
Unknown	1
Trading	8
Industry	53
Gas Station	104

Fig. 1: Polluter Activity.

When the environment agency of São Paulo publishes the Report of Contaminated and Remediated areas, it is also published a document with analysis for significant sources of polluted in the state, for the capital (São Paulo) and other regions in the state. In this report, it is possible to identify that the most polluting activity is the gas station, has 1,579 places, with a percentage of 73.5% of total brownfields[7]. These results are typical because the laws for identify and manager this areas is more consolidated[15]. Nevertheless, when looking to locally, the results of this research (Figure 1), is possible noted a variation of this values in the districts observed. The result for the gas station, in all the five districts, was 62%. About the principle environmental compartments affected in studied places, figure 2 has the results found.
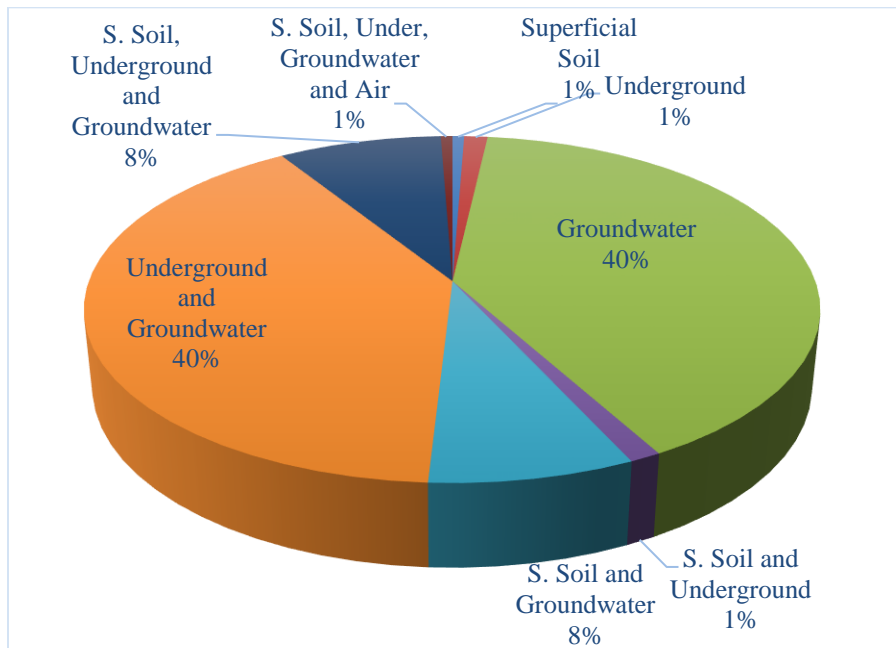
Fig. 2: Environment compartment affected.

Groundwater is the most environment compartment affected in 167 areas analysed. This issue is significant because access to an essential resource like water could become scarce. In the State of São Paulo, currently, approximately 80% of the municipalities are supplied entirely or partially by groundwater[16]. The existence of many areas contaminated can impair the use of groundwater to supply public even though in many cases the contamination does not reach deep aquifers[17], is still a relevant question to concern.

Was observed reutilization in 55 places according to Table 1. The principal reuse observed in this places studied is offices and trading following the residential use, as evidenced in Figure 3.
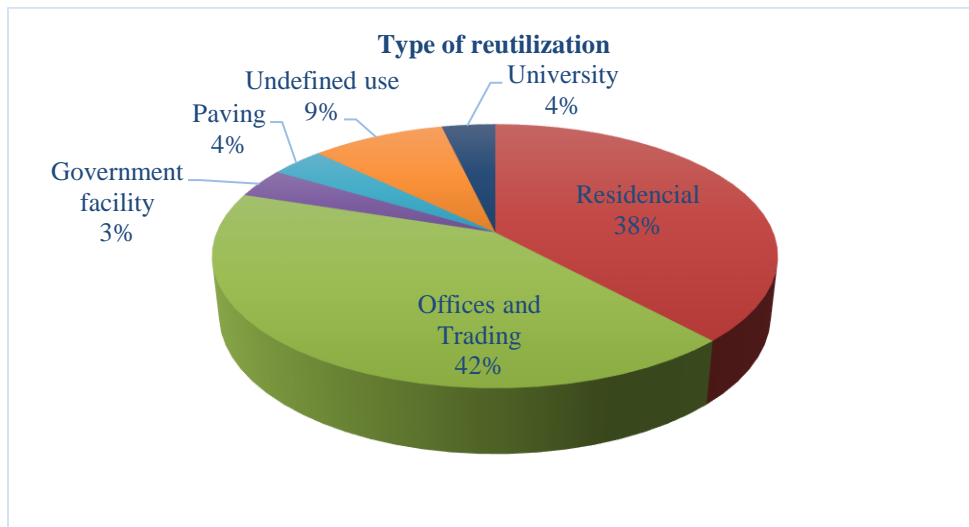

Fig. 3: Type of reutilization.

The next data, in Figure 4, are about the number of brownfields with confirmed risk, considering the districts separately.
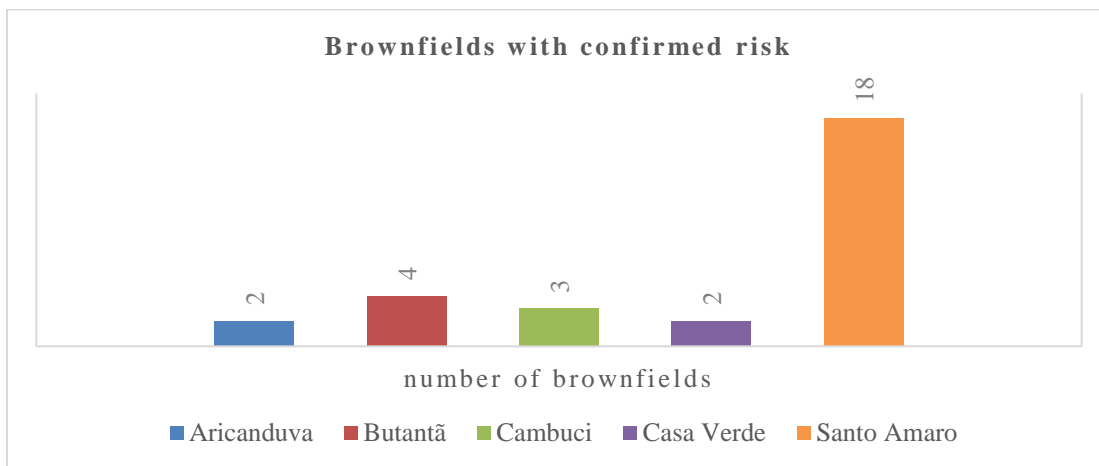

Fig. 4: Brownfields with confirmed risk.

Figure 4 evince the district of Santo Amaro has the most number of brownfields with confirmed risk. This value means 22.5% places with a confirmed risk of the total contaminated land identified in the district according Table1, and this result is exceedingly relevant from public health ambit.

3.1. District of Santo Amaro

Santo Amaro, according to Table 1, has the most contaminated district. Although these results was expected, Santo Amaro is a historic industrial district of São Paulo. Also has the most percentage of clean-up areas. Currently the district, according to the zoning law[18], is a well-diversified place, and has two large areas. First a predominantly residential area and a second wich mixed areas: territories of transformation whose objective is the constructive density, population and economic activities and public services, areas of economic development, aiming at the maintenance of existing non-residential uses. The following, Figure 5, shows the distribution of the contaminated areas on the district.
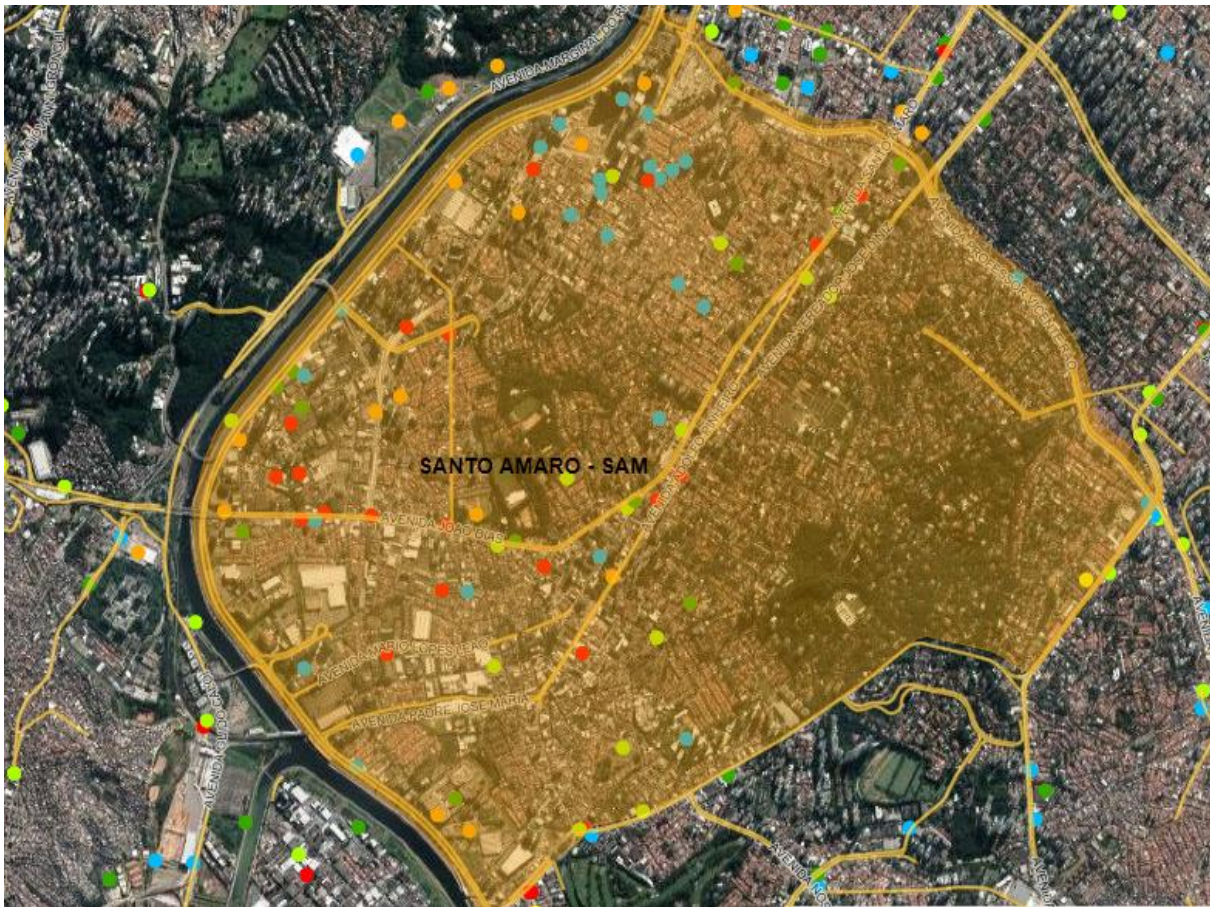
Fig. 5: Contaminated land in Santo Amaro.

Through figure 5 the residential zone and the mixed zone of the district of São Amaro are readily distinguishable. Contaminated and remediated areas are predominantly located on the left side of the image, while the residential area is located to the right. Given the mixed district character, is understandable the data referring to population density, of 4,317.60 inhabitants/km^2 the second lowest of the studied districts. It is also important to note how this district is transforming. Of the 80 contaminated areas present in the district, 33 are from industries, while 42 are fuel stations. This relationship between the number of areas coming from industries and gas stations is significantly different from the data identified in the city of São Paulo and looking at the data set of the 05 districts evaluated.

3.2. District of Butantã

District of Butantã has the second best relation between the brownfields number and the percentage of remediated areas. It has predominantly residential and commercial areas[18]. It is where the University of São Paulo located. Of the 26 contaminated areas, four have a confirmed risk; this means 15% of the total. The district follows the trend of the city; the origin of the contaminated areas is essentially gas stations.

3.3. District of Cambuci

The Cambuci district is in second place in the number of brownfields. According to Table 1, there are 26 areas. However, it has the lowest percentage of remediated areas in the districts evaluated, 21.43%. It is one of the oldest districts of the city of São Paulo and has an industrial tradition. Nowadays, it has a zone of qualification territory (maintenance of existing non-residential uses, promotion of productive activities and diversification of uses) and transformation territories (promotion of population density, economic activities, and public services)[18]. Unlike the trend of the city of São Paulo and the results of another historically industrial district, Santo Amaro, in Cambuci the number of contaminated areas from industrial activity

is higher than by gas stations. There are 12 areas derived from gas station for 14 to industries. Figure 6 illustrates the district and the contaminated areas.

Fig. 6: Contaminated land in Cambuci.

3.4. District of Casa Verde

Casa Verde district is the second in population density, 12,113.94 inhabitants/km². It is a mixed district, with predominantly residential areas, although most are composed of mixed zones and central zones, where diversification of uses or moderate population density is sought[18]. It follows the reality of the city, in which the primary cause of the contamination is the gas stations, 15 places. Relevant information identified in the analysis of this district is that all areas reused, three places, were appropriately remedied.

3.5. District of Aricanduva

The district Aricanduva is the most densely populated 13,106.21 inhabitants/km² and has the lowest price per square meter of the districts evaluated. It is a necessarily mixed district, including predominantly industrial areas and spaces where purpose is population density, economic activities, and public services. Also aims to maintain non-residential uses and foster productive activities[18]. As the Casa Verde district has all the reused areas adequately remediated, 4 areas, means 25% of the total contaminated areas identified in the region. Gas stations are also the most significantly responsible for contaminated

in this district, with 11 places. In this district, of the 16 identified areas, 10 are in the process of clean up or monitoring to evaluate the efficiency of the remediation process. Figure 7 exhibit the district and the brownfields.

Fig. 7: Contaminated land in Aricanduva.

4. Conclusion

The results indicated the process of revitalization and clean-up is happening in all districts evaluated, in Santo Amaro the process is more evident. It is the same place where the price of the square meter is the most expensive and had the highest percentage of contaminated areas with confirmed risk. However, the dynamic of revitalization process is different around the districts, and this is expected, given the essential factors of each district, as localization and the zoning law how can also be observed in this research. The data also showed that environment compartment more affected is Groundwater. The existence of many areas contaminated can impair the use of groundwater to supply public. Recognize the reality of the city is quite important to create comprehensive public policy. Local studies are essential because, in a big city as São Paulo, the districts can present different realities, originated on owner place history of land use and occupation, like Santo Amaro and Cambuci, two typical industrial districts, evaluated in this research. This difference means different answers on general public strategies to the revitalization of brownfields. Is necessary consider and understand aspects, like which places need more control in the revitalization process to ensure that the project of clean-up can be completed or what districts have more contaminated land with confirmed risk and how this can affect the public health. To build a Sustainable city that can organize, optimize own space, and offer safety to inhabitants should necessarily use the available data about brownfields and create analysis to support, as local studies, for offering more instruments to policymakers.

Acknowledgements

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