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Depollution of urban rivers for transport purposes: the Tietê and Pinheiros Rivers as an alternative to road freight transport

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Abstract

Objective: To relate the recovery of the main rivers in São Paulo city with the impacts on its urban mobility through ports and river transport routes.
Method: A documental research of the main data (trace, width, depth and location) and a bibliographical survey of the main researches on the theme in articles, theses and reports issued, mainly, by public organs such as CET (Traffic Engineering Company), Government of the State of São Paulo and IBGE (Brazilian Institute of Geography and Statistics) were carried out.
Originality/Relevance: The paper in question becomes relevant due to the fact that it analyzes an alternative to solve the problem of urban mobility from a different perspective: integrating the well-known rivers that cut the urban environment of São Paulo in order to take advantage of their hydric potential.
Results: From the information gathered, it was possible to elaborate a strategic plan identifying possibilities for the installation of intermodal cargo terminals, besides verifying which vessels could be used.
Social/Management Contributions: São Paulo's management constantly seeks to find solutions to the negative impacts of disorderly urbanization on the city's infrastructure and urban mobility, in addition to the problems of polluting its rivers. Evaluating the restoration of rivers in the region from the perspective of using them as an alternative to already saturated roads can bring benefits in various government spheres, in addition to improving the quality of life of the population of São Paulo.

Keywords: São Paulo City. Urban mobility. Depollution of rivers. Tietê River. Pinheiros River.

Despoluição de rios urbanos para fins de transporte: os Rios Tietê e Pinheiros como alternativa ao transporte rodoviário de cargas

Resumo

Objetivo: Relacionar a recuperação dos principais rios da cidade de São Paulo com os impactos em sua mobilidade urbana por meio de portos e rotas de transporte fluvial.

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Método: Realizou-se uma pesquisa documental dos principais dados (traçado, largura, profundidade e localização) e um levantamento bibliográfico das principais pesquisas voltadas ao tema em artigos, teses e relatórios emitidos, principalmente, por órgãos públicos como CET (Companhia de Engenharia Tráfego), Governo do Estado de São Paulo e IBGE (Instituto Brasileiro de Geografia e Estatística).
Originalidade/Relevância: O trabalho em questão torna-se relevante pelo fato de analisar uma alternativa para solucionar o problema da mobilidade urbana sob uma perspectiva diferente: integrar os tão conhecidos rios que cortam o ambiente urbano paulistano de modo a aproveitar seu potencial hídrico.
Resultados: A partir das informações levantadas, foi possível elaborar um plano estratégico identificando possibilidades de instalação de terminais intermodais de cargas, além de verificar quais embarcações poderiam ser utilizadas.
Contribuições sociais/para a gestão: A gestão paulistana constantemente busca encontrar soluções para os impactos negativos da desordenada urbanização na infraestrutura da cidade e em sua mobilidade urbana, além dos problemas de poluição de seus rios. Avaliar a restauração dos rios da região sob a ótica da utilização destes como uma alternativa às vias já saturadas pode trazer benefícios em diversas esferas governamentais, além de trazer melhoria da qualidade de vida à população de São Paulo.

Palavras-chave: Cidade de São Paulo. Mobilidade urbana. Despoluição dos rios. Rio Tietê. Rio Pinheiros.

Descontaminación de ríos urbanos con fines de transporte: los Ríos Tietê y Pinheiros como alternativa al transporte de carga por carretera

Resumen

Objetivo: Relacionar la recuperación de los principales ríos de la ciudad de São Paulo con los impactos en su movilidad urbana a través de puertos y rutas de transporte fluvial.
Método: Se realizó una investigación documental de los principales datos (traza, ancho, profundidad y ubicación) y un levantamiento bibliográfico de las principales investigaciones enfocadas al tema en artículos, tesis y informes emitidos, principalmente, por organismos públicos como CET (Empresa de Ingeniería de Tránsito), Gobierno de la Estado de São Paulo e IBGE (Instituto Brasileño de Geografía y Estadística).
Originalidad/Relevancia: El trabajo analiza una alternativa para resolver el problema de la movilidad urbana desde una perspectiva diferente: la integración de los conocidos ríos que atraviesan el entorno urbano de São Paulo para aprovechar su potencial hídrico.
Resultados: A partir de la información recabada, se logró elaborar un plan estratégico identificando posibilidades de instalación de terminales intermodales de carga, además de verificar qué embarcaciones se podrían utilizar.
Contribuciones sociales/de gestión: La gestión de São Paulo busca constantemente soluciones a los impactos negativos de la urbanización desordenada sobre la infraestructura y la movilidad urbana de la ciudad, además de los problemas de contaminación de sus ríos. Evaluar la restauración de los ríos de la región en la perspectiva de utilizarlos como una alternativa a las carreteras ya saturadas puede traer beneficios en diversas esferas de gobierno, además de mejorar la calidad de vida de la población de São Paulo.

Palabras clave: Ciudad de São Paulo. Mobilidad urbana. Descontaminación de ríos. Río Tietê. Río Pinheiros.

Introduction

Urbanization is characterized by an intense process whereby the urban population grows at a higher rate than the rural population. It is a phenomenon consequent to the growth and development of cities around the world, which began in developed countries from the British agricultural and industrial revolutions at the end of the 18th century. The unprecedented growth of the urban population occurred throughout the 19th century, both through continuous migration from the countryside to the city and due to the demographic expansion that occurred at the time.

The accelerated urbanization of the Metropolitan Region of São Paulo (RMSP) was extremely important during the 20th century, as the economy developed based on the expansion of industries. This phenomenon provided greater job offers, thus increasing the population of the city. Despite its economic importance, the region suffered negative impacts during the process: pollution (noise, air, soil, and water), violence, social inequality, lack of housing, and impaired urban mobility, among others.

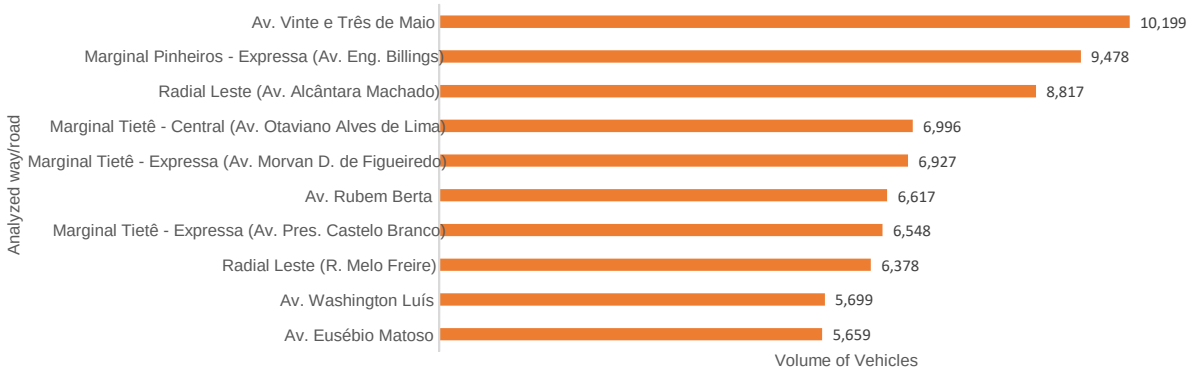
According to Pishue (2020), the city of São Paulo occupied the 24th position among the cities with the most congestion in the world and the 5th in Latin America, in 2019. The report analyzes congestion and mobility trends in 38 countries and 200 cities to provide data to improve urban mobility.

Like many other urban centers around the world, the public authorities in São Paulo city are constantly looking to find measures to solve the negative impacts of urbanization on its urban mobility. The RMSP presents an urban dynamic of incessant movement, with a worrying relationship between the number of vehicles and the roads available for circulation. According to data from the Brazilian Institute of Geography and Statistics [IBGE] (2021), the city of São Paulo had approximately 8.9 million vehicles for an estimated 12.4 million inhabitants, resulting in 7.2 vehicles per every 10 inhabitants, almost one vehicle per inhabitant. This amount of vehicles per inhabitant overloads roads that do not support this excessive number daily.

In addition to urban mobility policies, policies to restore the water resources of the main rivers of the largest metropolis in Latin America constitute one of the great challenges for the government. The Tietê and Pinheiros Rivers are part of São Paulo's everyday life, and their marginal ways are among the most important roads in the metropolis. According to the Report on the Main Road System by the São Paulo city Traffic Engineering Company [CET] (2019), the marginal ways are second only to Vinte e Três de Maio Avenue in the volume of vehicles at peak hours, both in the morning and the afternoon, with stretches with a volume close to ten thousand vehicles per hour, as can be seen in Figures 1 and 2.

Figure 1

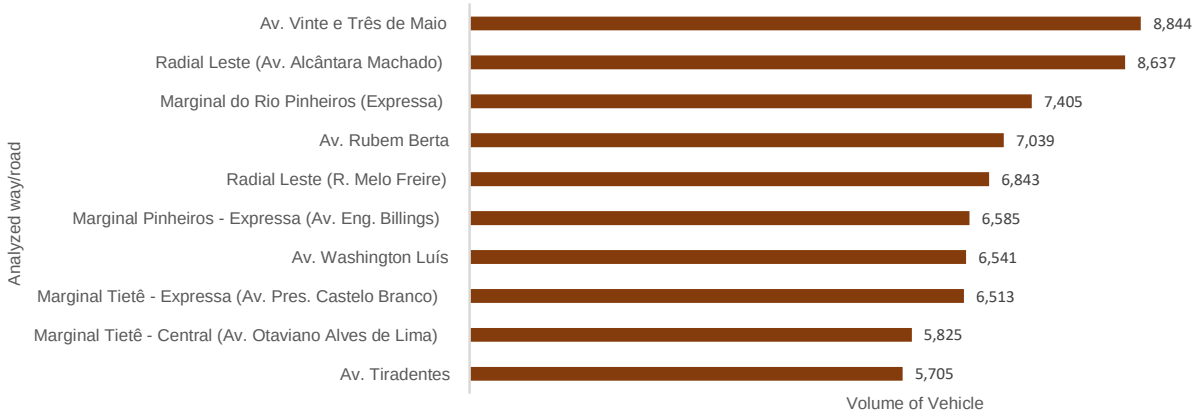
Ways with the highest volume of vehicles in São Paulo city, 2019 – Morning



Source: CET (2019)

Figure 2

Ways with the highest volume of vehicles in São Paulo city, 2019 – Afternoon



Source: CET (2019)

Those who live in São Paulo know that, before leaving home to work or crossing an avenue/a marginal, it is necessary to consult the traffic situation in real-time. For this reason, it is necessary to assess the spatial situation of the city in terms of mobility and what are the possible ways to solve the related problems.

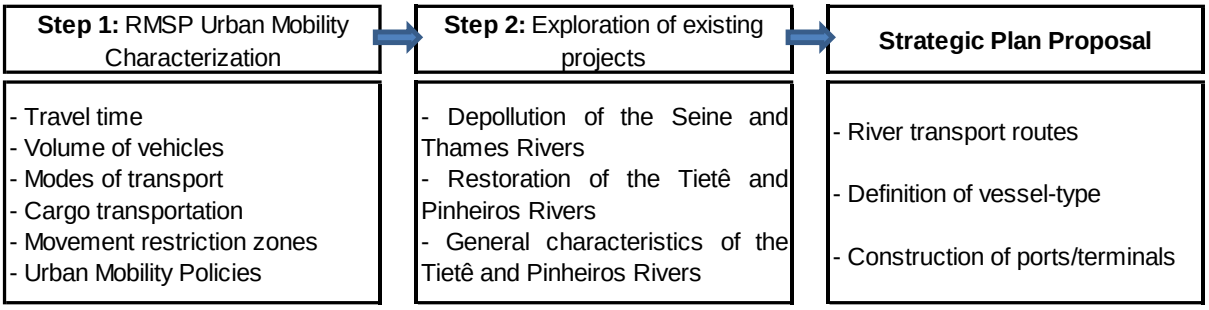
Based on these problems present in the daily life of the city of São Paulo, evaluating the restoration of rivers in the region from the perspective of using them as a means of transport can bring benefits related to sanitation (providing universal access to the sewage collection network), landscaping (improvement of the city's landscape through the revitalization of rivers) and urban mobility (use of rivers as a transport option).

Methodology

This paper was developed from two main aspects of analysis: urban mobility and recovery of water from urban rivers. Figure 3 shows a summary of the procedures that will be detailed below.

Figure 3

Research procedures



The first perspective was explored from an analytical viewpoint of the Metropolitan Region of São Paulo, to characterize urban mobility in the region. For this, data was collected from research on this topic in articles, dissertations, and reports issued mainly by public bodies such as CET, the Government of the State of São Paulo, and IBGE. Considering the exploratory nature of the work, the purpose of data collection is to superficially characterize the urban mobility of the RMSP in terms of travel time for displacements on the main roads, analysis of vehicle volumes, the modes used, the transport of loads on the roads, the zones restrictions within the city and urban mobility policies implemented in the city, among others.

The second perspective was explored through studies of projects in rivers in other countries, the general characteristics of São Paulo city rivers, and the history of projects for their recovery. Studies on other rivers demonstrate the challenges, planning, and water benefits of urban river clean-up projects carried out around the world, such as the River Thames and the River Seine. In addition, they serve as a basis for analyzing the rivers in São Paulo city, after all, one must understand how successful projects can fit into the reality of the city. For this, a survey was carried out of the layout of the rivers, width, depth, and location within the RMSP to identify the possibility of installing intermodal cargo terminals and verify which vessels can be used in the channels, to replace part of the flow of trucks on the marginal ways.

For this, a strategic plan was developed that consists of the construction of ports and river transport routes along urban rivers. The conception of this plan considered several aspects such as the analysis of the characteristics of the rivers, the vessel to be used based

on the vessels used on the Seine River, the routes to be traced respecting the design of the rivers, the materials to be transported considering that the transport river is slower and that the products do not have the need to reach their final destination quickly and the places that the ports would be installed considering the location of the main roads of the RMSP to facilitate the exchange between modes. Thus, it was possible to determine a connected system of canals within the city of São Paulo connecting the main avenues for the disposal of products such as horticultural products, urban waste, rubble, earth, recycling materials, aggregates from civil construction, and sediments.

Table 1 summarizes the main documents used to prepare the strategic plan proposed in this article, identifying the bodies consulted and the justification for their surveys.

Table 1

Documents consulted in public bodies and justification for their study

Document	Public body	Justification for study
Maximum Circulation Restriction Zone Map	CET	• Identification of the circulation zone for commercial vehicles in the city of São Paulo
Mobility in the Main Road System: Volumes and Speed	CET	• Survey of the volume of vehicles on the main ways of the city of São Paulo • Identification of ways in São Paulo with the highest vehicular flow • Definition of the river transport route • Determining the location of ports
Vehicle fleet research	IBGE	• Consult the vehicle fleet history of the city of São Paulo • Vehicle volume identification by category
Integrated Water Resources Management System Portal of the State of São Paulo	Government of the State of São Paulo	• Survey of São Paulo city rivers characteristics (location, route, depth, width, extension)
Rodoanel Mario Covas (Mario Covas Beltway). Transport for Sustainable Development.	DERSA	• Estimate of truck traffic volume in the RMSP
Transport Information Databank	Ministry of Infrastructure	• Identification of the main accesses (roads) to the RMSP • Determining the location of ports

General characteristics of São Paulo city rivers

To verify the water potential of the Tietê and Pinheiros Rivers, it is first necessary to analyze the characteristics of the rivers in terms of width, depth, average speed, and flow, as these attributes allow measuring which vessels could navigate through their waters.

According to data from the Government of the State of São Paulo (Governo do Estado de São Paulo, 2022b), the two rivers are between 60 and 100 meters wide, depending on the stretch. In the RMSP, this width was established after the rectification works and the subsequent implementation of the marginal ways.

As for the depth, in the first 30 centimeters, there are still stretches with oxygen for very little fish. The next two meters are made up of polluted water, full of waste forming a kind of toxic sludge that moves slowly. The last five meters are a gigantic garbage dump. In this way, the Tietê hides, seven meters deep, refrigerators, sofas, and car wrecks (ONG Mãe Natureza, 2014).

The Tietê River is one of the main Brazilian rivers and crosses the State of São Paulo. With a length of 1,100 kilometers, the river rises in the municipality of Salesópolis, at an altitude of 1,030 meters, covering practically the entire length of the State until it reaches its mouth on the Paraná River, located in the municipality of Itapura, on the border with Mato Grosso do Sul State (Oliveira, 2015). The Tietê River comprises 62 municipalities in São Paulo, and its basin comprises six drainage sub-basins (UGRHIs): Alto Tietê, where the RMSP is located; Piracicaba; Sorocaba/Médio Tietê; Tietê/Jacaré; Tietê/Batalha; and Baixo Tietê.

The Alto Tietê Basin (UGRHI-6) is defined as the area that covers the source of the Tietê River to the region of Pirapora do Bom Jesus, passing through the RMSP. With more than five thousand square kilometers, the area is home to 40 municipalities, 19 of which are fully included in the UGRHI-6 (Comitê da Bacia Hidrográfica do Alto Tietê, 2009).

From 1937 onwards, João Florence de Ulhôa Cintra, an engineer and urban planner for the City of São Paulo, was responsible for the studies and project for the rectification of the Tietê and Pinheiros Rivers, called "The Cintra Project". The project was carried out between the 1950s and 1960s, providing for the channeling and deepening of four meters of the Tietê River in the section between Guarulhos and Osasco, that is, in the stretch of river that is within the municipality of São Paulo (Pessoa, 2019).

The Tietê rectification work was carried out with public funds. The floodplain area, which was previously uninhabited due to the floods, was, over time, used for projects of public interest, such as the Tietê Bus Terminal, access to bridges, and the Anhembi Convention and Event Center (Pessoa, 2019).

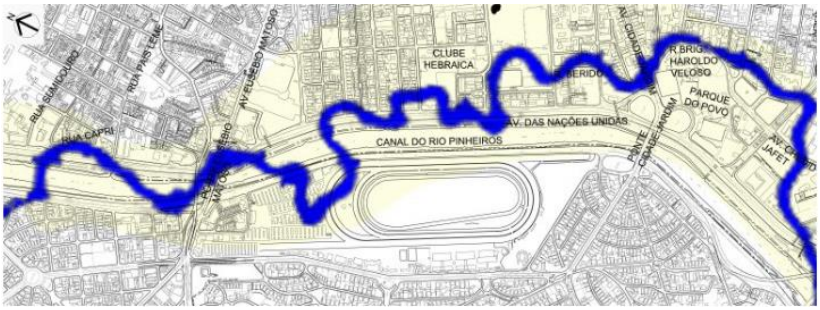
On the other hand, the Pinheiros River is a Brazilian river that cuts through the city of São Paulo, originating at the meeting of the Guarapiranga River with the Grande River and having its mouth on the Tietê River. In colonial times, the Pinheiros River was called Jurubatuba, which in Tupi means “place with many jeriva palm trees”. With the arrival of the Jesuits, it started to be called Rio Pinheiros, because of the large amount of araucarias (or Brazilian pine) that covered the region (Governo do Estado de São Paulo, 2022a).

The Pinheiros River is only 25 kilometers long, with an average width of 85 meters. As of 1940, work began on rectifying the river to end floods, channeling the water, and directing it to the Billings reservoir. In addition, conditions were created for the installation of an electric power generation plant. The rectification works, along with the construction of expressways for traffic, isolated the Pinheiros River from living with the population, which was previously

navigable. In addition to using the watercourse to move from one place to another, the city's inhabitants could practice physical activities and perform day-to-day tasks, using the river as a place of leisure (Governo do Estado de São Paulo, 2022a). During the rectification work, the Traição Pumping Plant was built, located near the Engenheiro Ari Torres Bridge, to control floods. Figure 4 compares the original river layout with the post-rectification layout.

Figure 4

Original river layout versus current post-rectification layout



Source: Encontra Pinheiros (2018)

History of interventions in the rivers of the RMSP

The metropolitan structuring of São Paulo, from the end of the 19th century onwards, is intertwined with the history of the spatial concentration of capital and industrial activities in the city (Oliveira, 2015). The urbanization process of São Paulo city incorporated European values and habits, which were characteristic of the heritage, mainly of the life of the elite.

The development of São Paulo attracted international companies, which settled intending to contribute to the urban structure of the city. The Canadian company, The São Paulo Tramway, Light and Power Company Ltd, or simply "Light", which settled and began operating in the city at the end of the 19th century, held the monopoly on its urban transport and electricity. In addition, Light began to explore the waters of the Tietê River from 1927 onwards (Andrade & Melo, 2018).

According to Ripoli (2016), the history of use and interventions of the Tietê River watershed can be divided into five periods: Sanitary-ism (1890 to 1930), Highway-ism (1930 to 1950), Metropolism (1950 to 1970), Environmentalism (1970 to 1990) and Reiterated Highway-ism (1990 to 2010).

Sanitarism took place at a time when sewage and garbage were already being dumped into the river so that these residues accumulated along the flooded areas. Sanitarians at the time were looking for a solution to contain these evictions, to fight the epidemics that proliferated in the city.

It is interesting to note that the policies for the recovery of the Tietê River date back to the end of the 19th century, a period in which the city of São Paulo was already undergoing an

intense process of urbanization. However, the supply network and sewage collection did not follow this growth (Andrade & Melo, 2018).

Highway-ism is characterized by the period of consolidation of the city's avenues, from the Plan of Avenues by Francisco Prestes Maia (1930) to the Regional Plan of São Paulo by Luiz Ignácio de Anhaia Mello (1950) (Ripoli, 2016).

Metropolism, on the other hand, covers the period of rectification of the Tietê and Pinheiros Rivers and the construction of marginal ways, which complements the period of Highway-ism. During the execution of the river rectification project, a discussion arose about the emergence of the metropolis, due to the growth of the city of São Paulo (Ripoli, 2016).

The Environmentalism period has as its main agenda the environmental concern around the Tietê River Basin, with the elaboration of the Ecological Park project (Ripoli, 2016).

Finally, the Reiterated Highway-ism brings again the discussion about mobility in the city, with a functionalist view of the river from the marginal ways. In this way, the expansion and restructuring of strategic points on the marginal ways would allow covering a greater demand, demonstrating, once again, the predominance of road transport in the city (Ripoli, 2016).

Although they happened at different times, the same principles can be observed over the years: property speculation, neglect of social issues, and prioritization of cars through the expansion of the road network (Ripoli, 2016).

The consumerist, mercantilist, and highway policy proves to be unsustainable, and society as a whole mobilizes in different ways in search of immediate changes (Avella Netto & Ramos, 2017). The accentuated urbanization process in developing countries brings to light problems inherent to life in cities, mainly related to transportation, basic sanitation, energy, security, and housing (Locatelli, Bernardinis & Moraes, 2020).

The consequences of interventions carried out from the 19th century to the beginning of the 21st century are seen daily in the RMSP. Instead of a city that welcomes the rivers and their forests, we see houses subject to flooding, chaotic traffic on the marginal ways, sewage and industrial waste dumps, and buildings that could be in more suitable places (Wilheim, 2013).

History of depollution projects in the rivers of the RMSP

Projeto Tietê ("Tietê Project")

Started in 1992, the Projeto Tietê aims to implement and expand the sewage collection and treatment infrastructure in the municipalities of the RMSP, thus contributing to the depollution of the Tietê River. According to the Basic Sanitation Company of the State of São Paulo [Sabesp] (2022b), the company responsible for the program, many advances have been

achieved since the beginning of the project, such as the increase in sewage collection and treatment rates, benefiting a population of more of 12 million people. The built infrastructure now serves more than 92% of the urbanized area of the RMSP and sewage treatment increased from 24% to 83% of the volume collected, according to data released by the Government of the State of São Paulo (Governo do Estado de São Paulo, 2021). During the execution, more than 1.8 million sewage connections and 4.8 thousand kilometers of interceptors, trunk collectors, and collection networks were installed, to collect the sewage and send it to the correct place of treatment.

By the beginning of 2022, the Projeto Tietê had already totaled US$ 3.3 billion in investment, making it the largest environmental sanitation program in Brazil. According to the study “Observando os Rios” by Fundação SOS Mata Atlântica (2021), from September 2020 to September 2021, the pollution spot on the Tietê River went from 150 kilometers of improper stretches to 85 kilometers, a reduction of 65 kilometers, or nearly 50%.

To carry out the study “Observando os Rios”, the Foundation used the Water Quality Index (WQI – Table 2), adapted from the index developed by the National Sanitation Foundation, in the United States, and obtained through the sum of physical, chemical, and biologicals found in water samples.

The study results from the measurement at 47 collection points spread along the Tietê River show stretches with positive trends in cities like Salto and Itu and stretches with negative trends like in São Caetano do Sul. In general, a trend of improvement in water quality in the Tietê River Basin can be seen, as can be seen in Table 3, the number and percentage of stretches and their respective water qualities.

Despite the overall positive trend, only 12.8% of the collection points were of good quality and none were of excellent quality. Therefore, there is still a long way to go before the waters of the Tietê River are recovered.

Table 2

Water Quality Index (WQI)

Water Quality Classification	WQI
Excelent	> 40,1
Good	35,1 – 40
Regular	26,1 – 35
Poor	20,1 – 26
Very poor	14 – 20

Source: *Fundação SOS Mata Atlântica (2021)*

Table 3

Comparison of the Tietê River Water Quality between 2020 and 2021

Results	2020		2021	
	Stretch	%	Stretch	%
Excelent	0	0,0%	0	0,0%
Good	3	6,4%	6	12,8%
Regular	33	70,2%	33	70,2%
Poor	11	23,4%	7	14,9%
Very poor	0	0,0%	1	2,1%

Source: *Fundação SOS Mata Atlântica (2021)*

Água Limpa Program ("Clean Water Program")

The Água Limpa Program, instituted by Decree No. 52,697, of February 7, 2008, aims to enable, through the granting of financing, the treatment of sewage collected and produced in municipalities in the State of São Paulo. Based on this program, it is the responsibility of the public authorities to provide the financial resources for the construction of sewage treatment stations and the implementation of pumping stations, through executive projects and the necessary technical follow-up. Operating for more than 15 years, the program serves 121 municipalities, benefiting more than 2.3 million inhabitants at a cost of approximately R$ 672 million, according to data from the State Department of Water and Energy [DAEE] (2022).

Água Limpa Program is directly linked to the reduction of pollution in the Tietê River, as it treats the sewage that is directed to streams and rivers that in their paths flow into it.

Novo Rio Pinheiros Program ("New Pinheiros River Program")

Like the previous ones, the Novo Rio Pinheiros Program is coordinated by the Government of the State of São Paulo through the Infrastructure and Environment Secretariat to clean up and revitalize the Pinheiros River. To this end, the program operates in the expansion of sewage collection and treatment, collection and disposal of solid waste, desilting the river, revitalizing the banks, and environmental education initiatives for the population.

Starting in 2019, the program has already been responsible for the collection of more than 700 thousand m³ of sediments through desilting and more than 71 thousand tons of solid waste. In addition, it connected more than 620,000 properties to the sewage network, serving more than 1.2 million people (Sabesp, 2022a).

The goal by the end of 2022 is to reduce the amount of sewage released, improve water quality and fully integrate it into the city. At the end of the project, the objective is to have an improvement in the odor, shelter aquatic life, and return the population to its banks (Sabesp, 2022a).

Examples of water recovery projects in urban rivers

River Thames, birthplace of the Industrial Revolution

Like the Tietê and Pinheiros Rivers, the Thames River suffered a long process of pollution. Known as the cradle of the Industrial Revolution, the city of London was characterized by the exponential growth of industries, mainly during the 13th and 19th centuries. Thus, the main river that cuts through the city began to receive industrial and residential waste from Greater London for years without any kind of treatment, reaching unsustainable conditions, and posing a risk to the health of the communities around it (Bento, 2021).

The River Thames is the main and longest river in England. In 1858, after a long period of waste disposal in its waters, the city of London decided to build sewer collection systems to combat diseases and the cholera epidemic, which were spreading through the population (Bento, 2021).

The first project to interrupt the discharge of sewage into the waters of the British River was designed by Joseph Bazalgette, which consisted of a combined sewage and rainwater drainage system, divided into three regions (North, South, and West), which would meet at different points, flowing parallel to the Thames towards the sea, being destined for its estuary – transitional environment between the river and the sea (Bento, 2021). The system managed to fulfill its role, being considered one of the greatest civil engineering projects in England in the 19th century (Stride, 2019).

According to Stride (2019), the sewage system developed by Bazalgette operates to this day, needing to incorporate new channels and carry out repairs and maintenance over time to keep up with the growth of the city of London. The sewage system, which had been designed for the population of London at the time (around 4 million inhabitants), began to be overloaded due to the decrease in the areas of natural drainage of rainwater. The construction of buildings, parking lots, shopping malls, and condominiums has reduced the drainage area, directing rainwater and wastewater into the River Thames.

In 2000, the London government formed a strategic study team, through the Thames Tideway Strategic Study (TTSS), the agency responsible for studying the problem. These studies sought to validate three possible actions to be carried out: 1) a separate storage system for sewage and rainwater; 2) the development of the sewage treatment and rainwater collection system; and 3) cleaning the surface of the river, along with a scheme to replace oxygen in the water (Bento, 2021). In December 2006, The London Tideway Improvements project was presented to the government, which, after a few rounds of negotiations, announced support for the execution of the works, authorizing Thames Water to start interventions in the main system.

The first part of the project consisted of increasing the capacity of existing sewage treatment stations, preparing these stations to be connected in the future to the Super Sewer, a tunnel 7.2 meters in diameter and 25 kilometers long, 65 meters below the river, with a storage capacity of around 1.6 million cubic meters. The purpose of this tunnel is to replace the 34 combined sewage channels (wastewater and rainwater), in addition to preventing around 20 million tons of pure sewage from being dumped into the river. Financed and built by Tideway Bazalgette Tunnel Ltd. and with a budget of 4.2 billion pounds, construction work on the Super Sewer began in 2015 and is expected to be completed in 2024 (Bento, 2021).

River Seine, the unpleasant companion of the City of Light

The Seine River is 776 kilometers long and is responsible for a large part of the drainage of the Parisian Basin, constituting a major artery of river navigation in the Paris region. Over the centuries, the river has had different functions such as navigation, leisure, water supply, sewage disposal, and other functions (Ikeda, 2016).

Due to the rural exodus, the city of Paris began to receive new residents, but it did not have the necessary infrastructure to support such demand so the basic services of sewage collection and treatment did not exist. Because it passes through the main industrial and urban center of the country, the Seine River became the target of sewage and rainwater discharges from the city of Paris throughout the 19th century (Ikeda, 2016).

The discontent of the population began to grow, so that, in the second half of the 19th century, several movements emerged – such as “la bataille à leau” (the battle of the water) and “la bataille du tout-à-l'égout” (the battle of the sewer) – that demanded action from the public authorities. In 1935, the city's general sanitation program was announced, after the ban on swimming in the river in 1923 and much opposition from the industries at the time that aimed at their economic interests. The objective of the program was to eradicate the epidemics that spread throughout the city and, for this, the project consisted of releasing the dirty waters of the Seine beyond the city of Paris, leading them to the neighboring cities through the sewer networks (Ikeda, 2016).

Despite the mobilization of public power, the waters of the Seine were still polluted. In 1960, scientists declared the river "biologically dead". Since then, several interventions have taken place to prevent waste from being dumped into the river and to properly dispose of the city's sewage for treatment (Neves, 2022).

In 1970, 40% of Parisian wastewater was treated. Until the 1980s, Paris' wastewater treatment – as in many large European cities – focused mainly on human excrement. Some chemical elements such as phosphorus, which can deprive rivers of oxygen, were ignored. Between 1980 and 1990, there was the introduction of stricter regulations and the construction of new treatment plants that filtered not only greater amounts of wastewater but also a greater

diversity of pollutants (Noack, 2021).

Host of the 2024 Olympic Games, the city of Paris intends to use the Seine River as a resurrected national monument, hosting Olympic marathon and triathlon events, in addition to holding the opening ceremony of the Games on the river. For this, the government approved a project that provides for the construction of a concrete tank 50 meters in diameter and 34 meters deep on the left bank of the river. The project aims to prevent rainwater that runs through the city streets, dragging garbage with it, from flowing into the Seine River. For this, the concrete tank will retain this water for up to 24 hours, which will later be pumped through underground pipes to treatment stations located close to the river (Neves, 2022).

Urban Mobility in the city of São Paulo

According to Costa and Silva (2013), São Paulo faces the threat of a collapse in the transport system daily, due to intense congestion and overcrowding of the public transport system.

Despite all the interventions that have been carried out over the years, as previously mentioned, it is necessary to look for different alternatives to solve the problem of urban mobility, since the traditional solutions no longer seem to have an effect.

The Sustainable Urban Mobility Index – IMUS (Costa, 2008) is a tool for monitoring sustainable urban mobility and evaluating the impact of public policies. According to the study carried out in the city of São Paulo by Costa and Silva (2013), the result obtained was 0.55, on a scale of 0.0 (zero) to 1.0 (one), where zero corresponds to serious mobility problems and one to sustainable mobility.

In this study, indicators related to accessibility (in public transport, on urban roads, parking lots), environmental aspects (pollution, use of clean energy), social aspects (quality of life, education for sustainable development), aspects of policy (public/private partnerships, investments in transport, urban mobility policy), infrastructure (paved roads, public transport routes), non-motorized modes (bicycle lanes, pedestrian paths), integrated planning (urban density, voids urban areas, Master Plan), urban traffic and circulation (traffic and pedestrian accidents, motorization rate, average traffic speed) and urban transport systems (punctuality, network extension, passenger-kilometer ratio).

Among all the indicators analyzed by Costa and Silva (2013), the RMSP presents serious problems of urban fragmentation, due to the characteristics of the road system and its transport networks, which have contributed to the loss of the city's environmental quality, in addition, to generate physical barriers that hinder the circulation of non-motorized modes of transport. In addition, the unequal distribution of resources aimed at motorized and non-motorized modes and the high rate of car occupancy stands out, as there is an established culture of prioritizing motorized means, coming mainly from the period of road transport.

Given the studies by Costa and Silva (2013) and by Ripoli (2016), the city of São Paulo, as well as several others around the world, has presented serious problems in its urban mobility systems. The accelerated growth of cities, the prioritization of motorized means of transport, and the ineffectiveness of basic sanitation programs and recovery of urban rivers have contributed to the current situation of the city.

Cargo transportation in the RMSP

The RMSP is the most complex and diversified in the country, being the main economic, financial, corporate, and services center in the country, with a Gross Domestic Product (GDP) of more than R$ 700 billion, 57% of the state's GDP and 20% of the country's GDP (IBGE, 2022). The region has a dynamism of services, mainly related to the transport and communication network, resulting in a wide range of structural challenges.

Urban mobility is one of the main challenges of the RMSP, which, in addition to the modes themselves and the quality of transport, is responsible for analyzing the time spent commuting, which is higher in peripheral areas, the costs of transport about the income of the population, the condition of the sidewalks, the layout of bicycle lanes and lanes, and the guarantee of accessibility.

To improve urban mobility in the city, some vehicle restriction measures began to be implemented in the 1990s. The first was the creation of the "Operação Rodízio" program in 1996, with the initial objective of minimizing air pollution and congestion problems. Based on this program, in 1997, the Motor Vehicle Restriction Program in the City of São Paulo was created, a forerunner of Operation Peak Hours, which aims to restrict the circulation of vehicles within an area of the city, from Monday to Friday, during peak hours in the morning (7:00 am to 10:00 am) and in the afternoon (5:00 pm to 8:00 pm), according to the end of the car license plate (Gati Junior, 2011).

Regarding cargo transport, the Road System Operations Department (DSV), linked to the Municipal Transport Secretariat (SMT), created the Maximum Circulation Restriction Zone (ZMRC) in 1997. To ensure distribution logistics, in the area defined by the ZMRC, the city of São Paulo allowed the circulation of the so-called Urban Cargo Vehicle (UCV), with a payload capacity of up to 3,000 kg, a maximum width of 2.20 m and a maximum length of 5.50 m, and Light Commercial Vehicle (LCV), with a length of more than 5.50 m and a maximum of 6.30 m. In Figure 5, it is possible to observe the ZMRC and the avenues that limit its coverage area.

Despite this, the measures were not enough to contain congestion and urban mobility problems in the RMSP. With a fleet of more than 175,000 trucks, the city of São Paulo faces almost daily, at peak hours, numbers close to 200 kilometers of congested roads (CET, 2008). According to data from Desenvolvimento Rodoviário S/A [DERSA] (2004), the expected number of daily trips by trucks through the RMSP in 2020 was approximately 150 thousand

trips. In general, the majority of truck movements through the RMSP are predominantly internal, between different areas of the metropolis (Zioni, 2009).

The city of São Paulo receives the flow of vehicles from ten highways. Below is a list of the roads along with the identification of each one of them (from A to J) in Figure 6:

- Anchieta (SP-150) [A] and Imigrantes (SP-160) [B]: the system is the connection between the metropolitan region of São Paulo and the Port of Santos, the Cubatão Petrochemical Complex, the industries and the factories of ABCD (Santo André, São Bernardo, São Caetano do Sul and Diadema), and the beaches of Baixada Santista.]

- Régis Bittencourt (BR-116) [C]: it is the connection between São Paulo and the south of Brazil. The highway is the main access to Curitiba and cities in Greater São Paulo such as Embu, Taboão da Serra, and others such as Registro, in the south of the State.

- Raposo Tavares (SP-270) [D]: connects São Paulo to Cotia and Votorantim, as well as other cities in the countryside of the State.

- Castello Branco (SP-280) [E]: a highway that passes through Carapicuíba, Barueri, and other cities in the countryside of the State of São Paulo.

- Anhanguera (SP-330) [F]: connects São Paulo to the Minas Gerais cities of Uberlândia and Uberaba, and to the Federal District. It passes through Jundiaí and the vicinity of important cities in São Paulo such as Barretos and Franca.

- Bandeirantes (SP-348) [G]: a highway that connects the capital of São Paulo to Campinas and the International Airport of Viracopos.

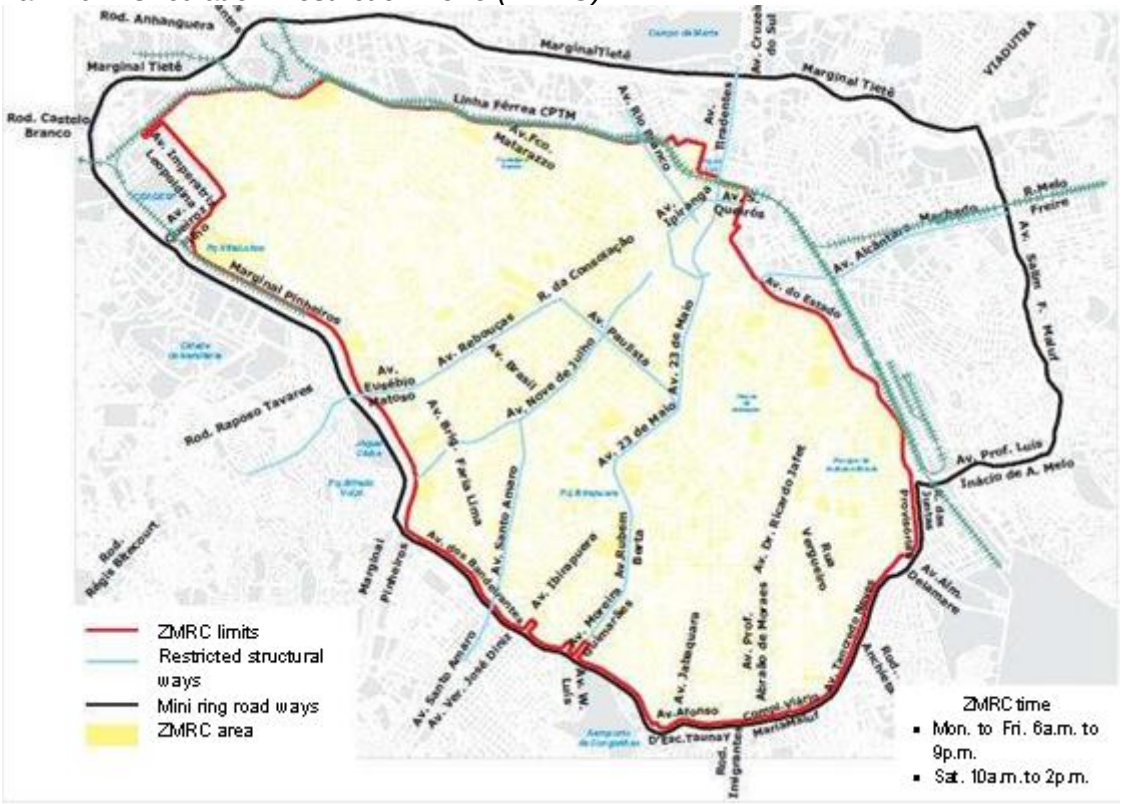
- Fernão Dias (BR-381) [H]: the highway connects São Paulo to the south of Minas Gerais State and Belo Horizonte. It passes through the São Paulo cities of Mairiporã and Atibaia. Gives access to the Dom Pedro II Highway.

- Presidente Dutra (BR-116) [I]: the access road for visitors from the State and city of Rio de Janeiro. It also connects the São Paulo cities of Guaratinguetá, São José dos Campos and Taubaté to the State capital.

- Ayrton Senna-Carvalho Pinto (SP-070) [J]: access via km 22.5 of the Tietê marginal ways. The Ayrton Senna, formerly the Trabalhadores Highway, connects São Paulo to the International Airport of Guarulhos and the Presidente Dutra and Carvalho Pinto highways. Used for those heading to Rio de Janeiro and the north coast of the State of São Paulo. Via Carvalho Pinto, it is possible to reach Campos do Jordão and Taubaté.

Figure 5

Maximum Circulation Restriction Zone (ZMRC)



Source: *Adapted from CET (2008)*

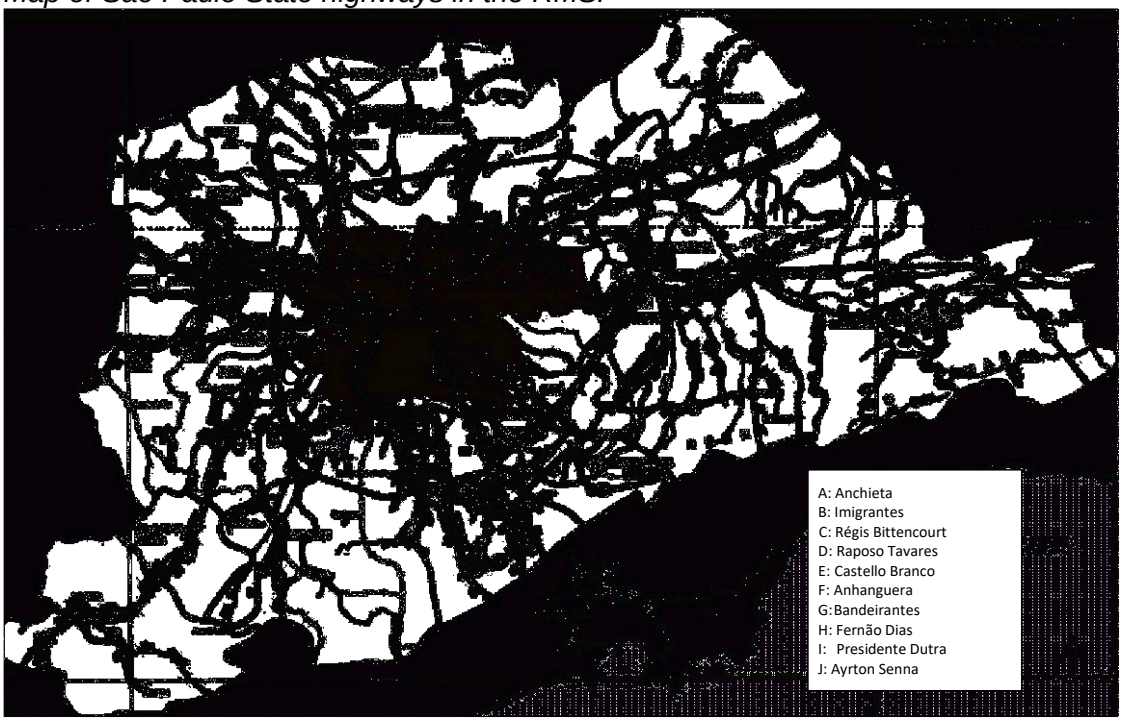
As can be seen in Figure 6, all state highways are connected to strategic points in the city of São Paulo, mainly the side roads of the Tietê and Pinheiros Rivers, to guarantee access to the main destinations in the State capital.

Thus, considering the large flow of cargo coming from these highways toward different locations in the capital, one can idealize the use of urban rivers for this purpose. For this, it is necessary to walk in the opposite direction to São Paulo's history: since it became a metropolis, in the 30s, São Paulo has spread towards and over urban waters, using them as a sewage deposit bed and for the implantation of the road system. Countless the rivers of the metropolis were covered by avenues: Radials Ways 9 de Julho and 23 de Maio that pass through the Saracura, Iguatemi, and Itororó rivers; Pacaembu and Sumaré Avenues, which covered the

rivers of the same name, in addition to more than 300 other streams in the São Paulo underground (Ikeda, 2016).

Figure 6

Map of São Paulo State highways in the RMSP



Source: Adapted from Ministry of Infrastructure (BRASIL, 2022)

Urban mobility and depollution of rivers

The city of São Paulo has been going through several changes regarding its means of transport and the way its almost 20 million inhabitants move daily. Ten years after the enactment of the law that establishes the guidelines for the National Urban Mobility Policy, the city of São Paulo has been transformed, but it is still far from an ideal urban mobility system (Folha, 2022).

Solutions to problems related to mobility in São Paulo are difficult to visualize, given its disorderly, heterogeneous, and often random growth. This growth affected the structure of the city, so that the rivers became extremely polluted due to the inefficiency of the sewage collection and water treatment system, the traffic of vehicles is intense at practically all hours of the day, the train and subway lines do not serve many parts of the city, especially in regions farther from the center, among others (Ikeda, 2016).

As discussed earlier, most interventions in regions close to urban rivers were based on road transport, through the creation and expansion of marginal ways. The city's urbanization process did not explore the potential of urban rivers as a means of transport, quite the contrary,

these rivers have been the destination of urban waste such as garbage and sewage for over a century.

In this way, this article introduces the analysis of the characteristics of the rivers and the mobility demands of the capital, relating them and seeking alternatives to solve one of the many urban problems of the RMSP.

Results and discussions

The results and analyzes were obtained through critical approaches to the characteristics of urban mobility and urban rivers in the RMSP. From the survey of information about these two aspects, it was possible to relate them and analyze them critically.

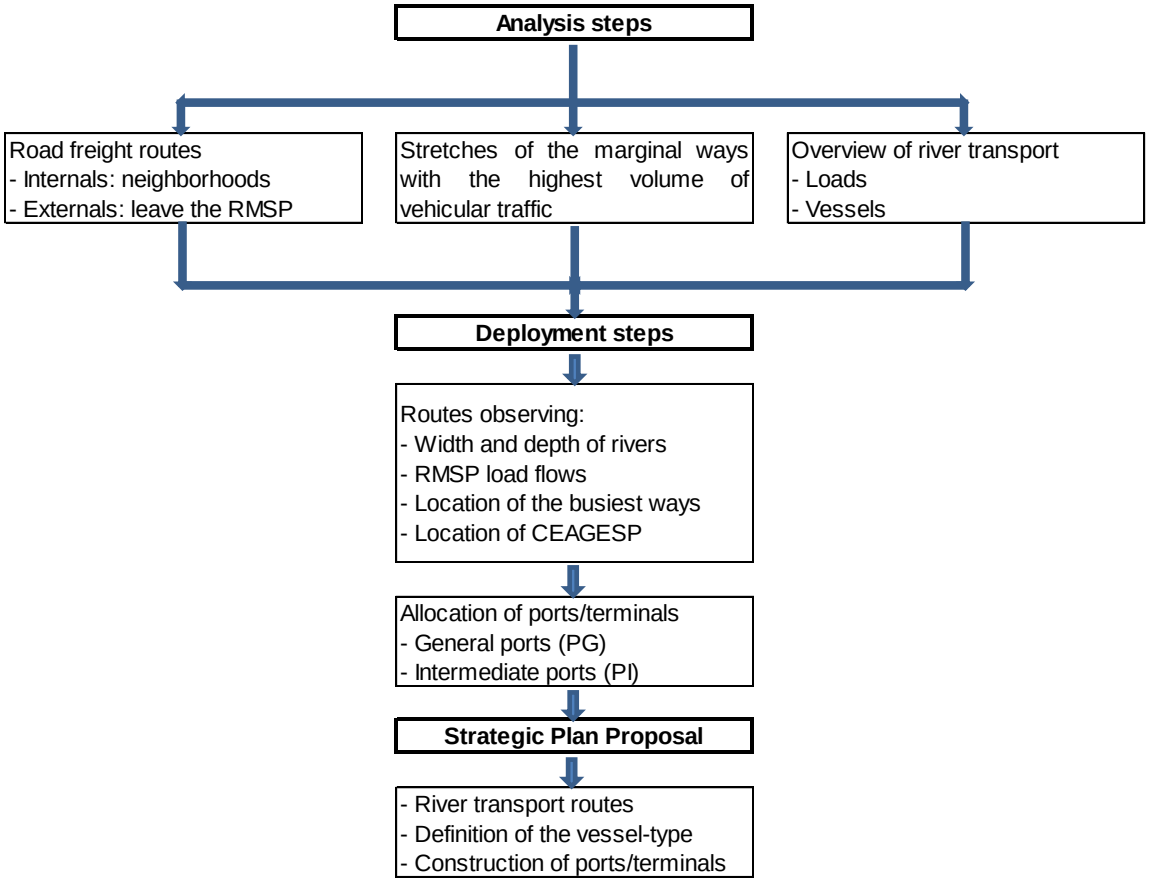
In recent decades, the RMSP has undergone several changes in its productive organization that have increased the flow of goods and merchandise. Due to its dynamism and accelerated development, the city creates new production and logistics arrangements, networks, and structures, to accommodate new trends and population growth.

Despite this dynamism present in the processes, the trend towards the use of road modes in the transport of cargo within the RMSP prevails. As previously discussed, the interventions on the margins of the main rivers in São Paulo, prioritizing the construction and expansion of roads, show the road character of the capital.

Thus, this topic presents an analysis of the main cargo routes within the RMSP, the marginal stretches with the highest volume of vehicles, and the panorama of river transport. After this analysis, the implementation of alternative stretches of routes by the river waterway modal will be approached, exploring the main rivers of the State capital: Tietê and Pinheiros. Figure 7 shows a diagram of the presentation of the results that will be exposed in the sequence.

Figure 7

Steps for obtaining the results



Cargo routes in the RMSP

According to a survey carried out by Zioni (2009), the areas with the highest truck traffic are the macrozones Osasco/Barueri, Jaraguá, Lapa, Limão/Cachoeirinha, Sé/Paulista, Santana/Tremembé, Guarulhos/Dutra, Mogi/Suzano, São Bernardo/ Diadema and Santo André/Mauá. Despite having been carried out more than 10 years ago, the study shows a trend that continues to this day: the flow between the main highways and avenues that make up the Mini Ring Road in the Municipality of São Paulo.

Among the aforementioned macrozones, they can be classified as internals or externals:

a) Internals: characterized by flows that occur between neighborhoods within the RMSP, such as: Sé/Paulista, Jaraguá, Limão/Cachoeirinha, Lapa and Santana/Tremembé.

b) Externals: characterized by flows that leave the RMSP or that occur between cities in the RMSP, such as: Guarulhos/Dutra, Osasco/Barueri, Guarulhos/Dutra, Mogi/Suzano, São Bernardo/Diadema and Santo André/Mauá.

Given the objective of the article in question, the focus will be on analyzing the flows of the internal macrozones, to find alternatives for these cargo routes.

Busiest ways in the RMSP

According to CET data (2019), among the 12 most loaded roads in the RMSP, only one of them – Rubem Berta Avenue – is not located close to the marginal ways of the Tietê/Pinheiros rivers. In addition, as can be seen in Table 4, there are 5 marginal stretches between the ways with the highest volume of vehicles at peak hours. Radial Leste, despite not being directly interconnected with the marginal ways, receives a large volume of vehicles from the Tietê marginal way.

Table 4

Busiest ways in the RMSP, 2019

Ways	Average number of vehicles at peak hours (morning or afternoon)
Vinte e Três de Maio Ave.*	10,199
Marginal Pinheiros – Expressa (Eng. Billings Ave.)*	9,478
Radial Leste (Alcântara Machado Ave.)*	8,817
Marginal way of Rio Pinheiros (Expressa)*	7,405
Rubem Berta Ave.	7,039
Marginal Tietê – Central (Otaviano Alves de Lima	6,996
Marginal Tietê – Express (Morvan D. de Figueiredo	6,927
Radial Leste (Melo Freire St.)*	6,843
Marginal Tietê – Express (Pres. Castelo Branco Ave.)*	6,548
Washington Luís Ave.*	6,541
Tiradentes Ave.*	5,705
Eusébio Matoso Ave.*	5,659

* Marginal ways or ways that have a connection with the Tietê/Pinheiros marginal ways

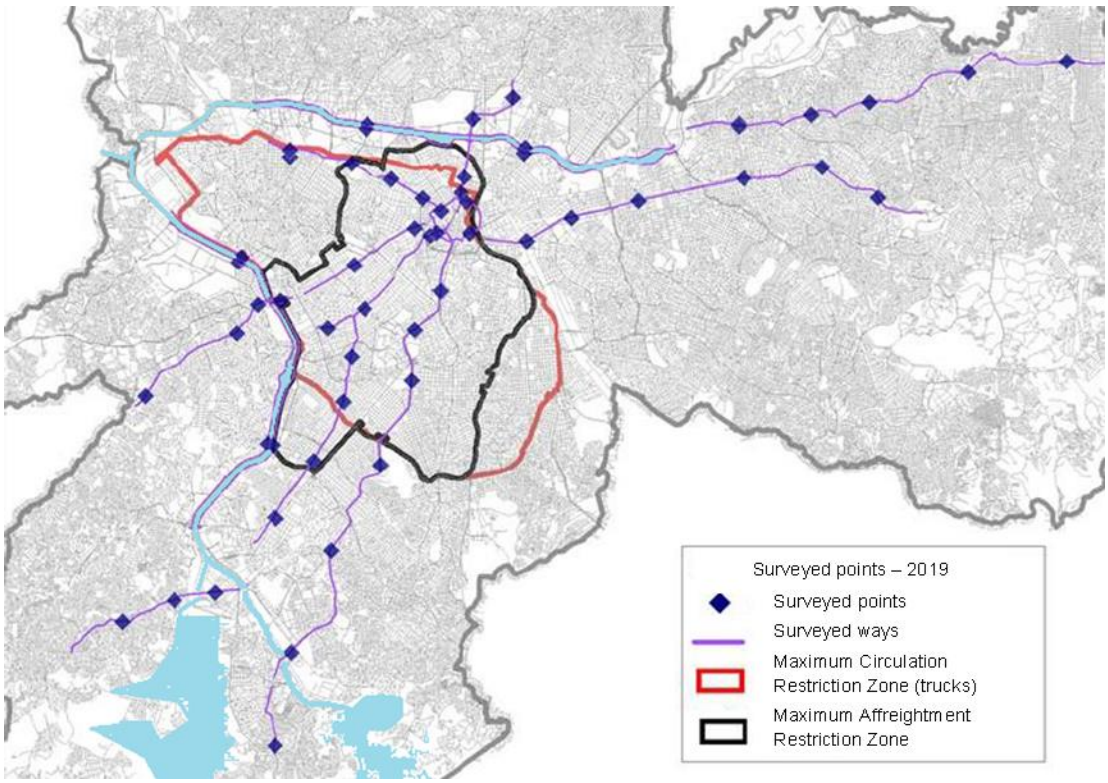
Source: *CET (2019)*

In Figure 8, it is possible to see where the points surveyed by CET for data collection are located. It can be concluded that most of the points are close to the marginal ways and within the ZMRC. In this way, the implementation of waterway routes along the Tietê and Pinheiros Rivers can be an alternative, after all, it would cover the areas restricted to the circulation of trucks and would be strategically located to carry out transport to the main ways of the São Paulo.

Water transportation, unlike road transport, does not work well with unevenness and interruptions in its routes. Thus, to establish transport routes within the RMSP, the existence of “obstacles” such as power plants, islands, and bridges must be analyzed. In addition, one of the objectives of this article is the creation of routes for transporting loads in large quantities without the need to reach their final destination quickly, as river transport is slower than road and rail. In this way, some materials that can be transported are: urban waste, rubble, earth, material for recycling, construction aggregates, and sediments.

Figure 8

Points surveyed by CET, 2019



Source: Adapted from CET (2019)

Proposed river transport

In addition to the materials listed above, some products can be transported, but under special conditions considering the fragility and degree of perishability of these products. River transport of fruit and vegetables is a great opportunity for the RMSP, given the strategic location of the Companhia de Entrepostos e Armazéns Gerais de São Paulo (CEAGESP).

CEAGESP, created in May 1969, has the function of marketing, distributing, and storing horticultural products, based on the leasing of spaces so that private traders can sell agricultural products to retailers (CEAGESP, 2022). Located in Vila Leopoldina, west of the city of São Paulo, CEAGESP borders the Pinheiros marginal way and is close to the region of

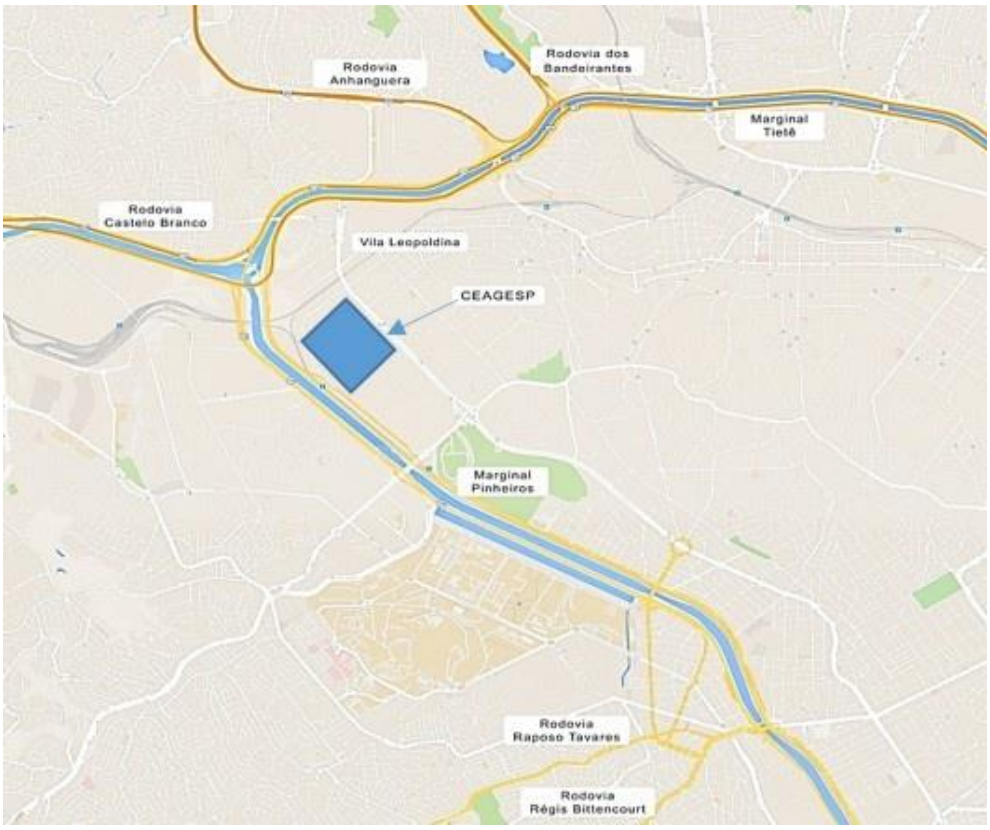
its mouth – the Tietê River, as can be seen in Figure 9.

Monthly, CEAGESP moves about 250 thousand tons of products and is responsible for approximately 60% of the supply of the RMSP, with a flow of more than 50 thousand people and 12 thousand vehicles per day (CEAGESP, 2022). Due to its importance for the supply of the city, taking advantage of the rivers in its surroundings could facilitate the transit of trucks to the place, since CEAGESP has a high flow of trucks.

Having listed the products and their relevance in transport, it can then be concluded that river transport would reduce traffic on the highways, draining the products through its channels. Additionally, it should be noted that river transport is less polluting than road and rail, as it requires less energy for displacement. River transport of one ton of cargo generates 4 times less CO2 than road transport (Ikeda, 2016).

Figure 9

Location of CEAGESP in the RMSP



Source: *Pereira (2017)*

To carry out river transport, it is necessary to select the type of vessel that will allow navigation in the most efficient way possible. There are several types of vessels used for the waterway transport of cargo, such as, for example, cargo ferries. However, its width can reach up to 30 meters, far from the reality of São Paulo, since the rivers have a minimum length of

approximately 60 meters.

In this way, the urban cargo boat (BUC) is the most viable type of vessel in terms of width, length, draft, and capacity so that it can carry out urban river transport of cargo (Ikeda, 2016). This type of vehicle is 50 meters long and 9 meters wide, making it a viable option considering the characteristics of the São Paulo rivers. In addition, the BUC can carry up to 500 tons of cargo. Meanwhile, an Urban Cargo Vehicle (UCV) only carries up to 3 tons, and a train car up to 40 tons. In other words: one BUC equals 167 UCV's or 13 train cars (Ikeda, 2016).

Routes and location of ports

To carry out the layout of cargo routes and the location of ports, it is necessary to observe the points already mentioned above related to the characteristics of rivers, cargo transport, and congestion in the RMSP. To obtain the most efficient route that can meet the necessary demands, the following aspects were observed:

1.Width and depth of rivers;
2.Main cargo flows in the RMSP;
3.Location of the busiest ways; and
4.Strategic location of CEAGESP.

São Paulo rivers have similar widths and depths. Considering a depollution scenario for both, the total depth would be close to 7 meters, a level more than necessary for the installation of the BUCs. In addition, as they are around 9 meters wide, it would be possible to implement more than one BUC sailing side-by-side (round trip) on each section, since the minimum width of the rivers is approximately 60 meters.

As for cargo flows, the ports must be located at strategic points, to meet the demand for cargo transport in the main locations of the RMSP. In addition, transport routes are often confused with the busiest ways in the city, therefore, river routes must relieve congestion on the marginal ways.

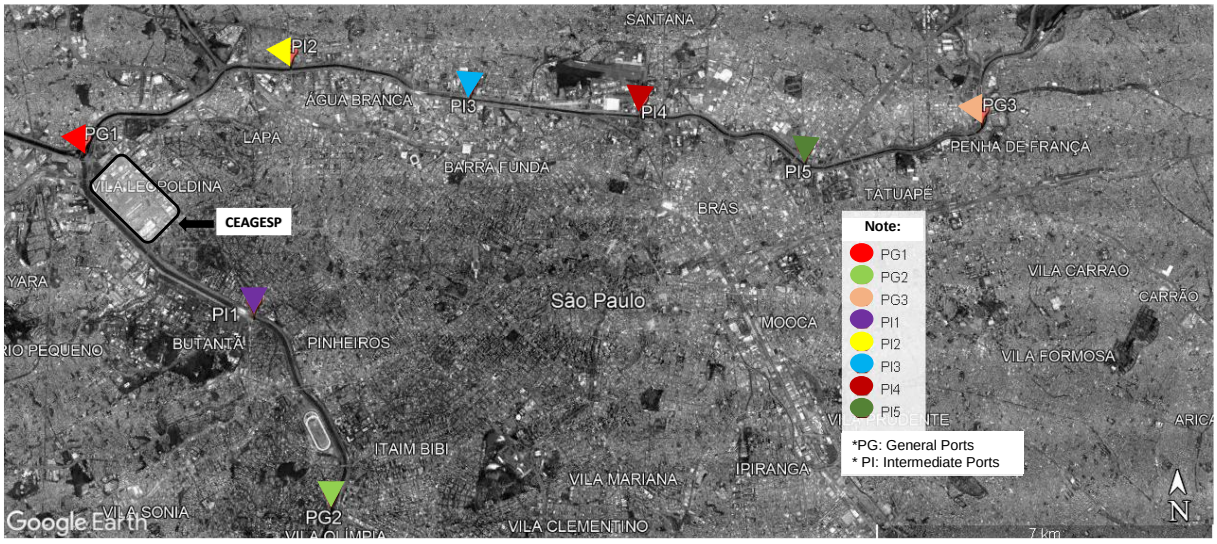
Finally, given the importance of CEAGESP, the ports must be strategically located, to meet the demand for transporting horticultural products in the region. In addition, CEAGESP is located close to several highways (Bandeirantes, Anhanguera, Castelo Branco, Raposo Tavares and Regis Bittencourt).

Thus, Figure 10 shows the distribution of ports along the two rivers in São Paulo. Eight ports were allocated along the rivers, 2 of them on the Pinheiros River, 5 of them on the Tietê River, and one at the meeting of the two rivers. The ports are represented by pegs of different colors and are distinguished into 2 groups: General Ports (PGs) and Intermediate Ports (PIs).

The implementation of the ports takes into account two criteria: the first is to connect the ports to the main roads in the city of São Paulo. The second considers its installation close to strategic points in the municipality.

Figure 10

Proposed location of ports



Source: Adapted from Google Earth (2022)

The General Ports are located at the ends of the routes (PG2 and PG3) and where the rivers meet (PG1), in addition to being essential for connecting the channels with the main highways that connect the RMSP with other cities. These ports are larger than the intermediary ones, as they concentrate the functions of sorting, processing, and final destination of any type of product, be it urban waste or horticultural waste. They are robust structures with the segmentation of areas so that the intermodal transfer (river/road or river/railway) is done quickly and segregated by product.

The Intermediate Ports are located in strategic regions with access to large avenues, where there is a need to transfer the product to another modal that will transport it to a region without access to the waterway. The intention of creating both types of ports was to optimize processes and improve the efficiency of product flow along the channels.

Transport between ports must be done by BUCs, as previously indicated (Ikeda, 2016), providing a large load capacity, spending little fuel, and polluting less than road transport. According to IBGE data (2021), it is estimated that the city of São Paulo has a fleet of 140,000 trucks. To replace part of this fleet with BUCs along the Tietê and Pinheiros Rivers, the proposal would be to implement routes between the PGs with 10 BUCs between PG1 and PG2 and 20 BUCs between PG1 and PG3. In this way, the total transport capacity of the system, considering all BUCs in operation, would be 15 thousand tons, equivalent to approximately 5

thousand UCVs. The division of routes must be done according to the number of PIs, thus having:

- PG1 to PG2: 10 BUCs (5 in each PG/PI segment); and
- PG1 to PG3: 20 BUCs (4 in each PG/PI and PI/PI segment).

Despite dividing the BUCs by sections, there is the possibility of carrying out longer routes, thus avoiding the need to change vessels (transshipment) to continue carrying out the transport.

Applicability and challenges

The action plan addressed in this topic seeks to bring a possible solution to the problem of urban mobility in the RMSP through the use of urban rivers. In this way, the main characteristics of the rivers were analyzed so that it is possible to implement port systems. The article in question did not address the applicability from the perspective of road structures and necessary adjustments on the marginal roads and surrounding buildings for the installation of ports. Thus, it only analyzed, in a concise manner, how the port distribution could be along the main urban rivers – Pinheiros and Tietê Rivers – and the estimation of the distribution of routes, to positively interfere in the flow of vehicles along the route. side roads and the main flow-generating poles in the city of São Paulo.

Therefore, it is believed that the next challenge would be the need to carry out a financial, logistical, and structural feasibility study for the implementation of the ports in question and their connections with other modes, to better understand the best alternative to solve the problem of urban mobility in São Paulo.

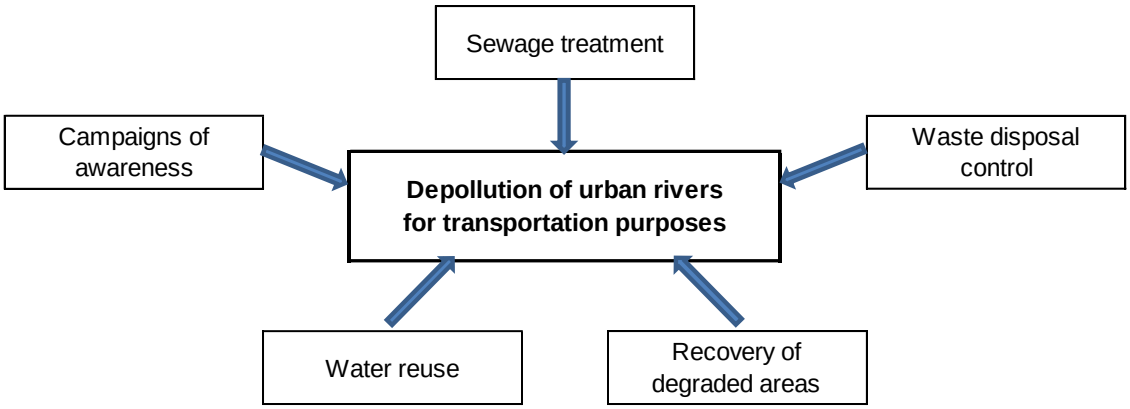
It is possible to list some of the solutions for the depollution of the Tietê and Pinheiros Rivers that also fit other urban realities around the world (Figure 11). These initiatives aim to help improve the water quality and marine life in these rivers:

1. Sewage treatment: One of the main causes of river pollution is untreated sewage. Building sewage treatment plants can help reduce the amount of pollutants entering rivers.
2. Control of waste disposal: The amount of solid and liquid waste that is discarded in rivers also contributes to pollution. It is necessary to implement solid and liquid waste control and management policies to avoid river pollution.
3. Rehabilitating degraded areas: Rehabilitating degraded areas along riverbanks can help reduce soil erosion and sediment entry into rivers, which can improve water quality.

4. Water reuse: Reusing treated water for non-potable purposes, such as garden irrigation and street washing, can help reduce the amount of water that needs to be withdrawn from rivers.
5. Awareness Campaigns: Educating and raising awareness among the population about the importance of preserving rivers and conserving water resources is essential to change people's habits and behaviors concerning the use and disposal of water.

Figure 11

Initiatives for the depollution of urban rivers for transport purposes



Conclusions

The article can be divided into two main topics addressed. The first of them addresses the depollution of the waters of the Tietê and Pinheiros Rivers. It is known that the Public Power of São Paulo seeks several different ways to recover the waters of its main rivers. Some programs have already been created with this objective and have not been successful, others are in progress with predictions to be finalized in the coming years, but still without the perspective of effectiveness. This reality is not far off, considering real cases of success in the European cities addressed throughout the article – Paris and London. Despite this, there are still some major challenges ahead for the complex and heterogeneous metropolis of São Paulo.

The second of them discuss the issue of urban mobility in the RMSP. The city of São Paulo lives in constant movement of people and vehicles that cross kilometers daily to study, work, and leisure, among others. As discussed earlier, urban quality is far below São Paulo's economic expression and far below the expectations of its population, with poorly distributed services and equipment. The city's road ideology was made explicit and how this modal was prioritized over the years. Vehicles on the busiest roads in the metropolis at peak times barely circulate, revealing the lack of planning to accommodate the number of vehicles at certain

times.

Thus, an attempt was made to unite both main topics: to improve urban mobility in the city through the use of clean urban rivers. For this, the chronology used was to start the work with the approach of the history of interventions and projects in the urban rivers of São Paulo, as well as river recovery projects in other cities, to understand the challenges for the São Paulo reality. Then, the analysis of urban mobility in the city was presented, as well as the volume of vehicles on the busiest roads and freight transport, to understand how the flows occur in the region.

Through the relationship between the two topics discussed, an action plan was drawn up based on the construction of ports and river transport routes along urban rivers. The plan in question consisted of distributing eight ports along the rivers, 2 of them on the Pinheiros River, 5 of them on the Tietê River, and one at the meeting of the two rivers. The ports are divided into 2 groups: General Ports, located at the ends of the routes and where the rivers meet, and Intermediate Ports, located in strategic regions with access to large avenues. From the distribution of these ports, it was possible to create routes for the transport of certain products by specialized vessels, thus making it possible to reduce the volume of trucks that cross the marginal ways daily.

It should be noted that the article in question only suggests one possibility to change the panorama of urban mobility in São Paulo and that it still needs financial, logistical, and structural feasibility studies so that it can be implemented, after all, there are still few studies in the literature that explore this theme. Therefore, the article contributes to highlighting the broad water potential of São Paulo, since its rivers connect the main highways of the State and cut through the busiest ways in the city, in addition to emphasizing that there are ways to improve urban mobility in the city using other modes that do not be the road transportation.

This article offers an initial analysis of the impact of the depollution of the Tietê and Pinheiros Rivers on the dynamics of urban mobility in the city of São Paulo. However, there are still many aspects that can be explored and complemented. One of the important topics that can be addressed is the analysis of the issue of the physical space of the installation sites of ports and terminals. It is necessary to analyze the availability of adequate space for the construction of these infrastructures, in addition to considering in more detail the possible interferences, such as bridges, slope, width, and depth of the river.

In addition, it is essential to carry out an analysis of the economic and financial viability of construction projects and the operation of ports and river terminals. It is necessary to evaluate the necessary investment, the expected financial return, the operational costs, and the possible sources of financing.

Another fundamental aspect that must be considered is the environmental analysis. The construction of ports and river terminals can cause significant environmental impacts, such

as degradation of water quality and loss of natural habitats. Therefore, it is important to assess the project's environmental impacts and develop mitigating measures that can reduce these impacts.

In short, several aspects can be addressed to complement the work in question. River transport is an important activity for sustainable development, and in-depth studies related to the depollution of urban rivers can contribute to this activity being carried out safely and sustainably.

Therefore, it can be said that the depollution of rivers for transport purposes is a topic of extreme importance. However, there is a lack of more concrete information on the subject both in national and international literature. Although there are several ongoing initiatives to clean up rivers, few works were found in the literature on the clean-up of rivers aimed at river transport. More research and monitoring may be needed to understand the impact of these initiatives on the health of the river and its associated ecosystems.

Moreover, in the specific case of the Tietê and Pinheiros Rivers, despite the measures taken to restore the quality of these water bodies, there is still a lack of reports and more detailed information on the progress of the depollution of these rivers. Thus, there must be more investment in research and studies that can contribute to the identification of effective solutions for the depollution of rivers for transport purposes, in addition to greater transparency in the dissemination of information and reports related to the subject. Only then will it be possible to guarantee that these rivers can be used safely and sustainably, contributing to the economic and social development of the regions where they are located.

Some initiatives cited in this article can help reduce not only the pollution of the Tietê and Pinheiros Rivers but also other rivers in Brazil and the world. However, it is important to emphasize that the definitive solution for the depollution of these rivers includes the implementation of a set of integrated and long-term actions, involving different sectors of society and governments.

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