STUDY OF NOx AND CO_2 EMISSIONS FROM MARITIME TRANSPORT IN THE PORT OF SALVADOR, BAHIA, BRAZIL

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Abstract: Maritime transport accounts for 90% of global trade. It is considered the means of transport with the best potential to contribute to the development of the world economy. However, emissions from maritime transport significantly contribute to the total atmospheric emissions in the port regions and their surroundings. In this context, Bahia has the longest coastline in Brazil, and the Port of Salvador is responsible for handling 57% of the State's exports. Thus, the objective of this study was to quantify NOx and CO2 emissions for the year 2015 at the Port of Salvador, considering the ship's operating mode as mooring (reduced speed). The results showed that maritime transport at the Port of Salvador was responsible for 61% of NOx and 31% of CO2 to atmospheric emissions in the region during 2015. The study revealed satisfactory results, representing an initial advance towards the building an atmospheric emissions inventory, considering the central sources with polluting potential in the Metropolitan Region of Salvador, Bahia, Brazil.

Keywords: Maritime transport, Atmospheric emissions, Metropolitan Region of Salvador, Ships.

ESTUDO DAS EMISSÕES DE NO_x E CO_2 DO TRANSPORTE MARÍTIMO NO PORTO DE SALVADOR

Resumo: O transporte marítimo corresponde a 90% do comércio a nível global, sendo considerado o meio de transporte com maior potencial para contribuição no desenvolvimento da economia mundial. Contudo, as emissões resultantes do transporte marítimo contribuem significativamente para o total das emissões atmosféricas em regiões portuárias e suas proximidades. Neste contexto, a Bahia tem a maior costa litorânea do Brasil e o Porto de Salvador é responsável pela movimentação de 57% das exportações do Estado. Assim, o objetivo deste estudo foi quantificar as emissões de NO_x e CO_2 para o ano de 2015 no Porto de Salvador, considerando o modo de operação do navio como sendo atracação (marcha reduzida). Os resultados mostram que o transporte marítimo no Porto de Salvador em 2015 contribuiu com cerca 61% de NO_x e 31% de CO_2 das emissões atmosféricas na região. O estudo demonstrou resultados satisfatórios, representando um avanço inicial para a construção de um inventário de emissões atmosféricas, considerando as principais fontes com potencial poluidor na Região Metropolitana de Salvador.

Palavras-chave: Transporte marítimo, Emissões atmosféricas, Região Metropolitana de Salvador, Navios.

1. INTRODUCTION

Maritime transport is directly related to economic development as it is an efficient means of transport with high potential in the contribution of the sector included [1]. Among the various segments that use maritime transport are international trade, bulk transport of various types of goods, food, and transport of people. In relation to other means of transport, ships stand out for transporting a volume of cargo, materials and people in less time and reducing costs in the long term [2-3]. In Brazil, the Todos Santos Bay (TSB) is the largest tropical bay in the world, located in the State of Bahia, which has the longest coastline in the country, where the ports of Salvador and Aratu-Candeias are located. Notwithstanding the COVID-19 pandemic, the Port of Salvador recorded an 8.12% growth in this year's accumulated movement in May, compared to the previous year [4].

In maritime transport, the fuels used are classified into two main types: Bunker or Intermediate Fuel Oil (IFO) or Marine Fuel Oil (MFO) which is used in large main engines in large ship systems. In Brazil, ANP Resolution No. 52/2010 establishes the maximum sulfur limit of 3.5%. For marine diesel (DMA) or Marine Gasoil (MGO) used in main engines, propulsion, in medium and small vessels, for example, passenger and passenger boats, it establishes the maximum limit of the sulfur content 0.5% by mass for marine diesel [5].

Emissions from maritime transport represent, significantly, the total emissions in port regions. This is because they use powerful engines and use heavy fuels that are rich in elements that react, interact, and accumulate, increasing their concentration in the atmosphere [6-7]. Cruises are the type of ship that consumes the most fuel due to the propulsion required to meet hotel needs [8-9]. Within this context, maritime transport still lacks studies aimed at its contribution to atmospheric emissions and its impact on air quality. Thus, it is essential to develop reliable methodologies that can quantify these emissions. An accurate estimate requires a reliable information base about the fuel consumption in the different modes of operation of a ship, as well as the characteristics of the fuel itself [10]. Therefore, the objective of this study is to quantify NO_x and CO_2 emissions at the Port of Salvador, considering the mode of operation as berthing (the ships operate at low gear), for the year 2015, considering the sulfur content in the oil fuel used by 3%.

2. METHODOLOGY

2.1 Procedure performed for calculating emissions

Initially, the Company of the Docks of the State of Bahia (CODEBA) was requested to record the entries and exits of ships from the year 2013. The methodology adopted for calculating emissions follows the Bottom-up approach as it is more precise in the calculation emissions in relation to methodologies based on fuel consumption. The methodology was based on the Entec study [11] as a function of the database, operating mode, load factor (FE) allowing for a better assessment of the study area.

The calculation of emissions from ships at the Port of Salvador at the time of berthing for the year 2015, considering the sulfur content in the fuel oil used at 3%, was performed according to Eq. (1) given by:

$$E_{atr}(g) = T(h)\left[\left(MP(kW)FC_{MP}(\%)FE(\frac{g}{kWh})\right) + \left(MA(kW)FC_{MA}(\%)FE(\frac{g}{kWh})\right)\right] \quad (1)$$

In Eq. (1), E_{atr} represents the mass (g) of a pollutant emitted when it is berthed in a port; T represents the time a ship spends berthed in a port (h); MP represents the value of the power of the main engine (kW); FC_{MP} represents the load factor of the main engine when the ship is berthed (%); FE represents the emission factor assigned to each ship in navigation mode, depending on the type of fuel used and the type of engine (g/kWh); MA represents the power value of the auxiliary engine (kW) e FC_{MA} represents the load factor of the auxiliary engine when the ship is berthed (%). The calculated emissions will be obtained in grams and converted to tons.

For each category of ships (bulk carrier, containers, general cargo, cruise ships, others), a certain MP (main engine) and MA (auxiliary engine) power value was used, the type of fuel used by them and the average speed value. The ships have engines powered by a fuel that is formulated from a fraction of petroleum and a mixture of thinners, composed of heavy diesel oil and light recycle oil (LCO), from the catalytic cracking process. The market follows the specification contained in the ISO8217 standard.

The time each ship spent berthed in a port was determined by calculating the difference between the departure date and the arrival date. Thus, it was decided not to consider the hours of entry into this port and, for ships entering and leaving the port on the same day, a berth time of 12 hours was assumed. For the others, the difference between the exit date and the entry date was calculated.

2.2 Study area

Bahia has the longest coastline in Brazil, and the Bahian ports stand out in the national port structure. The Port of Salvador is responsible for handling 57% of the State's exports, having 2,092 m of mooring berths with a depth ranging from 8 m (warehouses 1 and 2) to 15 m (container terminal and connecting pier), where eight ships can dock simultaneously.

The average frequency of ships docked is 75 per month, where their operations are facilitated by a modern container terminal with portainers, transtrêiner, forklifts, rech stackers and RTGs. Due to its natural characteristics, the port of Salvador is designed to operate mainly with containerized general cargo, being among the most important terminals in the country and one of the largest in the North/Northeast.

In Figure 1, the geographic location of the Port of Salvador is shown, which plays a decisive role for the Bahian economy, standing out in the handling of containers, general cargo, wheat, cellulose, and fruits, benefiting, among other factors, by its strategic position in relation to the European continent and Mercosur. Its area of influence includes, in addition to Bahia, the north of Minas Gerais, Sergipe, Alagoas, Pernambuco, Paraiba, Rio Grande do Norte and Ceará. It is also one of the main destinations on the Brazilian coastline cruise routes.

Figure 1. Geographical location of the maritime port of Salvador

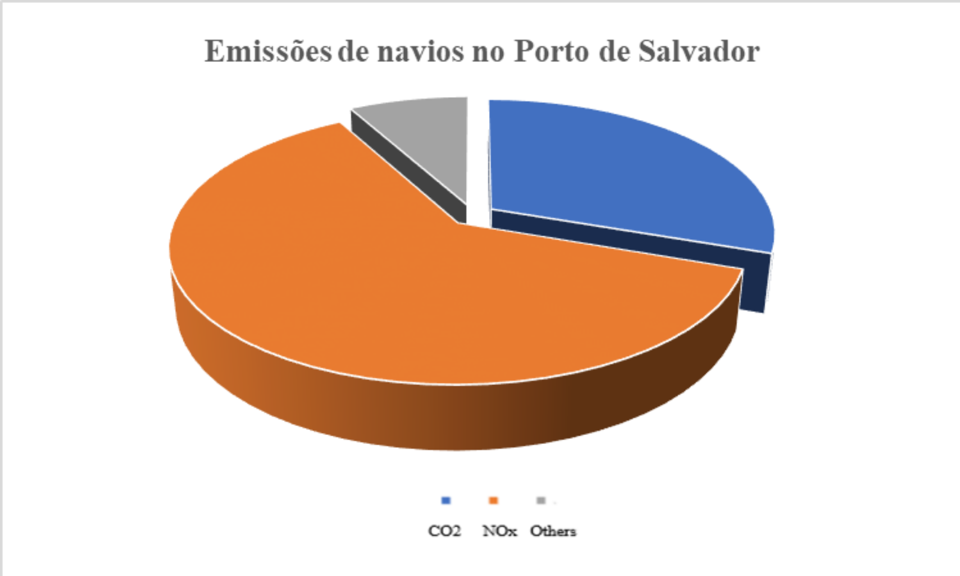
Source: Own elaboration

The Port of Salvador has received substantial investments in its infrastructure, such as the Via Expressa, which connects it to BR-324, the dredging of its access channel, the construction of a new maritime passenger terminal and modernization, purchase of new equipment. for the Container Terminal and modernization of the wheat reception structure.

3. RESULTS AND DISCUSSION

In Figure 2, the total emissions of NO_x and CO_2 and other pollutants in the maritime port of Salvador are shown when the ship is in the operating mode designated as berth for the year 2015. NO_x emissions are highlighted in blue, CO_2 emissions in orange and the total for other pollutants are aggregated in yellow as they are not the focus of this study.

Figure 2. NO_x and CO_2 emissions at the maritime port of Salvador in 2015



Source: Own elaboration

Normally, the pollutants emitted by ships are: CO_2, SO_2, NO_X, VOC and PM, although others are emitted, such as nitrous oxide (N_2O), carbon monoxide (CO_2) and hydrocarbons (HC) [14-15]. However, the aim of this study was to investigate the contribution of the maritime sector in NO_X and CO_2 emissions. This is due to the fact that these emissions are quite significant when compared to other pollutants.

The CO_2 remains in the atmosphere for a long period of time compared to other pollutants and its effects on the atmosphere last a long time after its emission. NO_x is a result of the combustion process in different engines. The fact that ships operate without major mitigation measures and these compounds are released in high quantities, when reacting with VOCs in the presence of sunlight, give rise to tropospheric ozone, which is a major component of 'smog' or photochemical fog. Exposure to these fogs can cause heart and respiratory problems, according to the United States Environmental Protection Agency (USEPA) [16-17].

Atmospheric emissions in seaports from ships berthed in ports are the most critical when compared to other modes of operation. This can be explained by the time the ships approached, maneuvered, remained berthed in the port and considerable consumption of RO (Residual Oil) in relation to the distilled fraction. Emissions from ships can be transported long distances in the atmosphere, from sea to land and from one continent to another [18] having impacts from regional to global scales. However, although on a global scale this contribution is small in total emissions in urban centers and areas of high population density, these emissions directly affect the population living in the vicinity of ports [19-20].

4. CONCLUSION

The aim of this study was to estimate the NO_x and CO_2 emissions of ships that docked at the Port of Salvador in 2015 using a methodology developed by Entec UK Limited. It should be noted that, for a region where the country's largest coastline is concentrated, accounting for about 57% of exports, studies such as this one is essential.

The results obtained showed that the contributions of NO_x and CO_2 pollutants were, respectively, 61% and 31%. This demonstrates the importance of this investigation regarding the harmful effects of the rise of these pollutants on the local atmospheric composition. However, as this is an estimation methodology, there are uncertainties associated with the category of ships and the fuel consumed by each category. Thus, it is suggested that for future work, programs based on the Automatic Identification System (AIS), implemented in ships, which is an automatic system for identifying vessels, should be used.

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