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USING SHERPA TOOL FOR ASSESSMENT OF EUROPEAN WATERBORNE TRANSPORT SECTOR IMPACT ON AIR QUALITY

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ABSTRACT – At European level SHERPA (Screening for High Emission Reduction Potential on Air) screening tool was developed by EU Joint Research Centre (JRC) to assist decision factors in evaluating the potential of air quality improvements resulting from localized emission reduction measures. In the paper, a discussion on quantifying emissions and an analysis of European waterborne transport sector is done with an assessment of most polluted areas and eventual potential on reducing emissions generated by waterborne transport.

Keywords: Sherpa, Air quality, Waterborne Transport Emissions.

INTRODUCTION

Waterborne transport can contribute to pollution in Europe through various emissions, including greenhouse gases, nitrogen oxides, sulfur oxides, particulate matter, and other harmful substances. These emissions can have negative impacts on air quality, human health, and the environment.

One of the main sources of emissions from waterborne transport in Europe is the use of fossil fuels in ships. Most ships use heavy fuel oil, which is high in sulfur content and can lead to the release of SOx, NOx and PM. Other sources of emissions from waterborne transport include ballast water discharge, anti-fouling paints, and accidental spills of oil and chemicals. These can have negative impacts on marine ecosystems and biodiversity, as well as human health in coastal and riverside communities.

To address these issues, the European Union has implemented various policies and regulations aimed at reducing emissions from waterborne transport. These include the Sulphur Directive (Directive 2012/33/EU), which limits the sulfur content in fuels used by ships operating in EU waters, and the Marine Strategy Framework Directive, which aims to protect and restore the marine environment through various measures, including reducing emissions from ships. [1] To address the issue of inland waterborne transport pollution in Europe, the EU has introduced several policies and measures. The most notable of these policies is the Inland Waterway Vessel (IWV) certification system, which sets emission standards for NOx and PM emissions from inland waterway vessels. The EU has also established the Blue Corridors project, which aims to promote the use of LNG

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and other alternative fuels in inland waterway transport.

In 2020, the MARPOL Convention members decided under IMO 2020 regulation notes the reduction of the Sulphur content of fuel oil used for ships from 3.5 % to a maximum of 0.5 % by mass [2]. A significant reduction of Sulphur oxide emissions from waterborne transport is expected in future years, at European level. Due to high transport load capacities the waterway vessels are considered environmental friendly ways of transport, when focus is on CO_2 emissions. However, as the main enforcements on limiting emissions levels only started in early 1990's, with limits for NOx and PM emissions, most of the marine and inland vessels in operation today are free of emission control. This is mostly due to high life span of engines designed for marine and inland water transport and is expected that vessel fleet renewal with new diesel engines will not happen before 2040. [3]

Methodology

The evaluation of the impact of emissions generated by marine and inland vessels is usually done using chemical transport models that include in their core pollutants transports, pollutants diffusion and pollutants atmospheric reactions. However, because these models require significant computing power they are applied on localized, limited areas, from 50 to 500 km in diameter.

The "Screening for High Emission Reduction Potentials for Air quality" tool (SHERPA) was been developed by the Joint Research Centre specifically to avoid this limitations and to run on regular computing systems while covering entire European continent. This screening tool simulates a chemical transport model, based on statistical data obtained from regulatory bodies of European countries and provides a fast response time for any given air pollutants dispersion [4].

SHERPA is based on source-receptor interaction and it was developed for the analysis of potential air quality improvements resulting from decision making stakeholders emission reduction measures. It is based on a simplified version of a chemistry transport model and provides estimates of concentration levels of precursor pollutants, NOx, NMVOC, PPM, SO2 and NH3, from a single or a group of activity sectors over a domain [5]. The SHERPA tool has 3 independent modules: source allocation, governance and scenario analysis, each focusing on a specific approach on air quality issues.

The main equation implemented in SHERPA is based on cell by cell approach, with a cell spatial resolution of 7x7 km^2 with EU available data on emissions and source-receptor models and emission reduction scenarios. The links between emission $\Delta E_{j,k}$ and concentration ΔC_i are computed cell by cell:

$$\Delta C_i = \sum_j^{Nprec} \sum_k^{Ncell} a_{i,j,k}^{1} \Delta E_{j,k} \quad (1)$$

This has the main benefit given by its spatial flexibility due to the fact that coefficients $a_{i,j,k}$ are approximated by a distance function:

$$a_{i,j,k} = \propto_{i,j} (1 - d_{i,k})^{-\omega^{i,j}} \quad (2)$$

Where *i* is the grid cell in which the concentration is estimated and *di,k* is the distance between cells *i* and *k* [6]

In SHERPA the areas of interest are defined on the European Nomenclature of territorial units for statistics (NUTS) and Gridded Nomenclature For Reporting (GNFR). In this study we used all European territory and focused on GNFR7, G_Shipping, national navigation including inland waterways sector.

RESULTS AND DISCUSSION

The SHERPA approach is based on GWR (Geographically Weighted Regression) and local modelling approaches, methodologies who uses bell-shaped kernel functions to determine weighted regressions of input versus output variables. [7, 8, 9]

In the scenario assumed in this study we focused mainly on NMVOC, SO2, NOx and PPM emissions generated from marine and inland shipping sector with inclusion of EMEP total emissions per sector (GNFR 7), countries (EU28 and outside) and applying automated SHERPA gridding methodologies, for the year 2022.

The results obtained are presented in figure 1 to 4.

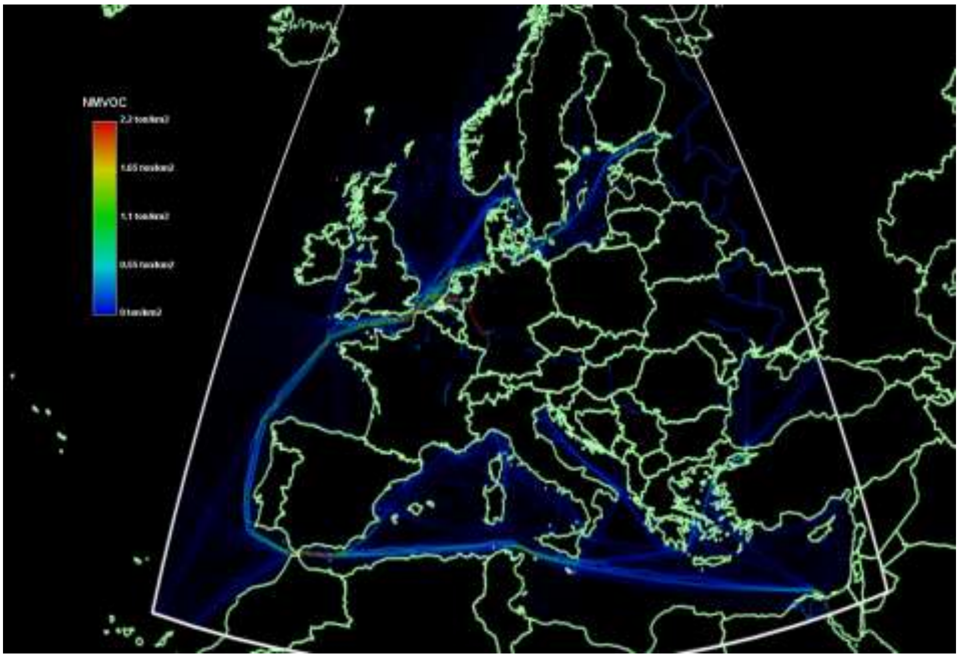

Figure 1 Europe-region level, NMVOC annual average concentration, exclusively GNFR7 water shipping navigation transport sector.

In figures 1 to 4 the relative impact of maritime and inland transport sector and facilities in Europe (EU28 and outside countries) on air quality is given as result of SHERPA modelling tool output, as pollutant concentration in ton/km^2. Figure 1 shows the results obtained for NMVOC emissions, reaching 2.2 ton/km^2 in intense maritime traffic coastal areas in North-West and South Europe.

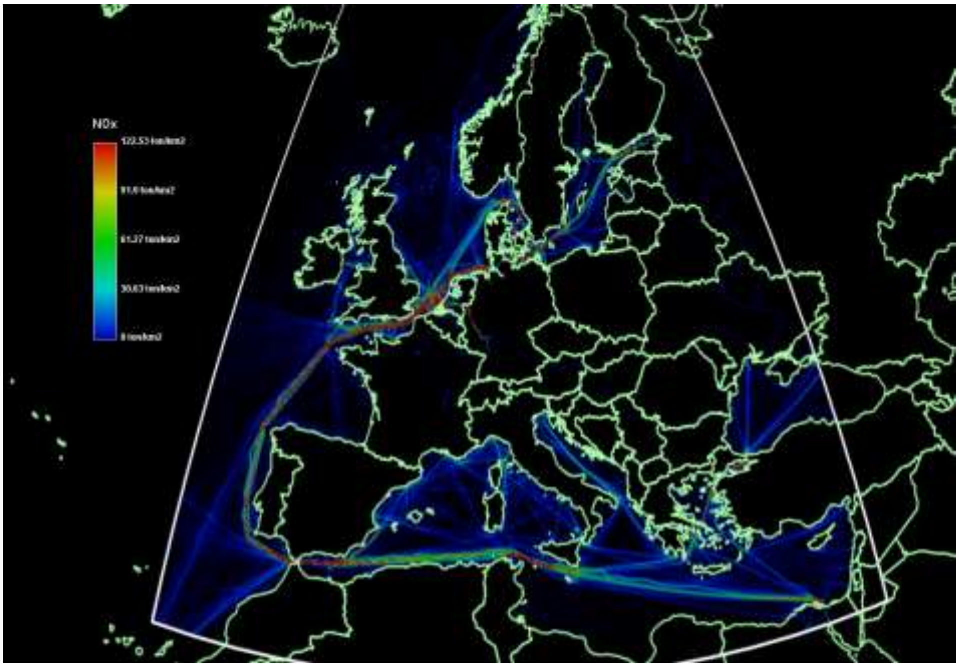

Figure 2 Europe-region level, NOx annual average concentration, exclusively GNFR7 water shipping navigation transport sector.

Figure 3 Europe-region level, PPM annual average concentration, exclusively GNFR7 water shipping navigation transport sector.

Figure 4 Europe-region level, SO_2 annual average concentration, exclusively GNFR7 water shipping navigation transport sector.

Figure 2, 3 and 4 shows the results obtained for NOx, PPM and SO_2 emissions, reaching 122 ton/km^2 for NOx, 5 ton/km^2 for PPM and 14 ton/km^2 for SO_2, all occurring in the intense maritime traffic coastal areas in North-West and South Europe.

CONCLUSION

Based on a study conducted by International Maritime Organization (IMO) in 2018, the overall contribution of water shipping to global anthropogenic GHG emissions was about 3% in 2018 [10] and considering this low contribution the maritime and inland water transport can be considered the most efficient method of international transportation of goods. However, even if the maritime transport sector has a low CO2 contribution than others, in terms of SO_2 and NOx emissions is relevant, with about 13% quota for SO_2 and 15% for NOx global emissions [10]. This data shows that naval shipping, especially on inland waters constitute a major source of local pollution, inland and on coastal areas.

Also, a research study conducted in France (2015-2016), [3] with direct measurements of emissions onboard of different types of marine and inland vessels, a pusher tug vessel produces up to 2 times higher emissions of NOx, CO and particulate matter than Euro V road trucks for 1 ton of goods transported. Similar results were found in this research, for example by running SHERPA for GNFR6 sector (Road transport) we found that emissions from road transport in Europe reached maximum of 44 ton/km^2 in comparison to 122 ton/km^2 for water transport and SO_2 of 1.3 ton/km^2 in comparison to 14 ton/km^2. At the same time the NMVOC emissions generated by road transport, 67 ton/km^2, are much higher than 2.2 ton/km^2 found for water transport.

In the recent years the European Union focused on reducing or eliminating the GHG emissions from all sectors, with an emphasis on energy and transport sectors. This study is intended to show that SHERPA tool can help researches and EU decision makers to implement more pin-point strategies in reducing pollution and GHG in geographical areas where it most frequently occurs.

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REFERENCES

1. E.U. (2012) Directive 2012/33/EU of the European Parliament and of the Council, amending Council Directive 1999/32/EC as regards the Sulphur content of marine fuels, 2012/33/EU, https://eur-lex.europa.eu/, (10.04.2023)
2. I.M.O (2020) Amendments to MARPOL annex VI, regulations for the prevention of air pollution from ships, MEPC 73/19/Add.1, Annex 1, page 2, https://www.imo.org/en/OurWork/Environment/ (10.04.2023)
3. Pillot, D., Guiot, B., Cotties, P.L., Perret, P., Tassel, P. (2016) Exhaust emissions from in-service inland waterways vessels, Journal of Earth Sciences and Geotechnical Engineering, 6(4), 205-225
4. Thunis, P., Degraeuwe, B., Pisoni, E., Ferrari, F., Clappier, A. (2016) On the Design and Assessment of Regional Air Quality Plans: The SHERPA Approach, Journal of Environmental Management 183(Pt 3) 952-958
5. Popescu, F., Vujic, B., Cioabla, A.E., Mrceta, U., Dungan, L., Trif-Tordai, G., Laza A. (2020) Using SHERPA screening tool for design and assessment of local and regional air quality management, Journal of Physics: Conference Series, 1781, 012055
6. Albrecht, D., Mara, T.A., Pisoni, E., Rosati, R., Tarantola, S. (2018) Sensitivity Analysis of the SHERPA Air Quality Model, EUR 29122 EN, Publications Office of the European Union, Luxembourg, doi:10.2760/78023, JRC110322
7. Wolf, L.J., Oshan, T.M., Fotheringham, A.S., (2018) Single and multiscale models of process spatial heterogeneity. Geographical Analysis, 50, 223–246.
8. Lloyd, C., (2010) Local Models for Spatial Analysis. CRC Press, Boca Raton. https://doi.org/10.1201/EBK1439829196
9. Belis, C.A., Pisoni, E., Degraeuwe, B., Peduzzi, E., Thunis, P., Monforti-Ferrario, F., Guizzardi, D. (2019) Urban pollution in the Danube and Western Balkans regions: The impact of major PM2.5 sources. Environment International, 133 (A), 105158
10. I.M.O. (2020) International Maritime Organization. Fourth Greenhouse Gas Study 2020, https://www.imo.org/en/OurWork/Environment/Pages/Fourth-IMO-Greenhouse-Gas-Study-2020.aspx (10.04.2022)

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