Impact of international shipping on European air quality

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Emissions from the marine transport sector contribute significantly to air pollution globally (Corbett & Fischbeck, 1997). Around 15% of global NOx and 5-8% of global SOx emissions are attributable to oceangoing ships (Eyring et al., 2005). Because nearly 70% of ship emissions are estimated to occur within 400 km of land, ships have the potential to contribute significantly to air quality degradation in coastal areas.

Shipping emissions are currently increasing, and even more so in the future due to the globalization of manufacturing processes and the increase of global-scale trade (USEPA, 2009). This increased flow of commercial ships into and out of ports does not only affect major ports, but also medium and small-scale ones. Although shipping contributes significantly to the international transportation sector, its emissions are not well quantified and are one of the least regulated anthropogenic sources.

In this context, the European Environment Agency initiated a project to investigate the current impact of the ship emissions on the ambient air levels of primary and secondary aerosols, and how the predicted future growth of ship traffic and the geographical expansion of waterways and ports, possibly combined with international regulations, will affect the atmospheric composition. In order to design and implement effective regulation to minimise environmental impacts of these emissions, detailed knowledge is necessary on their effects on climate and on their contribution to atmospheric pollution.

An in depth literature review was carried out focusing on the assessment of the impacts of shipping emissions and activities on urban air quality in coastal areas. The initial conclusion extracted from this review is that studies addressing this topic are relatively scarce, and that therefore there is a need to encourage this type of assessment in European coastal (and potentially, inland) areas. In particular, quantitative studies are especially scarce.

In addition to the literature review, the contribution of shipping activities to the degradation of European air quality and regional climate change was assessed by means of sensitivity chemistry transport simulations with the CHIMERE model based on the emission projections of the Global Energy Assessment.

The literature review evidenced that shipping emissions contribute to ambient PM levels in European coastal areas with 1-7% of PM_{10}, 1-14% of $PM_{2.5}$ (reaching a maximum of 20% in Genoa, Italy) and at least 11% of PM_1 (data for this size fraction available only for 1 location). Thus, it is evident that the impact of shipping activities increases with decreasing particle size. For the sake of comparison, contributions reported for non-European harbours (USA) were <5% of $PM_{2.5}$ in Los Angeles and 4-6% of $PM_{2.5}$ in Seattle. Spatially, shipping contributions to urban air quality degradation are higher in Mediterranean cities than in Atlantic coastal areas. However, it must be highlighted that results were obtained using different approaches and methodologies in the different regions, and thus may not be directly comparable.

The data available on gaseous pollutants is even more scarce than for PMx. Contributions from shipping to ambient NO_2 levels range between 7 and 24%, with the highest values being recorded in the Netherlands and Denmark. Increases in SO_2 concentrations were only reported in Sweden, as relative increases with respect to background concentrations and not in absolute terms.

Finally, current research evidences that shipping emissions impact not only the levels and composition of airborne particles and gaseous pollutants, but that they also may enhance new particle formation in urban areas and contribute to other forms of air quality degradation.

The modelling exercise evidenced that, to date, ships are responsible for about half of the NO_2 and SO_2 concentrations found over sea surface. In the future, SOx emissions are expected to be reduced, so that the contribution of ships to SO_2 over sea surface will decrease to about 1/3, whereas their contribution to absorbing BC will be higher than for the present-day.

In coastal areas, ships are responsible for about 7-8% of human exposure to particulate sulphate and 4% of the exposure to $PM_{2.5}$ and ozone peaks. The model results offer a good insight into the geographical variability of the impact, which is consistent with the estimates derived from ambient air monitoring.

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