Origins of PM_{10} in northern coast of France: a one year study to estimate maritime contributions in the Strait of Dover

C. Roche[1], F. Ledoux[1], M. Borgie[1], G. Delmaire[2], G. Roussel[2], M. Puigt[2], D. Courcot[1]

[1]Univ. Littoral Côte d'Opale, EA 4492 - UCEIV - Unité de Chimie Environnementale et Interactions sur le Vivant, F-59140, Dunkerque, France
[2]Univ. Littoral Côte d'Opale, EA 4491 – LISIC - Laboratoire d'Informatique Signal et Image de la Côte d'Opale, F-62228 Calais, France
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Presenting author email: frederic.ledoux@univ-littoral.fr

The Nord-Pas-de-Calais Region is one of the most concerned areas in France by exceeding of the PM_{10} daily mean limit value (50 µg.m^{-3}). For a better understanding of these phenomena, the most complete identification of PM_{10} source is crucial. In this region, numerous studies aiming to the characterization and identification of particles in urban area and in the vicinity of industrial emission have been performed. The objective of this work is to fill the lack of knowledge about the impact of emissions resulting from the marine compartment. It includes natural emissions such as sea salts (Manders et al. 2010) and anthropogenic emissions linked to the marine traffic especially in the English Channel, together with the Strait of Dover, that forms a narrow corridor with one of the greatest concentrations of shipping in the world (EEA, 2013) (700 to 800 vessels sailing per day).

The PM_{10} sampling and measurement campaign has been performed continuously from 2013/01/01 to 2014/04/15 at the Cape Gris Nez, a coastal French site selected to study marine impact, in front of the Straits of Dover. A complementary campaign has been performed in the port of Calais, from 2014/01/28 to 2014/04/21. PM_{10} levels were measured using MP101 analyzer and collected using Digitel® DA80 sampler (30 m^3/h, 24h, Pall® QAT-UP filter). The characterization of PM_{10} was performed considering trace metals, water soluble ions, EC/OC, biomass burning and biogenic particles organic tracers. These chemical parameters were considered to explain PM_{10} levels observed in the Nord Pas-de-Calais Region and to estimate the contribution of the maritime sector to the PM_{10} levels in coastal sites.

In 2013, at Cape Gris-Nez, PM_{10} mean value was 22.8 µg.m^{-3} and is very similar to those observed in several other sites in the Nord-Pas-de-Calais region. Six species explains about 80% of the total mass of PM_{10}: NO_3^-, OM, SO_4^{2-}, Cl^-, Na^+, and NH_4^+. Contributions of the different particles types were calculated; sea salts represents 22% of the total mass of PM_{10}. Concentration roses were drawn for the 33 studied species. Some elements show identical rose patterns such as V and Ni, known as tracers of fuel combustion, as well as Co, which all point to the North-Sea and the ferries shipping route between France and England.

An innovative Constrained Weighted Non Negative Matrix Factorization model developed with the LISIC laboratory has been used (Limem et al. (2014), Kfoury et al. (2016)). This model allows taking a priori knowledge by applying soft constraints on the sources profiles. 10 sources profiles were identified: sea-salts, aged sea-salts, secondary nitrates, secondary sulphates, crustal, biomass combustion, primary biogenic emission, marine traffic, combustion, metal source. The monthly evolution of their contribution evidences different behaviour between the sources: secondary nitrates are predominant during the cold seasons and appears to be the most involved in the PM_{10} peaks; Impact of marine traffic is mainly evidenced during the summer season. Study of the contribution roses evidenced that the impact of the marine traffic mainly results from long range transport despite the proximity of the English Channel and the North Sea.

For the year 2013, the mean contribution of the different sources were 37% for sea salts and aged sea-salts, 43% for the secondary inorganic aerosols, 7% for biomass combustion, 5% for marine traffic. This distribution varies highly depending on the period and more particularly during above daily PM_{10} limits values.

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