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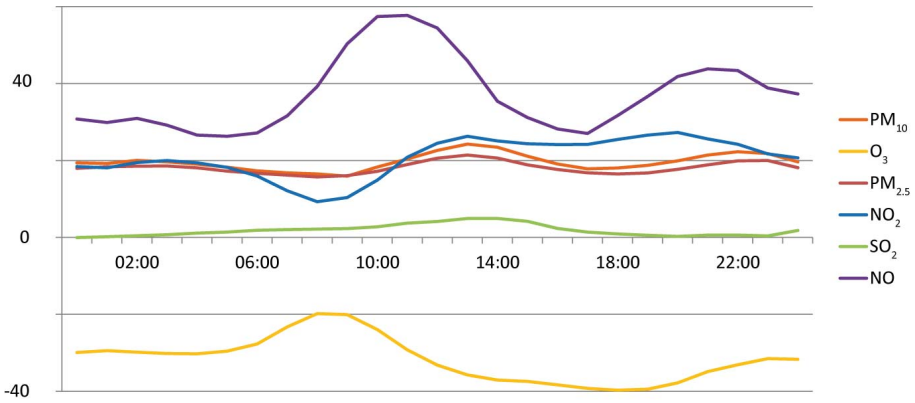
Urban fog and atmospheric pollution: contrasted effects on pollutants in Lyon (France)

RENARD, Florent[1*] ; FUJIKI, Kenji[1]

[1]University Jean Moulin Lyon 3, UMR 5600

Lyon (500 000 inhabitants), located in the southeastern France, is an industrial city, with a polluted atmosphere and many days of fog. This unfavorable atmospheric situation poses many health problems to people and harms the attractiveness of the city and the development of trade. Greater Lyon has the highest levels of fine particulates and nitrogen dioxide in the Rhone-Alpes region and is prosecuted by the European Union for non-compliance with the Directive of 21 May 2008 concerning the quality of ambient air and cleaner air for Europe. This area is disadvantaged by its geographical situation, with the presence of two major rivers (Rhone and Saone) and many reliefs, influencing the conditions of dispersion of pollutants in the atmosphere and makes the Lyon an atmospherically sensitive city, despite prevailing winds North-South or South-North oriented which tend to favor the dispersion of pollutants In addition, Lyon concentrates pollution from traffic, industrial, and tertiary sectors. In winter, temperature inversions (temperature higher in altitude than on the ground) promote stagnation of pollutants at low altitude. This phenomenon is amplified considerably during episodes of urban mist. As a first step, the evolution of the number of foggy days is studied, and explanatory factors are proposed. The months of October to January are the most affected, with an average of 7 days of fog in December and January, over the period 1949-2013. It is thus noticed a steady decline in the number of foggy days since 1921 until early 2000s, from more than 90 days to only fifteen, followed by stagnation and a slight increase in recent years. This trend is compared to the annual minimum temperatures of Lyon, following an opposite trend, with an increase until the late 2000s, from 6 degrees C to 9 degrees C, followed by a stagnation and a slight decrease. A strong relationship is obtained between these two parameters, but the average wind speed may also explain the decrease, limiting conditions for fog formation, with a more important mixing of the air. Again, it can be noticed an increase in the average wind speed and in the proportion of winds faster than 1 m / s until the early 2000s, and then a decrease. Finally, better controls of industrial air emissions also explain the decrease in the number of days with fog over the long term. In a second step, the concentrations of air pollutants (PM10, PM2.5, 03, NO2, NO and SO2) are studied with and without fog. A station in the center of the city records these pollutants since 2007 continuously, every hour. In 2013, during foggy days and comparatively to clear days, it is found a strong increase in PM 10 and PM 2.5, respectively from 22.3 μg.m-3 and 16.8 μg.m-3 to 39.7 μg.m-3 and 33 μg.m-3, above recommended thresholds. Concentrations of nitric oxide (NO) and nitrogen dioxide (NO2) are respectively 9.0 μg.m-3 and 27.7 μg.m-3 during clear days, passing to 52 8 μg.m-3 and 50.5 μg.m-3 during foggy days, exceeding the recommended values here too. And inversely, as a result of sunlight blocking by water droplets in suspension, there is a decrease in O3, from 42.4 μg.m-3 to 13.9 μg.m-3, while the SO remains stable and very low, at 1.2 μg.m-3(fig. 1). These observations made in 2013 are the same since 2007. Finally, the evolution of the concentration of PM 10 is studied during persisting foggy days, hours after hours. There is a steady and dramatic increase in the concentration with consecutive days of fog, going to an increase of 40 μg.m-3 on the fourth day. In conclusion, air pollution in urban areas under clear skies is already a major concern, but the action of the latter on health is particularly worrying during episodes of urban smog.

Keywords: fog, atmospheric pollution, particulate matter, Lyon, France



Average hourly evolution of pollutant concentrations (µg.m^{-3}) during foggy days, compared to standard days (Lyon city center, France ; 2007-2013)