Influence of meteorological parameters on air pollutant concentrations in León, Spain

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The presence of pollutants in the atmosphere may cause a negative impact on human health and the environment. The main air pollutants are carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), ozone (O_3) and particulate matter (PM). The correlation between the air pollutant concentrations and the weather variables provides valuable information about the emission sources and leads to a better understanding of the processes responsible for the spatial and temporal distribution of air pollutants. This enables policy makers to establish mitigation measures. The present study was carried out in León city, located in the northwest of the Iberian Peninsula (42° 36′ N, 05º 35′ W and 838 m above sea level). For this study, the data available in the Air Quality Network of Junta of Castilla y León (www.servicios.jcyl.es/esco) for the period between 1 January and 31 December 2016 were used. Two air quality stations were operating during the studied period (Fig.1): *i*) an urban traffic station located in San Ignacio de Loyola Avenue (*Station 1*, 05° 35'14"W 42° 36'14"N) and *ii*) a background station located in the Coto Escolar (*Station 4*, 05° 33'59"W 42° 34'31"N).

Fig. 1.- Map of León city(Spain) and location of both air quality stations

The climate is of Mediterranean type with continental features. Through the database of the Meteorological State Agency web page (www.aemet.es), the mean annual temperature, relative humidity, precipitation and days with precipitation of more than 1 mm (11 ºC, 68%, 488 mm and 82 days, respectively) for 2016, were obtained. In order to identify the most frequent weather type, a Circulation Weather Types classification (CWTs) was carried out (Lamb, 1972). The classification showed that during 2016 the CWTs were mainly anti-cyclonic (66 days), followed by two purely directional types, northeasterly (42 days) and northerly (34 days). Pollutant concentrations associated with weather types were characterized. In Fig. 2, the frequency of each wind direction recorded during the sampling period and the wind speed average for each direction are shown. In León, the winds come predominantly from the third and fourth quadrants, i.e.: the predominant directions are between NW and SW. Winds from the first quadrant are remarkably light (between 0.6 and 1.4 m s^{-1}), while those from the SW are the most intense (3.4 m s^{-1}).

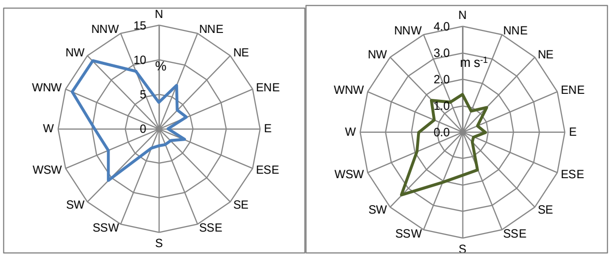

Fig. 2.- Frequencies of a) wind direction and b) wind speed

Station 1 shows higher pollutant concentrations than station 4 (Table 1), for sure due to the large contribution of traffic and urban heating systems near to the station.

Table 1.- Mean (± standard deviation) annual pollutant concentrations for stations 1 and 4 during 2016

	Station 1	**Station 4**
CO (mg m^{-3})	0.3 ± 0.2	-
NO (µg m^{-3})	17 ± 14	4 ± 6
NO_2 (µg m^{-3})	26 ± 14	12.0 ± 6.3
PM_{10} (µg m^{-3})	19.9 ± 9.3	12 ± 7
SO_2 (µg m^{-3})	8 ± 6	2.0 ± 1.6
O_3 (µg m^{-3})	-	54 ± 20

The correlation between CO, NO, NO_2, O_3, PM_{10} and SO_2 concentrations and meteorological parameters (mean temperature (T), minimum temperature (T_{Min}), maximum temperature (T_{Max}), relative humidity (HR), wind speed (ws) and accumulate precipitation (Prec)) was made using the nonparametric Pearson correlation method. The ws had a positive significant correlation with CO and O_3 (both with r = 0.2, p< 0.01). SO_2 concentrations had a positive significant correlation with T, T_{Min} and T_{Max} (r = 0.2, 0.1, 0.3, respectively, p< 0.01) in the station 1; however, in the station 4 they do not show a significant correlation. The opposite occurs with PM_{10}, which only shows a positive significant correlation with T, T_{Min} and T_{Max} in the station 4 (r = 0.4, 0.2, 0.4, respectively, p< 0.01). In general, the Prec and HR are negatively correlated with the pollutant concentration, suggesting that the removal by condensation or wet deposition is favored. T and T_{Max} were positively correlate with O_3 concentration (r = 0.5, p< 0.01), which is an indicator of photooxidation processes.
The polar plots (Fig. 3) show the variation of the daily PM_{10} concentrations with the wind direction and speed during 2016. A decrease in PM_{10} concentration with the increase of the speed was observed for both stations. This behavior is confirmed by the negative significant correlation observed between ws and PM_{10} concentrations (r = 0.5, p< 0.01). Authors as Elminir (2005) associated the highest atmospheric pollutant concentration linked to traffic (e.g., SO_2, PM_{10}) in urban sites to the low wind speed.

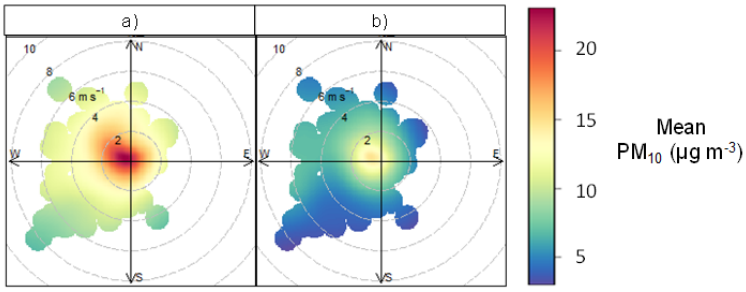

Fig. 3.- Polar Plots (PM_{10} concentration as a function of wind speed and direction) for a) station 1, b) station 4

Fig. 3 shows that the principal source of particles is located close to the sampling point. Also, the Pearson correlation coefficient shows, in both cases, a positive significant correlation between PM_{10} and NO, NO_2 and CO (r > 0.3, p < 0.01), that reflects the road traffic emission as common origin. However, there are differences in the PM_{10} concentrations registered in both stations. This fact is probably due to the different category of both stations: traffic (station 1) and background (station 4). Thus, station 1 is highly influenced by the emissions from the vehicles in the proximities and also by the domestic heating devices that are in the vicinity (mainly during cold months).

Acknowledgments

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