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Quantification and Spatialisation of the Concentrations of Particulate Pollutants (PM_{10} and $PM_{2.5}$) Emitted by Industries in the Dakar Region, Senegal

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Abstract

The present article describes and comments the data of the particle broadcasts (PM_{10} and $PM_{2.5}$) inventoried by the industrial sites for the years 2014 has 2018 and the evolutionary tendencies of the air pollution observed at the level of the industrial stations of the stationary measures in the city of Dakar. Two approaches have been used for the realization of these works: the inventory of the particle broadcasts by the industrial and the campaigns of the measurements, has different periods of the year, by stations of surveillance of the quality of the air of the CGQA situated in the region of Dakar. The obtained results showed a real impact of the industry dismissals on the pollution in the region of Dakar but also of the variation of the particulate pollution to the level of the city. The sector of the energy is the main issuing source of atmospheric particles (PM_{10}) in 2014 with dismissals to height of 58%. Concerning the cartographic representation the region is submitted to strong person concentrations going until 3000 kg/year of broadcasts. The extrapolation of concentration measure in PM_{10} shows a strong concentration in the West part of the city of Dakar with concentrations middle yearly passing 250 μg/m^3. During the whole period of 2015 to 2018, the level of yearly middle concentrations passed the 100 ug/m^3 and the maxima concentrations were greater than 550 μg/m^3. The evolutionary tendency of concentration of the $PM_{2.5}$ also follows those of the PM_{10}. These cartographies permitted us to identify the geographical zones spatially or the concentrations are most elevated. However, of the indicators and the levels, relative to the population potentially exposed to overtakings of the yearly value limits are reached also.

Keywords

Air Pollution, Respiratory Symptoms, PM_{10} and $PM_{2.5}$, Dakar, Industrial Emissions, Geographical Concentration

1. Introduction

During these last years, several studies put in evidence the exhibition to the pollution of air to the sanitary data. Exposure to air pollution can lead to chronic diseases such as cardiovascular and pulmonary illnesses (Evans et al., 2013). It results in an increase of mortality, a decrease of the life expectancy and a recourse increased to the cares (Evans et al., 2013). The improvement of the air quality is thus a major stake of public health (Shah et al., 2015). Gold in developing countries, especially in Africa, rare are ours countries that are especially interested in this spiny topic when it is about making the interrelationship with the industrial dismissals. The effects of the atmospheric pollution especially result from the daily exhibition to the PM_{10} pollutants and $PM_{2.5}$ (Shah et al., 2015).

According to the newspaper, The Lancet, 92% of the world's population, or more than nine (9) people out of ten (10) across the world, breathe excessively polluted ambient air. This study is based on the quality of outdoor air observed in 3000 renting around the world in 2019 (Philip & Landrigan, 2018). In developing countries, 98% of cities with more than 100,000 inhabitants do not respect the annual thresholds set by the WHO heart atmospheric particles (PM_{10} and $PM_{2.5}$) (WHO, 2018). However, 80% of deaths and hospitalizations heart cardiac reasons are attributable to the concentration levels of atmospheric particles (PM_{10} and $PM_{2.5}$) during pollution peaks at 80 μg/m^3. It is estimated that by 2060, air pollution could kill more than ten (10) million people worldwide (Medina, 2014). It is therefore this worrying situation which justifies the work of recent years. The present study takes this into account. The objective is to quantify and map the concentrations of particulate pollutants of industrial origin in the Dakar region.

2. Materials and Method

2.1. Description of the Study Zone

This study is carried out in the city of Dakar (**Figure 1**), capital of Senegal. The

Dakar region is located in the Cap Vert peninsula and covers an area of 550 km^2, or 0.28% of the national territory (ANSD, 2019). It is between 17˚10 and 17˚32 west longitude and 14˚53 and 14˚35 north latitude. It's limited to the East by the Thiès region and by the Atlantic Ocean in its northern, western and southern parts (ANSD, 2019).

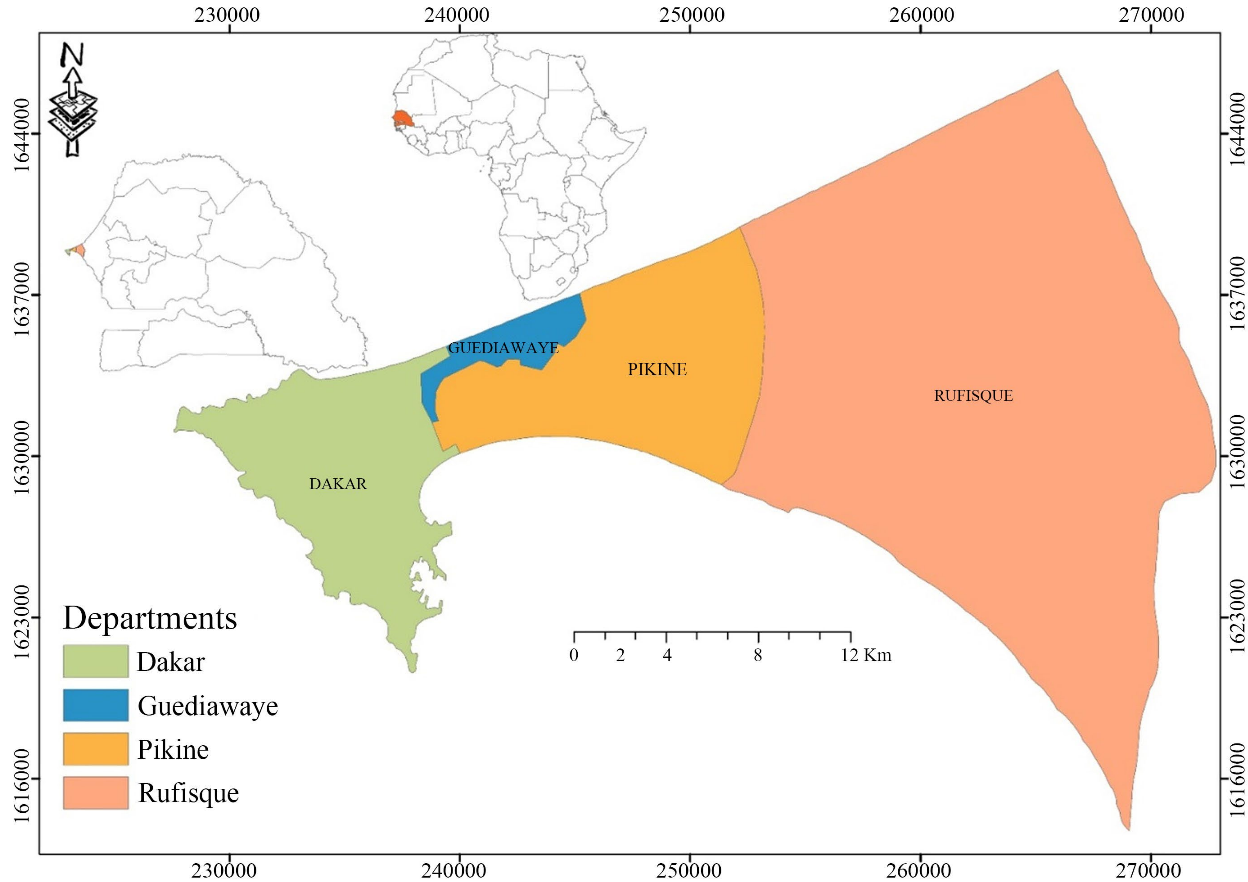


Figure 1. The card of Dakar (source: SALAO, 2025).

2.2. Approach Used

The realization of this inventory required the collection of a lot of data and involves several stages: the environmental survey, data collection, processing and analysis of the data. The methodology adopted is that of CORINAIR (AirParif, 2019). This method is presented in several methodological documents including the Atmospheric Emission Inventory GuideBook (Anaïs & Gwenaëlle, 2019). Furthermore, the development method chosen is based on the so-called "bottom-up" approach (AirParif, 2019). This method consists of crossing basic statistical information with unit emission factors depending on the emitting activity (**Figure 2**). The basic information was collected for the year 2014. He consists of listing in the most exhaustive way possible the major sources of emissions (generally industrial: Large Point Sources (GSP) and Surface Sources (SURF) in the Dakar region (**Figure 2**).

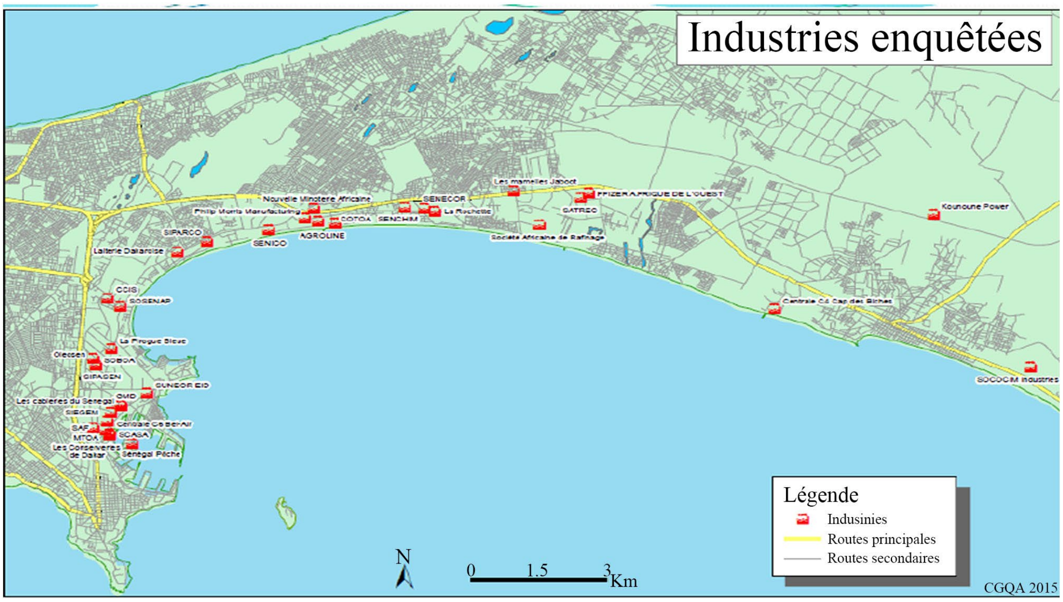


Figure 2. Location of industrial sites sampled in the Dakar region (CGQA).

The sources and emission are geo-referenced and projected onto geographic units. They are localized and are characterized through a data base. The quantity of the pollutants released is listed and Counted in unit of mass per unit of time in an Excel file. All these data are generally compiled and manipulated under a Geographical information System (SIG).

2.2.1. Geographical Framework of the Study

This inventory covers the entire Dakar region, notably the community urban Dakar, spread over an area of 550 km^2. It is carried out at the level of industrial establishments and particularly targets the Big Prompt Sources (GSP).

2.2.2. Reference Year

The year of reference represents the period during which the inventory was carried out which will serve as a basis of comparison for the inventories of subsequent years (Pujol-Söhne, 2014). For our study, the year of data reference is 2014.

2.2.3. Pollutants Taken into Account

The chemical species listed in this inventory are suspended particles: PM_{10} and $PM_{2.5}$. In this study, a comparison of the simulated levels against certain normative values will be carried out. In this survey a comparison of the levels simulated in relation to some normative values will be done.

2.2.4. Emission Factors (FE)

Emission factors are often expressed in units consistent with the unit of activity. They thus make it possible to link processes, combustions, solvent consumption, etc., with flows of pollutants (Pujol-Söhne, 2015). Generally, the basic formula used to estimate the emission factor of an activity data rests on the following equation.

$$\boldsymbol{E}_{i,j,t} = A_{j,t} \times EF_{i,j} \quad \text{or} \quad \boldsymbol{E}_{c,a,s} = A_{a,s} \times EF_{c,a} \times \left(1 - \frac{EF_{c,a}}{100}\right)$$

***F*~i,j~**: Unit Emission Factor relating to the pollutant or substance "*i*" and the activity "*j*" (in g/unit of activity);

$\boldsymbol{E}_{i,j,t}$: Emission rate relating to substance (or precursor) "*i*" and activity "*j*" during time "*t*" (in g/s), and

$\boldsymbol{A}_{j,t}$: Quantity of activity relating to activity "*j*" during time "*t*" (in activity unit/s).

ERi,j: Emission reduction effectiveness for pollutant "*i*" for activity "*j*" compared to the reference emission factor *EFi,j*.

2.2.5. Origin of the Emission Factors Used

In absence of an Emission Factor (EF) on the national level, an important work of documentation permitted us to constitute a data base of applicables, detailed and updated emission factors, guarantors of the quality of the inventory obtained (ATMO, 2013). These emissions factors come on the one hand from several studies and scientific literature, and on the other hand they come from a compilation of different reference works, available in aggregate: (EPA, OFEFP, EEA, TNO and CITEPA, IPCC, COPERT4). They are chosen to be the most relevant. Factors from the EPA guide are preferred. This is the latest version available at the time the methodology was developed (Xavier et al., 2019)

2.2.6. Emissions Data

Several values of the parameters mentioned below were used to model the dispersion of the pollutants considered for each emission point:

- height (m);
- diameter to the exit (m);
- speed of exit (m/s);
- flux of gases (m^3/s);
- temperature to the exit (K degrees);
- rate of broadcast (g/s).

These characteristic values are based on measurements taken at the source or similar installations, on values provided by manufacturers and based on emission rates or on values noted in the literature. Where applicable, emission conditions will include all gas and particle purification equipment.

2.2.7. Weather Conditions

Concentrations of pollutants in the atmosphere strongly depend on weather conditions (Li et al., 2013). Two types of seasons are distinguished in Senegal: Winter or rainy season (from June to October), and Summer or dry season (November to May), with temperatures between 22˚C and 30˚C, and significant variations between the coast and the interior. As the meteorological data were too incomplete during this period at the CGQA station (Hlm), we preferred to work with meteorological data (**Table 1**) from online sites (http://www.weatheronline.com/ and http://www.infoclimat.com/).

We also used Senegal weather station data. They are provided with an hourly time step.

Table 1. Temperature values during the study period.

	Jan	Feb	Mar	Apr	May	June	July	Augu	Sept	Oct	Nov	Dec	Year
Tmax˚C	24.5	23.5	23.4	24.6	25.3	29.1	30.5	30.7	30.9	31.4	29.1	27	27.5
Tmin˚C	18.6	16.6	17.9	19.1	20.8	24.2	26	26.3	25.8	26.7	23.8	21.8	22.4
Tmoy˚C	21.5	20.1	20.7	21.8	23.1	26.7	28.3	28.5	28.3	29.1	36.5	24.4	25

2.2.8. Compilation of Emissions Data

Emissions from point sources are compiled as described below. Each facility in the point source component of the inventory is assigned to the relevant source category that is reflected in the comprehensive emissions estimates. The classification includes categories, sectors and codes, which each installation is assigned. Class and subclass codes are defined internally by the CGQA. To avoid double counting of emissions when integrating point source data into the comprehensive inventory, the point source and area source data sets are reconciled.

2.2.9. The Model Used: The AirQUIS System

As part of this study, we used the AirQUIS System (**Figure 3**). It's a GIS-based integrated air quality monitoring and management information system developed by NILU for air quality assessment and planning (Sylla et al., 2017). It is focused on the use of all types of environmental data. It includes a user interface, comprehensive databases for emissions measurements, an emissions inventory database and a series of models to simulate (dispersion) concentrations and exposure of pollutants in the environment. ambient air, graphics, GIS (geographic information system) for data presentation (Diokhane et al., 2015). Its originality lies in the fact that in addition to the exploitation of modeling results and the management of air quality, it also incorporates a system for acquiring data from the different measuring stations distributed over the scale agglomeration.

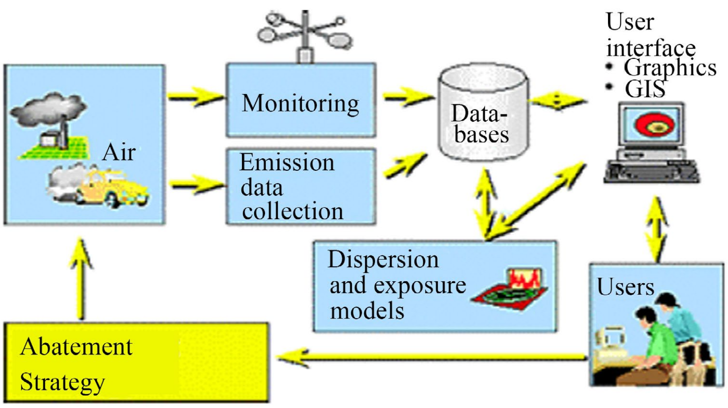


Figure 3. Data transfer method by the AirQUIS System.

3. Results and Discussion

3.1. Spatialization of Inventoried Emissions

➢ **Annual review of PM_{10} emissions**

The yearly balance of the industrial emissions of the suspended particles in abeyance of diameter aerodynamic inferior to 10 μg/m³ (PM_{10}) rise to 24204,29 kg/year for 2014 in the Dakar region. The present Table 2 share different sectors as well as the main types of sources responsible of these emissions.

Table 2. Quantities of annual PM_{10} emissions in kg/year in Dakar for the year 2014.

Sectors of activities	Quantities of broadcasts (kg/an)
Agro-Food	433.94
Cement factory	9191.15
Oil and drifts	118.41
Refinery	1819.68
Food Drinks	0.58
Industry of tobacco	19
Industry packing	65.37
Plastic and derivative	0.37
Plastic and derivative	0.09
Pharmaceutical industry	15.64
Cannery piscatorial products	332.84
Production electricity	12176.20
Strong simple manures to basis of nitrates	31
Total	24204.29

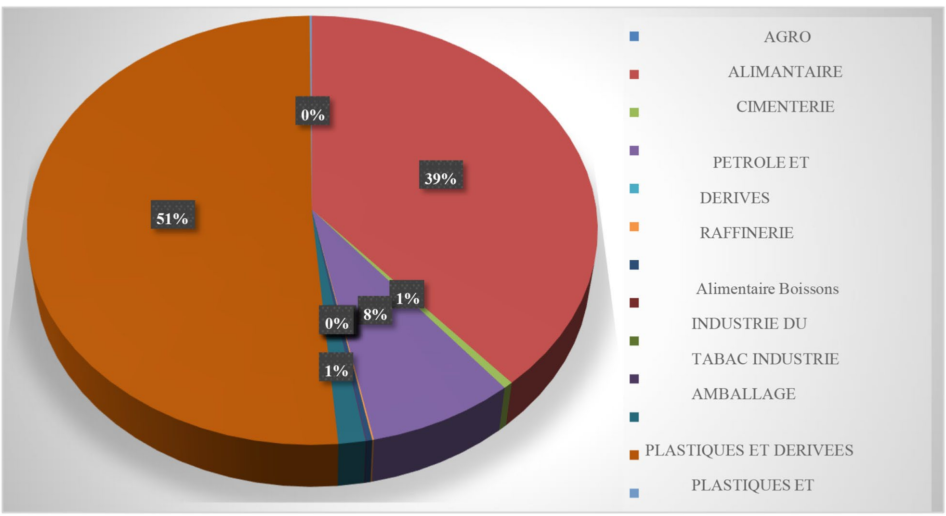


Figure 4. PM_{10} emissions in the Dakar region by sector of activity in 2014.

It is necessary to signal that the detailed data absence on facilities (boilers or chimneys, etc.) creates significant uncertainty in the results. The factors of particle emission being very different from an equipment to another. The three sectors that contribute the more to the broadcasts of PM_{10} are the sector of the electricity production, the sector of the cement factory and the sector of the refinement of oil (**Figure 4**).

The energy sector and the production of electricity in thermal power plants are the main sources of atmospheric particles (PM_{10}) in 2014. These emissions, up to 51%, come from the combustion of heavy fuel oil and diesel for electricity production. The sector of the cement factory represents the second source of PM_{10} in air with 39% of the total broadcasts. They are provoked both to the combustion of biomass in blast furnaces but also to the use of used oils and ordinary waste as fuel in the furnaces. The Refinery represents 8% of total PM_{10} emissions. The industries of plastics and derivatives, agri-food, tobacco manufacturing, flour, fishing products production and cereal handling together contribute to less than 3% of Dakar's PM_{10} emissions.

3.2. Sectoral Analysis of Emissions (Assessment by Sector of Activity)

3.2.1. Energy Production

The energy production sector is the contributory sector of PM_{10} with more than half (58%) of emissions in the Dakar region. The emissions from these installations are presented in the following table (**Table 3**).

Table 3. Quantity of PM_{10} emissions emitted by energy activities in Dakar in 2014.

Sector of activities: Energy	Quantities of broadcasts (kg/an)	Percentage
Production electricity	12176.20	
Oil and drifts	118.41	58%
Refinery	1819.68	
Total	14114.30	

3.2.2. Manufacturing Industries Sector

This sector concerns industrial activities excluding energy. A large number of activities are processed in this sector and each sub-sector requires different processing of the available data. The sheets are grouped into several sub-sectors which are: agri-food, chemicals, construction, materials (metals, cement, etc.) and others. The manufacturing industry emits 42% of PM_{10} emissions in the Dakar region (**Table 4**). Furthermore, the cement plant is the main contributor to the materials production sub-sector (metals, cement, etc.).

Table 4. Quantities of PM_{10} emissions due to manufacturing industries in Dakar in 2014.

Manufacturing Industries	Quantity of broadcasts (kg/an)	Percentage
Agro-Food	433.94	
Cement factory	9191.15	
Food Drinks	0.58	

Continued

Industry of tobacco	19	
Industry packing	65.38	42%
Plastic and derivative	0.37	
Plastic and derivative	0.09	
Pharmaceutical industry	15.64	
Cannery piscatorial products	332.84	
Strong simple manures to basis of nitrates	31	
Total	10089.99	

3.3. Simulation and Mapping

3.3.1. Spatial Distribution of Concentrations of PM_{10} Particle Emissions on Annual Average from Large Point Sources (GSP)

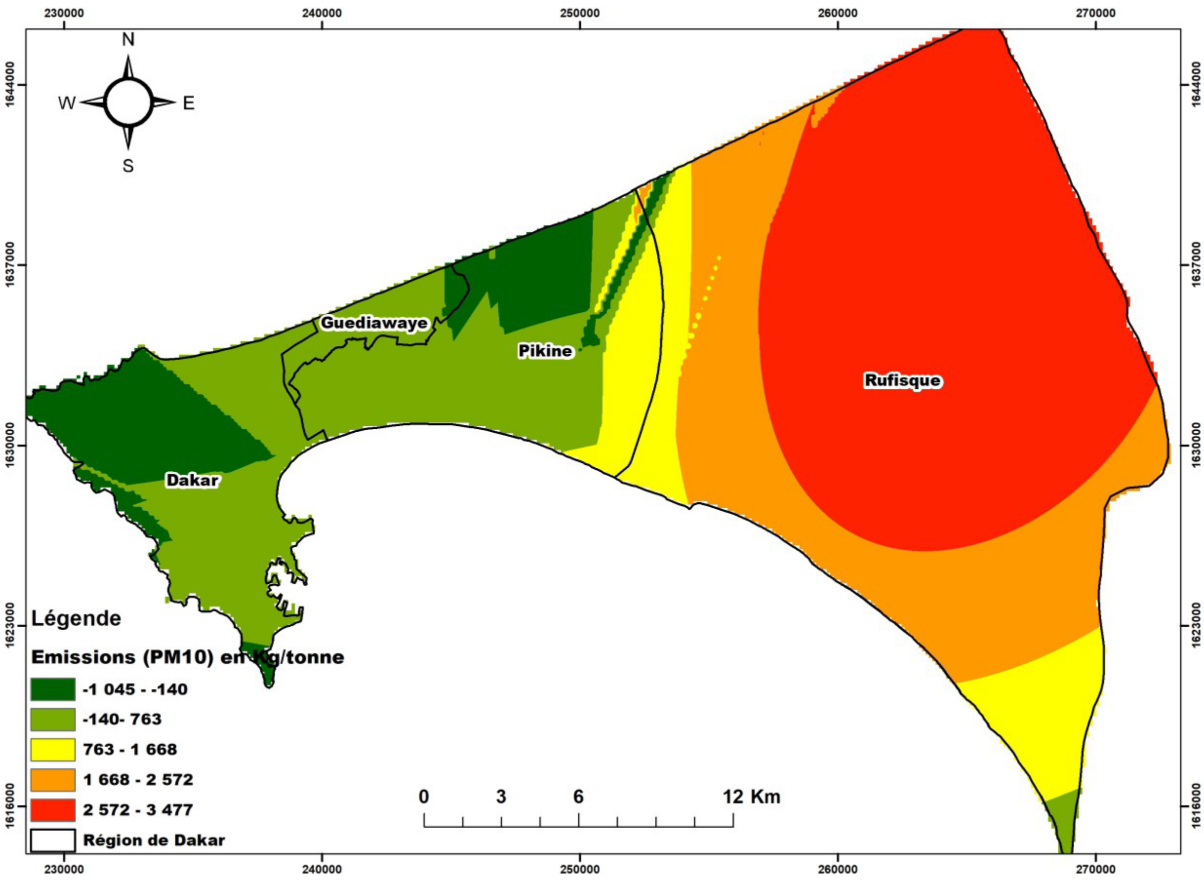


Figure 5. Spatial distribution of PM_{10} emissions in kg/tonne emitted by industries in the Dakar region in 2014.

The yearly emission concentration data calculated PM_{10} in each sheet every card are regrouped together a cartography. The emissions from the Dakar region mainly come from the energy production sub-sector due to the presence of the thermal power plant producing electricity (Kounune Power and Watsylla) which reject these emissions to the tune of 51%. Compared to the Cement Plant and the Refinery which release 39% and 8% of emissions respectively. The agri-food sector and plastic and derivatives are other important sources (3%). Figure 5 represents the spatial distribution of PM_{10} emissions from stationary sources in the Dakar region. These emissions were agglomerated by GIS, then spatialized at kilometer resolution.

The results of the cartographic representation clearly show the main areas loaded with PM_{10} particles. In addition, the town of Rufisque located east of Dakar, subject to high concentrations of up to 3000 kg/year of emissions, mainly due to generally weak winds associated with high emissions of pollutants emitted by industries, all the rest of the Dakar region has a low concentration of PM_{10}.

3.3.2. Spatial Distribution of Concentrations of Pm_{10} Particle Emissions on Annual Average in the City of Dakar (Observation Measure)

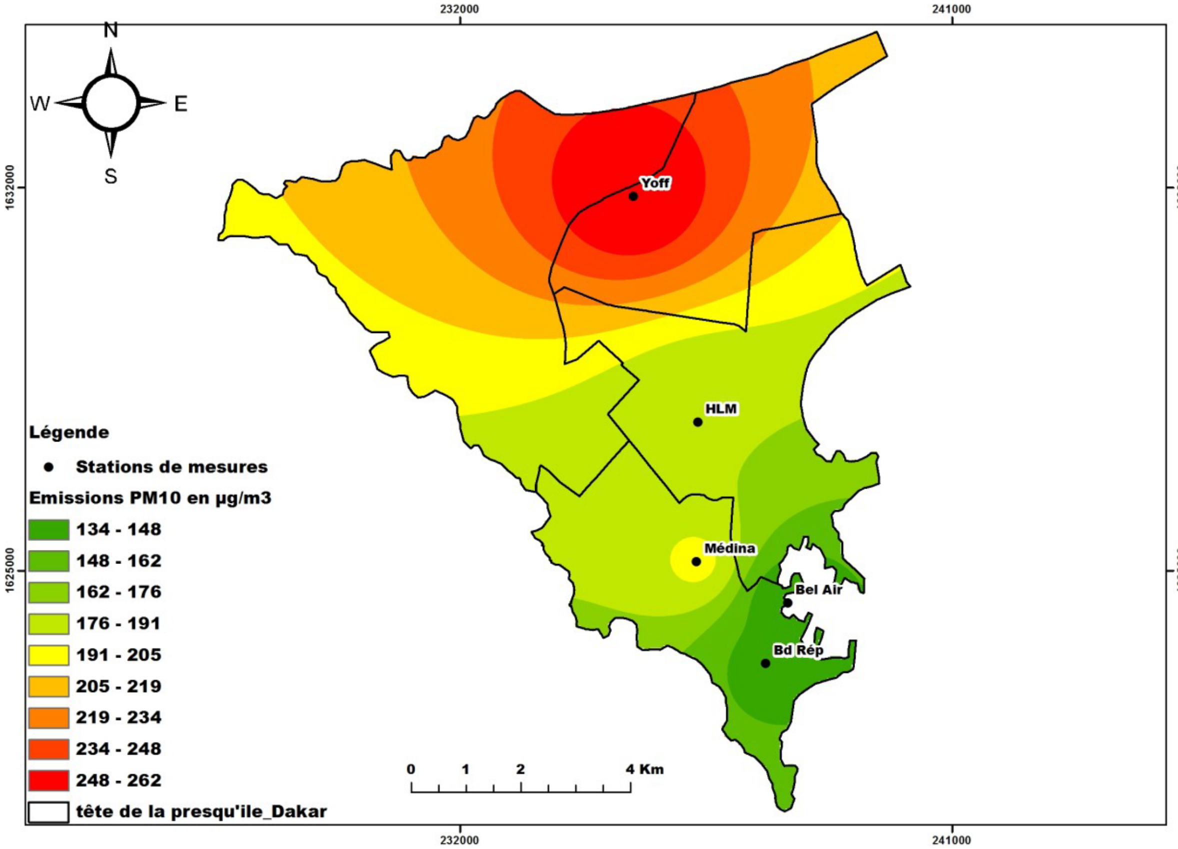


Figure 6. Spatial distribution of particle concentrations (PM_{10}) in the city of Dakar in $\mu g/m^3$ in 2015.

Concerning the simulation, the results of the extrapolation in PM_{10} show a high concentration of PM_{10} in the western part of the city of Dakar (North-West (Yoff)) with annual average concentrations exceeding 250 $\mu g/m^3$. In the central part of the city, PM_{10} concentrations remain slightly high above 150 $\mu g/m^3$. Finally, the drop in concentration is even more significant to the south of the city (Figure 6). This high rate of pollution is explained by the contribution of sea spray which governs this part of the city. This pollution due to sea spray is not potentially harmful to the population but could have considerable impacts on buildings

(buildings, etc., marbles, etc.). These results are consistent with the results obtained in the industrial emissions inventory. However, these PM_{10} concentration levels exceed 100 μg/m³.

3.3.3. Spatial Distribution of Concentrations of $Pm_{2.5}$ Particle Emissions on Annual Average in the City Of Dakar (Observation Measure)

The cartographic representation of $PM_{2.5}$ particulate emissions in the city of Dakar shows a high concentration in the South-East part of Dakar (Figure 7). These high levels of concentrations still remain well localized in the industrial free zone or in the immediate vicinity of the CGQA industrial station (Bel Air) and do not extend much beyond. Air quality in this area of the city is poor.

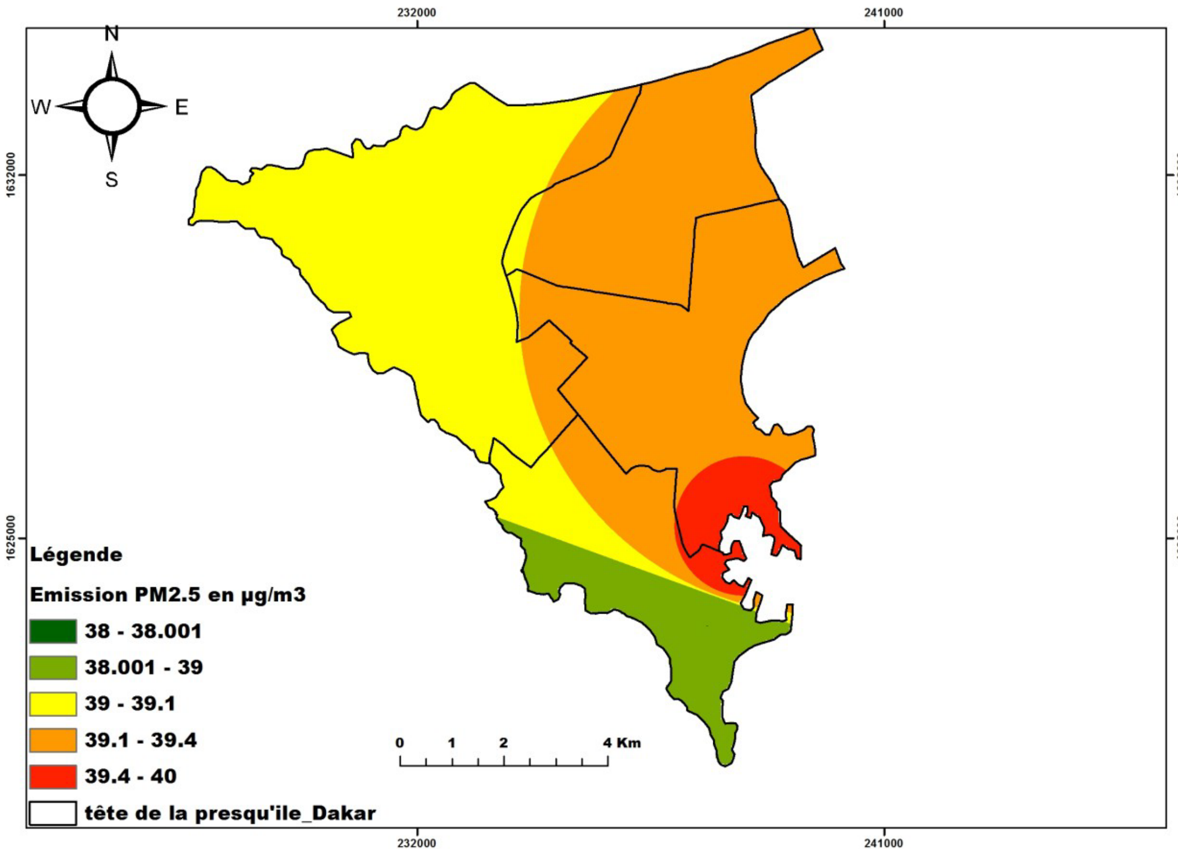


Figure 7. Spatial distribution of particle concentrations ($PM_{2.5}$) in the city of Dakar in μg/m³ (2015).

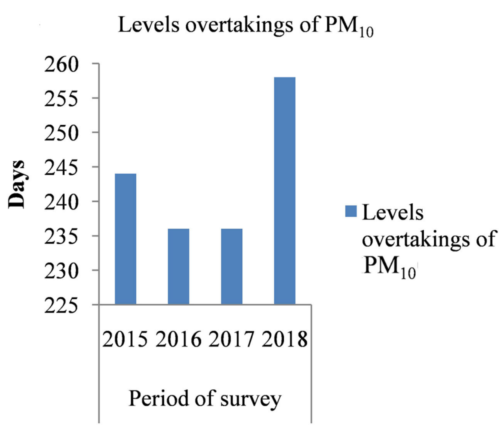
These results are consistent with the results mentioned in the case of industrial emissions inventories concerning continuous or fixed measurements of the origin of the source affecting this part of the city, in particular industries. These releases are often associated with significant $PM_{2.5}$ concentrations due to an extra-regional source but also to the significant transport of desert aerosols (Sahara) (Doumbia, 2012). The high concentration in Bel Air compared to the south of the city (Boulevard de la République) justifies this hypothesis. $PM_{2.5}$ concentrations are even higher on the outskirts of the Dakar urban area; good homogeneity of levels is observed in the center of the urban unit.

3.4. Assessment of Atmospheric Particles Concentrations ($PM_{2.5}$ and PM_{10}) between 2015 and 2018

Concerning the concentrations taken at the Bel Air fixed measuring station which is an industrial station, with the exception of the months of May to September, due in particular to the climate during this study period, the city experienced several exceedances Senegalese standard set at 80ug/m3. The months of January-April and October-December, each year, saw significant dust emissions into the atmosphere, leading to frequent peaks in the main regulatory thresholds set for this pollutant.

3.4.1. Evolution of PM_{10} Concentrations

For PM_{10}, the annual average concentration levels in ambient air measured over the four years at the Bel Air station (industrial) are higher during the first quarters, i.e. the first campaign periods (January-March) but also during the last quarters of the years studied, the last measurement campaign (October-December) (Figure 8). This situation results mainly from the presence of significant particles in suspension emanating from the emitters of these pollutants (industries, thermal power plants, etc.), but also from the presence of dust coming from the north of the (Sahara) at the city level (ANSD, 2019).



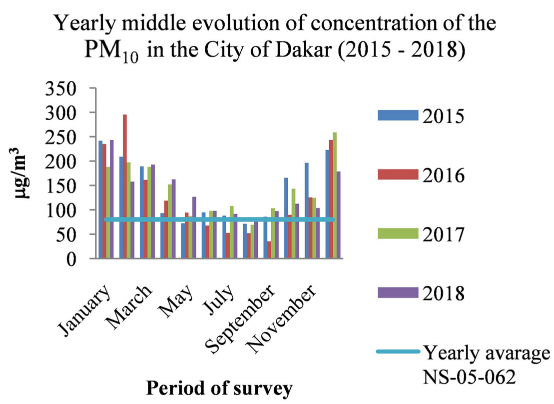


Figure 8. Evolution of average PM_{10} concentrations between 2015-2018.

Table 5. Average concentrations and level of PM_{10} exceedances between 2015 and 2018.

Continuous measure station (in µg/m³)	Percentage of the data validates	Concentrations averages	Concentrations hourly		Days/month/max
			Hourly Maxima	Numbers overtaking	
2015	73%	189.66	601.46	244	06/02/2015
2016	96%	131.56	771	216	25/12/2016
2017	90%	143	552	267	22/12/2017
2018	86%	136.33	612.40	258	23/03/2018

Throughout the period of years studied, the level of annual average concentrations exceeds 100 ug/m³ and maximum concentrations are greater than 550 µg/m³.

Six episodes of heavy pollution, exceeding 600 ug/m³, took place (**Table 5**). The annual limit values set by standard NS 05-062 (80 µg/m³) (ASN, 2003) were exceeded 974 days on the site (**Table 5**) during the periods studied from 2015 to 2018.

3.4.2. Evolution of $PM_{2.5}$ Concentrations

Just like for the PM_{10}, the $PM_{2.5}$ pollution levels seem to follow the same monthly variations. The concentrations were significant during the first two quarters of the period of the years studied. The value set by the WHO (25 µg/m³) was exceeded 654 times, with average concentrations exceeding 45 µg/m³ during the period from January to March, and 52 µg/m³ for the month of December. Several almost identical episodes of heavy pollution were observed during the months of January and February of 2015 and 2018 (around 100 µg/m³) during the period from 2015 to 2018 and more than 120 µg/m³ during the month of December 2017 (**Figure 9**).

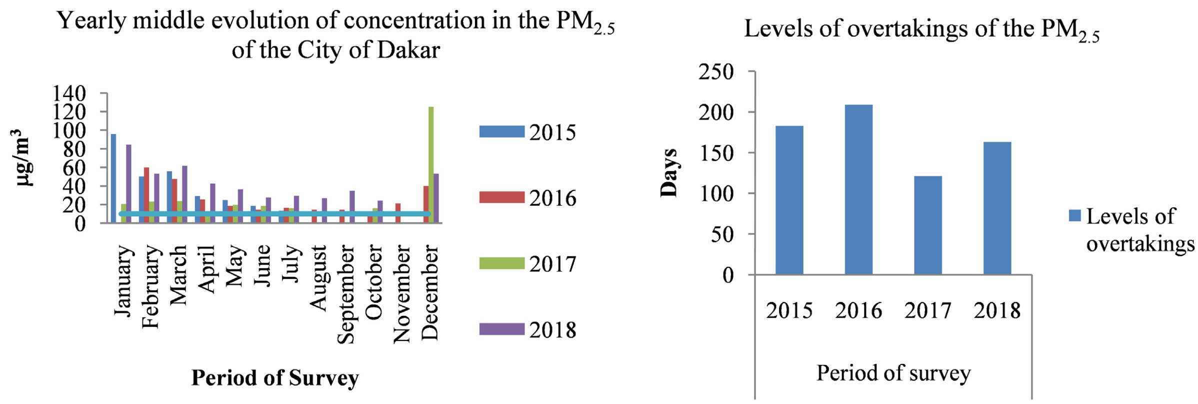


Figure 9. Evolution of average $PM_{2.5}$ concentrations between 2015 and 2018.

During the last measurement campaigns in the last quarter of each year, taking into account the rainy season, the station experienced a significant drop in concentrations which, however, remained significant compared to the guide value set by the WHO.

3.5. Discussion

3.5.1. Emissions Inventory or Spatialization

Despite some differences in the results, overall they are consistent with the literature. The results of PM_{10} are in agreement with those of the studies carried out by Ait-Bouh et al. (2013). In the case of $PM_{2.5}$, we noted on the one hand a concordance with those of Edwin & Mölders (2020), who noted that 50% of the emissions of the particles studied are due to industrial processes, 25% to mobile sources and 25% to combustion. On the other hand, it coincides with the study carried out in the city of Beyrout which highlighted that the largest share of particular materials was found in industrial sites (Borgie et al., 2014). However, with regard to the results of the observational measurements, we can conclude that there is a clear similarity with the modeling results confirming the areas most affected by these pollutants studied (PM_{10} and $PM_{2.5}$). As for the dispersion at the sources of pollution, our results highlight a strong contribution from point sources (industrial zones) for $PM_{2.5}$ and the northern region of the city (Yoff) more affected by PM_{10}. It also confirms this homogeneity in a large part of the city's urban areas, testifying to the high concentrations of PM_{10} recorded in public housing and Medina. According to these results, the impact of this pollution on the population is obvious; it can generally result in a range of health problems. Numerous studies have established a link between air pollution due to particles and the incidence of certain respiratory and cardiovascular diseases as well as premature death (Winiarek, 2014).

3.5.2. Concentration of Pollutants at the Bel Air Industrial Site

For the campaigns carried out between 2015 and 2018 at the industrial site, for comparison, the PM_{10} measurement campaigns in 2012 during the same period each gave concentrations significantly higher than the NS-05-062 standard, above 800 or even 900 μg/m^3 on average, with suburban type sites (Hlm and Medina) which respectively recorded peaks of 982 μg/m^3 on February 7, 2012 and 951 μg/m^3 on January 20, 2012. On the type sites, urban road traffic (Boulevard de la République) and urban industrial (Bel Air), the concentrations are respectively 851 μg/m^3 and 880 μg/m^3.

Like this year, we noticed almost the same trend with a drop in concentrations in the second and last quarter. It should be noted that in 2015, the measurements from the Yoff station showed double the exceedances compared to the other sites. The recorded concentrations are interpreted in a particular way, due to its geographical location close to the sea. Indeed, this site receives significant contributions of marine salts from the sea which are less dangerous for the population but which nevertheless have a considerable effect on the structures.

4. Conclusion

The results are consistent with the literature. Overall: The annual report of PM_{10} emissions in the Dakar region amounts to 24,204.29 kg/year for the year 2014. The energy production sector contributes to 58% of emissions and the manufacturing industry sector emits 42% of PM_{10} emissions. Concerning the result of the cartographic representation, it is the town of Rufisque located east of Dakar which is the most subject to high concentrations of up to 3000 kg/year of emissions. Furthermore, in a large part of the Dakar region, in the West, North and Center, concentrations are around 500 kg/year. However, the evaluation of PM_{10} concentration throughout the period of years studied, the level of annual average concentrations exceeded 100 ug/m^3 and the maximum concentrations were greater than 550 μg/m^3. Just like PM_{10}, $PM_{2.5}$ pollution levels seem to follow the same monthly variations. The value set by the WHO (25 μg/m^3) was exceeded 675 times, with average concentrations exceeding 45 μg/m^3 during the period from January to March, and 52 μg/m^3 for the month of December. Thus, this study highlights that atmospheric levels of suspended particles are subject to strong seasonality with higher levels in the dry season (1st and 2nd campaign) than in the rainy or wintering season (3rd Campaign). This phenomenon is explained by the increase in particle emissions into the air or anthropogenic discharges (industries, transport, domestic heating) which are at the origin of these exceedances, coupled with stable weather conditions (favoring the accumulation pollutants). On the other hand, the concentrations being higher throughout the campaign period, well exceeding the limit set by Senegalese standards and the WHO, it would be relevant to implement adequate measures for the reduction of these pollutants considered high priority in the future.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

AirParif (2019). *Emissions de polluants atmosphériques et de gaz à effet de serre* (p. 86). Bilan île de France.

Ait-Bouh, H., Benyaich, F., & Bounakhla, M. (2013). Variations Saisonnières des particules atmosphériques et ses composants chimiques dans la Ville de Meknès-Maroc. *Journal of Materials and Environmental Science, 4,* 49-62.

Anaïs, D., & Gwenaëlle, L. B. (2019). *Inventaire des émissions de polluants atmosphériques en France au titre de la convention sur la pollution atmosphérique transfrontalière à longue distance et de la directive européenne concernant la réduction des émissions nationales de certains polluants atmosphériques* (p. 656). Centre Interprofessionnel Technique d'Etudes de la Pollution Atmosphérique (CITEPA).

ANSD (2019). *La population du Sénégal en 2018* (p. 22). Agence nationale de la statistique et de la démographie.

ASN (2003). *Pollution atmosphérique—Norme de rejets* (p. 22). Association Sénégalaise de Normalisation.

ATMO (2013). *Méthode d'élaboration du cadastre des émissions atmosphériques en Rhône-Alpes* (p. 55).

Borgie, M., Garat, A., Cazier, F., Delbende, A., Allorge, D., Ledoux, F. et al. (2014). Traffic-related Air Pollution. a Pilot Exposure Assessment in Beirut, Lebanon. *Chemosphere, 96,* 122-128. https://doi.org/10.1016/j.chemosphere.2013.09.034

Diokhane, A. M., Jenkins, G. S., Manga, N., Drame, M. S., & Mbodji, B. (2015). Linkages between Observed, Modeled Saharan Dust Loading and Meningitis in Senegal during 2012 and 2013. *International Journal of Biometeorology, 60,* 557-575. https://doi.org/10.1007/s00484-015-1051-5

Doumbia, T. (2012). *Caractérisation physico-chimique de la pollution atmosphérique urbaine en Afrique de l'Ouest et étude d'impact sur la santé.* Master's Thesis, Université Paul Sabatier-Toulouse III.

Edwin, S. G., & Mölders, N. (2020). Indoor and Outdoor Particulate Matter Exposure of Rural Interior Alaska Residents. *Open Journal of Air Pollution, 9,* 37-60. https://doi.org/10.4236/ojap.2020.93004

Evans, J., van Donkelaar, A., Martin, R. V., Burnett, R., Rainham, D. G., Birkett, N. J., & Krewski, D. (2013). Estimates of Global Mortality Attributable to Particulate Air Pollution Using Satellite Imagery. *Environmental Research, 120,* 33-42.

https://doi.org/10.1016/j.envres.2012.08.005

Li, X., Wang, Y., Guo, X., & Wang, Y. (2013). Seasonal Variation and Source Apportionment of Organic and Inorganic Compounds in $PM_{2.5}$ and PM_{10} Particulates in Beijing, China. *Journal of Environmental Sciences, 25,* 741-750. https://doi.org/10.1016/s1001-0742(12)60121-1

Philip, J., & Landrigan, P. J. (2018). *The Lancet Commission on Pollution and Health.* https://www.thelancet.com/journals/lancet/

Pujol-Söhne, N. (2014). *Inventaire régional des émissions et des consommations Années 2005 à 2008—Méthodologie* (p. 72). ATMO Grand Est/France.

Pujol-Söhne, N. (2015). *Rapport méthodologique de l'inventaire des émissions en Nord-Pas-de-Calais* (p. 88). ATMO Grand Est.

Shah, A. S. V., Lee, K. K., McAllister, D. A., Hunter, A., Nair, H., Whiteley, W. et al. (2015). Short Term Exposure to Air Pollution and Stroke: Systematic Review and Meta-Analysis. *BMJ, 350,* h1295. https://doi.org/10.1136/bmj.h1295

Sylla, F. K., Faye, A., Fall, M., Lo, M., Diokhané, A., Touré, N. O. et al. (2017). Near-Road Exposure to Air Pollution and Allergic Rhinitis: A Cross-Sectional Study among Vendors in Dakar, Senegal. *Occupational Diseases and Environmental Medicine, 5,* 106-120. https://doi.org/10.4236/odem.2017.54010

WHO (2018). *Air Pollution Levels Rising in Many of the World's Poorest Cities, Genevea* (p. 4).

Winiarek, V. (2014). *Dispersion atmosphérique et modélisation inverse pour la reconstruction de sources accidentelles de polluants.* Master's Thesis, Université Paris-Est.

Xavier, D. M., Georges, C., & Hélène, V. (2019). Principes, méthode et conduite de l'Inventaire général du patrimoine culturel (p. 224). Ministère de la Culture et de la Communication.