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Research Article

# Analysis of Mass Concentration and Carbon Composition of PM2.5 During the Long Dry Season in Abomey-Calavi and Cotonou Cities, Benin

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## Abstract

Carbonaceous components are important components of fine atmospheric particulate matter ($PM_{2.5}$) and can affect the local environment, climate, and human health. The PM2.5, Organic (OC) and elemental (EC) Carbon concentrations were measured at Arconville (AT) and Mahoule (MT) traffic during the dry season in southern Benin cities of Abomey-Calavi and Cotonou. The data are collected with passive samplers and archived as daily averages from December 2016 to March 2017. To gain a better understanding of possible local and regional aerosol sources, the concentration of PM2.5, OC and EC, as well as the OC/EC ratio were evaluated overall. For the studied period, average concentrations of PM2.5 particles were 64 ±16 $\mu.gm^{-3}$ and 79 ±18 $\mu.gm^{-3}$ at AT and MT, respectively. Those of OC and EC were 31 ± 13 $\mu g{\cdot}m^{-3}$ and 9 ± 06 $\mu g{\cdot}m^{-3}$ for AT and 38 ± 16 $\mu g{\cdot}m^{-3}$ and 13 ±08 $\mu g{\cdot}m^{-3}$ for MT, respectively. Also, total carbon accounted for 62.5% of PM2.5 at AT and 64.56% at MT. The OC/EC ratios obtained in AT and MT were 3.44 and 2.92, respectively. These OC/EC ratios obtained in two cities are greater than 2, which confirmed the presence of secondary organic aerosols during this period on these two traffic sites.

## Keywords

PM2.5, Carbonaceous, Aerosol, Elemental Carbon and Organic Carbon

## 1. Introduction

Air pollution is a major environmental threat, particularly in Abomey Calavi and Cotonou where road transport has contributed considerably to the increase in the quantity of fine particles across the city and more particularly in Arconville and Mahoule. In recent years, PM2.5 pollution events in southern Benin, such as in the Cotonou city, have occurred frequently [1, 2]. The total carbon (TC) are crucial components in PM2.5. The total of the carbon aerosols in PM2.5 ranges from 32 to 50% in this city, which would be due to the pollution sources and different environmental conditions [1]. According to [3], the fossil fuels and biomass combustion emit the element carbon EC which is stable in the atmosphere. However, organic carbon sources are complex, which include both POC (primary organic carbon) and SOC (secondary organic carbon) [3, 4]. The EC and OC have an effect of the optical properties of the atmosphere; which explains the substantial influence on the climate change, atmospheric visibility and air quality [5, 4]. The world largest source of

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mineral dust is the Sahara which winds particles from the north and monsoons transport sea salt from the south [6]. According to [7], The dynamics of atmospheric flows particularly complex was made the West African monsoon system which negatively affects the predictability of weather events and climate change in the sub-Saharan area.

Recent work on epidemiological studies have helped to understand the association between concentrations of ambient particles in particular, the particulate PM2.5 and adverse health effects [8]. Due to the possible delayed health effects associated with the continuous exposure of a high-density population in urban areas, the air particle pollution is of particular interest [9]. Additionally, several studies have shown that the carbonaceous aerosols concentrations are positively correlated with the mortality of blood vessels and the respiratory system in urban environmental centers [10]. Therefore, determination of EC and OC concentrations is important in order to study air pollution, climate change, and human health [11]. Moreover, PM2.5 aerosol particles easily enter human lungs, which increases the incidence of respiratory diseases and risk of cardiovascular diseases and threatens the human health [12].

According to [13], policy makers must improve emission inventories and observations and support long-term measurements of air pollutants in urban and suburban areas. For this purpose, a state of an environmental aerosol monitoring system has been installed at AT in Abomey Calavi and MT in Cotonou for the collection of daily atmospheric PM2.5, OC and EC concentrations from December 2016 to March 2017. This paper focuses on fine-particle mass and particulate carbon species measurements performed in the two cities. In this work, several samples of deposited fine particle (PM2.5) were collected in order to have a preliminary understanding of their evolution during the dry season in these two cities.

## 2. Materials and Methods

PM2.5 and Carbonaceous Aerosols were monitored at Abomey-Calavi and Cotonou, two Southern Benin traffic sites, during a long dry period. In these two cities, measurements were performed from December 2016 to March 2017, near of the crossroads with heavy traffic. 09-h per day (09:00 to 18:00, local time) PM2.5 samples were collected at two urban sampling sites. This chosen time interval corresponds to peak hours, where traffic is heavy on both sites. The experimental site in each city is located at a major intersection with heavy traffic. Its were chosen as these traffic sites are characterized by a high density of 2 wheels.

At each site, we have a compact environmental monitor called EVM-7 (version 1.05 Quest Technologies). It allows you to take measurements of the airborne concentrations [14]. In this study, the sampling was carried out in two cities on quartz filters in order to measure the levels of PM2.5 mass and the levels of EC and OC.

The campaign to measure OC, EC, and PM2.5 was conducted in these two cities by collecting samples on 37 mm diameter filters in Arconville traffic (AT) and Mahoule (MT) during the long dry season (02 December 2016 and 20 March 2017). For gravimetric measurements and carbonaceous aerosol analysis, we used only quartz fiber filters. At each site, filter is exposed from 9:00 to 18:00, approximately 9 hours of exposure time per day. Before sampling, the filters were stored individually in Petri dishes, covered with aluminum foil once the sample had been taken, and then in packaging. Then they are returned to the laboratory for different analyses. The description of the material and methods of analysis are:

*Gravimetric analysis:*

Collections of aerosols were performed on the Quartz fiber filters. Quartz filters were weighed before and after sampling using a Mettler MC21S microbalance at Laboratoire d'Aérologie, Toulouse, France. The samples were kept for about 24 h in the weighing room at an ambient relative humidity of 30 ±15% before weighing. To lower carbon blanks, filters were preheated before being exposed [5].

*Analysis of carbonaceous aerosols:*

OC, EC and TC (total carbon, calculated by the sum of OC and EC) were measured on a 0.37 $cm^2$ punch from each quartz filter by thermo-optical reflectance following the Interagency Monitoring of Protected Visual Environments (IMPROVE) protocol [15]. The quartz fiber filters are burned 48 h at 480 ◦C before sampling to reduce the carbon content on the blank filter. The analyses are performed using a DRI model 2001 thermal/optical carbon analyser (Atmoslytic Inc., Calabasas, CA) [16].

After the Gravimetric and carbonaceous aerosols Analysis, we proceeded to determine the Concentrations of PM2.5, OC and EC. We then calculated the concentrations of the species by calculating the mass obtained on the volume of air pumped during the duration of exposure for each day. Finally, we calculated the sum of the concentrations obtained per day (PM2.5, OC and EC) over the sampling period over the total number of exposure days in order to obtain the concentrations of PM2.5, OC and EC [5].

## 3. Results and Discussion

PM2.5, OC and EC concentrations collected on PM2.5 filters at AT and MT were calculated. Average Concentrations of PM2.5 particles were 64 ±16 $\mu gm^{-3}$ and 79 ±18 $\mu gm^{-3}$ at AT and MT, respectively. Also, the daily average concentrations of OC and EC were 31 ± 13 $\mu g \cdot m^{-3}$ and 9 ± 06 $\mu g \cdot m^{-3}$ for AT and 38 ± 16 $\mu g \cdot m^{-3}$ and 13 ± 08 $\mu g \cdot m^{-3}$ at MT, respectively. Adding together the TC, it accounted for 62.5% and 64.56% of the PM2.5 at AT and MT. For this study, the OC/EC ratio was 3.44 at AT and 2.92 at MT. According to [15], OC/EC ratios obtained in two cities are greater than 2, which confirmed the presence of secondary organic aerosols during this period on these two traffic sites. We then compared the concentrations measured at the two sites and noticed that the PM2.5 concentrations measured at MT higher than those measured at AT. Also, these PM2.5 concentrations are higher than the concentrations recommended by the World Health Organization (25 $\mu.gm^{-3}$) (see Figure 1). It is interesting to underline that our measurements are higher by a factor of 2.5–3.2 than the WHO guidelines. Also, the papers of [1, 17-19] on road traffic sites give values close or slightly higher than our traffic values: 69.2 $\mu.gm^{-3}$ for Cotonou market in Benin, 80.7 $\mu.gm^{-3}$ for Dakar in Senegal, 57.8 $\mu.gm^{-3}$ for Constantine in Algeria and 59.7 $\mu.gm^{-3}$ for Harare in Zimbawe. PM2.5 concentrations measured in the two cities were compared with those obtained in African cities and we noticed that they agree with those measured on other traffic sites in certain African cities.

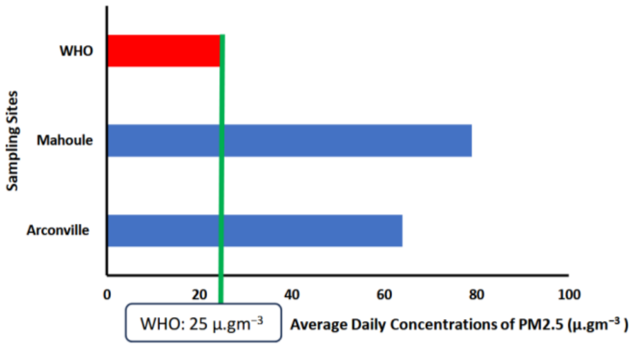


*Figure 1. Comparison of PM2.5 daily average concentrations at the two sites with WHO guideline. Green vertical line illustrates current WHO guideline.*

## 4. Conclusion

This study reports new observation of average concentrations of PM2.5, OC, and EC in the vicinity of major combustion source, i.e. traffic at AT and MT from December 2016 to March 2017. During the dry period study, the daily average PM2.5 concentrations were 64 ±16 $\mu.gm^{-3}$ and 79 ±18 $\mu.gm^{-3}$ at AT and MT, respectively. They are higher than the concentrations recommended by the World Health Organization. The OC/EC ratio was 3.44 at AT and 2.92 at MT, which confirmed the presence of secondary organic aerosols during this long dry period.

## Abbreviations

| | |
|---|---|
| WHO | World Health Organization |
| AT | Arconville Traffic |
| MT | Mahoule Traffic |
| PM2.5 | Particulate Matter |
| TC | Total Carbon |
| OC | Organic Carbon |
| EC | Elemental Carbon |

## Conflicts of Interest

The authors declare no conflict of interest.

## References

[1] Djossou, J., Mathos, K. P., Lamah, S. P., Yombouno, F. M., Camara, N., Diallo, A. M., Fofana, M. A. and Diallo, A. Characterization of Atmospheric Organic Carbon and Element Carbon of PM2.5 during the Long Dry Period in Cotonou, Benin. Open Journal of Air Pollution. 2025, 14, 14-28. https://doi.org/10.4236/ojap.2025.141002

[2] Djossou, J.; Akpo, A. B.; Liousse, C.; Léon, J.-F. Comparison of Measures of PM2.5 and Carbonaceous Aerosol in Air at Cotonou, Benin in 2005 and 2015. Environ. Sci. Proc. 2022, 19, 12. https://doi.org/10.3390/ecas2022-12824

[3] Lin, J. J. & Tai, H. S. Concentrations and distributions of carbonaceous species in ambient particles in Kaohsiung City, Taiwan. *Atmos. Environ* 2001, 35, 2627–2636.

[4] Kim, Y. P.; Moon, K. C. & Lee, J. H. Organic and elemental carbon in fine particles at Kosan, Korea. *Atmos. Environ* 2000, 34, 3390–3317.

[5] Djossou, J.; Léon, J.-F.; Akpo, A. B.; Liousse, C.; Yoboué, V.; Bedou, M.; Bodjrenou, M.; Chiron, C.; Galy-Lacaux, C.; Gardrat, E. Mass concentration, optical depth and carbon composition of particulate matter in the major southern West African cities of Cotonou (Benin) and Abidjan (Côte d'Ivoire). *Atmos. Chem. Phys* 2018, 18, 6275–6291

[6] Knippertz, P.; Todd, M. C. Mineral dust aerosols over the Sahara: meteorological controls on emission and transport and implications for modeling. *Rev. Geophys* 2012, 50 (1), 1–28.

[7] Basile Kounouhewa, Gabin Koto N'Gobi, Hervé Houngue, Lothar Müller, Michael Wirtz, Selçuk Yurtsever-Kneer, Helga Fink, Aron Kneer, Stéphan Barbe. Cotonou's next breath: Particulate matter monitoring and capturing, Scientific African, March 2020, 8, 2468-2276. https://doi.org/10.1016/j.sciaf.2020.e00367

[8] Pagano, P.; de Zaiacomo, T.; Scarcella, E.; Bruni, S.; Calamosca, M. Mutagenic activity of total and particle-sized fraction of urban particulate matter. *Environmental Science and Technology* 1998, 30, 3512–3516

[9] Vedal, S. Ambient particles and health: lines that divide. *Journal of Air & Waste Management Association* 1997, 47, 551–581.

[10] Cao, J.; Xu, H.; Xu, Q.; Chen, B.; Kan, H. Fine Particulate matter constituents and cardiopulmonary mortality in a heavily polluted Chinese city. *Environ. Health Perspect* 2012, 120, 373–378.

[11] Ma, L.; Hu, D.; Yan, Y.; Niu, Y.; Duan, X.; Guo, Y.; Li, W.; Peng, L. Pollution Characteristics and Source Analysis of Carbonaceous Components in $PM_{2.5}$ in a Typical Industrial City. *Aerosol Air Qual. Res* 2024, 24, 240014.

[12] Pathak, R. K.; Wang, T.; Ho, K. F.; Lee, S. C. Characteristics of summertime PM 2.5 organic and elemental carbon in four major Chinese cities: Implications of high acidity for water-soluble organic carbon (WSOC). *Atmos. Environ 2011*, 45, 318–325.

[13] Evans M. J.; Knippertz, P.; Akpo, A.; Allan, R. P.; Amekudzi, L.; Brooks, B.; Chiu, J. C.; Coe, H.; Fink, A. H.; Flamant, C.; Jegede, O. O.; Leal-Liousse, C.; Lohou, F.; Kalthoff, N.; Mari, C.; Marsham, J. H.; Yoboué, V.; Reimann Zumsprekel C. Policy-relevant findings of the Dacciwa project (2018), https://doi.org/10.5281/zenodo.1476843

[14] Ndong Ba, A.; Verdin, A.; Cazier, F.; Garcon, G.; Thomas, J.; Cabral, M.; Dewaele, D.; Genevray, P.; Garat, A.; Allorge, D.; Diouf, A.; Loguidice, J. M.; Courcot, D.; Fall, M.; Gualtieri, M. Individual Exposure Level Following Indoor and Outdoor Air Pollution Exposure in Dakar (Senegal). *Environmental Pollution* 2019, 248, 397-407.

[15] Ouafo-Leumbe, M.-R.; Galy-Lacaux, C.; Liousse, C.; Pont, V.; Akpo, A.; Doumbia, T.; Gardrat, E.; Zouiten, C.; Sigha-Nkamdjou, L.; Ekodeck, G. E. Chemical composition and sources of atmospheric aerosols at Djougou (Benin), Meteorol. *Atmos. Phys*. 2017, 130, 591–609.

[16] Chow, J. C., Watson, J. G., Kuhns, H., Etyemezian, V., Lowenthal, D. H., Crow, D., Kohl, S. D., Engelbrecht, J. P., and Green, M. C. Source profiles for industrial, mobile, and area sources in the Big Bend Regional Aerosol Visibility and Observational Study. *Chemosphere* 2004, 54, 185–208.

[17] Val, S., Liousse, C., Doumbia, E. H. T., Galy-Lacaux, C., Cachier, H., Marchand, N., et al. Physico-Chemical Characterization of African Urban Aerosols (Bamako in Mali and Dakar in Senegal) and Their Toxic Effects in Human Bronchial Epithelial Cells: Description of a Worrying Situation. Particle and Fibre Toxicology, 2013, 10, Article No. 10. https://doi.org/10.1186/1743-8977-10-10

[18] Terrouche, A., Ali-Khodja, H., Kemmouche, A., Bouziane, M., Derradji, A. and Charron, A. Identification of Sources of Atmospheric Particulate Matter and Trace Metals in Constantine, Algeria. Air Quality, Atmosphere & Health, 2015, 9, 69-82.

[19] Kuvarega, A. T. and Taru, P. Ambiental Dust Speciation and Metal Content Variation in TSP, PM 10 and PM 2.5 in Urban Atmospheric Air of Harare (Zimbabwe). Environmental Monitoring and Assessment, 2008, 144, 1-14.