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Characterisation Test of PM2.5 and PM10 Particulate Matter in the Ambient Air in Conakry City, Republic of Guinea

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Abstract

Air quality degradation is a major issue in the large conurbations on the shore of the Gulf of Guinea. Daily simultaneous samplings of PM10 and PM2.5 particulate matter (PM) were made at seven different sites during the dry period (December 2023 to March 2024) in Conakry city, Republic of Guinea. Measurements were performed in the vicinity of major combustion aerosol sources: UGANC (site traffic of Conakry University), CP (site of domestic and roads), CS (site of slaughterhouse), GCC (landfill site), AGEE (site of alumina unloading), NH (site of traffic and Landfill for garbage) and RTGB (site traffic). On seven different sites, the daily average concentration varied from 44.04 to 285.65 $\mu g.m^{-3}$ in PM2.5, 98.4 to 652.8 $\mu g.m^{-3}$ in PM10, respectively. Average PM2.5 and PM10 level were 182.40 ± 99.13 $\mu g.m^{-3}$ and 435.19 ± 246.27 $\mu g.m^{-3}$, respectively, with PM2.5 constituting 44.50 ± 10.01 %of the PM10 mass. Moreover, the average ratio of PM2.5/PM10 is equal to 79.29 % on CS site, which indicates that the PM2.5 had been one of the main contaminations affecting urban atmospheric environmental quality on CS site in Conakry city.

Keywords

PM2.5, PM10 Air Quality, Combustion Aerosol, Conakry, Guinea

1. Introduction

The concentrations of particulate matter (PM) in the ambient air have increased during recent years because of the rapidly increasing urbanization, industrialization, and the resulting anthropogenic activities [1]. Sub-Saharan Africa in general, but particularly the already densely populated southern West Africa (SWA hereafter), currently experiences strong population growth and urbanization [2]. However, air pollution is a major environmental health problem affecting large populations around the world [3]. It is a complex mixture of gaseous and particulate components, each of which has detrimental effects on human health [4]. Short-term exposure (from one hour to days) to selected air pollutants has been associated with human mortality [5]. According to [6], Aerosol particles of fines dimensions are recognised to have a strong impact on the environment and to be of concern in health-related effects. Most of the excess deaths attributable to air pollution exposure are due to acute ischemic/thrombotic cardiovascular events [4]. In addition to excess mortality, air pollution is associated with significant reductions in healthy life years and worker productivity [7] [8]. Particularly for the most studied and widespread air pollutants, *i.e.* particles with aerodynamic diameters under 10 and 2.5 μm (PM10 and PM2.5), air quality standards including safe thresholds have been established [9]. According to the Global Burden of Disease (GBD) study estimates, around 4.2 million total deaths were directly attributable to particulate matter smaller than 2.5 μm (PM2.5) ambient air pollution in 2015 [10].

According to [11] and [12], the aerosol particles in West African cities have strong implications for the population's health due to high aerosol concentration levels [13], with inflammatory impacts directly linked to pollutant emission sources. [12] highlighted the high toxicity of fine particles in Bamako and Dakar, with a stronger impact than in European cities such as Paris. The objective of this systematic review and meta-analysis was to synthetize the worldwide evidence on the effects of short-term exposure to PM (PM2.5 and PM10), on all-cause and/or cause-specific mortality, including cardiovascular, respiratory, and cerebrovascular mortality [5].

However, air pollution is not just a health problem [14]. It also has significant environmental consequences, contributing to problems such as acid rain, reduced visibility, ecosystem degradation, and climate change [15]. These consequences are not the subject of the research described in this article.

Atmospheric aerosol in West African rural areas and typical inter-tropical ecosystems has been the subject of research programs such as DECAFE [16] [17], IDAF [18] and EXPRESSO [19]. However, very little information exists on aerosols in West African cities [20]. The results obtained by [21] confirm that in West African big cities there is a "hot spot" of emissions, particularly due to the emissions from traffic and domestic fires. Nevertheless, pollution in urban African areas and their related health impacts have been poorly studied.

The literature contains a large amount of analysis and research results on the concentration of particulate matter (PM2.5 and PM10) [14]. According to [22], [23], PM is described in the literature as a mixture of metals, salts, organic compounds from combustion and elemental carbon. The particle composition and concentration are extremely changeable and depend on many factors such as climate variations, emission sources, and geographical position [24]. Its composition may change on a daily basis and even during the same day, intriguingly [25]-[28].

Furthermore, in addition to Saharan dust and biomass burning events, anthropogenic particulate pollution sources are still the main PM anthropogenic sources which are quite different on Abidjan and Cotonou cities. Note that biomass burning occurring around West Africa may also impact on Abidjan [20]. Among atmospheric pollutants, particulate matter (PM) plays an important role in air quality worsening in urban areas [29]. Therefore, observations for fine particle (PM2.5 and PM10) are needed for African cities [20], case of the city of Conakry. This paper focuses on fine-particle mass measurements performed over different sites in the city of Conakry. In this work, several samples of deposited fine particle (PM2.5 and PM10) were collected in order to have a preliminary understanding of their evolution during the dry season in urban Conakry.

2. Materials and Methods

2.1. Site Description

Our experimental strategy is based on sampling the polluted atmosphere of different site in the major western African city of Conakry in Republic of Guinea from the dry season. **Figure 1** gives the geographical position of Conakry city in Republic of Guinea. Conakry (9˚34′N, 13˚34′W) is the most important economical city in Republic of Guinea. It had 2.1 million inhabitants in 2022. Conakry's climate is tropical, with a dry season from December to March, and a rainy season due to the African monsoon that runs roughly from April to November [30]. Conakry is a coastal city dominated by winds from the African Gulf of Guinea monsoon. According to [31], the rainy season is dominated by the West African monsoon, corresponding to the southwestern prevailing winds advecting humidity and precipitation to the continent. The dry season from December to March is dominated by the northeasterly Harmattan wind [32], carrying mineral dust emitted from arid areas [33].

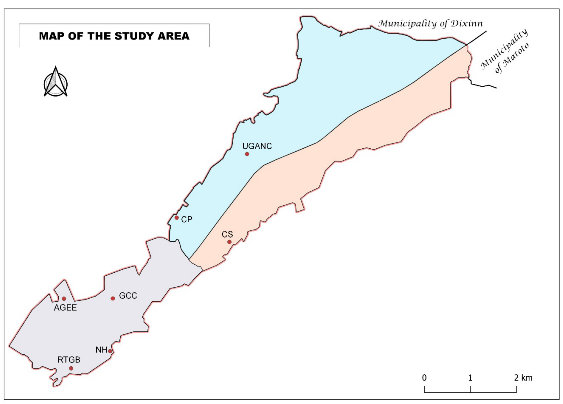

Figure 1. Map of the city of Conakry reporting the location of the PM2.5 and PM10 sampling seven sites.

Figure 1 gives the geographical location of each site within the Conakry citie. In order to carry out a characteristic study of atmospheric pollution in the city of Conakry, PM2.5 and PM10 particles were sampled on seven sites of representative sources. These seven Measurement sites stand as follow:

1) UGANC (site traffic of Conakry University, latitude 9˚32'45,3" North, longitude 13˚40'35,8" West);

2) CP (site of domestic and roads, latitude 9˚31′59,0″ North, longitude 13˚41′25,6 ″ West);

3) CS (site of slaughterhouse, latitude 9˚31′46,9″ North, longitude 13˚40′46,7″ West);

4) GCC (landfill site, latitude 9˚31′03,0″ North, longitude 13˚42′13,0″ West);

5) AGEE (site of alumina unloading, latitude 9˚30′59,0″ North, longitude 13˚42′22,4″ West);

6) NH (site of traffic and Landfill for garbage, latitude 9˚30′26,1″ North, longitude 13˚42′14,8″ West);

7) RTGB (site traffic, latitude 9˚30'15,6″ North, longitude 13˚42′42,7″ West).

2.2. Description and Principle of the Particle Sensor (TurnKey Dust Mate DM11992)

The device adopted is a sensor for pollution measurement. This device allows to measure manually dust levels at very low concentrations. In environmental mode, it will indicate TSP, PM10, PM2.5 and PM1 concentrations. The particles are sucked up using an internal pump (600 cm^3/s), circulating in front of the laser of a photometer which measures their dimensions (from 0.4 μm to 20 μm) and are trapped on a filter protecting the pump. Finally, 20,000 particles per second can be measured, which corresponds to a concentration of more than 6000 $\mu g/m^3$ (we generally consider a dust density of 1.5). The measurements have been made daily from 9:00 to 18:00. During this period of time, we are seeing large crowds on the various sites, depending on the activities being carried out. As in this work, it is the characterization of particles, we have chosen the two sizes of particles (PM2.5 and PM10) that are necessary in order to analyze the pollution in this city.

3. Results and Discussion

3.1. PM2.5 and PM10 Aerosols

The daily variability of particulate matter concentrations (PM2.5, PM10) averaged over the seven different locations is depicted on Figure 2 and Figure 3. Figure 2 shows the time series of daily PM2.5 obtained at the seven different sites for dry period in Conakry city. The daily average concentration of PM2.5 at the seven sites was 182.40 ± 99.13 $\mu g.m^{-3}$. During this period, the daily PM2.5 concentration varies from 44.04 to 285.65 $\mu g.m^{-3}$. The average daily PM2.5 concentration was 259.94 $\mu g.m^{-3}$ at UGANC, 261.8 $\mu g.m^{-3}$ at CP, 111.05 $\mu g.m^{-3}$ at CS, 44.04 $\mu g.m^{-3}$ at GCC, 45.16 $\mu g.m^{-3}$ at RTGB, 285.65 $\mu g.m^{-3}$ at AGEE and 269.17 $\mu g.m^{-3}$ at NH, respectively. The highest daily concentration of PM2.5 was obtained at GCC site and the lowest at AGEE site. The higher concentrations obtained at certain sites (259.94 μg.m^{-3} at UGANC, 261.8 μg.m^{-3} at CP, 111.05 μg.m^{-3} at CS, 285.65 μg.m^{-3} at AGEE and 269.17 μg.m^{-3} at NH) may be due by many area emission sources distributed around of sites.

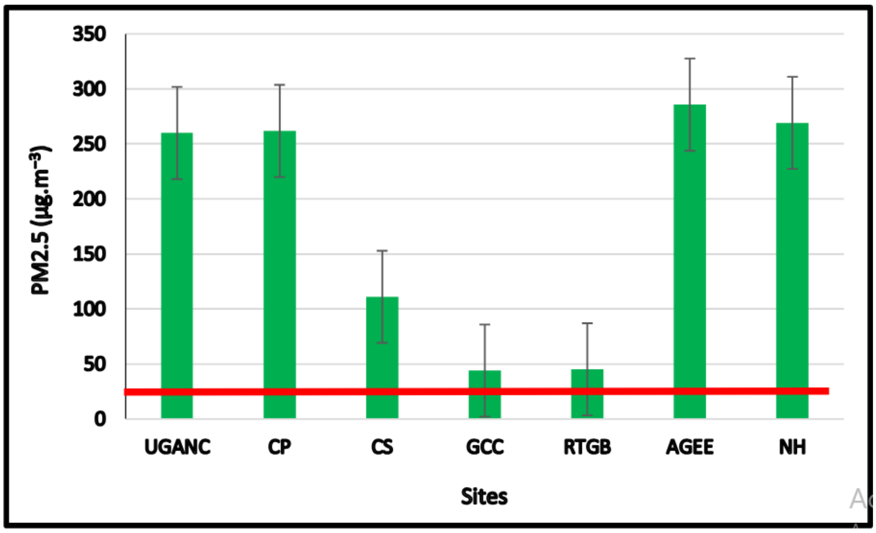

Figure 2. PM2.5 mass concentrations at the seven sites with those in other African cities. Red horizontal line illustrates current WHO guideline.

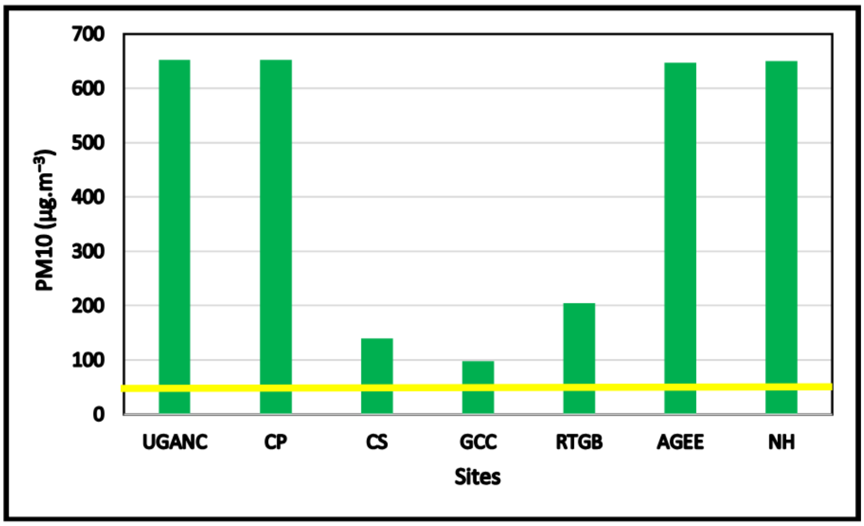

Figure 3. PM10 mass concentrations at the seven sites with those in other African cities. Yellow horizontal line illustrates current WHO guideline.

Figure 3 presents the daily concentrations of PM10 particles obtained at the seven sites. The average daily concentration of PM10 at the seven sites was 435.19 ± 246.27 μg.m^{-3}. The PM10 concentrations during the observation period, the daily concentration varies from 98.4 to 652.8 μg.m^{-3}. The average daily PM10 concentration was 652.79 μg.m^{-3} at UGANC, 652.8 μg.m^{-3} at CP, 140.05 μg.m^{-3} at CS, 98.4 μg.m^{-3} at GCC, 205.16 μg.m^{-3} at RTGB, 646.96 μg.m^{-3} at AGEE and 650.17

$\mu g.m^{-3}$ at NH, respectively. The highest daily concentration of PM10 was obtained at CP site and the lowest at GCC site. The high concentrations at certain sites could be attributed to a large number of industrial and motor vehicular emissions within the city.

The average PM2.5 and PM10 concentrations at certain sites were high, indicating serious particulate pollution and multi-source contribution to airborne PM2.5 and PM10 in this city. According to [6], the average daily values of PM2.5 and PM10 concentrations show significant variations from day to day. In the discussion, these measured PM2.5 and PM10 concentrations are juxtaposed with the daily average standards set at 25 $\mu g.m^{-3}$ and 50 $\mu g.m^{-3}$ (World Health Organization [34]), respectively.

3.2. The Ratios of PM2.5/PM10

Descriptive statistics for all valid observations of PM2.5 and PM10 concentrations from the seven sites in Conakry city are summarized in **Table 1**. Among the 7 sites, average PM2.5 mass in Conakry were very high on certain (259.94 $\mu g.m^{-3}$ at UGANC, 261.8 $\mu g.m^{-3}$ at CP, 111.05 $\mu g.m^{-3}$ at CS, 285.65 $\mu g.m^{-3}$ at AGEE and 269.17 $\mu g.m^{-3}$ at NH), apparently affected by many area emission sources distributed around of these sites. Average PM10 mass were also high on sites, indicating that a high-level particle emission occurred not only in the urban area, but also from other locations.

Table 1. Ambient PM2.5 and PM10 concentrations at 7 sites in Conakry City, Republic of Guinea.

Sites	PM2.5 ($\mu g.m^{-3}$)	PM10 ($\mu g.m^{-3}$)	PM2.5/PM10 (%)
UGANC	259.94	652.79	39.82
CP	261.8	652.8	40.10
CS	111.05	140.05	79.29
GCC	44.04	98.4	44.76
RTGB	45.16	205.16	22.01
AGEE	285.65	646.96	44.15
NH	269.17	650.17	41.40
Average	182.40 ± 99.13	435.19 ± 246.27	44.50 ± 10.01

From this table, the ratios of average daily PM2.5 to PM10 concentrations at the seven sites varied from site to site, ranging from 22.01 % to 79.29%, with an average of 44.50 ± 10.01%. The ratio of PM2.5/PM10 was 39.82% at UGANC, 40.10% at CP, 79.29% at CS, 44.75% at GCC, 22.01% at RTGB, 44.15% at AGEE and 41.40% at NH, respectively. Therefore, it is more important to control the fine particles on CS site. The PM2.5/PM10 ratio (79.29) on CS was higher than the other sites of study, indicating the fine particle pollution on CS site. According to [35], an average ratio of PM2.5/PM10 equal to 57.9%, indicates the PM2.5 had been one of the main contaminations affecting urban atmospheric environmental quality. We can say that the report found on our CS site confirms this information from [35].

3.3. Discussion

Our results show that the average concentrations of PM2.5 and PM10 at our urban sites are 182.40 ± 99.13 μg.m^{-3} and 435.19 ± 246.27 μg.m^{-3}, respectively. The average concentration of PM2.5 is 259.94 μg.m^{-3} for UGANC, 261.8 μg.m^{-3} for CP, 111.05 μg.m^{-3} for CS, 44.04 μg.m^{-3} for GCC, 45.16 μg.m^{-3} for RTGB, 285.65 μg.m^{-3} for AGEE and 269.17 μg.m^{-3} for NH. On the same sites, the daily average of PM10 is 652.79 μg.m^{-3} for UGANC, 652.8 μg.m^{-3} for CP, 140.05 μg.m^{-3} for CS, 98.4 μg.m^{-3} for GCC, 205.16 μg.m^{-3} for RTGB, 646.96 μg.m^{-3} for AGEE and 650.17 μg.m^{-3} for NH. Such values are presented in **Table 2** with other measurements existing in Africa for different cities. **Figure 2** presents daily PM2.5 obtained at the seven different sites for dry period with the standard recommended by the WHO (horizontal line in red color: 25 μg.m^{-3}). It is interesting to underline that all the values of PM2.5 including our measurements are higher by a factor of 1.8-11.4 than the WHO guidelines.

Table 2. PM2.5 and PM10 concentrations with other measurements existing in Africa for different cities.

City	Periods	Fractions measured	Mean concentrations (μg.m^{-3})	Site	References
Conakry	Dry Period	PM2.5	259.94	UGANC	In study
		PM10	652.79	Traffic	
		PM2.5	261.8	CP domestic	
		PM10	652.8	and roads	
		PM2.5	111.05	CS	
		PM10	140.05	slaughterhouse	
		PM2.5	44.04	GCC	
		PM10	98.4	landfill	
		PM2.5	285.65	AGEE alumina	
		PM10	646.96	unloading	
		PM2.5	45.16	RTGB	
		PM10	205.16	Traffic	
		PM2.5	269.17	NH traffic	
		PM10	650.17	and Landfill	
Harare, Zimbabwe	July to December 2002	PM2.5	59.70 ± 13.48	Road traffic, industry	[36]
Kenitra, Morocco	June 2007 and May 2008	PM2.5	51.32	Traffic site	[37]

Continued

Constantine, Algeria	23 December 2011 and 8 January 2013	PM2.5	57.8	Traffic site	[38]
Dakar, Senegal		PM	80.7	Residential and traffic site	[12]
Constantine, Algeria	23 December 2011 and 8 January 2013	PM10	105.2	Traffic site	[38]
Kenitra, Morocco	June 2007 and May 2008	PM10	115.12	Traffic site	[37]
Dakar, Senegal		PM	205.8	Residential and traffic site	[12]

The papers of [29] and [20] on road traffic sites give values close or slightly higher than our traffic values: 41 μg.m^{-3} for Harare in Zimbawe [36], 51 μg m^{-3} for Kénitra in Marocco [37] and 58 μg.m^{-3} for Constantine in Algeria [38]. In their study over Accra in Ghana, [39] reveal that the geometric mean of PM2.5 concentration is included in the 39–53 μg.m^{-3} range for roadside sites, whereas it is in the 30 - 70 μg.m^{-3} range for residential sites.

We also led the discussion on the daily average of PM10 concentrations. **Figure 3** presents daily PM10 obtained at the seven different sites for dry period with the standard recommended by the WHO (horizontal line in yellow color: 50 μg.m^{-3}). The daily concentrations of PM10 are higher by a factor of 1.9-13 than the WHO guidelines. The daily concentrations for PM10 recorded at Shobra which ranged from 154 to 360 µg.m^{-3} were high, due to heavy traffic and industrial activities in the area [40]. According to study carried out by: [37] during the period between June 2007 and May 2008, in Kenitra city and [38] during the period between 23 December 2011 and 8 January 2013, in Constantine, Algeria, the average PM10 concentrations were 115.12 μg.m^{-3} and 105.2 μg.m^{-3} respectively. The daily PM mean levels reported by [12] at Bamako city and Dakar city reached 205.8 μg.m^{-3} and 80.7 μg.m^{-3} respectively; these high concentrations are mainly due to traffic emissions and biomass burning used for cooking and heating purposes. The high PM10 levels were attributed to unpaved road and construction works around all sites. We can also say that the high levels of PM2.5 and PM10 were linked to heavy traffic in Conakry city especially during rush hours in the morning and in the evening.

We also determined the PM2.5/PM10 ratio on the seven measurement sites in the city of Conakry. The average ratio of PM2.5/PM10 was 44.50 ± 10.01 %. In the Conakry city, the PM2.5 had been one of main contamination affecting urban atmosphere environmental quality. Also, we can say that the pollution degree of PM10 in Conakry city was very high. The main reason possibly was owing to the dry and rainless climate and sandstorm from desert. According to [41], construction activities can be as an important source of PM10 and not PM2.5. The PM2.5/PM10 ratio found on the CS site is equal to 79.29; which indicates the

PM2.5 had been one of the main contaminations affecting urban atmospheric environmental quality [35] on CS site in Conakry city. According to [42], the high concentrations of PM measured on our sites may be due to the activities carried out at the Autonomous Port of the city of Conakry. Also, we can say that the high concentrations of PM2.5 and PM10 particles observed on some could be due to desert particles and biomass fires from Central Africa.

4. Conclusion

PM2.5 and PM10 mass were investigated at seven ambient air quality monitoring sites in Conakry city, Republic of Guinea. During the dry period study, the daily average PM2.5 concentrations ranged from 44.04 to 285.65 $\mu g.m^{-3}$ with an average of 182.40 ± 99.13 $\mu g.m^{-3}$, and the daily average PM10 concentrations ranged from 98.4 to 652.8 $\mu g.m^{-3}$ with an average of 435.19 ± 246.27 $\mu g.m^{-3}$. The ratios of average daily PM2.5 to PM10 concentrations at the seven sites varied from site to site, ranging from 22.01 % to 79.29 %. On average, PM2.5 constituted 44.50 ± 10.01 % of PM10 mass. The PM2.5/PM10 ratio found on the CS site is equal to 79.29; which indicates the PM2.5 had been one of the main contaminations affecting urban atmospheric environmental quality on CS site in Conakry city.

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Conflicts of Interest

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

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