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Evaluation of the Impact of Atmospheric Pollutants on the Health of the Populations of the City of Conakry

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Abstract

The aim of the study is to identify sources of atmospheric pollutants and assess their impact on the health of Conakry's population. Ten contaminant sources were identified. Sampling was conducted on suspended particles and gases. Physicochemical methods were used to determine pollutant levels. The results show that CO_2 is the highest gaseous pollutant at the Dar es Salaam landfill (708 μg/m^3), followed by CO (354 μg/m^3). The highest content of volatile organic compounds (VOC) was observed at the Tombo thermal power plant (475 μg/m^3). Nitrogen oxides and hydrocarbon pollutants (NO_x and C_nH_{2n+2}) at each site were relatively stable, with levels between (100 - 150 μg/m^3) and (450 μg/m^3), respectively. Suspended particulates (PM_{10} and $PM_{2.5}$) measured at various locations showed higher PM_{10} levels than $PM_{2.5}$. In particular, the highest PM_{10} content was observed at the Sangoyah soap factory (410 μg/m^3), followed by the Madina market (319 μg/m^3) and the Dar-Es-Salam landfill (318 μg/m^3). As indicated by the results, these contamination levels far exceed European and World Health Organization standards. This study highlights the need to adopt a strategy to reduce pollution levels at these critical points to protect the health of the city's population.

Keywords

Air Pollutants, Population Health, Contamination Levels, Pollution

1. Introduction

Human evolution is marked by a significant increase in quality of life and methods of resource exploitation. This is reflected in population growth and the rapid expansion of urban areas [1]. Progress in industry is a key advantage in controlling the environment and organizing space according to human needs [2]. Additionally, road traffic is extremely dense, with many outdated vehicles running on diesel fuel, especially in public transport [3]. In Europe, energy is the primary source of pollution, contributing to 70% of sulfur oxide emissions and 21% of nitrogen oxide emissions. However, road transport significantly contributes to emissions of carbon monoxide (CO), NO_x, and particulates of 2.5 μm and below ($PM_{2.5}$). Populations in large urban areas directly inhale these pollutants [4].

In this respect, African countries are not as concerned about air pollution as European countries. Differences in development between countries impact air quality in these regions [5]. Sociological, climatic, and economic factors influence the sources of chemical pollutant emissions in African regions [6] [7].

However, the capital of the Republic of Guinea, Conakry, combines multiple elements that affect air quality, making it one of the most polluted cities in the world. Conakry is home to most of the country's political, economic, and social infrastructures, resulting in a high population density in a small area. The city's location on a peninsula limits its spatial expansion, leading to extremely high densities and raising concerns about the coexistence of industry and population. Along with its industrial nature, urbanization and the region's economic and demographic development have expanded the transport sector.

At the same time, vehicles are mainly second-hand and concentrated in urban areas, leading to increased pollution levels. This raises questions about the population's ability to cope with environmental challenges. The aim of this study is to assess the health contamination risks for the population of the city of Conakry.

2. Materials and Methods

2.1. Geography and Demographics of the City of Conakry

The city of Conakry is located at 9˚34' latitude North and 13˚34' longitude West. Conakry is a peninsula covering an area of approximately 308 km^2, with a length of 34 km and a width varying between 1 and 6 km [8]. The latest 2014 administrative census projected the population of Conakry to be 2,095,705 inhabitants in the year 2022 [9].

Conakry can be divided into two parts: the continental part, which includes its five communes—Kaloum, Dixinn, Matam, Ratoma, and Matoto—and the maritime part, consisting of the Loos Islands. The inhabited islands are Kassa, Room, and Fotoba, while Ile Blanche (also known as Ile du Commandant) and Ile Corail are uninhabited. The Loos Islands are underappreciated and seldom visited, despite the maritime space being synonymous with openness and opportunity. With their picturesque landscapes, welcoming populations, and rich history, these islands are valuable assets and attractions for Conakry.

2.2. Concentration of Suspended Solids (SS)

To determine the content of suspended particles and gaseous pollutants, several formulas and methods are used to assess their concentration, particle size distribution, and sedimentation rate.

The concentration of suspended solids is generally determined by the gravimetric method (see formula (1) below).

Gravimetric method

The gravimetric method is the most commonly used technique for measuring the concentration of suspended solids. This method involves filtering a water sample through a pre-weighed filter, drying it to evaporate the water, and then weighing it again to determine the mass of retained particles [10].

$$MES = \frac{M_f - M_i}{V} \quad (1)$$

M_f stands for final filter mass after filtration (in mg);

M_i stands for initial filter mass before filtration (in mg);

V stands for volume of filtered sample (in L);

MES concentration is expressed in mg/L.

2.2.1. Particulate Matter Mass Concentration (PM_{10} and $PM_{2.5}$)

Suspended particles are often classified by size, such as PM_{10} (particles with a diameter of less than 10 micrometers) and $PM_{2.5}$ (particles with a diameter of less than 2.5 micrometers). The mass concentration of these particles in the air is expressed in micrograms per cubic meter (μg/m^3). This formula is used to determine particulate mass concentrations [11].

$$PM = \frac{M}{V} \quad (2)$$

M stands for total mass of particles collected in a filter (in μg)

V stands for volume of air sampled (in m^3).

2.2.2. Sedimentation Rate

Sedimentation rate measures the rate at which particles settle out of a gas phase [12].

The general formula for sedimentation rate (V_s) is:

$$V_s = \frac{2}{9}\frac{\rho_\rho - \rho_g}{\eta} \quad (3)$$

ρ_ρ stands for particle density (in kg/m^3);

ρ_g stands for density of surrounding gas (in kg/m^3);

ρ_g stands for acceleration due to gravity (in m/s^2);

d stands for particle diameter (in m);

η stands for dynamic gas viscosity (in Pas).

2.2.3. Total Particle Mass Concentration

For fine and ultrafine particles, total mass concentration can be calculated from particle density and volume.

$$\text{Total mass concentration} = N \times \frac{4}{3} \times \pi \frac{d^3}{8} \rho_P \tag{4}$$

N stands for total number of particles per unit volume of air;

d stands for average particle diameter (in m)

ρ_P stands for particle density (in kg/m^3).

2.2.4. Stoke's Law of Particle Falling Speed

This law determines the speed at which a particle settles in a fluid (gas) under the influence of gravity [13].

$$V_t = \frac{2}{9} \frac{\left(\rho_p - \rho_g\right) g r^2}{\eta} \tag{5}$$

V_t: Final velocity of the falling particle (in m/s);

r stands for particle radius (in m);

g stands for acceleration due to gravity (in m/s^2);

ρ_P stands for particle density (in kg/m^3);

ρ_g stands for gas density (in kg/m^3);

η stands for gas dynamic viscosity (in Pas).

2.2.5. Particle Deposition Rate

The deposition rate measures the quantity of suspended particles deposited on a given surface per unit of time [14].

$$\text{The deposition rate} = \frac{M}{A \times t} \tag{6}$$

M stands for mass of particles deposited (in mg);

A stands for surface area over which particles are deposited (in m^2);

t stands for exposure time (in s or days).

2.2.6. Emission Factor

The emission factor is a formula used to evaluate the quantity of particles emitted by a specific source, such as an industrial chimney [15].

$$E_E = \frac{M_P}{U_P}; \tag{7}$$

E stands for emission factor;

M_P stands for mass of particles emitted;

U_P stands for production or consumption unit.

These methods are used with instruments such as gravimetric filters, impactors, and particle analyzers to measure particle content.

3. Results and Discussion

The results from various measurement points show high levels of several pollutants (gaseous and organic), indicating significant air pollution in the study area (see Figure 1). Analysis of this figure shows the concentrations of gaseous and organic pollutants at various locations. Among these, the Dar-Es-Salam landfill has the highest level of CO_2 pollution at 708 ppm, indicating a significant source of pollution, likely linked to the decomposition of organic waste and waste combustion. In contrast, Usine Tafagui has the lowest CO_2 pollution level at 70 ppm, suggesting either an absence of polluting activities or better management of emissions. Commercial zones such as Marché Madina and Port Autonome Conakry have high CO_2 pollution levels (490 ppm and 506 ppm, respectively), probably due to heavy human and industrial activity.

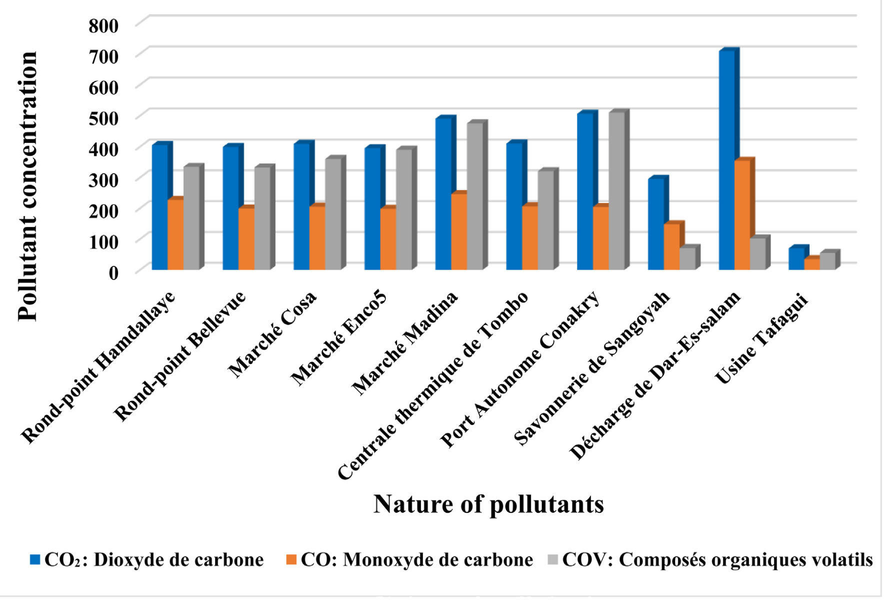

Figure 1. Types of gaseous pollutants and volatile organic compounds.

In addition, carbon monoxide (CO) levels were high at the Dar-Es-Salam landfill (354 ppm), indicating incomplete combustion of organic materials. However, locations such as markets and traffic circles recorded CO levels ranging from 198 ppm to 246 ppm, suggesting moderate emissions, likely due to vehicles and commercial activities. In contrast, the Usine Tafagui location had the lowest CO level (35 ppm), consistent with that recorded for CO_2.

The highest VOC (Volatile Organic Compounds) content was recorded at the Port Autonome Conakry (510 ppm), likely due to emissions from unburned fuels and industrial activities. In contrast, VOC levels at the Dar-Es-Salam landfill and Usine Tafagui are relatively low (102 ppm and 55 ppm, respectively), indicating limited sources of VOC emissions. Markets such as Cosa market of and Enco5 market show high VOC levels (360 ppm and 390 ppm), possibly due to the evaporation of solvents, fuels, and other chemicals used or sold. These results corroborate those observed by [16] regarding the impact of volatile organic compounds on photochemical pollution.

High levels of CO and VOC pollution in densely populated areas, such as markets and traffic circles, can pose health risks, including respiratory and cardiovascular diseases. CO_2 emissions also contribute to climate change, with potentially serious environmental effects.

Figure 2 shows the concentrations of three types of pollutants (NOx, NO_2, and C_nH_{2n+2}) measured at different sites in the study area. These pollutants are key indicators of air quality, particularly in urban areas where the main sources include vehicles, industries, and combustion activities.

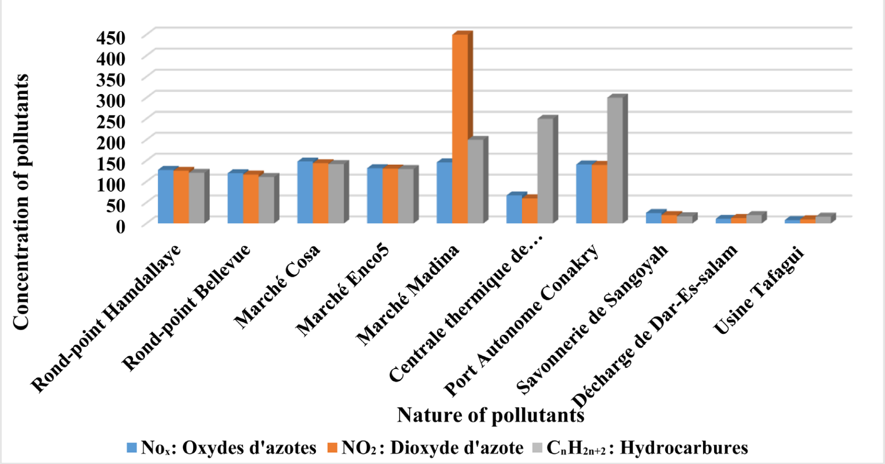

Figure 2. Pollutant types NOx, NO_2 and hydrocarbons (C_nH_{2n+2}).

Locations such as Rond-point Hamdallaye, Rond-point Bellevue, Cosa market, Enco 5 market, and Centrale Thermique de Tombo present similar NO_x and NO_2 pollution levels, with slightly elevated NO_x concentrations.

Madina market shows an exceptionally high NO_2 concentration (around 450 mg/m^3) compared to other sites, indicating a potentially localized source of NO_2 emissions, likely linked to high traffic density or industrial activities.

In addition, locations such as the Port Autonome de Conakry and the Dar-Es-Salam landfill recorded high concentrations of hydrocarbons (C_nH_{2n+2}), likely linked to organic emissions from maritime activities or waste management.

On the other hand, sites such as Savonnerie de Sangoyah and Usine Tafagui showed the lowest pollution levels for all pollutant types, suggesting minimal industrial impact or effective control measures.

The results show significant differences in pollutant distribution, depending on activity type at each site. Madina market displays a marked anomaly with a very high concentration of NO_2. This could indicate problems specific to this area, such as poorly maintained vehicle engines or incomplete combustion sources, consistent with [17] observations on urban emissions due to heavy traffic. The high levels of hydrocarbon pollution (C_nH_{2n+2}) at the Port Autonome de Conakry and the Dar-Es-Salam landfill corroborate findings of [18], which link hydrocarbons to emissions from port activities and waste management operations, including combustion and organic decomposition.

The sites with the lowest pollution levels, such as the Savonnerie de Sangoyah and the Usine Tafagui, could benefit from better pollution control infrastructure or low volumes of polluting activity. This observation aligns with [19], who found that industries with modern filtration systems emit fewer gaseous pollutants.

Analysis of air pollutant concentrations at different sites in the study area reveals significant variations in PM_{10} and $PM_{2.5}$ levels (**Figure 3**). This graph shows measured concentrations of PM_{10} and $PM_{2.5}$ at various sites, including the Hamdallaye and Bellevue traffic circles, the markets (Cosa, Enco5, and Madina), the Tombo thermal power plant, the Autonomous Port, the Sangoyah soap factory, the Dar-Es-Salam landfill, and the Tafagui factory.

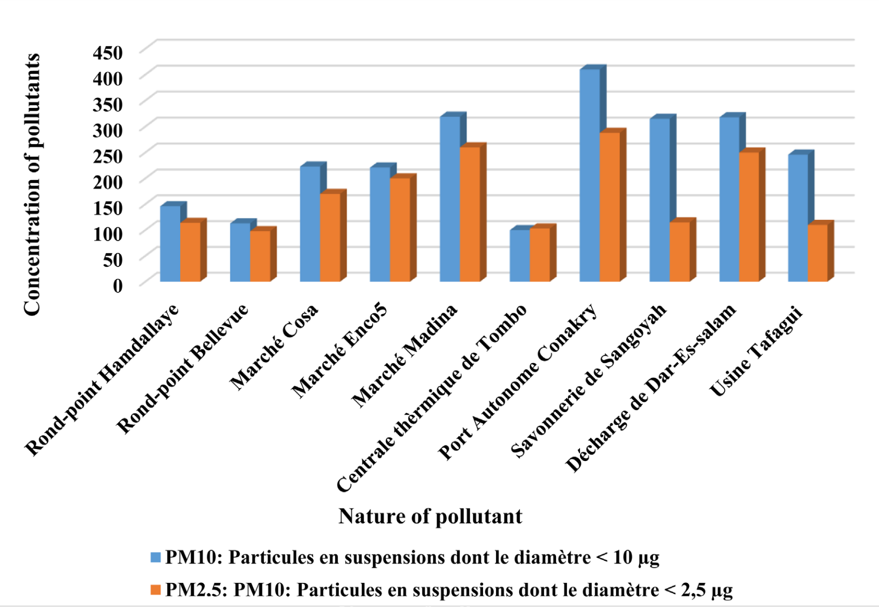

Figure 3. Pollutant types for suspended particulates PM_{10} and $PM_{2.5}$.

Rond-point Hamdallaye recorded moderate concentrations of PM_{10} (146 µg/m^3) and $PM_{2.5}$ (114 µg/m^3). However, the highest pollution levels for PM_{10} (410 µg/m^3) and $PM_{2.5}$ (288 µg/m^3) were observed at the Port Autonome de Conakry, likely due to ship emissions and port activities. Additionally, high PM_{10} (318 µg/m^3) and moderate $PM_{2.5}$ (115 µg/m^3) levels were recorded at the Dar-Es-Salam landfill, indicating the influence of waste decomposition and combustion. In contrast, the lowest concentrations of PM_{10} (246 µg/m^3) and $PM_{2.5}$ (110 µg/m^3) were measured at the Using Tafagui, possibly due to stricter environmental controls or low industrial activity.

The data obtained (**Figure 3**) show that PM10 and PM2.5 pollution levels vary considerably according to human and industrial activity in each area. The Port Autonome de Conakry shows very high pollution levels, consistent with findings by [19], who identified ports as major pollution sources due to ship emissions and logistics activity.

In addition, the Dar-Es-Salam landfill site shows high concentrations of suspended particulates, consistent with the findings of [11], who noted that open dumps and waste combustion activities are major sources of PM_{10} and $PM_{2.5}$ particulates. In contrast, the relatively low levels observed at Usine Tafagui could suggest the effectiveness of certain pollution control measures or favorable meteorological conditions that effectively disperse pollutants.

The results corroborate trends observed in other works [20] [21], demonstrating that implementing emission reduction policies in industrial and port areas can significantly reduce suspended particulate pollution levels.

Furthermore, the study by [22] on the impact of fine particles on urban health confirms the data obtained and focuses on sites with high levels of $PM_{2.5}$ particles to protect vulnerable populations, particularly children and the elderly. According to [22], an estimated 20 million Europeans experience daily respiratory problems, highlighting the role of fine particles smaller than 2.5 μ in pollution-related mortality associated with cardiopulmonary and cardiovascular diseases.

4. Conclusion

The aim of this work is to assess the impact of air pollution on the health of Conakry's population. Ten contaminant sources were identified, and levels of air pollutants (suspended particles, hydrocarbons, and gases) were measured at various sites. Physicochemical methods determined concentrations, showing CO_2 as the highest gaseous pollutant at the Dar-Es-Salam landfill (708 $\mu g/m^3$), followed by CO (354 $\mu g/m^3$). The highest volatile organic compounds (VOC) content was observed at the Tombo thermal power plant (475 $\mu g/m^3$). Nitrogen oxides (NO_x) and hydrocarbons (C_nH_{2n+2}) exhibited relatively stable concentrations at each site, ranging from 100 - 150 $\mu g/m^3$ and 450 $\mu g/m^3$, respectively. Suspended particulates (PM_{10} and $PM_{2.5}$) showed higher PM_{10} levels compared to $PM_{2.5}$. These contamination levels exceed European and World Health Organization standards. This study highlights the need for a strategy to reduce pollution levels at critical points to protect the health of the city's population.

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Conflicts of Interest

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

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