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Research Article

Evaluation and Determination of the Physical Properties of Gasoline and the Presence of Fine Particles in the Ten Districts of the City of N'djamena

Haroun Ali Adannou[1, 5, *], Podo Mahamat Matar[2], Tchang Banda Constantin[3], Achta Hamid Saleh[4], Simon Ngos III[5]

[1]Department of Physics and Chemistry, Ecole Normale Supérieure de N'djaména, N'djaména, Chad

[2]Department of Geology, University of N'Djam éna, N'djaména, Chad

[3]Department of Geographic Information Systems and Remote Sensing, African Regional Institute of Geospatial Information Sciences and Technologies, Ile-Ife, Nigeria

[4]Department of Chemical Engineering, Université la Francophonie de N'Djaména, N'djaména, Chad

[5]National Higher School of Engineering of Maroua, University of Maroua, Maroua, Cameroon

Abstract

The context, which allowed to write this article is the fact that we have noticed an increase in the environmental impact caused by the poor management of car parks and fuel sellers as well as the proliferation of service stations that do not respect any standards. The illegal storage and marketing of petroleum products, especially gasoline, in the city of N'Djamena is the main factor of vulnerability and criticality of air pollutants, thus demonstrating the growing environmental impact in the city of N'Djamena. The presence of Polycyclic Aromatic Hydrocarbons (PAHs) as well as that of fine particles which are part of the Persistent Organic Pollutants (POPs) and characterize by their toxicities, their persistence in the environment, their bioaccumulation in living tissues, and their long-distance transport. Thus, the main objective of this work is to determine and evaluate the physical properties of gasoline and the presence of fine particles in the ten districts of the city of N'Djamena. These are the species sold on the street and presenting a danger to users. The main idea would be to look for gas stations and points of sale that comply with the regulations in force and those that do not. Then physical analyses were carried out on different types of gasoline consumed and then the air quality was measured with a Purple Air sensor. In conclusion, a complete structure of the ten districts with their degrees of pollution as well as the number of gas stations and fuel sellers on the street will be listed.

Keywords

Polycyclic Aromatic Hydrocarbons, Bioaccumulations, Physical Analyses, Environment, N'Djamena

[*]Corresponding author: harounali100@Gmail.com (Haroun Ali Adannou)

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1. Introduction

In N'Djamena, the use and marketing of certain hydrocarbons does not comply with any standards in force or the regulations provided for this purpose. Their evaporation and discharge into unregulated nature significantly affects the ecosystem.

Hydrocarbons are the largest fraction of crude oil, accounting for between 65% and 95% of most crude oil [1-5]. Petroleum products are introduced into the environment in the form of refined products: fuels and oils, their composition depends on the origin of the oil and the sudden operations during refining. There are about 230 components for petrol and around 2000 for heavy fuel oil [6]. There are two types of fuels: heavy fuels such as naphtha and heavy fuel oils, and light fuels such as petrol and diesel. Heavy fuels have a density (d) greater than 1 and will therefore accumulate at the level of the groundwater floor. In sufficient quantities, they will constitute an immiscible phase called DNAPL (Dense Non Aqueous Phase Liquid). On the contrary, light fuels have a density (d) of less than 1 and will therefore accumulate on the surface of the slick. The immiscible phase will be called LNAPL (Light Non Aqueous Phase Liquid) [7, 8]. Pollution by these products is one of the most accentuated and dangerous forms of pollution [9, 10]. They can be found in air, water, soil and sediment. In terms of their biodegradation rate, the biodegradation rate is higher for saturated hydrocarbons, followed by light aromatic hydrocarbons, high molecular weight aromatic hydrocarbons, polar compounds having the lowest degradation rate. Saturated hydrocarbons include n-alkanes, branched alkanes, and cycloalkanes (naphthenes). Normal or linear chain alkanes are the most abundant and degradable: n-alkanes with carbon numbers greater than 44 can be metabolized by microorganisms, but those with 10 to 24 carbon atoms (C10-C24) are generally more readily degradable. Branched alkanes are more resistant to biodegradation than n-alkanes and the more branching they increase, the less susceptible these compounds are to microbial degradation. Cyclic hydrocarbons constitute a significant fraction of the hydrocarbons in most crude oils, they are more difficult to degrade than the previous two series because of their toxicity following the interaction with the cell membrane of microorganisms [11-14] As highlighted in the summary, the context, which allowed us to write this article is among other things the fact that there is a growth in the environmental impact caused by the poor management of the vehicle fleets of fuel sellers as well as the proliferation of service stations that do not respect any standards. To understand the impact generated by hydrocarbons that do not respect any storage and sales standards, we had to identify in each district the number of service stations, street vendors and stations that do not respect any standards. We then took samples in each district of the city of N'Djamena and determined the physical properties and the presence of fine particles. Then the air quality was measured with a Purple Air sensor. The conclusion of this work will allow us to understand and have a paper such as this present article which will talk about the scientific elements, the different degrees of pollution as well as the number of service stations and fuel sellers in the street.

2. Materials and Methods

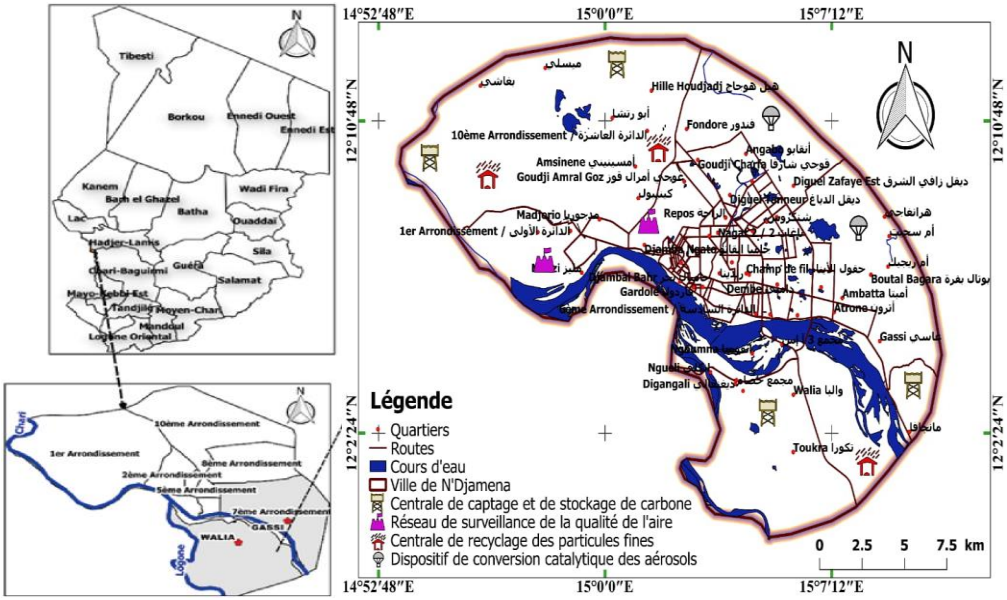


Figure 1. Location of study area.

The city of N'Djamena is located in western Chad between longitudes 15°02' and 15°07' East and latitudes 12°03' and 12°10' North. It lies at the confluence of the Chari and Logone rivers and covers an area of 12,000 hectares. The administrative capital and largest city of the Republic of Chad, N'Djamena is divided in to ten arrondissements. The climate in the study area is Sahelian, characterized by a short rainy period and a long dry period. It is marked by the alternation of two air masses: the Libyan anticyclone and the Saint Helena anticyclone.

The arrondissements are subdivided into districts, within the districts there are squares separated by streets. The outlying districts of the rapidly expanding city are not yet well structured in squares.

2.1. Equipment

The equipment used for physical analysis consists of reagents, solvents, glassware and analytical equipment used for characterization:

For density

DDM-2911 RUDOLPH RESEARCH ANALYTICAL brand automatic density meter, consisting of oscillating sample tube, electronic excitation system, frequency counting and display;

Bath running at a constant temperature within the desired range;

Outer capillary tube made of TFE-fluorocarbon with a tip adapted to the opening of the oscillating tube;

Flow or pressure adapter used as an alternative means of introducing the sample into the density meter by pump or vacuum;

Thermometer calibrated and graduated to 0.1 ℃ and a thermometer holder attached to the instrument to set and observe the test temperature;

Bottle to contain the sample to be analyzed.

For distillation

ASTM D86 distillation apparatus of JSR 1009BA brand incorporated with a condenser and a heating device;

1. Distillation flask;
2. Thermometer;
3. 100 mL graduated test tube.

For Reid Vapour Pressure

TVR tester apparatus of brand JH0 103 13;

1. Fuel chamber with a volume of 140 cm3;
2. Inner tube with a volume of approximately 550 cm3;
3. Connection device for air and fuel chambers.

2.2. Physical Characterization Methods

The quality of the smuggled species was determined on the basis of the following physical parameters:

1. Density at 15 ℃ measured using a DDM-2911 RUDOLPH RESEARCH ANALYTICAL automatic density meter;
2. ASTM distillation determined by JSR 1009BA brand distiller;
3. Reid Vapour Pressure measured using a JH0 103 13 brand TVR tester;

2.2.1. Determination of Density at 15 ℃

According to ISO 12185, equivalent to the American ASTM D4052 document, a small volume (approximately 0.7 mL) of the liquid sample is introduced into an oscillating sample tube and the change in oscillation frequency caused by the change in tube mass is used in conjunction with the calibration data to determine the density of the sample [15].

2.2.2. Determination of ASTM Distillation

According to the NA 1445 standard, equivalent to ASTM D86, a 100 mL test portion is distilled under prescribed conditions appropriate to the nature of the product [16].

2.2.3. Determination of the Reid Vapour Pressure

According to ASTM D323, the principle is to fill the fuel chamber of the switchgear with the sample previously cooled and connected to the air chamber. The device is immersed in a bath at a constant temperature of 37.8 + 0.1 ℃ and is shaken until a constant pressure is observed. The value read on the pressure gauge is the Reid vapor pressure [17].

3. Results

Physical Character Analysis Results for Contraband Species.

3.1. Physical Characteristics: Density at 15 ℃

The d 4^{15} obtained for the average representative samples of contraband species are grouped in the following table:

Table 1. *The d_4^{15} obtained by the different sampling tests.*

Characteristic	Density at 15 ℃	Unit	Methods
samples	Essence of Contraband		
E1	644.2		
E2	643.6	Kg/m^3	ASTM D4052
E3	646.3		
E4	644.4		
E5	638.9		
Specification	Min	715	
	Max	780	

From Table 1, it can be seen that the densities at 15 ℃ obtained by the various tests belong to the range [715; 780] set for the specification of the super 90 petrol, so it can be deduced that the contraband species analysed are not compliant from the point of view of density.

3.2. ASTM Distillation of Pooled Samples

The boiling temperatures obtained as a function of the volumes of distillates collected are noted in the following table:

Table 2. *Boiling temperatures of the distilled fractions at 10%, 50%, 90% and PF of the different sampling tests.*

Characteristic	boiling temperature Essence of Contraband					Spécification	Méthods
	E1	E2	E3	E4	E5		
T10 %	69.5	67	70	71	70.6	70 max	ASTM D86
T50 %	118	119.9	122	121	123	120 max	
T90 %	191	197	189	191	190	190 max	
PF	208	252	203	209	204	205 max	
Résidu	1.9	2.9	2.7	2.6	2.2	2.0 max	
Unité	℃						

Nomenclature:

1. T10%: Temperature 10% distilled T50%: Temperature 50% distilled
2. T90%: 90% Distilled Temperature PF: End Point

Based on the results obtained, we can define some important points that are directly related to the operation of the engine, which are:

1. The TEB obtained by the 10% point are compliant within the required limit.
2. The TEB of the 50% point is slightly above the required standards. They ensure that the petrol is correctly volatile when the engine is restarted, which allows maximum power to be extracted;
3. The TEB of the 90% points and the PF are not compliant, since they are above the set limit (190 ℃ and 205 ℃).

The Residue R of these species has reached the maximum limit (2% by volume), which confirms a significant presence of heavy fractions in these species.

Reid Vapour Pressure

The RVP obtained for the different samples of contraband species are grouped in the table below:

Table 3. *The RVPs obtained by the different sampling tests.*

Characteristic	Reid Vapor Tension	Unit	Méthods
samples	Essence of Contraband		
E1	74.18	KPa	ASTM D323
E2	74.53		
E3	75.75		
E4	73.08		
E5	74.2		
Spécification	Min	-	
	Max	74	

The TVR directly determines losses during storage and handling. Its specifications impose a maximum of 74 Kpa not to be exceeded. It can be seen that the values of the TVR obtained are higher than the maximum limit set by the standard. This shows that these species are not compliant from the TVR point of view. [17]

3.3. Analysis of the Proliferation of Petrol Stations and Points of Sale by Arrondissement

We present here the maps of the ten (10) Arrondissements of the city of N'Djamena. Then we will give for each district the result of the measurements taken on the presence of particles in the atmosphere.

N°	Stations-services	1ER ARRONDISSEMENT
1	OILIBYA (EX HM)	
2	LONI	
3	SAL SABIL	
4	CORNAYE	
5	Choix. DES JEUNES	
6	SAFINA	
33 Station Private without name		
Between 30 and 48 Street vendors		

Figure 2. Map of the first arrondissement with the different gas stations.

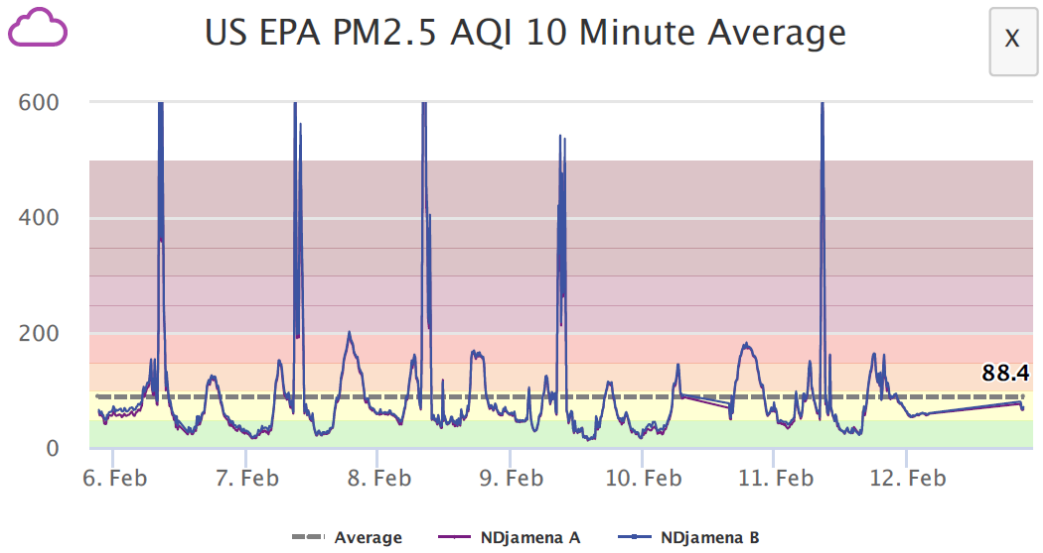


Figure 3. Measurement of air quality in the first district of the city of N'Djamena.

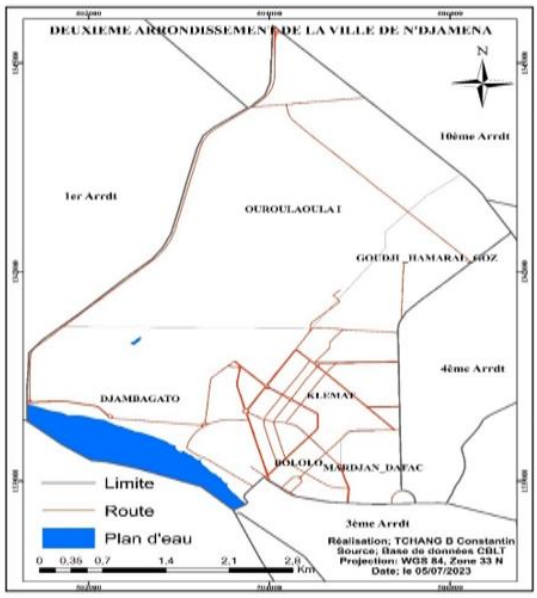
	Stations services	2EME ARRONDISSEMENT
1	TOURTA INTERNATIONAL	
2	H MALO	
3	SOULY ECOGIEX (SOSADEP)	
4	TOTAL BOLOLO	
5	SOPETRANS	
6	AL NIZAM (GSS)	
7	AL MANNA	
8	BLACK STAR	
9	SPP KASSER (SOPETRANS)	
10	AP	
11	TOTAL CHARI	
12	TOTAL KOUFRA	
19 Private, unnamed service stations		
Between 30 and 38 Street vendors		

Figure 4. *Map of the second arrondissement with the different gas stations.*

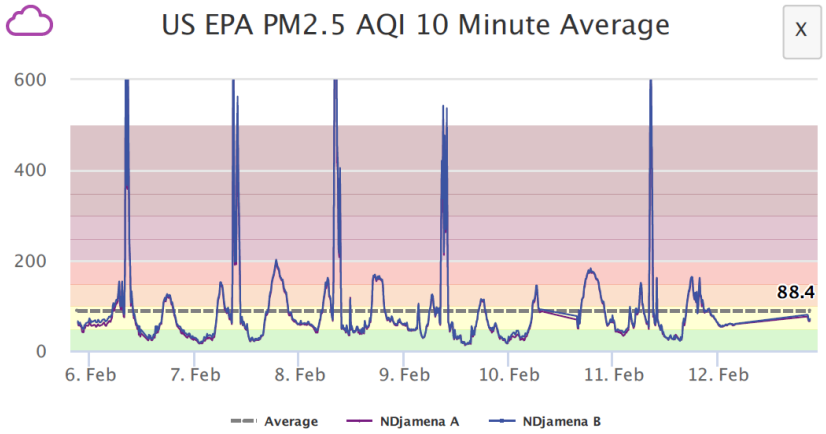


Figure 5. *Air quality measurement in the 2nd district of the city of N'Djamena.*

	3EME ARRONDISSEMENT
1	OILIBYA
2	SOPET GOUDJI
3	M.A.A
4	OILIBYA MOSQUEE
5	SOSADEP
6	OILIBYA
13 Unnamed Private Service Stations	
Between 24 and 38 Street vendors	

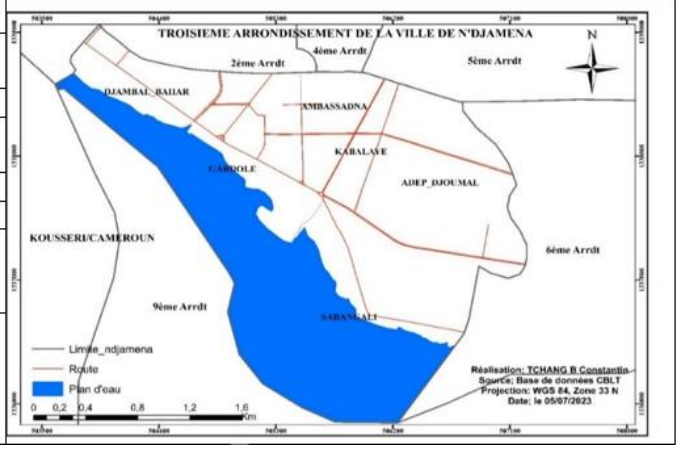


Figure 6. *Map of the 3rd arrondissement with the different gas stations.*

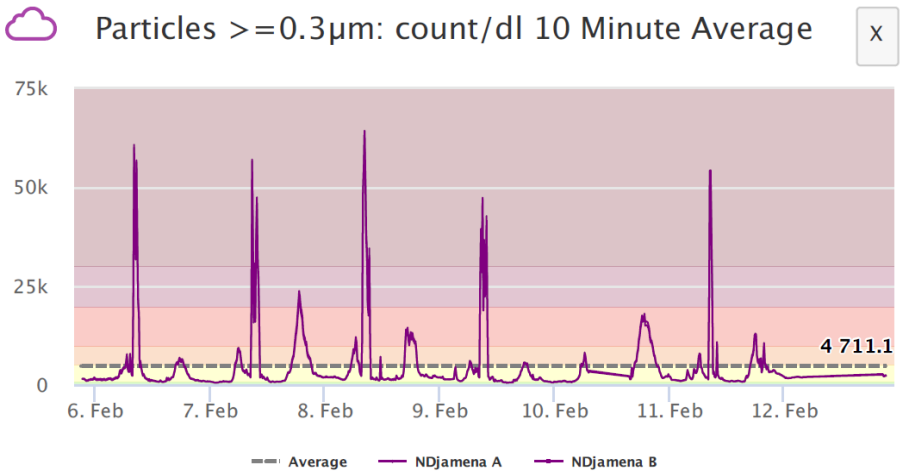


Figure 7. *Air quality measurement in the 3rd district of the city of N'Djamena.*

	4EME **ARRONDISSEMENT**
1	TOTAL SABANGALI
2	HYGIENE, RUE DE 30M
3	TOTAL GOUDJI
4	LA ROTATIVE
5	BELLE KOSSEMI
6	SSGM
7	AF OIL
8	NIMRO
9	OIL TCHAD
23 Unnamed Private Service Stations	
Between 40 and 58 Street vendors	

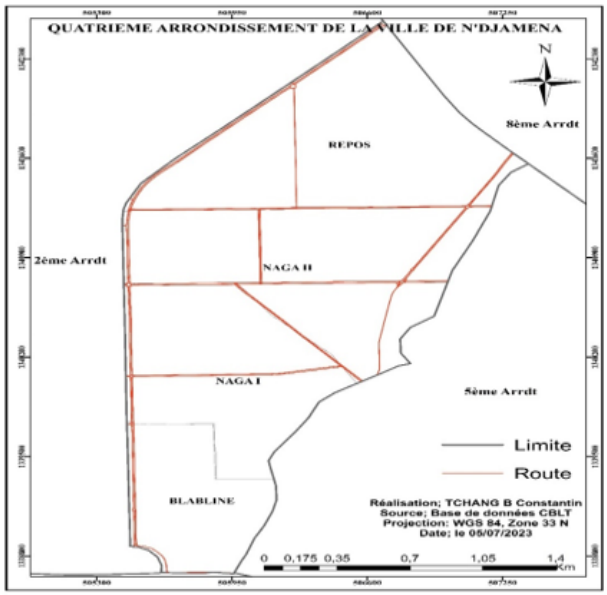


Figure 8. *Map of the 4th arrondissement with the different gas stations.*

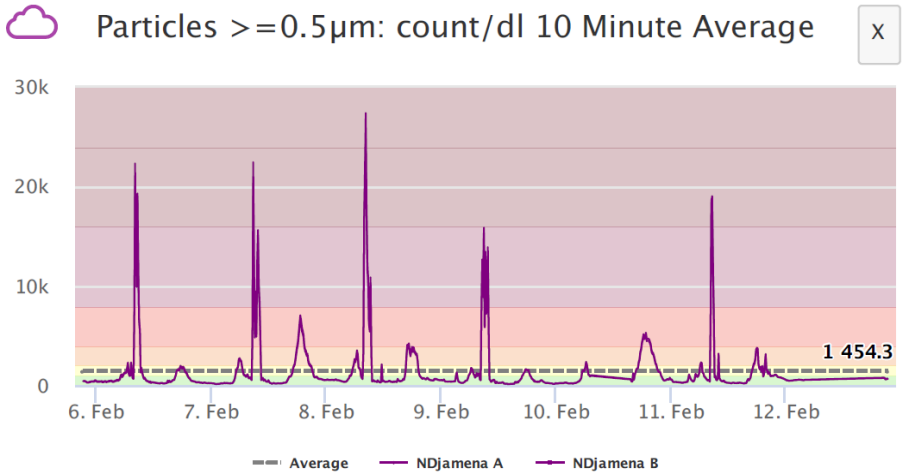


Figure 9. *Air quality measurement in the 4th district of the city of N'Djamena.*

	5EME **ARRONDISSEMENT**
1	SPCG
2	Sud Voyage
3	Sopetrans
4	Tamouraye (Excellence)
5	Logone
6	Abouna
7	Gracias
8	3SH
9	Total Palais
10	Sopetrans
11	Alhamdou
23 Unnamed Private Service Stations	
Between 40 and 60 Streets vendors	

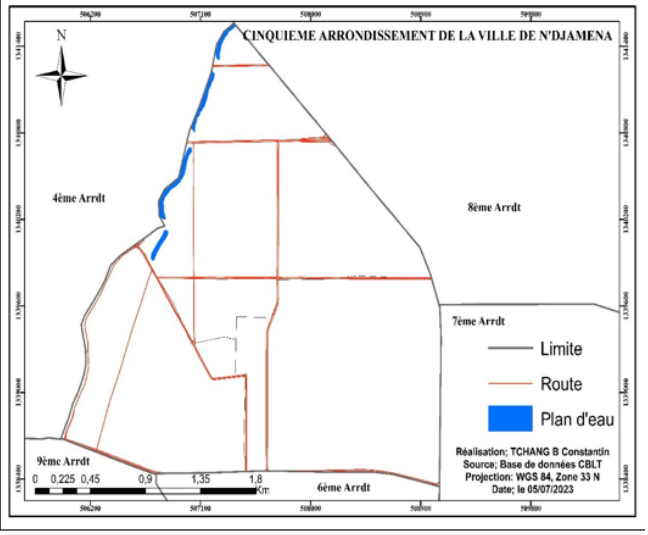


Figure 10. *Map of the 5th arrondissement with the different gas stations.*

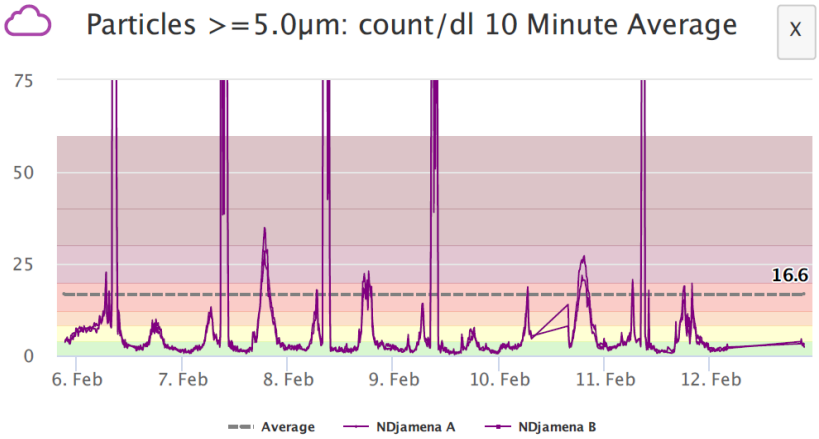


Figure 11. *Measurement of air quality in the 5th district of the city of N'Djamena.*

		6EME **ARRONDISSEMENT**
1	Tradex Paris-Congo	
2	SABARNA	
3	Zoumour	
4	SPT	
5	Mama	
6	Tahir	
7	Oilibya	
8	Amana Petrole	
12 Unnamed Private Stations		
Between 28 and 38 Street vendors		

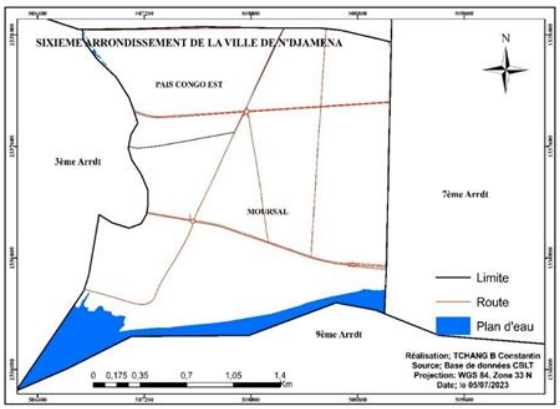


Figure 12. *Map of the 6th arrondissement with the different gas stations.*

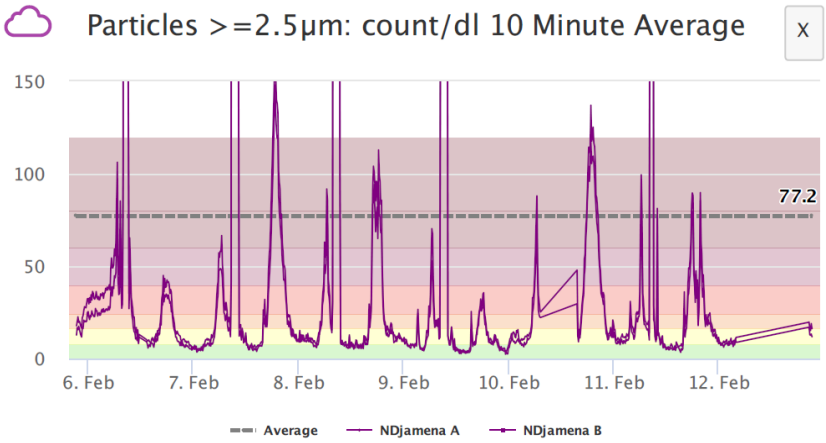


Figure 13. *Air quality measurement in the 6th district of the city of N'Djamena.*

For the seventh arrondissement, there are several stationsFor the seventh arrondissement, there are several gas stations.

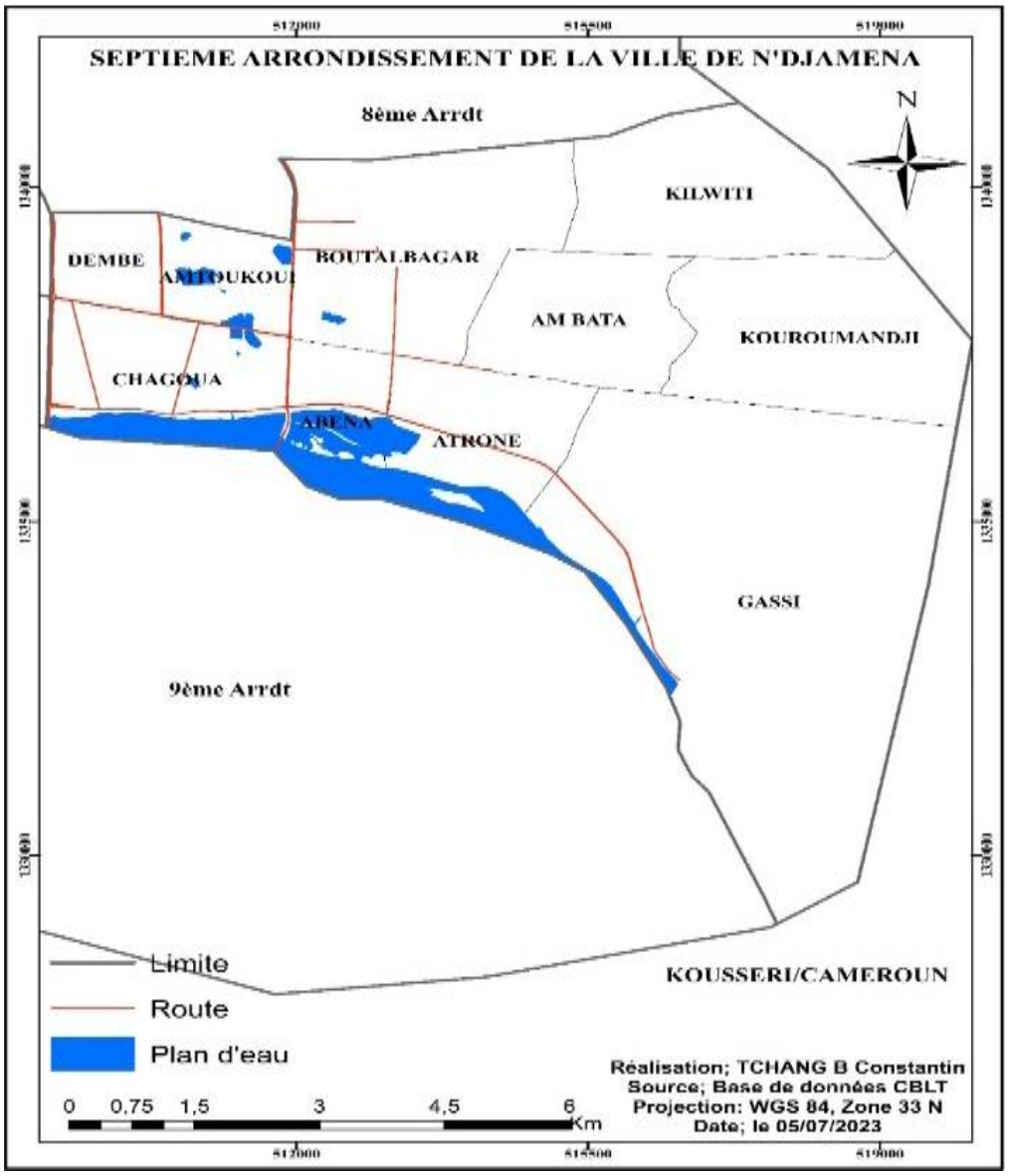


Figure 14. *Map of the 7th arrondissement with the different gas stations.*

Soprimex; Total dembe; Ssgm; Total double voie; Tchad hydrocarbure; Al indjaz; Dalil; Afripet; Wafackna; Al firdosse; Keira oil; Modjobok; Al watane; Aromsin; Yago; Bahr b13; Inter indjaz; Reservoir du sud; Abou nadjawa; Kageber (dahar); Total gassi-lycee; Samhan3; Hedjilidje (ecrp); Amco dembe: Sedigui intenational; Salsabil maniti: Aahbm; Amana.

Between 50 and 68 street vendors in this district and nearly 13 other unnamed stations that do not comply with any standards and regulations in force.

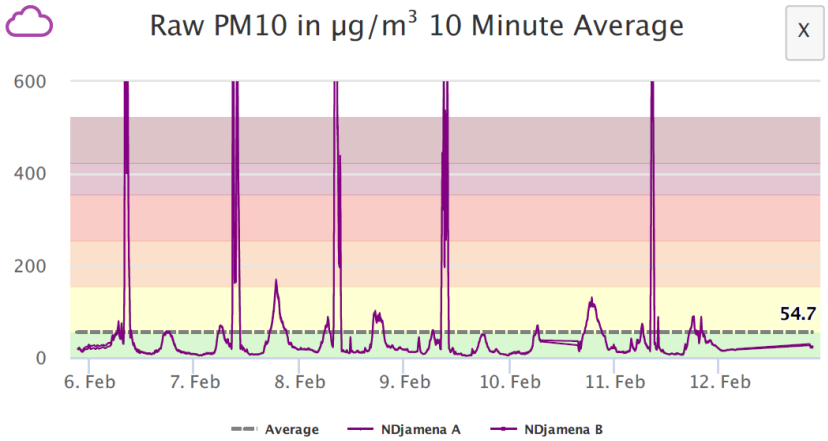


Figure 15. *Air quality measurement in the 7th district of the city of N'Djamena.*

For the seventh arrondissement, there are several gas stations:

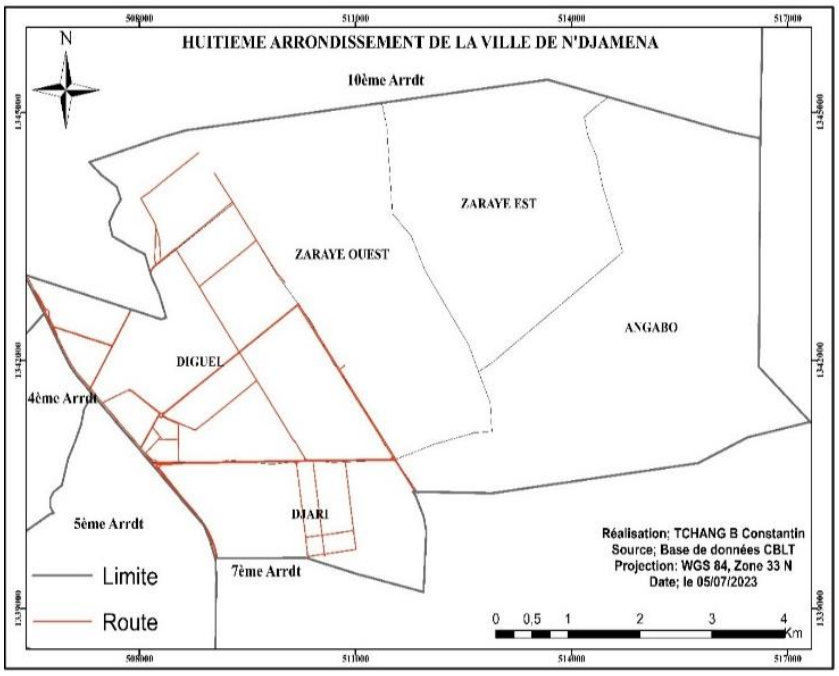


Figure 16. *Map of the 8th arrondissement with the different gas stations.*

OILIBYA (Ex HANANA); TOTAL HAMAMA; DAR ASSALAM; SOPETRANS (SOCACO); TOTAL NDJARI; SAMHAN; BAHAR B13; TCHAD HYDROCARBURE; ATI; IKRAM; LA CHARI; AL TAWHID; AL TANWIR; SPAP; AL ADALA; TIBA; AZIZ/ABOUNA; SOSADEP; SALAMA; DOUNAMA; AMI DU MONDE; BMH/ABDJERTE; ECRB; AL WIHDA; SOUGUI; SEDIGUI INTERNATIONAL; GABINE; TATA; KEIRA OIL; HADJELIDJE; SAMHAN 1; SAMHAN 2; WADI HAMRA; SABRINE ABH (ABOURACHID); HYGIENE TCHAD; AL WAZNA;

AL RIZEGATE; DINGUESSOU; DAHAR; AMCO; MODERNE; DJAMAL; BATHA.

Between 50 and 68 street vendors in this district and nearly 13 other unnamed stations that do not comply with any standards and regulations in force.

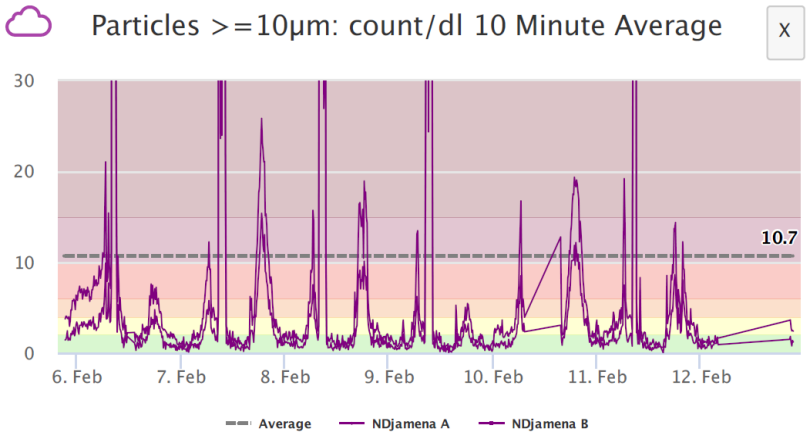


Figure 17. *Air quality measurement in the 8th district of the city of N'Djamena.*

		9EME arrondissement
1	AL AMINE	
2	AL AMINE	
3	TOTAL WALIA	
4	TRADEX	
5	AL NAKHIL	
6	BIR HAMIYA	
7	AL FATAH	
8	BAHAR B 13	
9	SPS	
10	GUERA	
19 Station Private without name		
Between 40 and 58 Street vendors		

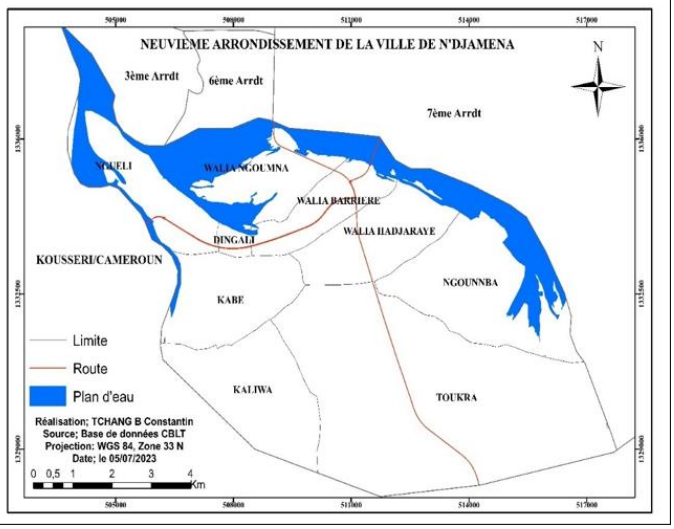


Figure 18. *Map of the 9th arrondissement with the different gas stations.*

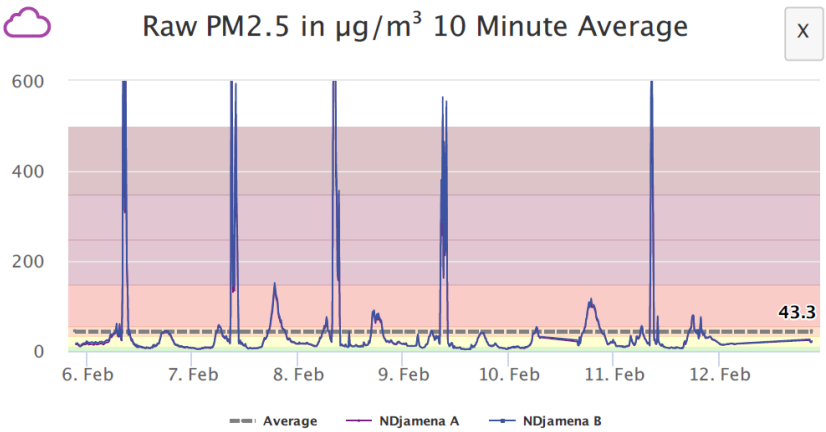


Figure 19. *Measurement of air quality in the 9th district of the city of N'Djamena.*

		10ème arrondissement
1	TOTAL WAR	
2	ACCOURAA	
3	ARADIP 2	
4	SEDIGUI INTERNATIONAL	
5	ABOUNA	
6	ARADIP	
7	NORD VOYAGE	
8	E2MT AVENIR	
9	SOSADEP	
10	LA LUNE	
11	TOTAL CHARAFA	
17 Station Private without name		
Between 35 and 58 Street vendors		

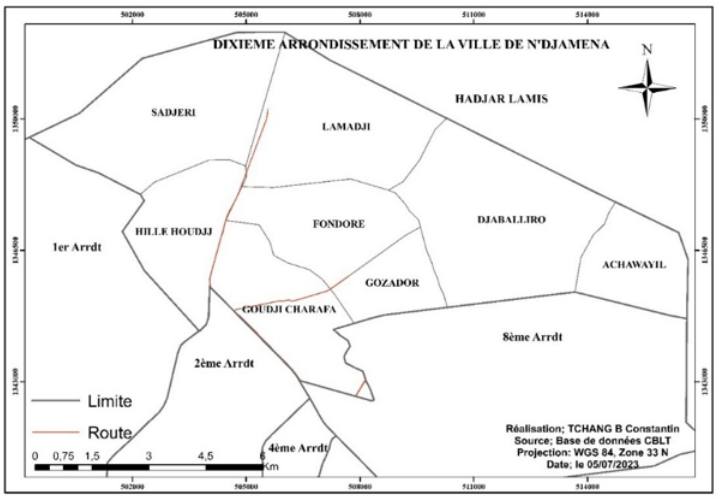


Figure 20. *Map of the 10th arrondissement with the different gas stations.*

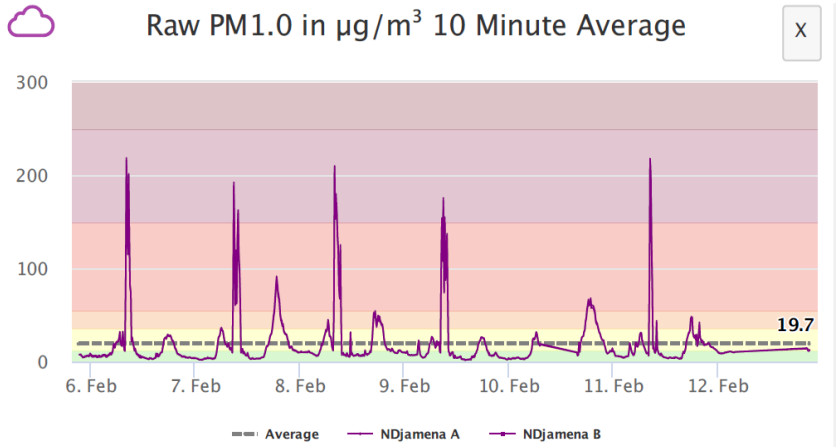


Figure 21. *Air quality measurement in the 10th district of the city of N'Djamena.*

4. Discussion

Discussion of the grouped interpretations of air quality measurements in the 10 ten arrondissements and the different maps with their service stations Air pollution

For recent studies, in 2019, Safa Omar conducted a study on the physicochemical parameters of fine particles PM10 and PM2.5 using a DEKATI impactor in the city of Tiaret, Algeria [18]; in 2020 and 2021 Haroun et Al respectively presented an analysis on the impact of petroleum products, in particular gasoline, and therefore the presence of elements promoting the existence of polycyclic aromatic hydrocarbons as well as the presence of fine particles PM of different sizes in the city of N'Djamena. The Environmental Impact of Polycyclic Aromatic Hydrocarbons: Mechanism of Extraction by Bio-Surfactant in a Microwave. [19] and then a work on "Influence of Solar Radiation on Questionable Gasolines Sold in N'Djamena: ASTM D86 Distillation Analysis and Standardized Tests Related to Atmospheric Pollution and Corrosion. [20] in his various works have highlighted the elements promoting the pollution of the environment. Studies show that volatile organic compounds (VOCs), including some hydrocarbons, are irritating to the lungs, carcinogenic, mutagenic and/or toxic to reproduction. In combination with nitrogen oxides (NOx), VOCs contribute to the formation of ground-level ozone (tropospheric ozone). During the surveys, Haroun et Al (2021) [20] demonstrate that people living with barrels used for storing hydrocarbons sometimes presented particularities of diseases: Coughs and headaches were very common among those surveyed. In the work of [20], and [21-26], they explain the presence of fine particles (PM10) according to the most harmful fine dusts are particles with a diameter of less than 10 thousandths of a millimeter. They penetrate deep into the lungs and the smallest can even reach the blood system and vital organs.

They were able to notice in some patients the presence of traces or drops of blood in their spit. In our work, we established and followed the same procedure three years later and we noticed that the results are still growing negatively. We also noticed in people selling gasoline on the street, a strong characteristic of respiratory disorders and aggravated by severe coughing sometimes leading to bleeding rejected in their spit.

For sulfur dioxide (SO_2), a gas, naturally present in small quantities in oil, is responsible for a large part of acid rain and air pollution affecting urban and industrial areas. More recently, it has also been recognized that SO_2 emissions contribute to the formation of secondary inorganic aerosols containing fine particles harmful to human health. In humans, exposure to a high concentration of SO_2 can lead to respiratory disorders, respiratory tract diseases and aggravation of pulmonary and cardiovascular diseases [27]. Regarding nitrogen oxides (NOx): emissions of these toxic gases, which cause acute respiratory diseases and chronic bronchitis. NOx also contribute to the formation of tropospheric ozone [20].

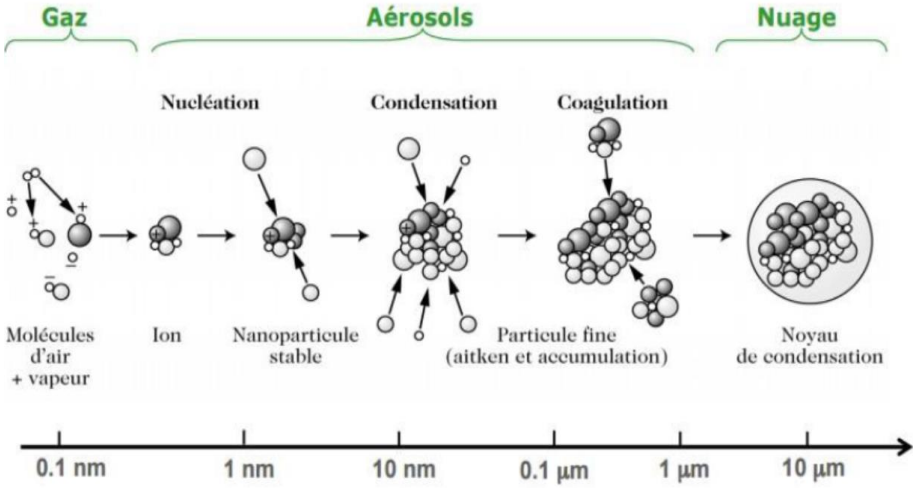


Figure 22. *Sources and microphysical processes influencing the size distribution and chemical composition of atmospheric particles according to [18].*

There is also carbon dioxide (CO_2), the main pollutant from the combustion of energy, as well as carbon monoxide (CO), an odorless gas resulting mainly from the incomplete combustion of fossil fuels. Inhaled CO binds easily and quickly to hemoglobin (pigment of red blood cells, oxygen carrier to cells), and there is then a reduction in the supply of oxygen throughout the body, leading to asphyxiation of the organs.

A detailed study on soil pollution is discussed in the work of [20] also demonstrates the presence of heavy metals in the combustion of petroleum products leading to the emission of heavy metals (lead, cadmium, mercury, etc.), which are highly toxic to humans and animals. These accumulate in the food chain. Lead hinders blood formation and child development, cadmium is toxic to microorganisms, mercury is toxic to humans, plants and microorganisms [28]. For this purpose, petroleum products sold on the street and along roadsides come mainly from countries such as Nigeria and some from Cameroon, but also a combination of the two which causes an even greater risk of contamination proven in several researches. The work of Kloff, Sandra and Clive Wicks states the level of pollution caused by the combustion of fuels is often higher in cities [29]. In the reports consulted, the main air pollutants associated with combustion or releases are nitrogen oxides, sulfur oxides, particulate matter, polycyclic aromatic hydrocarbons, and volatile organic compounds that are released into the air. Once in the air, these components react to produce secondary pollutants such as ozone [30].

Air pollution caused by fuel combustion is associated with increased human mortality, respiratory and cardiovascular diseases, and cancer [31]. The majority of these toxic effects in the environment are associated with the soluble aromatic fraction such as benzene, toluene, ethylbenzene, xylenes, and naphthalenes. Apart from the impacts of spills, these substances pose a greater risk to humans than to wildlife [32].

People working in the exploitation, distribution and transportation of petroleum products are the most exposed to volatile organic compounds that evaporate from petroleum and petroleum products in the case of our present study. Some products or components are known or suspected to be carcinogenic (e.g. gasoline, mineral oils, benzene, benzo (a) pyrene, 1, 3-butadiene). Others can have adverse impacts on the nervous system (e.g. benzene, n-hexane, toluene and xylene) [33, 34].

Storage and transportation of fuels pose a risk of fire and explosion.

Air pollution caused by fuel combustion is associated with

increased human mortality, respiratory and cardiovascular diseases, and cancer. [35]

In the works of (Mochalova et al., 2002) it can be verified that hydrocarbons are among the most widespread and dangerous pollutants for the environment [36]. And many researchers talk about pollutants and contamination of soils and sediments by hydrocarbons which still remains a major problem (Christensen et al., 1996; Malawska and Wilkomirski, 2000; Cozzarelli et al., 2001; Dror et al., 2001; Nikanorov and Stradomskaya, 2003). [37-41].

5. Conclusions

This work consisted of evaluating and determining the physical properties of gasoline and the presence of fine particles in the ten districts of the city of N'Djamena. It allowed to highlight the proliferation of gas stations in the city of N'Djamena, the nameless gas stations as well as the inaccurate number of women street gasoline sellers. This allowed us to take samples and analyze the physical properties namely the Density at 1542 ℃; the ASTM Distillation; the Reid Vapor Pressure, of the different samples by district. A detailed study of the mapping of each district with the measurements of the presence of particles was given. It should be noted that the use and marketing of certain hydrocarbons, in particular that of gasoline, the subject of our current work, does not comply with any standard in force or the regulations provided for this purpose. Their evaporation and release into unregulated nature considerably affects the ecosystem. The factor of all the presence of particles in the environment and in the human health of the population of N'Djamena is however not subject to an adequate study to allow the lifting of measures and the incentive to use hydrocarbons not only healthy but with respect for the standards in force of the State. PM2.5 is the mass of particles whose diameter is less than 2.5 μm and which is approximately 1 / 10th the size of a human hair. It is one of the main pollutants that the US EPA measures because of its potential for adverse effects on health. For each measurement by district, we note that the peak of the observed diagram is a function of the daily heat. This confirms our results on the evaluation and determination of the physical properties of gasoline and the presence of fine particles in the ten districts of the city of N'Djamena. The presence of each element that the sensor was able to identify is more or less worrying to the extent that no state structure speaks about it. This work allows to establish an idea of monitoring and evaluation of the environmental situation according to the consumption, handling and storage and distribution of these dubious species in the city of N'Djamena.

Abbreviations

PAHs	Polycyclic Aromatic Hydrocarbons
POPs	Persistent Organic Pollutants
DNAPL	Dense Non Aqueous Phase Liquid
LNAPL	Light Non Aqueous Phase Liquid
VOCs	Volatile Organic Compounds

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Author Contributions

Haroun Ali Adannou: Conceptualization, Funding acquisition, Methodology, Resources, Writing – original draft, Writing – review & editing

Podo Mahamat Matar: Data curation, Methodology

Tchang Banda Constantin: Formal Analysis, Investigation

Achta Hamid Saleh: Formal Analysis

Simon Ngos III: Supervision

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Conflicts of Interest

The authors declare no conflicts of interest.

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