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State of atmospheric pollution between vulnerabilities and criticalities from 2007 to 2022 and a projection in 2030 focused on the proliferation of gasoline sales in the city of N'Djamena

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Abstract

According to the World Health Organization (2008), 1.3 million annual deaths worldwide are attributable to air pollution, and that the latter is the cause of 16% of the total number of deaths. Among air pollutants, particles play an important role in worsening air quality in urban areas. The city of Ndjamena has recorded an increased proliferation of hydrocarbon stations since 2007 to the present day. The analysis of the vulnerability and criticality of pollutants from 2007 to 2022 and a projection to 2030 were made. For a response relating to the subject of our research, we chemically characterized two types of gasoline by following the recommended parameters. The result obtained following these analyses shows that street gasoline has a more or less negative result compared to gasoline produced, stored and sold in accordance with standards and regulations in Chad. We note that the analyzed contraband gasolines have negative results unlike other types of gasoline sold at the pump (some service stations) in terms of: - ASTM distillation, confirming the presence of significant heavy fractions, the Octane Index, presenting a minimum limit required by the standard for super 90 gasoline. Total sulfur, which reaches the maximum limit required and finally, Corrosion giving the maximum limit required by the standard in terms of corrosion. We also noted the presence of traces of water and unidentified solid debris at the bottom of most of our contraband samples.

Keywords: Air Pollution; Vulnerability; Criticality; Species

1. Introduction

Hydrocarbons are part of everyday life, they are ubiquitously present in the environment due to the multiplicity of their origins, both natural and anthropogenic [1-3]. They are among the most toxic wastes. Spilled on land and/or evaporated into the atmosphere, they will result in significant and early pollution on a global scale. Given the increase in global population and the high demand for electricity, fuel and combustibles, the exploitation of oil deposits has continued to increase since the beginning of the 19th century. However, the production, transformation and use of oil entail risks of pollution (accidental and chronic) for the environment, which can influence the ecological balance and sometimes lead to the destruction of the ecosystem [4]. Hydrocarbons are organic compounds consisting mainly of carbon and hydrogen. They are used as fuel, combustibles, lubricating oils and as basic products in petrochemical synthesis. They are non-renewable resources. There are three main families of hydrocarbons: aliphatic hydrocarbons (alkanes, alkenes and alkynes), monocyclic aromatic hydrocarbons (benzene, toluene and xylene) and polycyclic aromatic hydrocarbons (PAHs). The last types of hydrocarbons, i.e. PAHs, are hydrocarbons that contain at least two fused benzene rings. There are more than a hundred of them existing in the environment. Some have alkyl groups, halogens or sulfur, nitrogen and oxygen atoms in their structure. Among these compounds, sixteen (16) are defined as priorities by the United States

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Environmental Protection Agency (US EPA). They contain 2 to 6 benzene rings and are the most frequently sought and analyzed in environmental risk studies because they are recognized as environmental pollutants and are known for their carcinogenic and/or mutagenic properties [5]. As a result, they occupy a special place within environmental concerns. In addition to their carcinogenic and/or mutagenic characteristics, PAHs have a very marked hydrophobic character [6] and adsorb more easily on particulate matter [7]. Non-compliance with standards for the use of hydrocarbons, the proliferation of service stations, and the lack of knowledge of the dangers linked to hydrocarbons depending on the presence of PAHs is a current context that we are all confronted with. The dispersion of PAHs is a complex phenomenon that is difficult to generalize even if most of them are dispersed in particulate form and deposited within 100 m of the road axis [8]. On the ground, the impact is mainly marked up to 30 m on either side of the road [9]. PAH deposits are more numerous under prevailing winds; concentrations are not maximum at the edges of the road but at a variable distance depending on the morphology of the site. Some of them (PAHs) have moderate toxicity, with common effects: their repeated or prolonged inhalation leads to symptoms such as headaches, dizziness [10]. At high concentrations, they also cause disorders of the nervous system and the digestive system. PAHs are part of the Persistent Organic Pollutants (POPs) because they are characterized by their Toxicity, their Persistence in the environment, their bioaccumulations in living tissues, and their Long-distance Transport. These hydrocarbons of large molecular mass tend to be deposited near the road while those of lighter molecular mass are transported more than 30 m when the site is cleared. In a configuration in excavation, the deposits are more significant [8]. PAHs from vehicle emissions result both from incomplete combustion of the fuel and from more or less complex chemical transformations of the different compounds initially present there. They can therefore come from the fuel used or be formed during the combustion of hydrocarbons either by pyrolysis, in the absence or lack of oxidizing species, or by carbonization. At room temperature, PAHs are in the gaseous, liquid or solid state, either free or adsorbed, and this is the case for the majority of them, on dust or particles [11-12].

2. Materials and Method

2.1. Presentation of the study area

Our work took place in almost the entire city of N'Djamena, to do this we subdivided the city into districts. 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. 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.

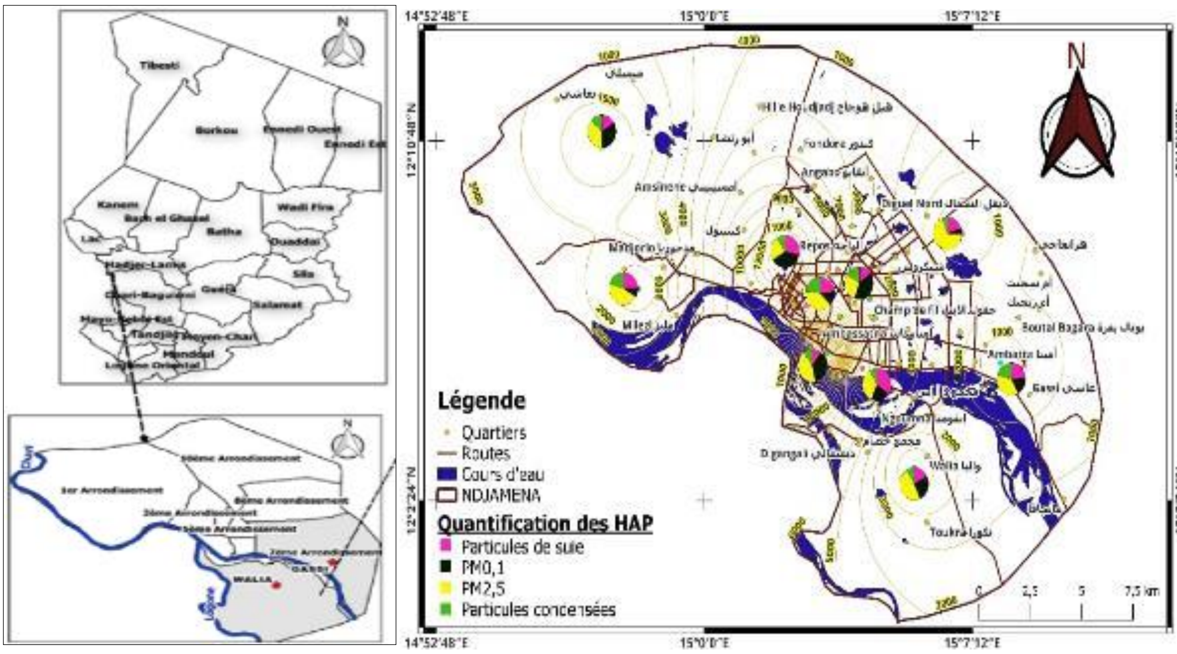

Figure 1 Map of palliative strategies for reducing the impacts of the spread of PAHs.

2.2. Materials

- Koehler-K88620 Portable Octane Number Analysis Apparatus
- 2-2-4-trimethylpentane (isooctane),
- n-heptane
- Sindie XOS Sulfur Analyzer Apparatus
- Sample Cup or Sample Cell
- X-ray Transparency Film
- JSR2101 Copper Blade Corrosion Measuring Apparatus;
- Copper Blade; Blade Holder; Bomb; Test Tube; Water Thermostat Bath; Thermometer;
- Polishing Product
- Analysis Methodology for the Chemical Characterization of Gasoline

The chemical parameters studied are:

-Octane Number, Sulfur Content and Copper Blade Corrosion

2.3. Determination of Octane Number

According to ASTM D2699, D2700: Two standardized methods are used to measure the octane number of a fuel. These are the Research RON method (ASTM D 2699) and the Motor MON method (ASTM D2700). [13-14].

1.2 Operating mode:

- Turn on the Octane Number meter;
- Calibrate the meter following the manufacturer's instructions;
- Pour the sample into the appropriate test vial up to the fill line marked on the vial;
- Place the vial into the meter's sample tube;
- Close the lid and press “read”;
- Read the RON and MON value printed directly by the meter.

2.4. Determination of Sulfur Content

Following ASTM D4294 [15].

2.5. Operating mode:

- Turn on the device, wait until the temperature has stabilized at 40 °C;
- Pour 6 mL of sample into the Sample Cup;
- Place the transparent film above the Sample Cup;
- Open the cover/drawer of the device, insert the Sample Cup into the device and close the cover/drawer;
- Press the "Read" button;
- After scanning the X-ray beam, the result of the sulfur content in ppm will be automatically displayed on the device display;
- Note and convert the result into % of mass and round it to three significant figures.

2.6. Determination of Copper Blade Corrosion

According to the NA 566 standard equivalent to ASTM D130: [16].

2.6.1. Procedure:

- Turn on the corrosion apparatus and wait until the bath temperature is stable at 50 °C.
- Place a 40 mL test sample of completely clear gasoline, free of suspended water, in a perfectly clean and dry test tube and slide a copper strip into it within one minute of the final polishing using sandpaper.
- Place the tube in the bomb and then in the bath;
- After 3 hours ± 5 minutes, remove the strip, rinse, dry and compare the color of the copper strip to the graduated color scale on the series of corrosion reference strips and note the number corresponding to the corrosivity of the sample according to ASTM standards 1a and 4c.

- A score of 1a indicates little or no corrosion, except for a slight discoloration that is barely detectable; 1b indicates slight tarnishing; And so on up to 4c, which means the copper strip is severely corroded, blackened and pitted with rust. result and discussions

3. Result of the chemical characterization of gasoline

3.1. Research Octane Number

The RONs obtained for the different sampling tests are grouped in the table below:

Table 1 The RONs obtained by the different sampling tests

Characteristic	Research Octane Number : RON	Unit	Méthods
samples	Essence of Contraband	-	ASTM D2699
E1	87.4		
E2	87.8		
E3	89.3		
E4	87.4		
E5	86.9		
Specification	Min	90	
	Max	-	

From Table 1, it can be seen that the Octane Index of smuggled gasolines are not compliant since they are lower than the minimum value required by the standard for super 90 gasoline. However, using gasoline with too low an octane index in an engine risks spontaneous ignition due to compression in the cylinder. When such spontaneous ignition occurs, combustion occurs under abnormal conditions that strain the engine, particularly the connecting rod and crankshaft. In this case, we are then faced with engine knocking, signals of abnormal heat in the combustion chamber.

3.2. Sulfur content

The sulfur contents obtained for the different sampling tests are grouped in the following table:

Table 2 Sulfur contents obtained by the different sampling tests

Characteristic	Sulfur content	Unit	Methods
samples	Essence of Contraband	% m/m	ASTM D4294
E1	0.049071		
E2	0.048665		
E3	0.049065		
E4	0.047446		
E5	0.048964		
Specification	Min	-	
	Max	0.05	

From Table 2, it can be seen that the total sulfur content in smuggled gasoline is unsatisfactory since it has almost reached the maximum limit required by the super 90 standard. However, a high sulfur content has a significant impact on people, the environment and machinery. For people, respiratory and cardiovascular diseases. For the environment, formation of acid rain, destruction of the ozone layer, etc. For the engine, sulfur can cause wear and corrosion of the engine. For proper use, strict compliance with this quality criterion is essential

3.3. Copper blade corrosion

The corrosion results obtained for the different tests of contraband gasolines are shown in the following table:

Table 3 Copper blade corrosion results obtained by the different sampling tests

Characteristic	Copper blade corrosion	Unit	Methods
samples	Essence of Contraband	Cotation	ASTM D130
E1	1b		
E2	1b		
E3	1b		
E4	1b		
E5	1b		
Specification	Min	-	
	Max	1b	

From Table 3, we note that the results obtained by the copper blade test limited by (< 1b), are not compliant. They indicate that the presence of sulfur compounds in these gasolines is corrosive. The presence of sulfur that is organically combined is transformed into sulfurous anhydride which in the presence of water vapor forms a particularly corrosive dilute sulfuric acid. And when the engine is running, its harmful fumes pollute the atmosphere; when stopped, the engine cools down and, by condensation, the combustion products cause direct corrosion of the tanks and suction lines. The sulfur compounds present in petroleum products are the main causes of air pollution problems and corrosion caused by petroleum products, especially street gasoline in our specific case.

4. Discussion

The results obtained show that the combustion of sulfur contained in fuels and combustibles leads to the formation of gaseous sulfur oxide SO2. Studies have shown that the generation of SO2 by this combustion process generates around 60 million tons of SO2 per year worldwide. This SO2 contributes mainly to urban pollution and acid rain. Those present in fuels contribute to sulfur oxide emissions and increase the production of particles by engines and therefore constitute a brake on the elimination of nitrogen oxides in exhausts. Sulfur is then transformed during combustion into SO2 and SO3 to then become a very corrosive acid which is sulfuric acid [17-22].

In our work, copper being particularly sensitive to the presence of corrosive compounds, we used a copper blade corrosion test. The copper blade immersed for 3 hours at 50 ° C in a sample of gasoline. Depending on the quality of the sample, each result was different. We were able to see that gasolines with a more volatile characteristic had a different color from heavier gasolines.

We note that the analyzed contraband gasolines present negative results unlike other types of gasoline sold at the pump (some service stations) in terms of:

- ASTM distillation, the TEB of the 90%, FP and residue points are in excess of the control limits; this confirms the significant presence of heavy fractions in contraband gasolines; which does not meet any standard.
- Octane index, contraband gasolines have a low octane index, lower than the minimum limit required by the standard for super 90 gasoline.
- Total sulfur, contraband gasolines are sulfurous since they have almost reached or even exceeded the maximum limit required by the standard.

- Corrosion, the smuggled gasolines analyzed reached the maximum limit required by the standard in terms of corrosion.

We also noted the presence of traces of water and unidentified solid debris at the bottom of most of our smuggled samples.

However, we can say that the results of the smuggled gasolines analyzed are out of specifications under normal analysis conditions and therefore do not comply with the standards in force used for standardized hydrocarbon tests in Chad.

4.1. Analysis of the criticality of pollution beaches in the city of N'Djamena

4.1.1. Analysis of the criticality of pollution beaches in the city of N'Djamena in 2007

In 2007 there was not yet a crude oil refinery in Chad. There were certainly some gas stations but not in large quantities as we see today. The situation shown on the map of the city of N'Djamena is structured by a criticality of some trend ranging from negligible pollution to very high pollution with disastrous consequences.

Thus we notice that the new districts going further north of the city were not too polluted; this can also be explained by the fact that in these areas dominated by housing and therefore not enough businesses in the sector is less polluted.

On the contrary, we notice a concentration of extreme pollution from a part of the first district, which extends to the second, third, fourth, fifth and sixth districts. Pollution is from the strong to extreme trend. For all these districts of the city of N'Djamena, businesses, companies are concentrated in this area. We can therefore understand that the influx of vehicles and machinery as well as gas stations in these areas have increased the state of air pollution. A relatively strong trend is also seen towards the ninth district which is one of the main entrances for commercial trucks. There are therefore two roads, that of Nguéli and that of Toukra. A few gas stations in these areas but heavy traffic because the Nguéli road bordering the city of Kousserie in Cameroon is used for a cross-border exchange. That of Toukra serves as an exit and entry for all transport vehicles going from N'Djamena to the South and from the South to N'Djamena.

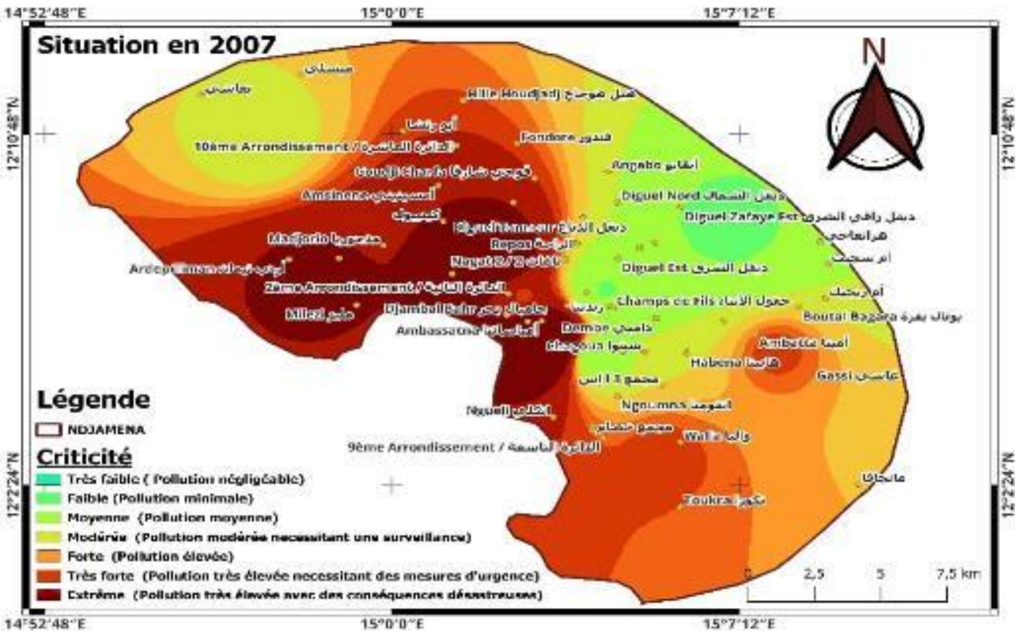

Figure 2 Map of the criticality of pollution in 2007 in the city of N'Djamena

4.1.2. Analysis of vulnerability based on pollution in 2007 in the city of N'Djamena

During the period 2007, we note on the map an increased vulnerability over almost the entire city. We note that there is a greater concentration in populated areas, particularly the tenth district; that of the seventh, eighth and part of the ninth district whose density in terms of population is high unlike the rest of the districts of the city of N'Djamena.

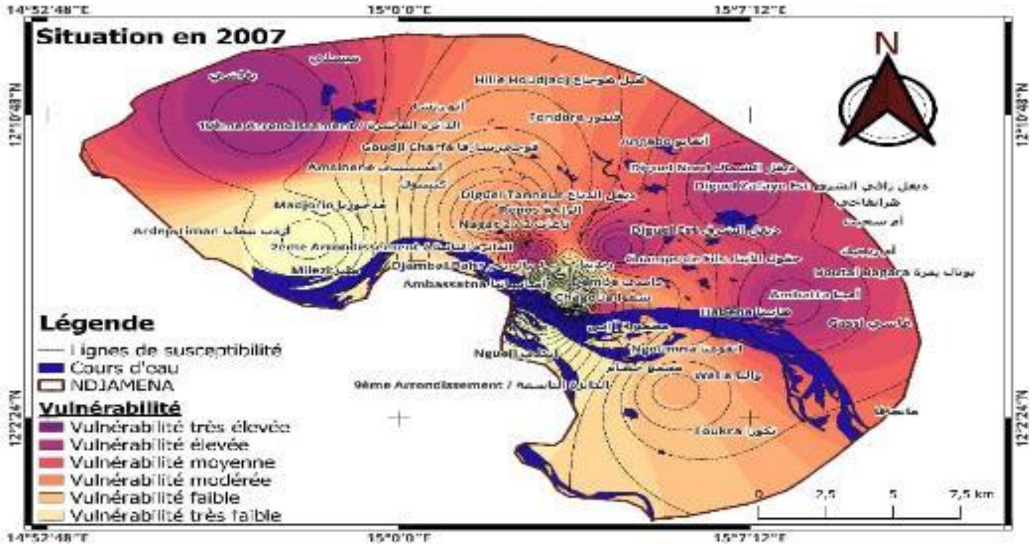

Figure 3 Map of vulnerability according to pollution in 2007 in the city of N'Djamena

4.1.3. Analysis of the criticality of the pollution ranges of the city of N'Djamena in 2012

The map of the year 2012 is structured by a pollution trend extending from that of 2007, that is to say a concentration of extreme pollution from the first district, which extends to the second, third, fourth, fifth, sixth but also it affects the entire ninth and tenth districts. The other districts are still on the very low to moderate bar. In 2012, the refinery has already seen the light of day, it totals one year of implementation and the service stations not controlled by the regulatory agencies and the Ministry of Petroleum at the time have begun to see the light of day. The rather strong trend of the polluted area which is all the more different from those of 2007 is remarkable.

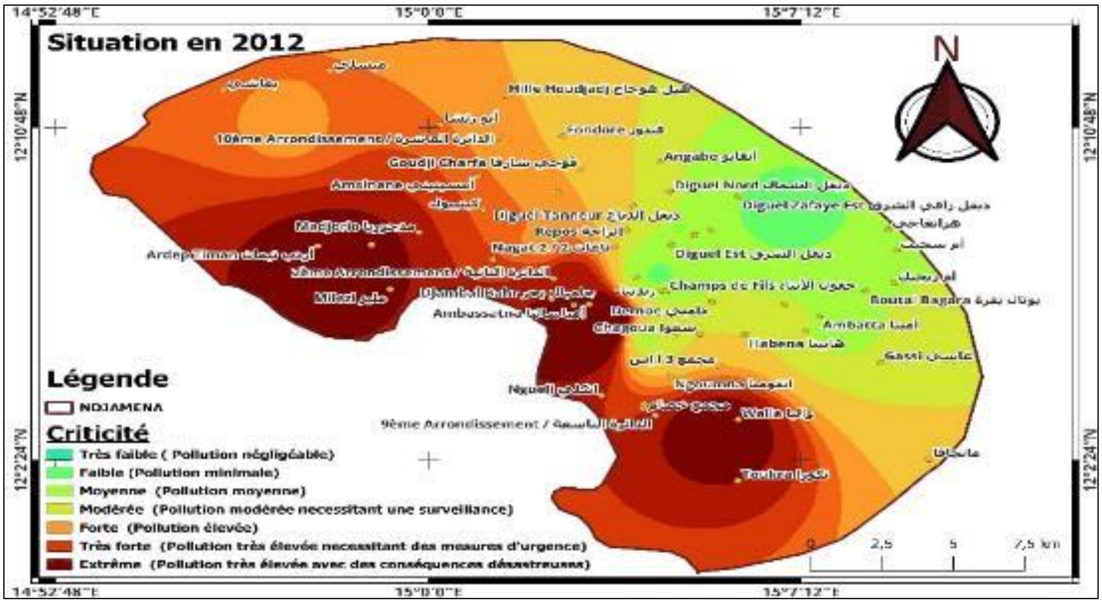

Figure 4 Map of the criticality of pollution in 2012 in the city of N'Djamena

4.1.4. Analysis of the criticality of the pollution ranges of the city of N'Djamena in 2017

2017, pollution extends this time towards the eighth district, research of gas stations has demonstrated that the trend in terms of the number of gas stations not respecting the standards and the largest number of gas stations is between the seventh and eighth districts of the city of N'Djamena. The map shows us a notable advance of heavy pollution towards these two areas in addition to the trend of the years 2017.

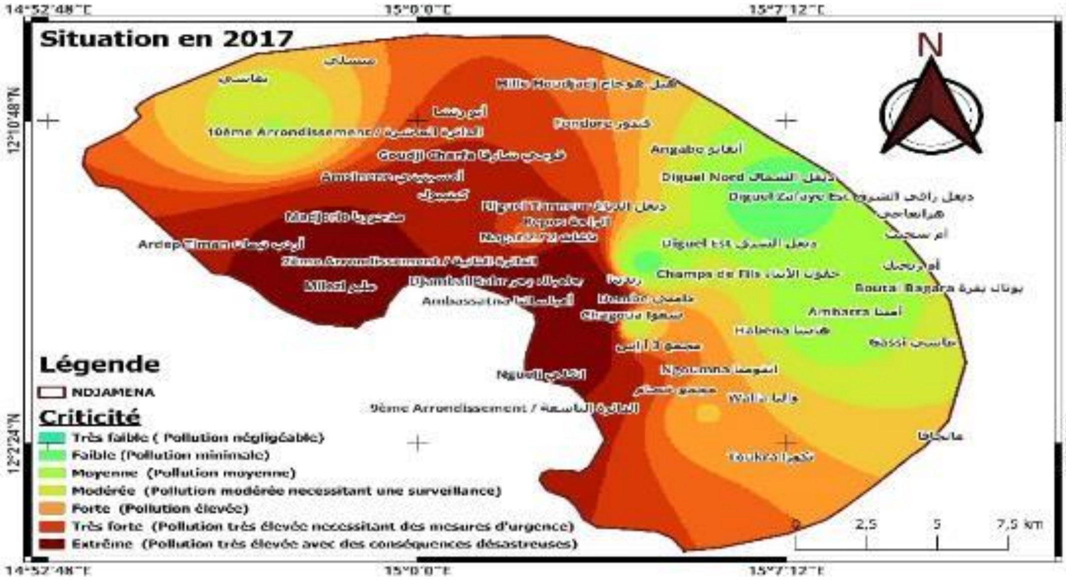

Figure 5 Map of the criticality of pollution in 2017 in the city of N'Djamena

4.1.5. Analysis of the criticality of the pollution ranges of the city of N'Djamena in 2022

2022, pollution increases from the fifth district to the eighth district, research on gas stations has shown that the trend in terms of the number of gas stations not meeting standards and the largest number of gas stations is between the seventh and eighth districts of the city of N'Djamena, it also happens that at this time we have identified the most women fuel sellers in these areas, inevitably contributing to the trend in air pollution; we also note that across the entire map, areas with low predominance have decreased very drastically. The map shows us a stronger advance of very high pollution requiring emergency measures for all the different districts

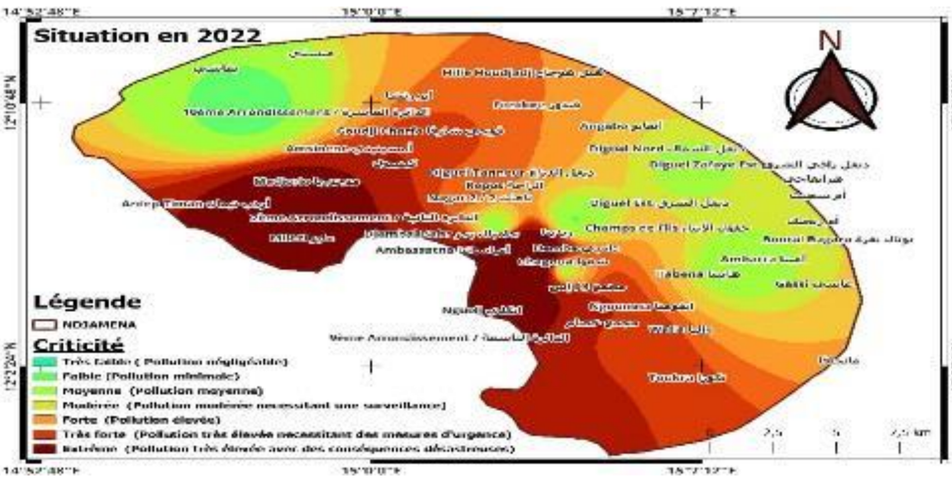

Figure 6 Map of the criticality of pollution in 2022 in the city of N'Djamena

4.1.6. Analysis of vulnerability based on pollution in 2022 in the city of N'Djamena

As for the state of vulnerability based on pollution in 2022, we see that most of the city of N'Djamena or almost all of it is below the pollution threshold. This is alarming since it is a response from low to very high vulnerability. As in the case of criticality, the map shows us a stronger progression of very high pollution requiring emergency measures for all the different districts.

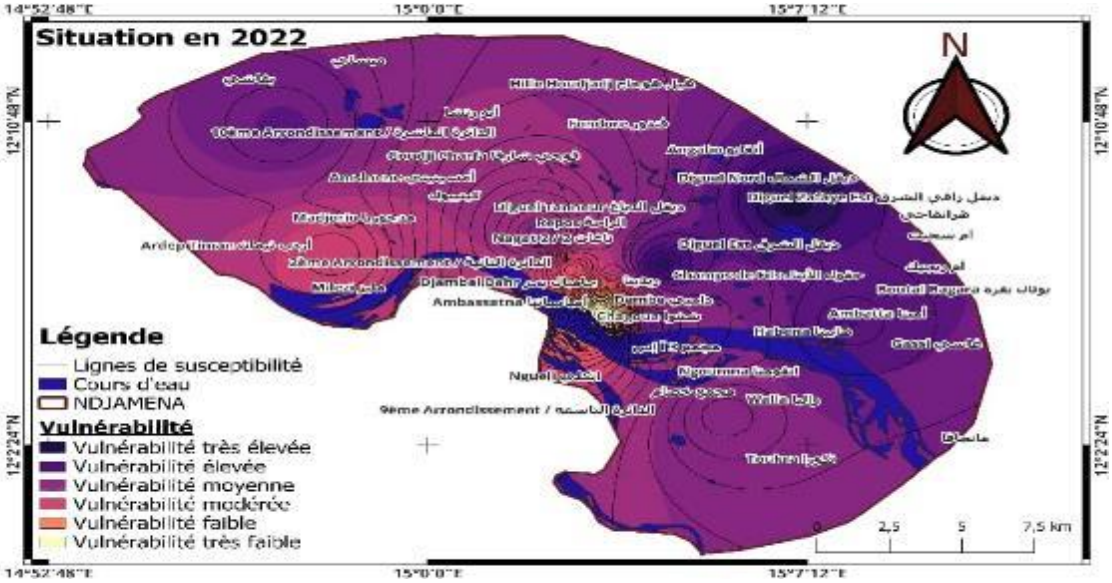

Figure 7 Map of vulnerability according to pollution in 2022 in the city of N'Djamena

4.1.7. Analysis of the prospective criticality in terms of pollution in the city of N'Djamena by 2030

According to our analyses based on the results obtained and the trend of activities on the ground[23-24], if nothing is done to regulate the effect of the propagation of pollution in the city of N'Djamena, we risk having by 2030 a trend of criticality in most of the districts of the city from an average situation to a very extreme situation. The map below shows us the extent of the critical pollution situation by 2030

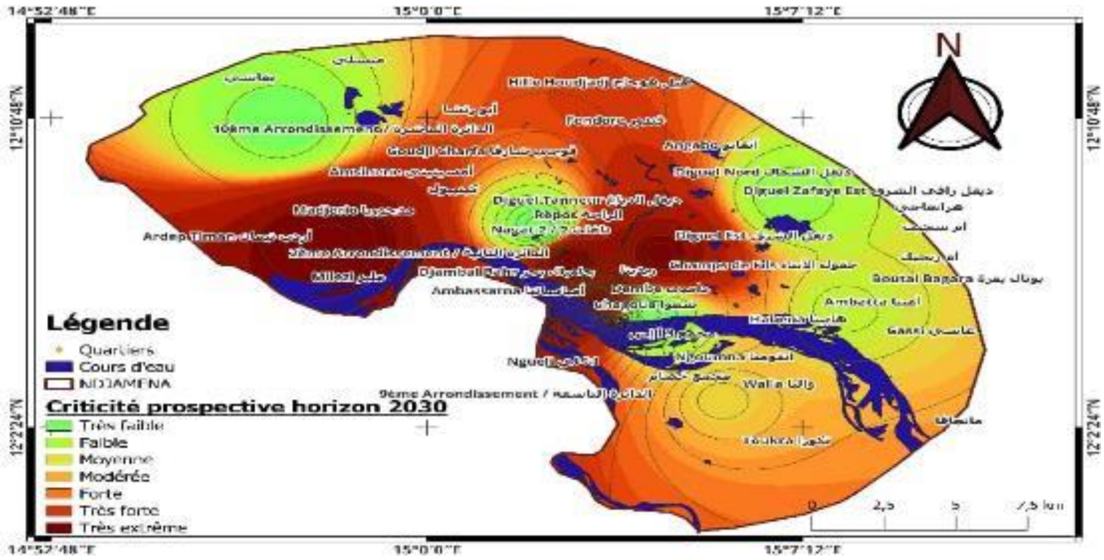

Figure 8 Prospective criticality analysis map for 2030 in the city of N'Djamena

4.1.8. Analysis of prospective vulnerability in terms of pollution in the city of N'Djamena by 2030

A projection was made on the vulnerability based on the low to hyper high trend, we also note as for the case of the criticality analysis that there is an emergency throughout the territory if the restrictive responses to the current situation are not taken seriously. The map describes to us roughly the critical situation of an accentuated vulnerability throughout the city of N'Djamena [25].

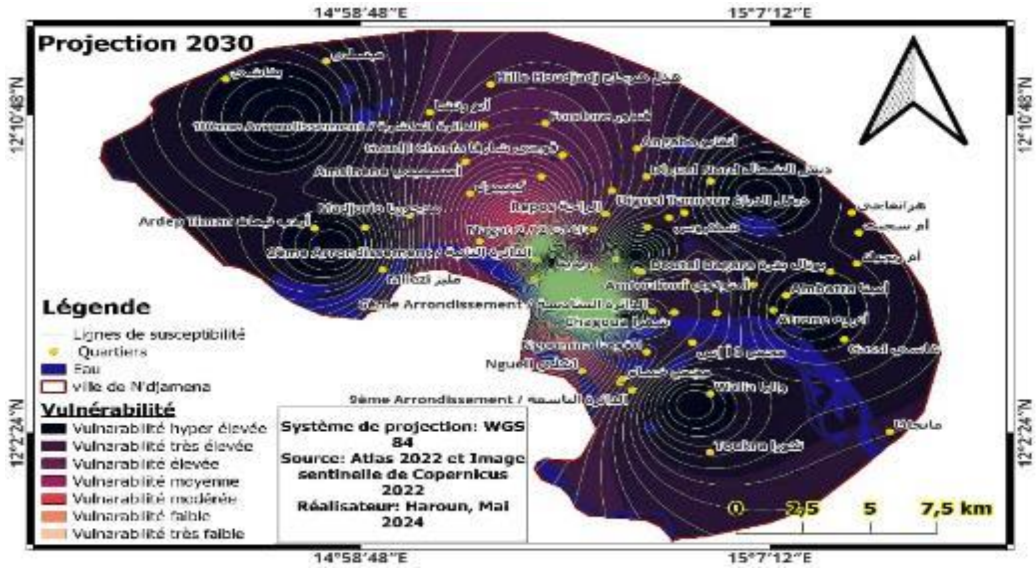

Figure 9 Vulnerability analysis map on a projection to 2030 in the city of N'Djamena

5. Conclusion

Despite the many studies conducted on air pollution by particles, uncertainties remain. It is more or less complex to treat particulate pollution in an urban environment, this is indeed due to the modifications resulting from different meteorological factors (wind, precipitation, etc.), topographical (slope, etc.) and urban morphology, which constitute limiting factors in the dispersion of these pollutants [26-28] The various analyses that we have made on the criticality and vulnerability functions of atmospheric pollution in the city of N'Djamena, thus bringing together all ten districts that the city has, demonstrate with amazement the need for urgent decision-making on emergency measures for all the different districts. So in our research context, the first map that we listed on this document is a Map of palliative strategies for reducing the impacts of the spread of PAHs as well as the presence of fine particles that can play a role in the impact caused by the spread of the latter (PAHs and PM2.5 and PM10). From this map, if the necessary conditions for the installation of sensors are met and the proliferation of service stations are regulated by the ministry in charge of oil through its various branches linked among other things to the sale, storage and distribution of petroleum products in the city, we hope to have in the coming years a criticality and vulnerability less dangerous than the current and prolonged state of the environmental situation.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflicts of interest.

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