

BOKO, Gbètoho M. Joachim “Air Pollution And Respiratory Diseases In African Big Cities: The Case Of Cotonou In Benin” in Martin J. Bunch, V. Madha Suresh and T. Vasantha Kumaran, eds., *Proceedings of the Third International Conference on Environment and Health, Chennai, India, 15-17 December, 2003*. Chennai: Department of Geography, University of Madras and Faculty of Environmental Studies, York University. Pages 32 -43.

AIR POLLUTION AND RESPIRATORY DISEASES IN AFRICAN BIG CITIES: THE CASE OF COTONOU IN BENIN

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Abstract

To face the social and economical crisis of the end of the eighties in most African countries, and especially the unemployment problem, Beninese developed another urban mode of transportation called “zemidjan” (which means “Get me quickly”). This new two-wheeled vehicle taxi helped a lot of people to survive at the most critical phase of the crisis. This sector expanded in the 1990s: in 2002, preliminary statistics show about 160,000 “zemidjan” in Benin and 72,000 in Cotonou. The motorcycle exhaust, emitting air pollution all day long, creates health risks for drivers, passengers and the residents of the streets they ply. This is the reason Cotonou is one of the most polluted cities in west Africa. The pollution contributes to respiratory diseases and other ailments: respiratory infection, cardiovascular diseases, cancer, etc.

This paper sets up the problem of the city of Cotonou through environment quality indicators analysis (such as air quality) and uses statistical analysis methods, to give an overview of the situation. It also estimates and forecasts the human health risks to which people living in the “zemidjan” job, and people living in the city of Cotonou and its neighbourhood, are exposed to today, and will be in the coming decades. It reviews the measures taken by central and local governments to protect citizens again these risks. It ends with recommendations to help solve both the problem of pollution caused by the “zemidjan” and the problem of respiratory diseases that are a consequence of the former, but also to the urban planning problem underneath.

1. INTRODUCTION

Most of west African big cities are facing nowadays one of their biggest challenges for the new millennium: reduce air pollution in cities and contribute to the improvement of the quality of the living environment for citizens. Indeed, it is current to see while crossing African cities a big smog covering the air. Air pollution can be seen everywhere in big cities due to the crowdedness of cities and the uses of motor engines emitting big fumes. Wear white clothes and cross the city of Cotonou on a motor bike: after half an hour, your white clothes are not white anymore. Plus, even if you don't wear white clothes, one can smell a fume odour on you. The situation is worse at some periods of the daytime: from 7:00 am to 9:00 am, from 11:00 am to 1:30 and from 6:00 pm to 8:30 pm. This is the daily situation of most west African cities like Cotonou in Benin, Lomé in Togo, Niamey in Niger and Ouagadougou in Burkina Faso.

The problem results from many situations:

- the increase in the number of imported vehicles from Europe called “venus de France” or “France au revoir” . Most of those vehicles are ageing ones and when used in the city, contribute for a large part to the air pollution;
- the increase of the in-town moving demand due to demographic growth and urbanization, but also to the concentration of most offices in one side of the cities and the bad road infrastructures;
- the increase in the number of two-wheeled taxis called “zemidjanⁱⁱ” in Benin, “oleyia” in Togo and “kabu kabu” in Niger . This mode of urban transportation is increasing to face the increase of in-town transportation demand. [6]
- the bad quality of petrol for motors. Indeed, most of the time, the petrol used contains a large amount of lead which is rejected in the air later by motors. However, the percentage of oil in carburant for engines, the mix of oil and petrol is above the standard.

All these factors contribute to increasing the bad quality of air in African big cities and lead to negative effects on human health. People living in big cities or along the most polluted roads are exposed to the consequences of that inconvenient air quality.

This paper will focus on the case of Cotonou to describe the situation and show how urgent it is to take measures to reverse the trend of the evolution of the environmental situation of west African big cities.

In the following lines, the objectives and methodology of the paper will be described, after which the problem will be explained. The consequences of air pollution on human health will be highlighted after which a conclusion and a few recommendations will follow.

2. OBJECTIVES AND METHODOLOGY OF THIS PAPER

The objectives and the methodology of this paper are:

- present the case of Cotonou regarding air pollution and its consequences on human health with a focus on respiratory illnesses; this will be done through a literature review. There are some studies available from the Ministry of Environment, Habitat and Urbanism (MEHU), but also some medicine thesis on the subject;
- evaluate the human health risk for people living from the “zemidjan” activity, but more generally people living in the city; this can be tackled through literature review and statistical analysis of available data on health risk in Cotonou;
- report on the forecast of air pollution indicators and its risk in the coming decade; this will be mainly based on a study done by a private consulting cabinet for the MEHU;
- review the measures taken by local and central government of the city of Cotonou to reverse the trends; this is based on literature review and an interview with an official, the Director for Programming and Prospective of the MEHU;
- make recommendations and suggestions to help solve the problem; this will be done through literature review and from the own experience of the author about local planning and sustainable development.

For general information about the subject of air pollution and human health, many websites have been visited. Another objective is to take advantage from the diversity of people

attending this Third International Conference on Environment and Health to share and exchange experience with delegates coming from different parts of the world and try to find solutions that apply the best to African cities, but especially the city of Cotonou.

3. THE PROBLEM

In this part of the paper there will be a short presentation of the city of Cotonou, the problematic air pollution in Cotonou with regards to air quality indicators in the city, an overview of the main air pollution agents and factors with a highlight on the contribution of the transportation system in air pollution in Cotonou.

Short presentation of the city of Cotonou

Benin is a small country of 112,622 km² and a population of about 6.5 million people. The Republic of Benin is located in West Africa in the Guinea Gulf, between the Republic of Togo at its West side and the Federal Republic of Nigeria at its East side. It is limited in the north by the Republic of Niger and Burkina Faso, and in the south by the Atlantic Ocean. With a littoral of 124 km long, its distance from North to South is about 672 km and reaches a width of 324 km. [8]

Cotonou is the most important city of the Republic of Benin because it is at the same time, economical capital and political and administrative centre of the country. It covers an area of about 7,900 hectares from a side to another of a channel (the lagoon of Cotonou). Cotonou is located 6°21 North latitude and 6°26 West longitude. The urban space of Cotonou is divided between habitat zones, social and administrative equipments and non social equipments. The urbanised area of Cotonou (about 5,000 ha) represents 74% of the total surface of the city. The population of Cotonou is about 700,000 inhabitantsⁱⁱⁱ and represents about 11% of the total population of the country. [1] Cotonou is limited in the south by the Atlantic Ocean. Its harbour is one of the things that attracts people.

The problematic of air pollution in Cotonou

In Cotonou, when one steps out of the house and is on the road, he can actually see the air getting polluted; a cloud from the exhaust of cars or motor bikes or a scooter. After an hour of wandering in the city one can't help smelling of fumes. This is one of the manifestations of air pollution in Cotonou. At rush hours (from 7:00 am to 9:00 am, from 11:00 am to 1:30 pm and from 6:00 pm to 8:30 pm) one can see a black or white cloud of fume suspend in the air. At some specific crossroads like St. Michel, Marina and Notre Dame, the situation is worse than in other parts of the city. Many air pollutants were discovered when some measurements were made to analyse air quality in Cotonou. Among these pollutants, the major are CO, SO₂, HC, O₃, Pb, NO_x and some suspended particulate matters. Official documents show the following situation concerning air pollution in Cotonou: [10]

- the daily emission of CO is about 83 tons;
- a low rate of SO₂ (actually non detected by measurement tools);
- the daily emission of HC is about 36 tons;
- the concentration of HC in the air reaches a maximum value of 2000 µg/m³ with a mean value of 180µg/Nm³. For instance, the concentration of benzene in Cotonou is evaluated

to 80µg/Nm³ with an average value of 7.2 µg/m³. The guide values for pollution by benzene are between 5 µg/m³ and 10 µg/m³;

- 10% of the transportation network in Cotonou suffer from a too high level of lead (Pb), with a maximum value of 13 µg/m³ (compared to an accepted value of 2 µg/m³);
- acceptable level of NO_x pollution (with a concentration of 50 µg/m³);
- pollution by ozone is preoccupant and is higher than admitted concentration levels.

There is also a high concentration of CO₂ in the atmosphere of Cotonou and a lot of suspended particulate matter (in dust, fumes, mist and smoke). SPM present in the air in Cotonou are less than 10 micro and are the most dangerous, said a study of the MEHU.

To view how much of an emergency the situation is, lets compare the situation of the city of Cotonou to the World Health Organization (WHO) standards, as there are actually no national standards for air quality in Benin:

Table 1: WHO Guidelines values (1999) for common pollutants

Pollutant	Annual ambient air concentration (µg/m ³)	Guideline value (µg/m ³)	Concentration at which effects on health start to be observed (µg/m ³)	Exposure time
CO	500-7000	100 000	Not applicable	15 min
		60 000		30 min
		30 000		1 hour
		10 000		8 hours
Lead	0.01-2.0	0.5	Not applicable	1 year
NO ₂	10-150	200	365-565	1 hour
		40		1 year
O ₃	10-100	120	Not applicable	8 hour
SO ₂	5-400	500	1000	10 min
		125	250	24 hour
		50	100	1 year

Source: <http://www.who.int/>

Pollution agents and factors in Cotonou

Many factors and agents contribute to the high level of pollution of the city of Cotonou. Among them, there are:

➤ **The urban transportation system and the two-wheeled taxis “Zemidjan”:**

The phenomenon of “zemidjan” is a social response to the economical and socio political crisis of the eighties in most west African countries (unemployment of young graduates, compression of workers due to privatisation of the former national enterprises, the growth of poverty, the low purchase power of populations, etc.) and particularly in Benin under the former Marxist-Leninist regime. Since then the number of motorcycles taxis has continued to grow. In 2002, there were 83,000 of them on the streets in Benin, 40,000 in Togo and 2,350 in Niger. The 2002 preliminary statistics show about 160,000 “zemidjan” in Benin, including 72,000 in Cotonou. The number of the “zemidjan” is still increasing because of the incapability of the common transportation system to meet the demand for urban mobility and the insufficiency and the bad road infrastructures (zemidjan can go everywhere by anytime). The motorcycle exhaust, emitting air pollution all day long, create health risk for drivers, passengers and the residents of the streets they ply[]. The zemidjan job is risky because most of motorcycle taxis are second hand engines imported from Japan and Europe. It is shown that the two-wheelers are responsible for 59% of daily emission of CO and 90% of daily emission of HC in Cotonou[]. The whole transportation system is responsible for air pollution for some pollutants in the proportions shown in the following table:

Table 2: The contribution of transportation to the global air pollution in Cotonou:

Pollutant	Contribution in percentage
CO2	30 %
NOx	77%
HC	75%
SO2	25%
CO	80%

Source : Ministry of Environment Habitat Urbanism (MEHU) [10]

The transportation infrastructure is indexed for it is insufficient. Indeed, because of this lack of roads, motor bikes and other vehicles have to slow down in big traffic jams during which the emission of CO is very high. This contributes to heat the city.

➤ **The quality of petrol sold in the informal sector**

The bad quality of carburant for motors is another factor of pollution in Cotonou. Indeed, most of the time, the petrol used by most of the two-wheeled vehicles contains a large amount of lead that is rejected in the air later by the motors (it is cheaper and even though it is illegally sold, this activity continues to grow). On the other hand, the percentage of oil in carburant for engines using a mix of oil and petrol is above the standard. Sometimes, people use of 8 to 20% of oil for a standard of only 4%. [1], [2], [10]

➤ **Urban planning problem**

Most of the attraction centres (trade centre, industrial zone, offices, the harbour, schools, etc.) are located in the same area of the city. Due to that, most of the in-town movements are directed to the same side and people use the same axis of road. This explains why this axis is always saturated. Plus, while planning the existing road infrastructure city managers didn't take into account the rapid growth of the urbanization of Cotonou.

➤ **The development of second hand cars and motorbikes import**

The second hand cars import is growing in Cotonou because of the geographic position of Benin. Indeed, Benin is a king of “door to the sea” for many of the hinterland countries such as Niger, Burkina Faso, Mali, etc. but the matter is that most of the imported vehicles are very old. The average age of these vehicles is around 12 to 15 years old and sometimes even older. Many of these old engines are used in Benin and are also responsible for air pollution in Cotonou. Ageing motorcycles cover 80% of transportation needs in west African cities. [6]

4. CONSEQUENCES

In this part will be tackled the consequences of bad air quality on human health in general, with a focus on respiratory diseases. As far as it is possible (depending on data availability) a human risk analysis will be done with regard to the situation in the coming years.

Let's note that the consequences of air pollution on human health depends upon the exposure to the considered pollutant. From the literature, one learns that there are several consequences of air pollution on human health. The most important are classified per pollutants as below: respiratory infections, cardiovascular diseases, lung cancer and other cancer, eye ailments and irritability, etc. [6]

For the specific case of respiratory illnesses, these are highlighted in the table below, and classified by pollutants:

Table 3: Respiratory affections dues to air pollution

air pollution	respiratory system diseases
sulphur dioxide	asthma, bronchitis, croup pseudo croup
nitrogen oxide	look at "ozone"
heavy metals	diseases of the kidney, intoxication
carbon monoxid	headache, dizziness, suffocation
organic compounds	cancer, diseases of the nervous system
ozone	mucosal stimulation, eye irritation

Source: <http://www.bionet.schule.de>

Current consequences on human health in Cotonou

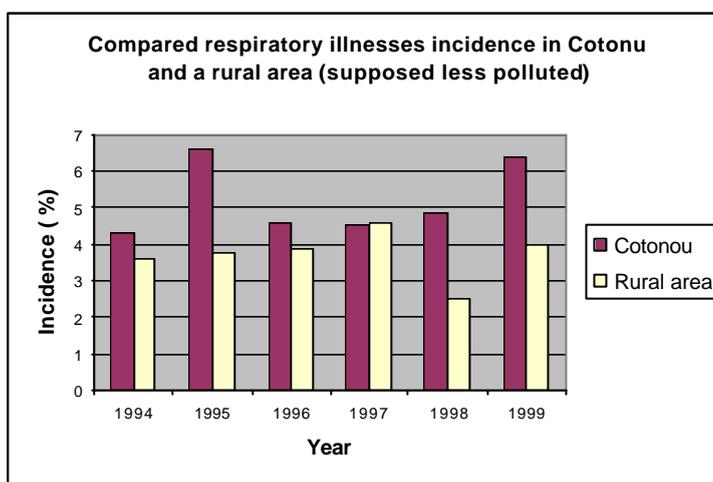
The activity of “zemidjan” is a job of high health risk for the drivers as well as for the population, said the report of the “Study on the impact of two-wheeled vehicle, urban transportation modes and their perspective development in WAEMU - member countries”

carried out for the West African Development Bank (WADB). Moreover, some other specific studies and thesis of Beninese Health Science Faculty show that [4] :

- more than 62% of “zemidjan” suffer from respiratory diseases;
- 70.7% of them suffer from muscular and bone affections;
- 26,5% suffer from eye ailments and;
- 11,4% suffer from larynx affections.

Even though determining objectively the specific effect of air pollution on human health, when comparing statistics of the evolution of respiratory diseases of Cotonou to those of other non urban areas, one can say that air pollution may to some extent be responsible for the increase of respiratory affections in Cotonou. This can be justified by the fact that respiratory diseases are the most sensitive to air pollution and are the most linked to the pollutants.

The graph below shows the compared evolution in the incidence of respiratory diseases in Cotonou and a chosen rural area:



The graph shows that the incidence of respiratory illnesses in Cotonou are most of the time higher than in the less polluted area (rural area). For some years like 1995, 1998 and 1999, the incidence of respiratory diseases in Cotonou is almost double, compared to the rural area.

Moreover, a χ^2 test performed on these data showed, apart from the year 1997 that, the probability of rejecting by error the hypothesis of equality of incidences in Cotonou and the rural area, is less than 0.1%. for the year 1997 the probability of rejection by error of the hypothesis of equality of incidences of respiratory affections in Cotonou and the rural area, is of 50%.

The conclusion is that air pollution in Cotonou may be taken as responsible for the increase of respiratory affections incidence, compared to rural areas. This link is confirmed by the observation that the higher incidences are attached to the most of polluted parts of the city [10].

Situation of air quality and its consequences for the coming years

According to the study on air quality in Cotonou, the situation of air pollution in Cotonou might be the following (comparison made with the reference situation of the year 2000) in the coming years: [10]

- without any change in moving habits, transportation demand and the composition of the park of 2 wheeled and 4 wheeled vehicles, (with regard to the age of vehicles) emission of pollutants will increase by a huge proportion. For example, the CO emission will show an increase of 40% in 2005 and of 98% in 2010. This impressive increase in CO emission is supported by the hypothesis that the road infrastructure remains the same, and, in consequence, the congestion of the traffic as well;
- The increase of Pb emission will increase by 50% in 2005 and reach 2 times the level of the reference situation in 2010;
- 25 km of road (which is 17% of the road infrastructure) will be above standards for NOx emissions in 2005 whereas 20% of the road infrastructure (about 30 km) will overcome the standards in 2010;
- 32 km of road (21%) will be above air quality standard for Pb emissions in 2005 whereas 38km will reach this situation in 2010. Plus, concentrations of lead will be 8 times ahead of the standards;
- even though diesel engines are limited now in Cotonou, some problem of SO2 emissions may rise in 2005 and get worse in 2005.

The consequence for human health from the above described situation can be imagined: probably an exponential increase in respiratory diseases and other illnesses linked to air pollution.

5. MEASURES TAKEN BY LOCAL AND STATE GOVERNMENTS

To face the problem of air pollution in Cotonou, many actions have been undertaken by the Ministry of Environment, Habitat and Urbanism. But since the last local elections of December 2002 and January 2003 most of the actions on the urban environment of Cotonou have been transferred to the local city government. Among measures taken, there are:

Legal measures

Some application decrees have been taken about the Cadre-Law on Environment, which have been voted on since 1999. More concretely, there is the Decree N° 2001-110 of April 4th, 2001. With this decree, some standards have been set up to control vehicle import on the Beninese territory. Below in table 4a and table 4b are these standards.

Table 4a: Standards for 4 wheeled vehicles import to the Beninese territory Source: MEHU, [11]

Year of application of standards	Distance done by the vehicle (or year of use)	Parameters				
		CO (g/km)	CO (%)	NO _x (g/km)	VOC ^{iv} (g/km)	SPM
Till 2003	< 80,000 km (<5 years old)	2.1	2	0.25	0.15	0.12
	> 80,000 km (>5 years old)	2.6	2	0.37	0.19	0.12
2001 and after	< 80,000 km (<5 years old)	1.1	1.5	0.13	0.08	0.08
		1.1	1.5	0.13	0.08	0.08

> 80,000 km (>5 years old)

Table 4b: Standards for 2 wheeled vehicles import to the Beninese territory

Type of motor	Parameters				
	CO (g/km)	CO (%)	NO _x (g/km)	VOC (g/km)	SPM
2T ^v	8.0	2	7.5	0.1	NA
4T	13.0	2	3.0	0.3	NA

Source: MEHU, [11]

Specific actions to measure air quality and define air quality standards for Benin

In 1998 and 2000, two important studies were carried out on the request of the Ministry of Environment, Habitat and Health to measure air quality in the city of Cotonou and define some specific standards for urban air quality. Air quality standards as suggested in October 2000 to the MEHU by Tractebel Development Engineering and Benin – Consult (a private consulting company) can be seen in the following table:

Table 5: Air quality standards suggested to Beninese government

	CO	HC	NO ₂	SO ₂	PM ₁₀ ^{vi}	Pb	O ₃
Short run exposure	40 mg/m ³ for an average exposure of 1h	NA	0.2 mg/m ³ for an average exposure of 24h	0.2 mg/m ³ for an average exposure of 1h and 0.365 mg/m ³ for an average exposure of 24h	0.150 mg/m ³ for an average exposure of 24h		0.08 ppm for an average exposure of 8h
Long run exposure	10 mg/m ³ for an average exposure on 8h	NA	0.1 mg/m ³ for an annual average exposure	0.08 mg/m ³ for an annual average exposure	0.05 mg/m ³ for an annual average exposure	2 µg/m ³ for an annual average exposure	

Source: MEHU, [10]

Tax restrictions for a better air quality

Some specific tax restrictions have been taken by the MEHU to at least avoid the degradation of air quality in Cotonou. For example, new buses for the purpose of public transport are free of taxes. In the same way, cars which are bought new are lower taxed whereas the second hand cars are charged a lot more. Moreover, 2T motorbikes are being more taxed than 4T motorbikes, to drive people to abandon the former for the second, as the 4Ts are proven less pollutant than the 2Ts for some pollutants such as CO and CO₂.

These specific fiscal measures aim to promote private initiatives for public transportation services to meet the demand for urban transportation. More concretely, the government is setting up a programme of loan granting to privates for the launching of nine (09) bus lines of public transportation for the city.

Periodical control of gas emissions by 2 wheeled and 4 wheeled vehicles

For the last couple of months, car and motor bikes are controlled for their gas emission almost once a month. The first controls were informative as no punishment was given to owners of vehicles that have proven pollutant. The government organized a free training for some mechanic specialists to regulate pollutant gas emissions by motors. After this period of time, some sanctions started to be taken against recidivist pollutants. The controls are still being carried out but the population is very angry because of the amount of money they have to pay (about 35€).

A circulation plan for Cotonou

On the request of the MEHU, a circulation plan has been drawn for the city of Cotonou to make more fluent the traffic in the town. In this plan, some new streets and roads are to be built to increase the existing road infrastructure of the city. The implementation of this circulation plan requires a big amount of investment, but the first part has started.

Some of the measures take by the MEHU are working well. Among them, there is the periodical control of gas emission by vehicles in the city. A result of this action is that the CO emission in the city tend to be reduced by 25% said an official of the MEHU. The Beninese are slowly changing their 2T motorbikes for 4T ones. Other measures do not work that well. In that way, laws are still weak because of corruption. About the selling and the used of bad quality petrol, no concrete measure have been taken. There are some laws that forbid the selling of carburant elsewhere than the formal petrol stations, but no control of this rule is really done. Those who are involved in this activity seem not to be worrying about those laws.

5. CONCLUSION AND RECOMMENDATIONS

From data available, one can conclude that air pollution is one of the greatest threat for human health in African big cities in general, but particularly in Benin for the coming years: Cotonou is the most polluted city on the African continent, recognizes the MEHU. The increase of respiratory illnesses in Cotonou, compared to other less urbanized areas of Benin is the proof that it is more urgent than ever to take strong measures to avoid a chaotic situation in the coming years. In that way, the MEHU did and is still doing a lot. But this is not yet sufficient because for years, almost nothing was done against air pollution in Cotonou. The challenge for the actual local government of the city is to take the turn.

A few recommendations can be made to help in solving or at least reversing the trend of the air quality indicators in Cotonou:

- set up a permanent and formal monitoring system for air quality management in the city to help following periodically the impact of the measures taken and to evaluate their efficiency;
- some local and stronger laws and rules should be created to regulate air pollution in the city;

- above all, the involvement of the population living in the city is essential. The more they will be involved in the decision making processes, the more concerned they will feel in the implementation of decisions about air pollution and air quality;
- some specific researches and studies should be carried out on the perception and behaviour of the population towards environment issues and particularly air pollution and air quality. In the same idea, some specific studies should be carried out on the awareness of the population on the impact of air pollution on human health. The knowledge from these studies may help in choosing the best strategies to get people through a communication campaign.

Instead of alleviating poverty, actual managers of the city can leave, at least, a less polluted air to the future generations.

Actions for reducing air pollution and its consequences on human health will cost a lot, but they are required to change the trend in statistics.

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5. <http://www.bionet.schule.de>
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ⁱ The Netherlands Development Organization and CIFRED and Centre Interfacultaire pour la formation et la Recherche en Environnement pour le Développement Durable (CIFRED), University of Abomey-Calavi, Benin

ⁱⁱ "Get me quickly!" in a local language (Fon).

ⁱⁱⁱ 3rd General Census of Population and Habitat, 2002: Provisional results.

^{iv} Volatile organic compounds.

^v 2Ts are motorbikes that use a mix of petrol and oil as carburant, whereas 4Ts are motorbikes that use only petrol.

^{vi} Small particulate matter with diameter of less than 10 µm.
