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## Urban Air Quality in Cotonou

As with many other developing African major cities, environmental problems in Cotonou are more and more noticeable. These problems are the result, amongst other things, of air pollution caused to a large extent by the transportation sector.

In this context, the « *Clean Air Initiative in Sub-Saharan African Cities* » coordinated by the World Bank launched a study to evaluate air pollution. The results of this study are shown in this note and the following items are addressed:

- estimation of the present global level of air pollution in Cotonou
- determination of transportation's role
- evaluation of the risk to human health and estimation of resulting expenses
- examination of foreseeable future pollution
- evaluation of results of measures likely to be taken to reduce pollution
- proposal of a strategy for the implementation of these measures

### Global air pollution level in Cotonou

In order to establish better knowledge of the global level of pollution

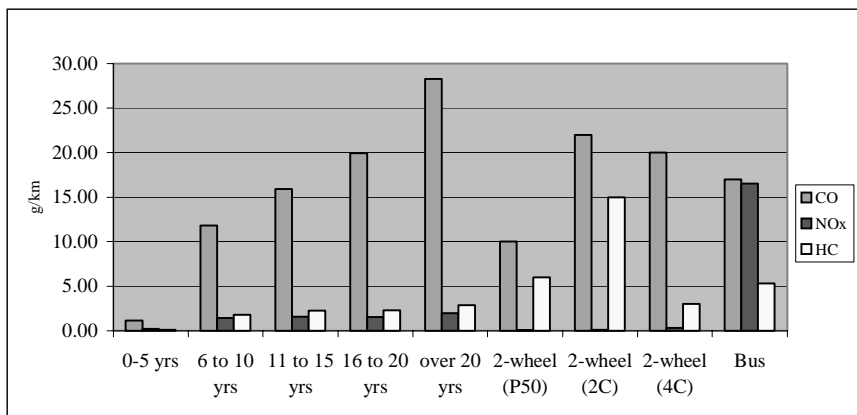
in Cotonou, existing data on air quality was completed through a campaign of measures taken in this study relating to carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), volatile hydrocarbons (HC), sulfur dioxide (SO<sub>2</sub>) and ozone (O<sub>3</sub>). The places as well as the measuring periods were chosen in order to, afterwards, distinguish the role of transport in global pollution. The results indicated high pollution at certain intersections. CO concentration reached 18 mg/Nm<sup>3</sup> (almost double the norm). The value level obtained for HCs indicates a crucial problem for this pollutant. On the other hand, pollution by NO<sub>x</sub> remains within acceptable limits (concentration of 50 µg/Nm<sup>3</sup>) and the concentration in SO<sub>2</sub> is less than the detection limits of the measuring equipment. Finally, ozone concentration is high and could exceed European limits.

### Transport's share

Benin's energy schedule shows that the transport sector is a high-energy consumer. It represents 62 percent of the country's oil expenses, four times more than the industrial sector. Moreover it has to be noted that transport mainly has a very local impact on air quality. This is why atmospheric pollu-



# Findings



tion along Cotonou's major highways is almost all caused by transport. This was confirmed from results of various analyses: CO concentration level outside of the city was 10 times less than at the main intersections.

#### Human health risks

The impact of air pollution on an individual's health from a vehicle's exhaust is determined by the increase in a large range of illnesses from respiratory and lead related illnesses to allergies and skin illnesses. A specific analysis of hospital data clearly indicates that air pollution in Cotonou is responsible for the high frequency of severe respiratory infections. Also, as concentrations of lead in the air are much higher than the norm, one can deduce that a certain number of neurological symptoms are developed mainly in children.

The cost of these respiratory ailments was analytically evaluated at approx. 600 million FCFA p.a. Based on similar studies the global cost of lead related ailments for the city could be estimated at some 20 billion FCFA. The cost of air pollution in Cotonou's air therefore reaches approx. 1.2 percent of the country's GDP.<sup>1</sup>

#### Predictable evolution of pollution

Even though results from measuring are available it seemed advantageous to estimate gaseous emissions from urban transport from mathematical simulations of present and future traffic. Impact upon air quality is calculated using a dispersion model. This method not only gives more detailed results on the present situation but also allows an estimation to be made on air pollution evolution and to test certain solutions and evaluate their effectiveness.

Six pollutants, existing in urban transport, were used in this study: carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), volatile organic components (COV) or hydrocarbon or volatile hydrocarbons (HC), sulfur dioxide (SO<sub>2</sub>), suspended particles of less than 10 µm diameter (PM<sub>10</sub>) and lead (Pb).

Traffic was calculated in the city's roads using an Origin-Destination matrix for travel on a mathematical model representing the urban network.. Results from this calculation produce the number of 4 and 2 wheel vehicles in the city's represented axes and their speed.

As shown in the following table, an other important factor in emission evaluation is the composition

of the vehicle pool: age and type of vehicle, fuel used.

An analysis of the registered vehicle pool in Cotonou shows that the majority of vehicles are over 10yrs old with an average of 12.5 yrs. A high number of 2-wheel vehicles are also in circulation in Cotonou. It is more difficult to estimate their number and cylinders, as registration is not mandatory for them.

On the basis of these traffic results, the retained pollutant emission was calculated as well as concentration along the highways. Results show daily emission to be approx. 83 tons of CO<sup>2</sup> of which 59 percent is generated by 2-wheelers and 36 tons of HC<sup>3</sup> which can be almost entirely accounted for by 2-wheelers.

Regarding impact upon air quality, HC concentration is higher in certain places than 2 000 µg/Nm<sup>3</sup> and some problems pertaining to standards respect for Nox were observed. Furthermore, a sur-concentration in lead is noted for 10 percent of the network with a maximum of 13 µg/Nm<sup>3</sup> (approx. 6 times more than the acceptable level).

Estimation of the foreseeable evolution of pollution in future years is based on the simulated evolution of city traffic. Using the same reference method, emissions and impact upon quality were calculated. The obtained results show that, without behavior or vehicle pool modifications, emissions increase steadily and independently of the considered pollutant. A large increase in emissions and in concentration of different pollutants in the air is noted:

- emissions will double on average by the year 2010
- in 2010, Pb concentration will

- reach 8 times more than the norm in certain places
- in 2005, pollution problems from  $\text{SO}_2$  will become noticeable.

Given the evolution in the pollution level obtained from these calculations, the situation will obviously worsen and become unacceptable before 2010. It is therefore most important to take appropriate measures immediately to limit, as much as possible, the degradation of air quality in Cotonou.

### Measures envisaged and their effectiveness

Measures envisaged to limit this negative situation could be grouped into three categories according to their intrinsic nature. The first category groups together technical and institutional measures concerning the vehicles themselves destined to reduce total pollution through individual reduction of emissions. For example:

- stricter regulations for the quality of vehicles for sale in Cotonou
- replacing 2 cycle motorbikes by 4 cycle motorbikes that pollute less especially in HC emission
- modification of 2 cycle engines to reduce emissions
- improvement of 2-cycle oil quality and of gas/oil mixtures
- establishment of technical controls for 2-wheelers
- improvement in the carburant sector
- establishment of trained mechanics.

A second category of possible interventions concerns operational measures aimed at improving effectiveness, in terms of pollution, in the urban transport sector. Especially in:

- the reorganization of public transport in Cotonou ; and
- all actions aimed at improving traffic conditions.

Finally, measures allowing a decrease in travel demand (urban planning policy, densification of dwellings and the implementation of social measures that would reduce individual travel) constitute the third category of possible actions.

### Analyzed scenarios

Four different scenarios were analyzed. Hypotheses retained for these scenarios are:

- Scenario of reference (maintenance of present conditions)
- Optimization of the network (application of the transport plan)
- Measures for modal distribution (establishment of a public transport system integrating moto-taxis)
- Vehicle improvement: updating the average age of vehicles, introduction of the catalytic exhaust for modern vehicles, diminution of sulfur and lead levels in carburant, replacement of 2 cycle motorbikes by 4 cycle ones.

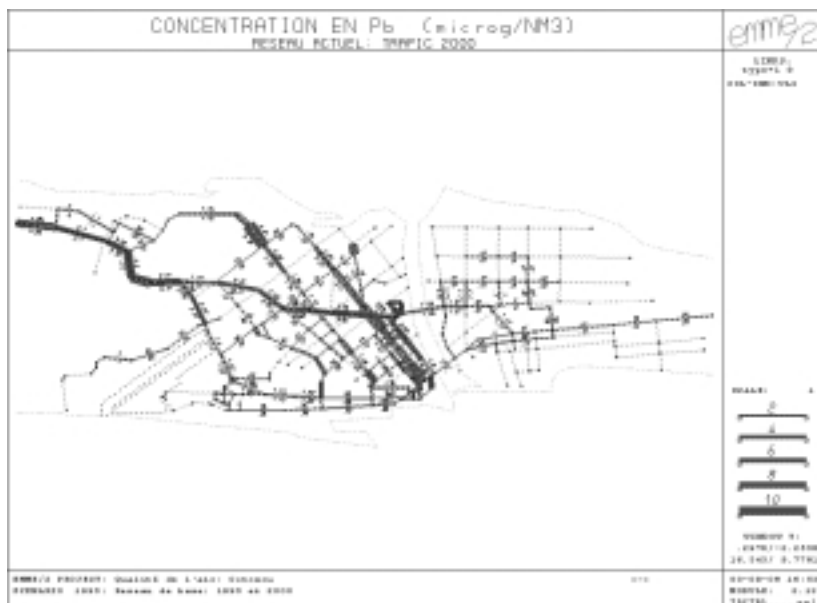
### Results

Emission levels and average concentration in the optimized network case are generally less than in the case of the network. On the other hand, the maximum observed concentration throughout the network is higher than in the case of the optimized network.

The scenario regarding implementation of a public transport system as defined in the transport plan policy has little effect on the pollution level. This is mainly due to the fact that the frequency and capacity of the public transport network defined in this policy is too weak in relationship to the number of moto-taxis in circulation.

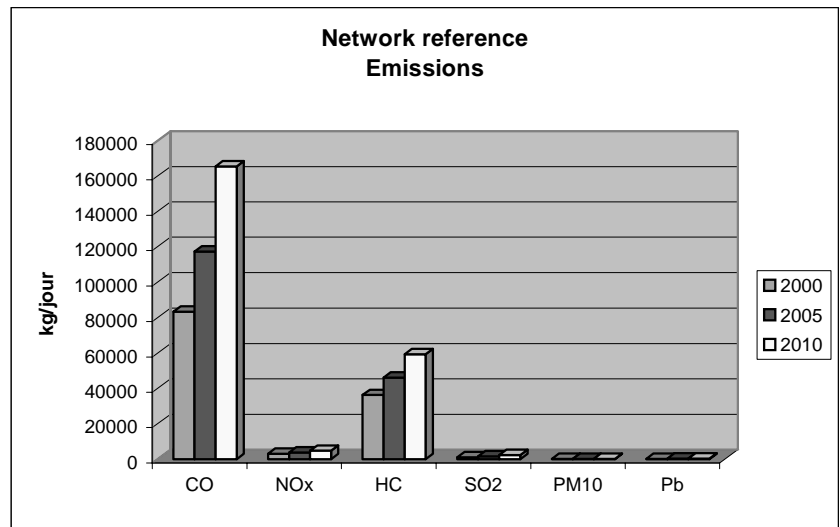
The scenario concerning measures to be taken for vehicles and for carburant quality demonstrates a slight positive effect, especially on Pb and  $\text{SO}_2$  concentration. On the other hand, the effect on  $\text{NO}_x$  is quite negligible.

The cumulated effect on measures taken on vehicles and carburant along with optimizing traffic conditions remains the solution that presents the most significant improvement.



## A strategy proposal

Upon examining results and taking into consideration difficulties in implementing certain measures, the various steps to be taken can be prioritized. It should be noted however that for pollutants such as CO and NO<sub>x</sub>, none of the proposed measures would allow emission level or concentration to be lower than the one presently observed. Air quality deterioration linked to traffic increase will be slightly diminished. On the other hand, taking radical measures on items pertaining to vehicles will greatly diminish SO<sub>2</sub> and lead pollution but could increase NO<sub>x</sub> presence. Thus no one solution can totally solve the problem. A combination of and a balance amongst the various actions must be sought in order to minimize the global effect of traffic caused air pollution.



The resulting priorities are:

1. Traffic reorganization through highway prioritization, road surface improvement and modal separation.
2. Measures should be taken on vehicles and carburant quality simultaneously
3. Implementation of a public transport system that would be developed and attractive enough to present a real alternative to the existing transport system. This is the most difficult strategy to be implemented as it would have to be accompanied by measures allowing:

- Maximum utilization of the public transport system
- An acceptable economic reconversion of the large number of "zémidjans" (moto-taxis)

1 Compare with Dakar : 2,7 percent of GNB; Ouagadougou: 1,6 percent of GNB.

2 In relationship to 50 tons in Dakar and 64 tons in Ouagadougou.

*This article was originally published as Sub-Saharan Africa Transport Policy Program (SSATP) Technical Note No. 33, June 2001. The complete study on which this article is based is available upon request at: [pbultynck@worldbank.org](mailto:pbultynck@worldbank.org). For further information about SSATP Technical Notes, please contact [mdesthuis-francis@worldbank.org](mailto:mdesthuis-francis@worldbank.org), or visit the website at [www.worldbank.org/afr/ssatp/](http://www.worldbank.org/afr/ssatp/)*