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RESEARCH ARTICLE

IMPACT OF AIR POLLUTION ON THE HEALTH OF POPULATIONS IN INDUSTRIAL ZONES AND SURROUNDING AREAS IN THE SOUTHERN REGION OF ABIDJAN – IVORY COST

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ABSTRACT

Industries release suspended particulates (PM 2.5, PM10, TSP) with high concentrations in the various industrial sites and their surroundings in South Abidjan Region. However, the exposure to fine particles leads to an increased risk of cardio respiratory mortality such as lung cancer, asthma and obstructive lung disease. This study aims to highlight the impact of industrial activities on the health of populations living in and around industrial areas. The methodological approach is based on documentary research, interviews, surveys of people living in industrial and control areas, of the Autonomous Port of Abidjan staff and employees of some health centers. The results show the prevalence of pathologies such as asthma, allergic cough, pollen allergy and respiratory cancer in the populations interviewed, in both control and industrial zones. This study indicates that there is a strong presumption that all these diseases could be related to industrial activities in South Abidjan Region.

INTRODUCTION

The industrial zones in Abidjan south region are made up of heavy and light industries. They are composed of chemical, mining, textile and food industries. These industrial activities are well known to be the main source of anthropogenic emissions of nitrogen oxides into the atmosphere (Krzyzanowski and Cohen, 2008). Atmospheric emissions from factories and other sources of gas combustion release into the air Nitrogen oxides (NO_x), Sulphur dioxide (SO₂), Carbon monoxide (CO) and Carbon dioxide (CO₂) as well as various other organic compounds and particulate matter (Soro and *al.*, 2008). The strongest pressures relating to the most dangerous pollutants are hydrocarbons from the refinery company SIR, dyes & fixers from textile industry. discharge of Sulphuric acid come from UNILEVER company (formerly called Blohorn) and SIVENG company; and discharge of organochlorine and organophosphorus compounds emitted by SHELL chemistry company that are particularly dangerous for humans and lagoon fauna, surface treatments, leather treatments (Sika, 1987). These gases are toxic, harmful and destroy the ozone. Acute effects of air pollution are those that occur rapidly, a few days or even hours after exposure. Many studies have investigated the relationships between daily variations in air contaminant concentrations and health indicators.

The results of these time series studies show an increase in mortality on days with higher levels of pollution compared to days with lower levels (Burnett *et al.*, 2004). However, what is the impact of these air pollutants on the health of populations living in and around industrial areas?. The aim of this study is to show the impact of air pollution on the health of people in and around industrial areas.

MATERIALS AND METHODS

Presentation of the study area

Data collection technique: Our investigation focused first on a health survey among households living in industrial areas and on a survey in reference areas, i.e. areas at a distance away from industrial zones. The objective is to find out whether populations living in industrial areas are more exposed to pollution-related diseases than those living in reference areas. Then, it also focused on conducting a health survey at the Port Autonomous of Abidjan and another survey in health centers. The objective of the survey of health workers is to verify the results obtained by the health survey of households. The health workers examine the populations during consultations, and can confirm or deny the results from the households' survey.

Finally, an interview was conducted with officials in the relevant departments responsible for industrial risk management, namely the Ministry of the Environment through the DGE, and its entities CIAPOL and ANDE, the PAA through the Hazardous Materials, Disaster Management and Port Ecology departments.

Tools: These questionnaires were transferred to the Sphinx software and then processed.

Sampling: As the statistical documents from the last census of 2014 were not yet available for each district at the time of our surveys, we used data from the 1998 RGPH of the INS. With this data and with the natural growth rate, we established a calculation that allowed us to have estimates of the population of 2008.

Determining the sample size

Far from being an exhaustive survey, we opted for the unequal probability method using the following statistical formula:

We opted for the poverty rate of households because the level of risk, living in the vicinity of industrial zones, the standard of living of the populations and the proximity to their places of work could justify the choice of their settlement in these different illicit districts. t : 95% confidence level, (typical value 1.96) m : 5% margin of error, (typical value 0.05%)

In total, we have 382 households that will represent the sample size, and it is this population that will be surveyed. The choice of households was based on a multi-stage survey, the first stage being the choice of the municipalities, the second stage being the choice of neighborhoods in the industrial zones. The third stage is the choice of neighborhoods in the reference areas. The fourth stage is the choice of heads of households in the control areas. The fifth level is the choice of households in the control areas.

RESULTS

In industrial areas: Allergic cough (15.92%) is the recurrent disease noted during the survey in the different neighborhoods of the industrial zones. Respondents in the Treichville industrial zone and the Marcory industrial area (zone 4) suffer particularly from pollen allergy (07.09%), asthma (08.85%) and respiratory tract cancer (08.85%) (Image 2). Allergic cough is predominantly found in the Marcory industrial area and in the Treichville area.

In reference areas: According to the respondents, 10.4% suffered from Rhinitis, 14.1% from allergic cough and 8.3% from Asthma. These diseases are recurrent in Koumassi and Port-Bouët, while in Marcory and Treichville, rare cases of allergic cough and asthma are observed (Image 3).

Synthesis: When we combine the illnesses of the respondents in the last six months in the industrial zones and in the control zones, the recurrent illnesses are asthma (15.09%) and allergic cough (25.47%). Pollen allergy (5.66%) and cancer of the respiratory tract (1.88%) were very low. Allergic cough is found in almost all the neighborhoods of the control zone in different proportions. These diseases were identified in the municipalities of Koumassi and Port-Bouët. In Port-Bouët that cases of pollen allergy, asthma, allergic cough and respiratory tract cancer were found, while in Koumassi, only cases of pollen allergy, asthma and allergic cough were observed. Whatever the proportion of the disease, the diseases identified in the control zone and the industrial areas are almost same despite the difference in proportions.

PAA workers: The PAA staff who were interviewed had suffered in the last 6 months from cough (25%), rhinitis (14.4%). These illnesses seem to be recurrent. However, asthma (4.4%), pollen allergy (3.3%), acute bronchitis (1.1%), bronchopneumonia (1.1%), bronchiolitis (1.1%), cancer of the respiratory tract (2.2%), angina pectoris (2.2%),

intrauterine problem (1.1%), intoxication (5.6%) and dermatological problems (4.4%) were mentioned but with small proportions. Similarly, to confirm all these pathologies, we visited health centers to interview the medical staff in order to confirm the presence or recurrence of the above-mentioned pathologies in these different areas.

Health workers: In response to the question: “During consultations, what are the recurrent symptoms observed in patients?” Several symptoms were listed but the most dominant were cough, rhinorrhea (snot), nasal obstruction, breathing difficulty (dyspnea) (Table 1). The most dominant diseases observed during their consultations are acute and chronic bronchitis, allergic cough, asthma, dermatological problems.

Statistics on symptoms and diseases observed during consultations:

Over a period from 31/08/2016 to 28/09/2016, according to the medical emergency registers of the General Hospital of Port-Bouët, out of 891 patients, 222 patients presented the symptoms linked to air pollution related diseases. Based on this population sample, 73.13% come from Port-Bouët, 16.42% from Koumassi and 10.45% from an unspecified origin. The recurrent symptoms are chest pain (24.62%), pruritus (14.17%), cough (33.58%) and cold (14.17%). The least recurrent signs were rash (1.49%), rhinorrhea (2.24%), chronic cough (1.49%) and wet cough (2.98%). Après les urgences médicales, sur 1300 patients des consultations générales, 201 patients présentent des signes ou ont des maladies liées à la pollution de l'air. In addition to medical emergencies, out of 1300 patients of general consultation, 201 patients show symptoms or have diseases related to air pollution. Children or infants regularly present symptoms such as cold (31.42%), dry cough (17.17%), wet cough (16.91%), breathing difficulties or dyspnea (15.40%), simple cough (13.59%). Asthma (31.16%), rhino bronchitis (23.37%) and rhinitis (12.98%) are the most recurrent diseases that we noted in the pediatric consultation register. The rarest diseases are mycosis (01.29%) and low birth weight (01.29%). However, whether they are of small proportions or not, they correspond in most cases to those identified during the surveys in the industrial zones and the control zones

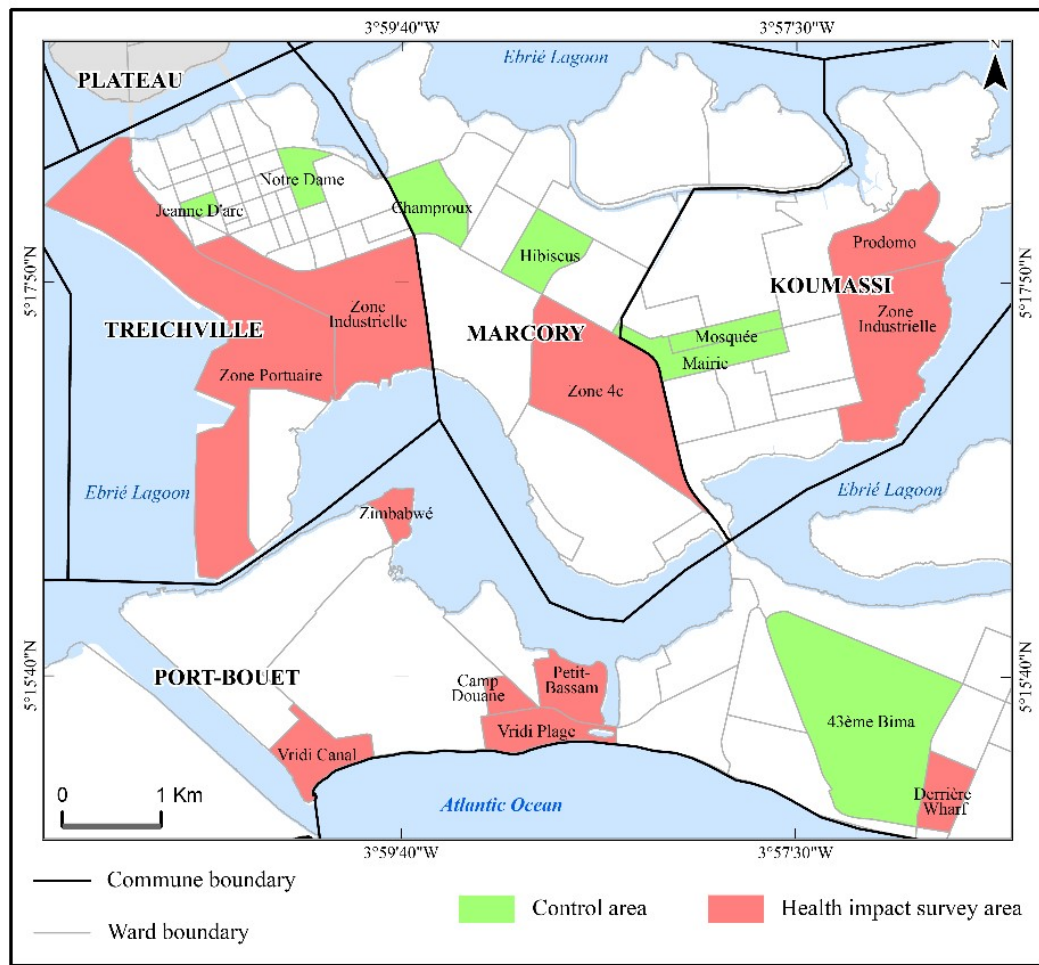
DISCUSSION

In the industrial areas, people breathe the pollutants emitted by the factories while in the control areas, where there is no industry activity, the air should not be polluted. However, no analysis has been carried out on the air quality in the control areas, but the surveyed population shows the same pathologies as the population living in the industrial areas. The works of several authors confirms these results. This recurrence of respiratory diseases in the control areas could be explained either by the wind direction or by the geographical landscape. It would be likely that the wind coming from the industrial areas is directed towards the control areas thus transforming the atmosphere which can harm the health of the populations. Depending on the landscape feature (basin, hill), the atmosphere may have higher concentrations of pollutants in remote areas than in industrial areas. One study has determined the likely hazard zones for human settlement, (Kablan and *al.*, 2013, p. 217). The industrial zone of Port Bouët is home to a large part of the mining and energy industry. Given the nature and scale of the industries present, the industrial area of the municipality of Port-Bouët is certainly the industrial area in Abidjan that emits the largest amounts of CO, CO₂, NO_x, SO₂, H₂S, VOCs, PM, aldehydes and benzene to the atmosphere from industrial sources (TECSULT, 2006, p.3-2). Therefore, the dispersion distance of the particles is x (SO₂) = 2.68 km; x (NO₂) = 2.83 km; x (CO₂) = 1.21 km. Within a maximum radius of 2.83 km in the vicinity of the entire ZIP and in relation to the above-mentioned wind direction, a few sites at risk of air pollution can be mentioned. These are the eastern part of Treichville, the municipality of Marcory, the west of Koumassi and Port-Bouët (locality of Vridi - Petit-Bassam) which are exposed to CO₂, SO₂ and NO₂ pollution over distances of 2.68 km; 2.83 km; and 1.21 km respectively (Kablan and *al.*, 2013, p. 217).

Table 1. Recurrent symptoms and diseases observed during consultations during consultations

Symptoms	Number	Frequency (%)	Diseases	Number	Frequency of diseases during consultations (%)
No	1	4,5	No answer	1	4,5
Cough	17	77,3	Acute and chronic bronchitis	13	59,1
Rhinorrhea (snot)	14	63,6	Broncho-pneumonia	8	36,4
Nasal obstruction	12	54,5	Chronic obstructive pulmonary disease (COPD)	1	4,5
Breathing difficulties	10	45,5	Pollen allergies	6	27,3
Chest difficulty	8	36,4	Asthma	11	50,0
Sneezing	9	40,9	Allergic cough	13	59,1
Watery eyes	2	9,1	Rhinitis	2	9,1
Hemoptysis	1	4,5	Bronchiolitis	3	13,6
Pruritus (itching)	6	27,3	Respiratory tract cancer	4	18,2
			Intoxication	3	13,6
			Dermatological problem	10	45,5
Total	22		Total	22	

(Source: YAO Natacha, 2016 Field study)



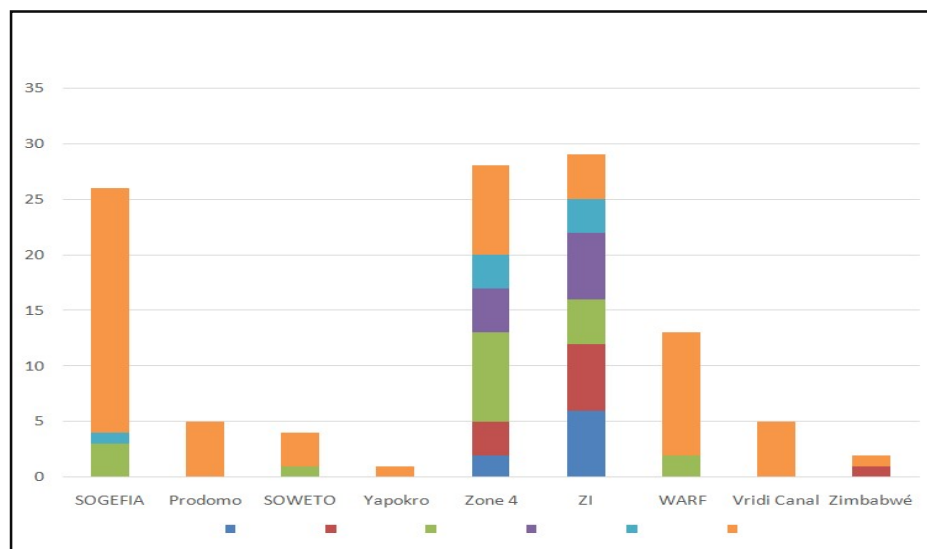
Realization: YAO Natacha, 2017

(Source: YAO Natacha, enquête de terrain 2016)

Image 1. Diseases contracted six months before the survey

Legend



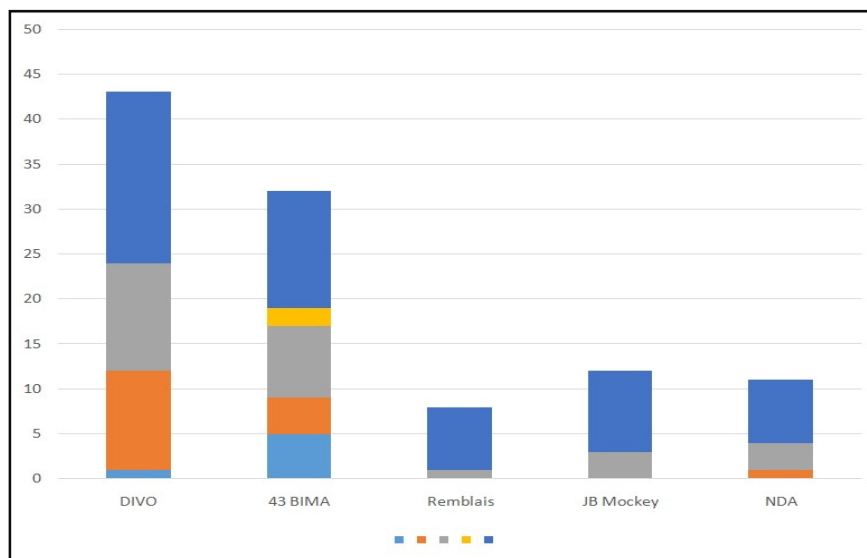


(source: YAO Natacha, 2016 field survey)

Image 2. Diseases contracted six months before the survey in different industrial areas of the south Abidjan region

Legend

- Pollen Allergy
- Respiratory Tract Cancer
- Asthma
- Intra-diseases
- Allergic cough
- Others diseases



(source: YAO Natacha, 2016 field survey)

Image 3. Diseases contracted six months before the survey

Legend

- Pollen Allergy
- Asthma
- Allergic cough
- Respiratory Tract Cancer
- Others diseases

Scientific studies show that fine dust is an important risk factor for cardiovascular health. Of all the health effects, the impact on the cardiovascular system is the most important. It accounts for 80% of deaths attributable to air pollution. The long-term consequences of prolonged overloading are even more severe than the short-term impact of smog episodes (FOEN, 2014, p.9). Scientific research has shown that air pollution has adverse effects on the health of the population. Exposure to the air contaminants that make up this pollution is associated with increased mortality and morbidity, particularly in the respiratory and cardiovascular systems. Studies have also shown that there is no concentration of contaminants below which no effect is observed. Also, the results of research conducted over the last 20 years demonstrate with certainty that air pollution contributes to morbidity and mortality in the population (Bouchard et al., 2008, p.1). It is now established that children have a particular vulnerability to pollution, as they are in the growth phase, and that fetal development, infant, child and adolescent growth correspond to periods of high vulnerability to toxins. (Laaidi and al., 2010, p.296).

CONCLUSION

These industrial activities emit pollutants into the air, including particulate matter (PM 2.5, PM10 and TSP) and other air pollutants (NO, CO, SO₂, H₂S and NH₃), which influence the air quality of industrial areas. However, these concentrations should not be underestimated as they can have effects on the health of populations. A health survey was carried out and it was found that diseases such as asthma, allergic cough and pollen allergy and respiratory cancer are recurrent. Regardless of the proportion of the disease, the diseases identified in the control/reference zone are almost identical to those detected in the surveyed populations in the industrial zones. In view of the above, and even if we cannot state with certainty that these diseases are linked to industrial activities in Abidjan South, this study confirms that of Kablan and al. (2013), which states that it is the local population that is exposed to pollution and cardiovascular infections such as bronchitis, asthma, sinusitis and gastritis (Wognin, 2008). In the sectors around the ZIP, several infections caused by pollution have already been reported in some of the studies cited by Pottier and al. (2008), including acute respiratory infections (Koné and al., 2006).

Conflicts of interest: No conflict interest.

Source of funds: This work was carried out using our own resources.

Abbreviations list

ANDE: National Environment Agency
 CIAPOL: Ivorian Anti-Pollution Centre
 CRV: Respiratory Tract Cancer
 CO: Carbon Monoxide
 CO₂: Carbon Dioxide
 COV: Volatile organic compounds
 DGE: Directorate General for Environment
 H₂S: Hydrogen Sulphide
 INS: National Institute of Statistics
 NO_x: Nitrogen oxides
 O₂: Dissolved oxygen
 PAA Autonomous Port of Abidjan
 PM: Particulates Matters
 PM10: Particles with a diameter of less than 10 micrometers
 PM2.5: Particles with a diameter of less than 2.5 micrometers
 RGPH: General Census of Population and Housing
 SO₂: Sulphur dioxide
 TSP: Total Particulate Matter
 ZIP: Industrial Port Area

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