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Air pollution and environmental risks related to plastic waste recovery activities at the GVD-Niger plant in Zinder

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Abstract
This article focuses on the environmental pollution generated by the activities of the company called Waste Management and Recovery (WMR) Niger. The objective of this study is to assess the impact of the activities of the WMR branch in Zinder on air quality and the associated risks through measurements inside the factory and in around fifty neighboring households, using a multifunction detector. Particulate matter (PM 10/PM2, 5/PM1), temperature and relative humidity were the parameters monitored. A questionnaire was also administered to local residents to gather their perception of their neighborhood with the company. The results show that air pollution is very significant in the WMR enclosure where the average concentrations far exceeds the WHO guide values (GV) for PM 10 and PM2.5, which are respectively 34 to 999 µg/m3 and 39 to 999 µg/m3. Protective measures are provided for the health and safety of workers. On the other hand, in households, the values are well below the WHO GVs. Nevertheless, from the perceptions of local residents, there emerges an attitude of fear for their health because of the smoke emitted by the chimney.

Key words: *Air pollution, plastic waste, recovery, impact, GVD-Niger, Zinde*

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I. Introduction

The preservation of the environment and its many socio-economic issues occupy a large place in the challenges of this century. The incessant growth in production leads to a drop in the levels of natural reserves of raw materials and generates a large quantity of waste (1). Waste is both a risk and a resource, but when it is disposed of without precautions, it risks degrading landscapes, polluting the environment and exposing humans to nuisances and dangers, some of which may be very serious (2). In the cities of the South, the deterioration of the environment is much more caused by the lack of means, of organization and galloping urbanization. This can easily be seen in the management of household solid waste (3).

This waste generates nuisances that expose populations to multiple environmental risks. The problem of waste management in general is largely due to the practices and behaviors of individuals. Solid waste is most often evacuated by children, in an anarchic manner, in poorly controlled neighborhood dumps (4). Municipalities ensure the pre-collection, collection and storage of solid waste as best they can (5). In Niger, a country in the South where the growth rate of cities of 3.7% per year (6) is significant, waste sorting is not a common practice. The deposited waste is always scattered by the wind and the animals and sometimes the rain. In some cities, waste is thrown into the sewage disposal gutters (7). In Zinder, the second largest city in Niger, solid waste management is inadequate and unsustainable given the inadequate discharges (4).

In addition, the landfilling of this waste, especially plastic, poses a serious problem almost everywhere, because it is often blown away or mixed in fermentable waste and transported to growing areas. Plastic products, created from a non-renewable resource, are intended to be thrown away, and therefore replaced by another plastic product, which we will also dispose of when it has lost its usefulness in our eyes. This model assumes an infinite and unlimited creation of plastic which is not scientifically possible given the limited nature of the resource that allows its production.

Faced with the ever-increasing needs for material resources and the requirements and conditions for preserving the environment in a vision of sustainable development, it has become necessary and imperative to find opportune possibilities for reusing and recovering plastic waste. The studies undertaken (8; 9) have demonstrated that it is possible to manage these in various forms through energy recovery, mechanical recovery (material) or even chemical for the development of new materials such as cementitious composites, which appears as one of the best solutions for the disposal of plastic waste, due to its economic and ecological advantages.

On the one hand, the recovery of waste makes it possible to reduce the negative environmental and social externalities linked to plastic waste. However, the experiments carried out in this field testify to the complexity of this sector and the diversity of the actors involved in it. Indeed, the combustion of plastic waste most often releases fumes containing substances toxic to health and the environment. Considering the adverse effects that poor air quality can cause, several studies have been conducted worldwide. Nevertheless, few studies mention the assessment of air quality and its effect on respiratory health (10). The most harmful pollutants for respiratory health are particulate matter (PM2.5 and PM 10), carbon monoxide, ozone,

If in developed countries, the health and environmental impacts of the recovery and recycling of plastic waste have been the subject of scientific research (in particular the 2007, 2009 and 2020 reports of RECORD in France; 2020 report of the NGO Green Peace in Canada, 11), in southern countries such as Niger, studies on such aspects are rare. It is in this context that this study focuses on the health, safety and environmental aspects of the recovery of plastic waste from the NGO GVD in the city of Zinder through the measurement of certain environmental parameters and the survey of perceptions.. The general objective is to assess the environmental and social impacts related to plastic waste recovery activities within the GVD company.

II. Materials And Method

Materials

Description of the device IGERESS WP6930S

The IGERESS WP6930S multi-function ambient air quality detector is a device capable of detecting and measuring the levels of formaldehyde (HCHO), volatile organic compounds (TVOC), PM 10/PM2.5/PM1, temperature and relative humidity in the ambient air. It is a device to evaluate what we breathe in the ambient air. It is simple to use and requires no reagents.

Figure 1: the IGERESS WP6930S multi-gas detector

For the mode of use, it is without difficulty with its ten (10) keys. Calibration essentially concerns HCHO and TVCO, it requires air free of these pollutants. It is possible to carry out this operation in optimal conditions such as early or late at night, provided that it is not subject to pollution from vehicles or factories. For particles, temperature and relative humidity, the laser reader is configured at the factory. This device provides easy reading as all the air quality test results are clearly displayed on the colorful LCD screen just after a few minutes after it is turned on. On the other hand, a delay of 10 minutes is necessary to stabilize the reading of HCHO and TVCO.

Description of measurement parameters
Formaldehydes or HCHO

Formaldehyde is a generic term that designates the family of pollutants in the form of gases (part of the VOCs). It is a chemical present around us and used in the manufacture of objects, furniture, paintings etc. It can be present in large numbers and often toxic to human health. The measurement range varies between 0 and 1,999 mg/m3.

VOCs or TVOCs

Total Volatile Organic Compounds (TVOC) is the sum of VOCs found in an air sample. They include a multitude of substances, which may be of biogenic (natural) or anthropogenic origin. The most famous are butane, toluene, ethanol (90° alcohol), acetone and benzene found in industry, most often in the form of organic solvents (in paints or inks). They are also harmful to health. The measurement range varies between 0 and 1,999 mg/m3.

Particulate matter (PM 10 PM2.5 PM1)

PM or particulate matter refers to fine particles suspended in the air. There are multitudes of them, but the problem is that many are toxic to our body, through our breathing.

PM 10 airborne particles with an aerodynamic diameter less than 10 micrometers. The measurement range varies between 0 and 999 µg/m3;

PM2.5, whose diameter is less than 2.5 micrometers, called ‘fine particles’. The measurement range varies between 0 and 999 µg/m3;

PM1, whose diameter is less than 1 micrometer, called ‘very fine particles’. The measurement range varies between 0 and 999 µg/m3.

Temperature and relative humidity

These parameters are particularly important in the context of respiratory allergies, heat and relative humidity, favoring the presence of mites and volatile molds which can have an effect in asthmatics.

Methodological approach

The method used to carry out this study includes the following steps:

-The documentary review which allowed the genesis of the literature on the theme;

-Field visits which made it possible to administer a questionnaire and an interview guide to local residents and workers in the plastic waste recovery sector;

-Measurements of the concentrations of indoor air pollutants in the factory premises and in the households neighboring the GVD center;

-The processing of collected data.

Sampling technique

The study concerned all the households located within a radius of three hundred meters (300 m) around the GVD plastic waste processing unit. A total of fifty one (51) households were identified and interviewed. Respondents were interviewed of their own free will, simply by presenting the subject of the survey and respecting confidentiality.The questionnaire that served as a data collection tool was sent to all the people selected for the survey. Questions were asked, with more explanation, if necessary, to the respondents and the correct answers are checked off directly on the survey sheet. These surveys make it possible to verify the perception of local residents on the activities of this plant, in order to detect the idea they have about the presence of the upgrading plant in their immediate environment. The questionnaire was aimed primarily at the heads of households or, failing that, a person in the household aged 18 or over. The questionnaire covers as a whole the socio-economic situation, and the perceptions of the neighborhood of the respondents with the plastic waste treatment center.

In addition to administering the questionnaire, the concentrations of pollutants in the ambient air of households neighboring the center are measured with the intelligent multi-toxic gas detector IGERESS model WP6930S (test range: 0–1,999 mg/m3 for formaldehyde, 0–1.999 mg/m3 for VOC and 0-999g/m3 for particles (PM1/PM2.5/PM 10).

Measurement protocol
In neighboring households

Measurements were made twice in each household, at plant operating hours. The first was held at the time of the survey and a second visit after two (2) weeks, in order to get an idea of the degree of pollution in the neighborhood.

In the factory

A measurement campaign then concerned two points, one of which was at the level of the melting point of the plastic waste and the other a few meters away (approximately 40 meters), in order to check the functioning of the device and the variations of the concentrations according to the distance. For sampling at the second point listed, we retained an average of the hours during three times of the day (9 a.m., 12 p.m. and 3 p.m.).

Also, to touch on worker health and safety issues, a workstation observation sheet and an interview guide for workers were developed and used in the context of this study.All the results were entered and analysed in SPHINX 5 Plus and Excel 2013 software.

III. Results

Individual perceptions of air quality in the neighborhood near the plant

Figures 2 to 4 below provide information on the individual perception of local residents' air quality. 47% of respondents believe that the air quality is acceptable in their neighborhood according to Figure 2. However, the majority of respondents believe that their neighborhood is in danger. With regard to the factory's activities, the majority of respondents (64.7%) think that they have a negative impact on the air quality of the neighborhood (figure 3). To this effect, 62.7% say that they are not satisfied with their neighborhood with the factory.

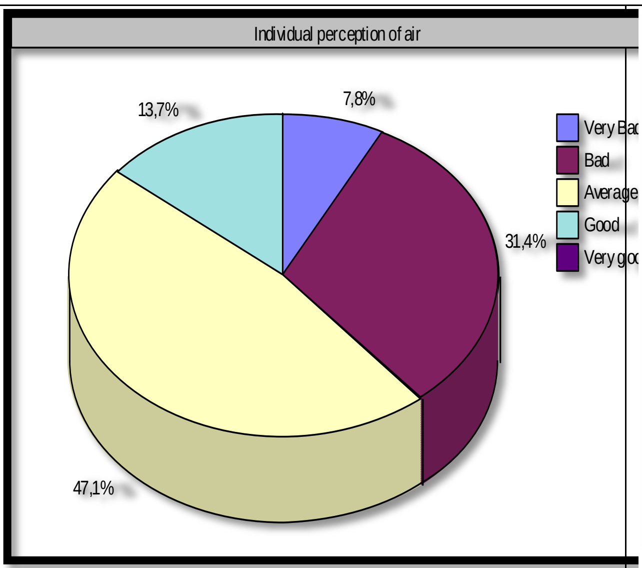


Figure 2*:* *S*urvey of residents' perceptions of current ambient air quality

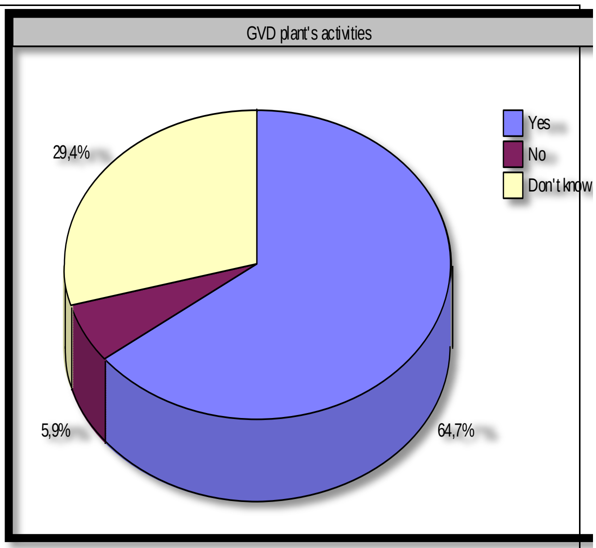


Figure 3: Perception of the impact related to the activities of the GVD plant

Among the local residents who settled before the start of activities at the GVD plant, the majority stated that the air quality was average. Figure 4 gives us an overview of the comparison of air quality that respondents make between the current situation and before the installation of plastic waste recovery activities. More than half of the respondents (54.5%) could not answer, while 41% said that the air quality in the neighborhood was better compared to the current situation.

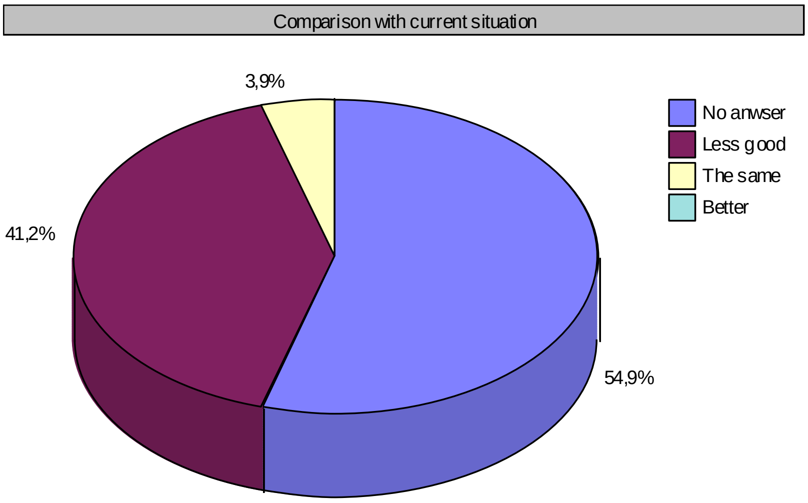


Figure 4:*Comparison of current air quality to that of before*

With regard to the nuisances linked to the activities of the factory, the majority of respondents cited smoke, the smell of incineration and a few rare cases of particles as perceived nuisances.

Table 1:*types of nuisance cited by respondents*

Type of nuisance listed	Number of respondents	Proportion (%)
Plastic incineration smell	18	35.3
Fume	21	41.2
particles	4	7.8
Not answered	7	13.7
Total	***51***	***100***

Result of the measurements taken in the houses surveyed

The measurements taken in the houses surveyed show the results of figures 5, 6 and 7: The two curves correspond to the two measurements taken at the level of the 51 households during the survey period (with the values of the first measurement campaign in blue and that of the second campaign in red).

PM1 concentrations

Figure 5 shows the variation of PM1 for the two measurement campaigns. For the first, the values vary between 1µ g/m3 at the level of household no. 42 and 22 µ g/m3 at the level of household no. 25. For the second measurement campaign, the minimum and maximum values are recorded respectively at 5 µ g/m3 at the level of household no. 36 and 19 µ g/m3 at the level of household no. 14.

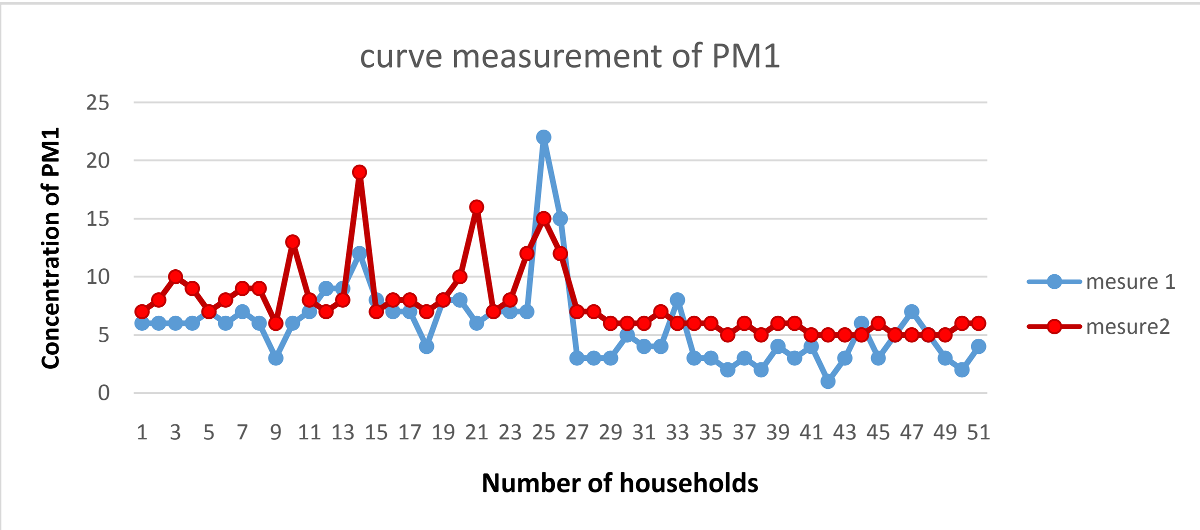


Figure 5:*PM1 measurement curves at the household level*

PM 2.5 concentrations

Figure 6 shows the variation in PM2.5 concentrations for the two measurement campaigns. For the first, the values vary between 3µ g/m3 at the level of households n ° 36, 38, 42 and 50 and 29µ g/m3 at the level of household n ° 25. For the second measurement campaign, the minimum value is 5 µ g/m3 recorded at the level of households n ° 35 and 37µ g/m3 and the maximum value is 26µ g/m3 at the level of household n ° 15.

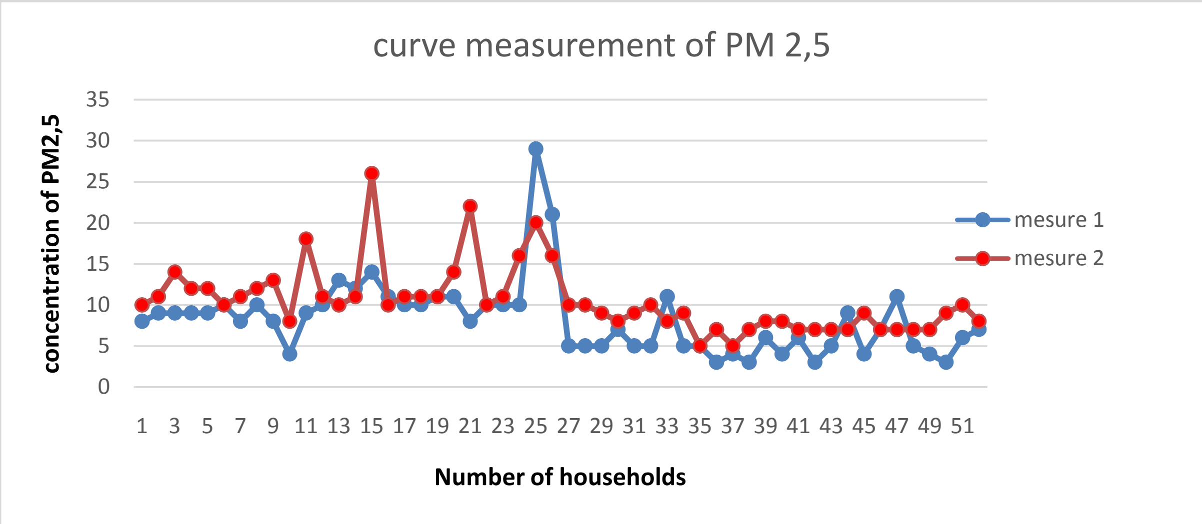


Figure 6:*PM2.5 measurement curves at the household level*

PM 10 concentrations

Figure 7 highlights the variation in PM 10 concentrations, the minimum value of which is 3µ g/m3 at the level of households n ° 41, 48 and 50 and the maximum value is 33µ g/m3 at the level of household n ° 24 for the first campaign. For the second, the minimum value is 8µ g/m3 recorded in eleven households and the maximum value is 30µ g/m3 at household level 14.

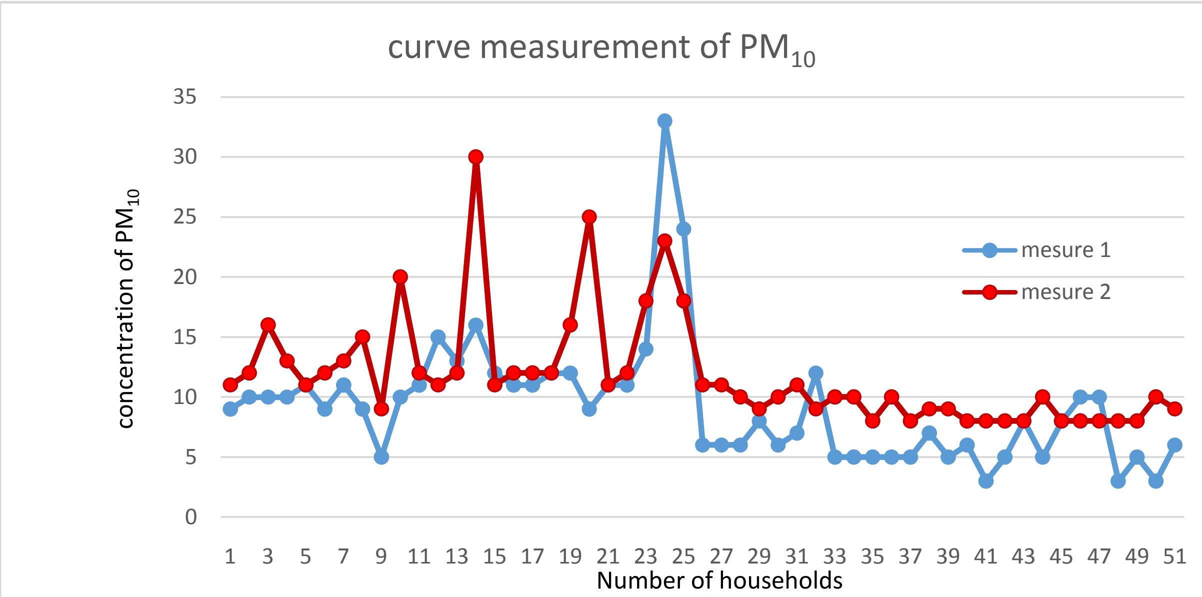


Figure 7:*PM10 measurement curves at the household level*

Humidity level

The graph below shows the variation in the humidity rate at the level of the households in the study. The reading of figure 14 shows a variation of the value of the relative humidity between 25% at the level of household n ° 25 and 52% at the level of household n ° 49 and 50.

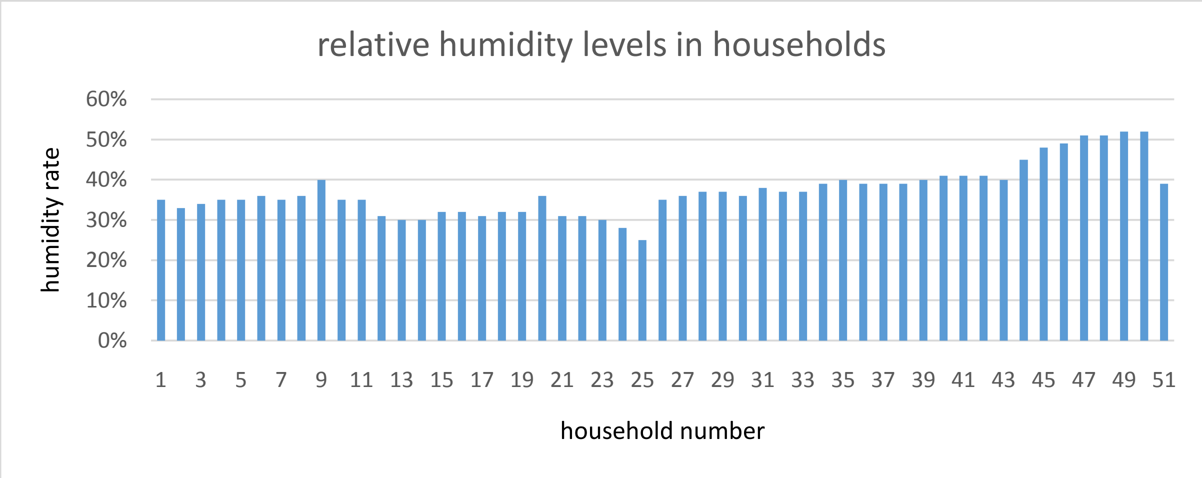


***Figure 8:**Relative humidity rate in surveyed households*

Concentrations near the plastic waste transformation focus

Figure 9 below shows the valuestaken near the plant. PM1 values vary from 25 µg/m3 to 999 µg/m3, while PM 2.5 values vary from 34 µg/m3 to 999 µg/m3 and from 39 µg/m3 to 999 µg/m3 for PM 10.

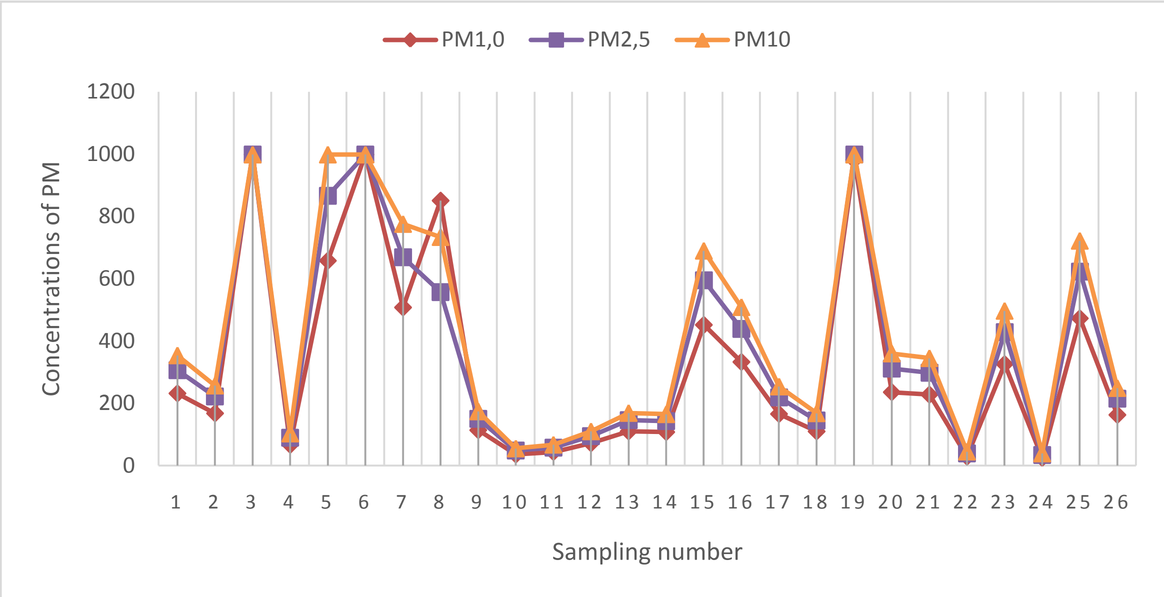
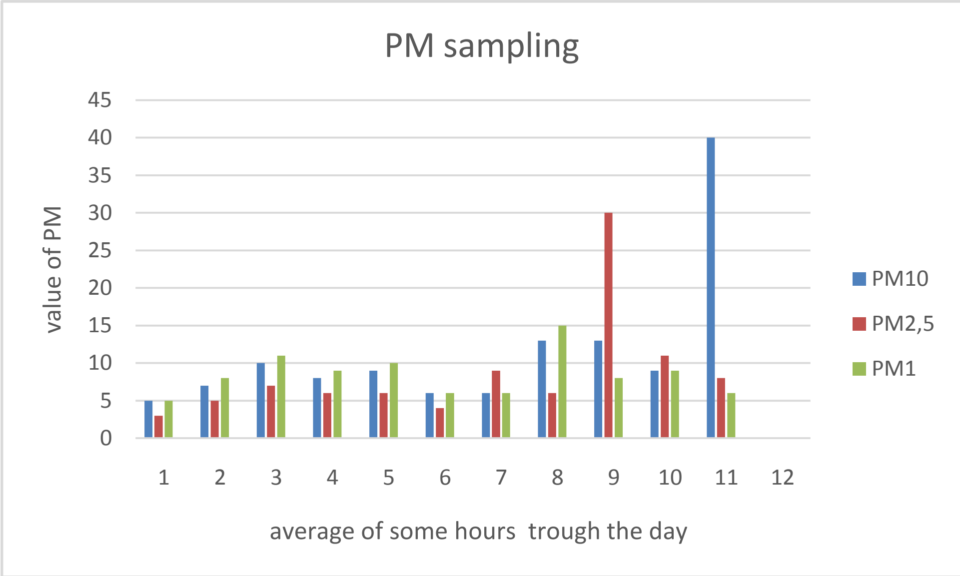


***Figure 9:**Concentrations of PM1, PM2, 5 and PM 10 at the melt reactor*

The variations in the concentrations of the various pollutants at a distance of about 40 meters from the melting hearth are represented in figure 10. It can be seen that the minimum values recorded are respectively 3µ g/m3, 5µ g/m3 and 6µ g/m3 for PM1; PM2, 5 and PM 10.



Picture 10:*PM valuesmeasured a few meters from the plant*

Result of the interview with the workers of the plastic waste recovery plant

The results of the investigations show that more than half (75%) of the plant's employers say they are aware of the risks associated with their plastic waste recycling activities. With regard to possible accidents/incidents in the context of the work they carry out, almost all of the respondents were victims at least once during their activities.

Among the workers who have been victims of an accident, the most common cases are minor injuries (cuts to fingers and arms); burns; headaches and stomach aches (for those who are newly recruited).

The personal protective equipment provided at the GVD factory level are work overalls, masks, gloves and safety shoes.

Result of the observation of the factory workstations

According to the observation sheet of the plastic waste recovery plant, it appears that the workers have a changing room and showers in good condition. In addition, the plant is in a ventilated room and there is good natural and mechanical ventilation. Access roads and passages are cleared. However, there is only one portable fire extinguisher at the plant level.

IV. Discussion

Air pollution is recognized as an important public health problem, responsible for health effects, which are well documented from research findings conducted in many parts of the world (10). The ultimate effect of air pollution on public health is premature death (12).

In the households concerned by this study, most respondents perceive the olfactory nuisance (bad smell) and the smoke that is released during the factory's activities as the most worrying. Indeed, despite the preliminary sorting carried out, the raw material is not rid of all the dirt, which increases the bad smell. Nevertheless, a study conducted by Zakari et al (13) at the level of the 5th arrondissement of the city of Niamey on the perception of risks in the neighborhood with gas stations which are listed as being dangerous and unhealthy establishments revealed that local residents are unconcerned about the dangers involved.

Also, the connection of a chimney of approximately 12 meters allowed the distant evacuation of gaseous emissions, but depending on the direction of the wind, some residents still complain of smoke, especially those who are a few steps away. From the factory. This has led the majority of residents to think that their neighborhood is in danger because of the activities carried out by the GVD centre.

The relative humidity rate in the surveyed households is acceptable, although the measurement campaign was held during the rainy period. Indeed, studies have proven significant associations between humidity in dwellings and the risk of mold development responsible for worsening asthma (14).

In the plant, measurements of the concentration of particles (PM1, PM2, 5 and PM 10) near the cast iron reactor gave alarming results. These concentrations far exceed the threshold values set by the World Health Organization (WHO) for 24 hours and the annual averages (15). This proves that workers in this sector are extremely exposed to various pollutants, some of which remain to be determined. These are likely to cause serious risks to the health and safety of workers in this plant if the protective measures are not respected. To this end, the GVD center emphasizes individual protective measures for workers.

Overall, the indoor air particulate measurement campaigns of the houses visited during the survey give acceptable values, they are below those obtained in Lomé in Togo (87g/m3 for urban sites and 32g/m3 in rural sites) (10). For PM1, the WHO has not recommended a threshold value for these types of particles because they are considered very dangerous, even at low doses. The two measurements of PM2.5 particles give values which are slightly higher than the WHO standard in 24 hours in the area where the measurement campaign took place (<15µ g/m3). On the other hand, they are lower than those taken from urban houses in Dakar (200µ g/m3) (16).

The PM 10 concentrations sampled in homes are below the threshold values recommended by the WHO (2021), which is 45µ g/m3 after 24 hours. However, these values may vary from place to place, depending on the direction of the wind. Thus, the work of Zakari et al. (13) who dealt with air pollution by carbon monoxide (CO) in households in the 3rd municipal district of the city of Zinder proved that the weather conditions and the place of measurement (kitchen or living room) make the average values of the pollutants oscillate.

The interview with workers in the plastic waste recovery sector revealed cases of discomfort, especially for beginners.

The visit to the workstations within the factory allowed us to observe and carry out on-site investigations and to check the conformity of the answers given by the workers during the various interviews. Employees are equipped with overalls, gloves, safety shoes and masks and this has been verified during observation visits, however to avoid smoke and dust at eye level goggles will be necessary and for inhalation, anti gas will be needed. Also, the locker room is in good condition, although it lacks cabinets and a resting place for workers).

The showers are also operational with running water supply. These visits also enabled us to detect negligence on the part of workers regarding health and safety conditions (wearing of PPE above all) and this proves the cases of minor accidents and incidents listed by the GVD employees surveyed. For the lockers, there are a few signs in places such as the gas bottle depot and the signposts at the various channels. The cases of accident of this structure are not documented because the related risks are low, but it deserves a particular look for the conformity with the standards in force.

V. Conclusion

Within the framework of a problem at the heart of the concerns, this work allowed the adaptation and the highlighting of the risks related to the activities of valorization of the center GVD, as well as its opportunities. The main objective of this study was to assess the environmental and social impacts related to plastic waste recovery activities within the plant. To carry out this study, we used a method of sampling the concentrations of particles present in the indoor air at the level of fifty-one (51) houses having been the subject of the household survey. The study focused on determining the perception of the populations living near the GVD-Zinder plant on the quality of the air they breathe in their neighborhood. A campaign to measure air quality parameters including PM1/PM2, 5/PM 10 and relative humidity took place in the households of the people surveyed, within the factory and a few meters from the factory site. The values taken are compared with the WHO guide values. In addition, observations of the health and safety conditions at work of the employees within the factory were made. The two main types of recycled solid plastic waste, namely rigid plastics and flexible plastics, are collected by a network of collectors and resold to the GVD center at more acceptable prices. The values taken are compared with the WHO guide values. In addition, observations of the health and safety conditions at work of the employees within the factory were made. The two main types of recycled solid plastic waste, namely rigid plastics and flexible plastics, are collected by a network of collectors and resold to the GVD center at more acceptable prices. The values taken are compared with the WHO guide values. In addition, observations of the health and safety conditions at work of the employees within the factory were made. The two main types of recycled solid plastic waste, namely rigid plastics and flexible plastics, are collected by a network of collectors and resold to the GVD center at more acceptable prices.

The results obtained show that it is a poorly structured sector but promises a bright future, given the significant contributions it continues to make in the sustainable management of waste in the city of Zinder, especially at a time when people's minds are focused on circular economy processes. However, the latter faces specific problems because the recovery of plastics requires mastery of the techniques, costs and environmental and health impacts of such a sector.

This study revealed the following impacts:

-on the environmental level, the recovery of plastic waste into secondary products allows Zinder to reduce garbage dumps which will have a direct impact on sanitation, the reduction of greenhouse gas emissions and certain diseases. It also saves the raw material which is oil;

-on the social and health level, this unit does not generate any significant negative effects for local residents and their workers, however work to correct nuisances and good environmental communication will be necessary for the continuation of this work in order to optimize some costs.

From an economic point of view, the recovery of plastic waste is profitable for a whole chain of actors, from society to the inhabitants of surrounding neighborhoods and villages, including municipalities and technical services and users. Also, the materials obtained could compete technically and financially with cement-based materials.

Although carried out on the basis of a representative sample, this study does not claim to be exhaustive or complete, nevertheless the main fields covered deserve special attention for the sustainability and restoration of the notoriety of this factory.

However, a more in-depth study will make it possible to judge the quality of the results obtained during the present study. This study thus paves the way for new studies to better understand the issue of waste management as a whole, throughout the country, by showing the challenges that remain to be met in order to achieve the objectives of ecological recycling.

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