

Sources and Propagation Mechanism of Odor Nuisance in the Landfill of Al Hoceima, Morocco

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SUMMARY

Waste landfills represent a potential health risk. Indeed, it is possible that chemicals migrate out of the site and pollute the environmental media (water, air, soil). Populations living near these sites can then become contaminated through the air they breathe, the water they drink or the plants that grow on these polluted soils. Several studies have shown the existence of health effects in relation to waste storage activity or the proximity of storage sites, respectively for workers and for local populations [1-5]. Currently in Morocco, 36% of urban household waste is destined for landfill in controlled landfills. A dozen-controlled landfills have already been set up. This less polluting solution than fly tipping is far from being a panacea. In the city of Al-Hoceima located in the North of Morocco, the problems caused by the controlled landfill affecting public sanitation is one of the constraints encountered by the managers of the landfill such as the group of Nkor-Rhiss communes and the delegate company PIZIRNO. This study aims to identify the impacts of the Al-Hoceima controlled landfill on local residents, especially odor nuisance. In addition to the inconvenience caused, odors are the source of fears of exposure to pollution that could prove dangerous. In this work we present an exploratory descriptive study, based on observation grids, surveys and interviews with landfill staff and residents. The study showed the potential for a marked impact of olfactory nuisances on populations. It follows from this the importance of improving the operation of the landfill to reduce gaseous emissions and therefore the exposure of populations to olfactory nuisances.

Keywords: Household Waste; Controlled Landfill; Public Sanitation; Olfactory Nuisances; Odors

Introduction

Landfill is the oldest method of disposing of urban waste. It is the last link in the chain of their management. It has always been considered the preferred waste treatment method due to its particularly low cost. In Morocco, interest in landfills, whose establishment was wild and spontaneous, has increased considerably and the priority of actions has been given to controlling the impacts generated by the multiplication of these uncontrolled sites. During the last decade, the concern relating to landfills has been integrated by the decision-makers concerned into the strategies of sustainable development. And with the support of the state, many large cities currently have new

controlled landfills as part of the national program for the management of household and similar waste (PNDM) [6]. The Al-Hoceima intermunicipal controlled landfill is part of this very ambitious program. It was created in June 2008 to deal with the anarchic management of solid waste in the municipalities of Al Hoceima, Beni Bouayach, Imzouren and Ajdir. The delegated management contract is established between the Nekor Ghiss group of municipalities, and the Pizzorno environment Morocco group represented by its subsidiary TEORIF, for a period of 15 years. Six years after the commissioning of this waste landfill, it seemed judicious to carry out an initial study of the impact of this landfill on the environment and exactly on the neighboring population who claim their fears because odor nuisance

caused by this site. The objective of this study is, on the one hand, to determine the exact sources of this olfactory pollution and to determine the radius of the propagation of these odors, and on the other hand, to propose the measures to be taken to reduce odor nuisance.

Description of the Study Site

The Al Hoceima controlled landfill, the construction of which required a budget of 47.5 million DH, has a storage capacity of 37,000 tons of waste, on an annual average, and extends over a total area of 34 ha (Figure 1). This site is located 16 km southeast of the city of Al Hoceima and about 3.5 km northeast of Izafzafene, with Lambert coordinates $X= 510,000$ m and $Y= 633,000$ m (Figure 1). It is intended for the burial of waste from the city of Al Hoceima, Beni Bouayach, Imzouren and Ait Youssef or Ali in addition to the municipalities of Izemouren and Ait Kamra (from July 2012). For the station of Al Hoceima, the calm wind covers 17% of the year, while 56.65% of the winds have a force of 1 to 3 m/s, 20% are between 4 to 6 m/s, 5 % are

between 7 and 9 m/s and only 1% of the winds exceed 10 m/s. Winds from the south and southwest are predominant, followed by winds from the west and north. 70% of the winds come from the South, 20% from the North and 10% from the West. In winter and spring, the winds are from the west to southwest, with occasional short and violent storms from the east. During the dry season, summer and autumn, the general regime is from east to north-east (the "chergui"), with daily alternation of sea and land breezes. This dry, hot wind is sometimes replaced, for short periods, by a westerly regime [7]. Regarding rainfall, the average annual rainfall is around 428 mm. It is characterized by an irregularity that manifests itself in the amount of water falling from one year to another, as well as the intensity of the rains. Winters are often wet and cool, while summers are hot with short-lived rainfall events [8]. We limited ourselves in the characterization of the study environment to climatology given the role of these two parameters in the fermentation of waste and the dispersion of odors.



Figure 1: Geographic location of the AL Hoceima controlled landfill.

Materials and Methods

Sources and Methods of Data Collection

To accumulate different points of view to investigate converging aspects, the study used a variety of data sources:

- Direct observation: it allowed us to appreciate the process of the propagation of Odors. The observation was carried out using an observation grid.
- The semi-structured interviews were carried out with the staff working in the controlled landfill.
- Analysis of complaints from the neighbouring population.

- The compulsion of certain documents: such as documents which are related to the actions carried out by the various stakeholders in the management and operation of the controlled landfill.
- A questionnaire in the form of a grid intended for the population surrounding the landfill site.

Sampling

To conduct sample surveys that are valued for their detailed data, accuracy and representativeness, careful selection of the study sample is required. This step is essential to be able to interpret the re-

sults of the study on the sample at the level of the total population. The principle of sampling implies that all the individuals or “units” of the population considered must have, at best, the same probability of being part of the chosen sample. The following graph illustrates the

principle used to do so. During our study, we were able to collect information from several residents close to the CET, their geographical positions are given in (Table 1) and well-illustrated in (Figure 2).

Table 1: Geographical positions of the samples.

Riverains	X (m)	Y (m)	Riverains	X (m)	Y (m)
R1	633285,7	510084,1	R15	639638,8	509484,7
R2	632998,0	510371,7	R16	632350,7	506703,7
R3	632278,8	509460,7	R17	631823,3	510779,3
R4	632830,2	509604,6	R18	630816,4	509844,3
R5	634148,8	511114,9	R19	630888,3	509149,1
R6	633501,5	510995,1	R20	634292,6	510227,9
R7	634987,9	511330,7	R21	635227,6	510563,5
R8	631128,1	509508,7	R22	635731,0	510827,2
R9	631607,5	510251,9	R23	635563,2	509412,8
R10	635731,0	511258,8	R24	634556,3	509340,9
R11	636018,7	510036,1	R25	633861,1	508717,5
R12	636522,2	510275,8	R26	632854,2	508310,0
R13	636522,2	511738,3	R27	632494,6	508813,4
R14	634915,9	512625,3	R28	632087,0	508310,0

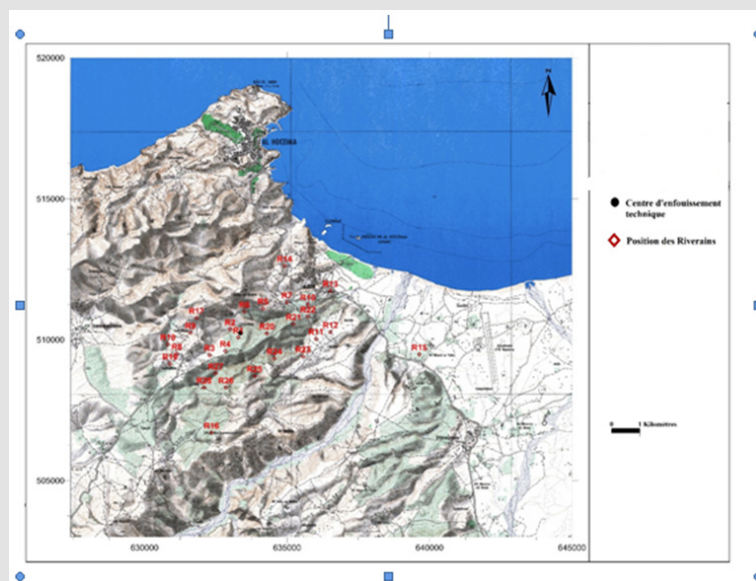


Figure 2: The location of the samples and their locations vis-à-vis the controlled landfill The staff.

The staff Regarding the personnel who work within the controlled landfill and who take care of the operation are distributed as follows:

- A state engineer in environmental engineering.
- Three technicians.

- Twenty workers (unskilled labor).

We collected the information of all the staff given their limited number.

Results and Discussion

The questionnaires, observation grids and interviews, collected either directly by our investigators or through the landfill managers, are analyzed using the computer tool (STATA). The results drawn from the complaints of the population are also presented and discussed. The survey was conclusive (Table 2). All residents have smelled the smell at least once during the year apart from the R15 located in the center of the rural commune of Sidi Bouafif (far from the landfill). 15 of them only smell the smell in winter and with a low frequency, except for R5, R6 and R10 who smell the smell during the summer with a medium frequency, given their approach to the site. The remaining

12 smell the odor in both seasons: half with low frequency and the rest with frequent to medium frequency since they are closest to the site (R1, R2, R3, R4, R9, R20). The time of appearance of odors and its duration depend on the geographical location and therefore on the microclimate of the area. Outside, there are two periods, one between 10 p.m. and 4 a.m. for a duration of 3 hours and another period between 4 a.m. and 8 a.m. for a duration of 2 hours. The intensity of the odor ranging on a scale from 1 to 5, varies for 70% of residents between 1 and 2 and 22% between 3 and 4, the 7% represented by R1 and R2 are at 5 therefore of high intensity since they are located at the edge of the site.

Table 2: Data extracted from the study concerning the perception of the smell, its intensity and the frequency of its appearance.

Riverains	x	y	Perception de l'odeur	Heures de perception		Fréquence d'apparition	Intensité de l'odeur
				hiver	été		
R1	633285,7	510084,1	Oui	04h-08h	18h-10h	Fréquente	5
R2	632998,0	510371,7	Oui	05h-08h	19h-09h	Fréquente	5
R3	632278,8	509460,7	Oui	03h-06h	23h-05h	Assez Fréquente	3
R4	632830,2	509604,6	Oui	04h-06h	18h-09h	Fréquente	3,5
R5	634148,8	511114,9	Oui	-	21h-04h	Moyenne	3
R6	633501,5	510995,1	Oui	-	22h-05h	Moyenne	3
R7	634987,9	511330,7	Oui	-	23h-05h	faible	3
R8	631128,1	509508,7	Oui	-	04-09h	faible	2
R9	631607,5	510251,9	Oui	05h-08h	18h-03h	moyenne	2
R10	635731,0	511258,8	Oui	-	23h-02h	Assez Fréquente	2
R11	636018,7	510036,1	Oui	06h-07h	03h-08h	faible	2
R12	636522,2	510275,8	Oui	-	03h-08h	faible	2
R13	636522,2	511738,3	Oui	-	23h-02h	faible	1,5
R14	634915,9	512625,3	Oui	-	06h-05h	rare	1,5
R15	639638,8	509484,7	Non	-	-	jamais	0
R16	632350,7	506703,7	Oui	-	06h-05h	une fois	1
R17	631823,3	510779,3	Oui	-	18h-03h	faible	1,5
R18	630816,4	509844,3	Oui	05h-09h	06h-12h	faible	2
R19	630888,3	509149,1	Oui	06h-07h	04-09h	faible	2
R20	634292,6	510227,9	Oui	06-07h	23h-05h	Assez fréquent	4
R21	635227,6	510563,5	Oui	05-06h	23h-06h	faible	3
R22	635731,0	510827,2	Oui	05-06h	02h-05h	faible	2
R23	635563,2	509412,8	Oui	-	23h-06h	rare	1
R24	634556,3	509340,9	Oui	-	23h-08h	rare	2
R25	633861,1	508717,5	Oui	-	22h-05h	rare	1
R26	632854,2	508310,0	Oui	-	22h-06h	rare	1
R27	632494,6	508813,4	Oui	05-09h	23h-08h	faible	2
R28	632087,0	508310,0	Oui	-	22h-06h	rare	1

Modeling of Results

By integrating meteorological data, the effect of relief, the perception of odors and their intensity, we were able to produce models representing the dispersion of the plume in the CET area, according to 4 scenarios:

Scenario I:

It can be described as a critical scenario, where a large area will be threatened by the dispersion of the smell from the landfill, including the inhabited areas of Izafafen, Ajdir and Azghar municipalities, even if it will be at low intensity. The dispersion of the plume is ovoid in direction North-East widened on the East side. This shape is explained by the corridor of North-East and South-West direction winds where the CET is located. The phenomenon of the valleys is clearly present in addition to the neighboring reliefs which are in the form of steps descending towards the watershed of Oued Ghiss. This scenario is expected between 10 p.m. and midnight or between 3 a.m. and 6 a.m. during the summer when the winds are fairly calm, and the landfilling and waste treatment are not carried out correctly due to material or human problems.

Scenario II:

The threatened area is medium, it corresponds to the socio-cultural center of Ajdir as well as the population located on the road leading to the landfill and a small population located east of Izafafen, even if the smell will be of low intensity. The dispersion of the plume is ovoid in a North-East direction. This scenario is planned in winter between 3 a.m. and 7 a.m. or between 6 p.m. and 10 p.m. or if there are moderate winds and the landfilling and treatment of waste are not carried out correctly due to material or human problems. This scenar-

io can also be expected during the summer between 10 p.m. and midnight or between 3 a.m. and 6 a.m., but with the following conditions: an average climate with moderate winds and the treatment is carried out correctly without incident.

Scenario III:

The threatened zone is intermediate between scenario II and scenario I. It corresponds to the Southwest of Ajdir, the West of Azghar and the North East of Izafafen, even if the smell will be of low intensity. The dispersion of the plume is ovoid in a North-East direction widened on the East side. This shape is explained by the corridor of North-East-South-West direction winds where the CET is located where the phenomenon of the valleys is clearly present in addition to the neighboring reliefs which are in the form of steps descending towards the watershed of Oued Ghiss. This scenario is planned in winter between 3 a.m. and 7 a.m. or between 6 p.m. if an incident occurs in the landfill compartments and leachate storage basins. This scenario can also be expected during the summer between 10 p.m. and midnight or between 3 a.m. and 6 a.m., if this summer is hot with calm winds and the treatment is done correctly without incident. This study detailed the phenomenon of dispersion of odors from this landfill and the primordial role of climatic factors in the dispersion of odors. Residents located within a radius of 2 km are often threatened by this sensation, but with a variation in intensity.

Determination of Odor Sources

The results of the semi-direct interviews which were carried out with the staff of the landfill show that 83.3% confirmed that the intensity of the olfactory nuisances is strong while 16.7% confirmed that the intensity is medium (Figure 3).

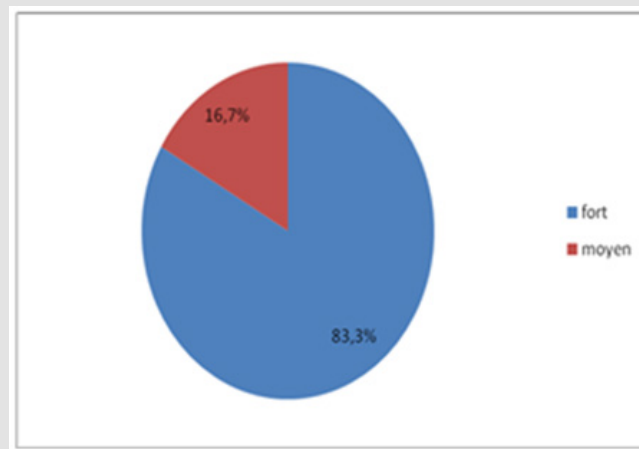


Figure 3: The intensity of smell on the CET according to employers.

Assuming there are four sources of odors:

- Uncovered garbage in lockers and dumping of fresh garbage during operation.
- Leachate stagnating in storage and those circulating in the WWTP (aeration basins and manholes).
- Absence of a biogas capture installation which escapes directly into the air without any recovery.
- Other problems related to the mode of operation: poor compaction of waste, cleanliness of machinery, compactors, and trucks.

The results of the survey to determine the sources of odor nuisance are shown in (Figure 4). 66.7% of those surveyed confirmed the presence of three sources while 33.3% reported the presence of four sources: they are added to the three sources the biogas which escapes into the air without any recovery. The lockers release numerous malodorous volatile organic compounds (VOCs) into the air,

fermentable organic substances and biogas, which are the source of major nuisances for the neighbourhood. These odors can reach a very large perimeter around the site (about 2 km). The fourth source of odors (biogas) which was not mentioned by 66.7% of people from unqualified employers since they have a lack of information on how waste works in a landfill bin and on the type of products generated by the biological/chemical decomposition of waste. On the other hand, 33.3% of respondents (engineers and technicians) are the most aware of the exact sources of olfactory nuisances. About biogas, its composition in major molecules (methane, carbon dioxide, oxygen, and nitrogen) is very variable and depends above all on the composition of the waste. Biogas also conveys a multitude of organic substances such as aldehydes, ketones, alcohols, aromatic compounds, halogen compounds and organosulfur compounds. The risks associated with biogas can be separated into risks for humans (toxicity of trace substances, asphyxiation of local populations) and risk of pollution of the atmosphere (greenhouse gases) (Figures 5-8).

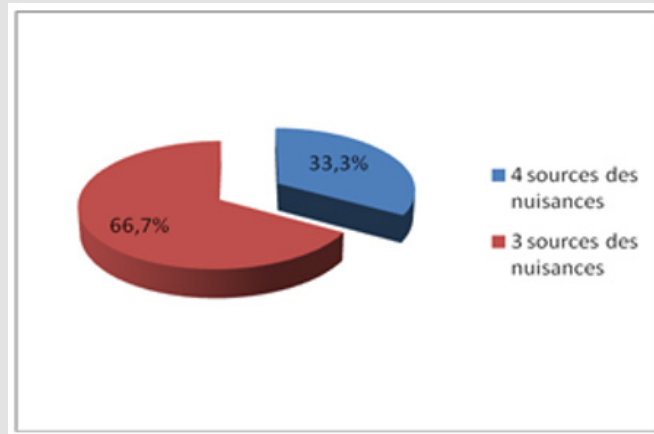


Figure 4: Sources of odor nuisance in the controlled landfill.

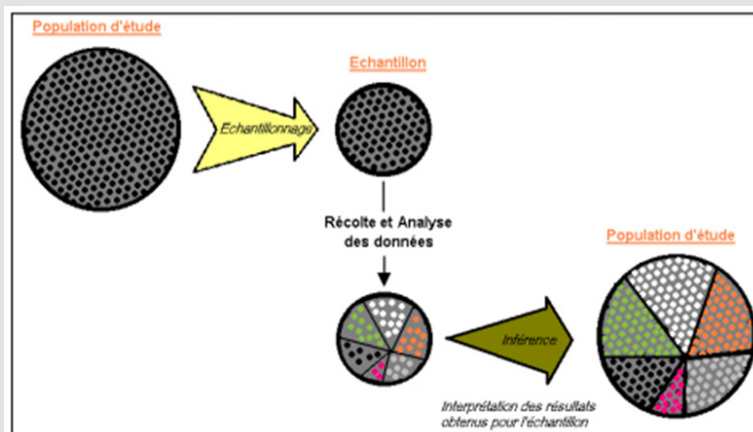


Figure 5: Diagram illustrating the methodology chosen in the sampling Location of residents.

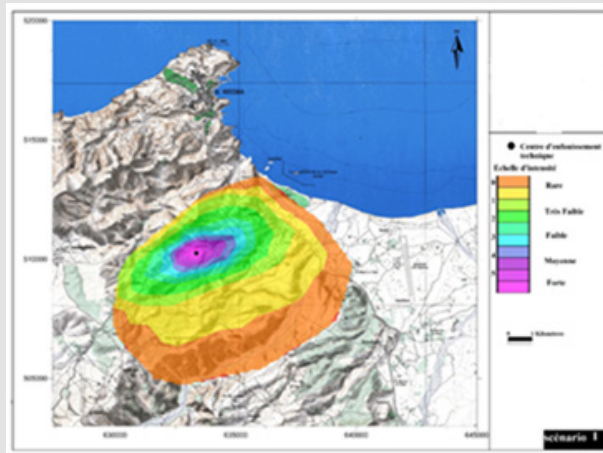


Figure 6.

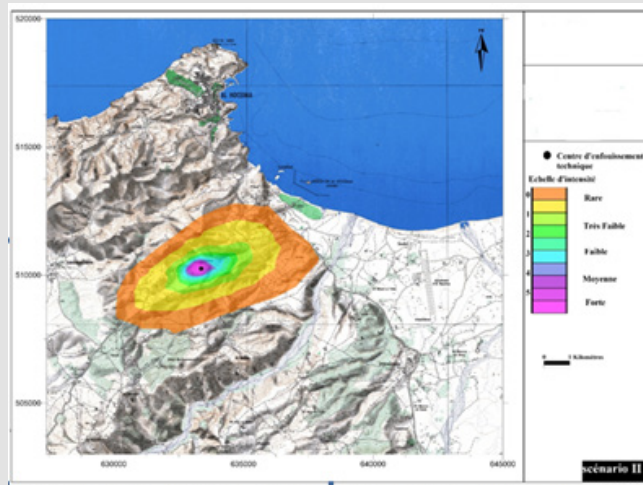


Figure 7.

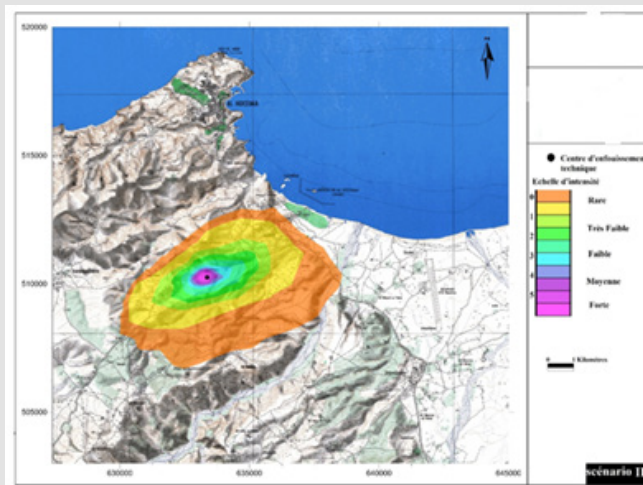


Figure 8.

Proposed Solutions to Minimize Odors at the Landfill

For the minimization of olfactory nuisances and the improvement of the treatment of the smell at the CET of AL Hoceima, certain points must be improved:

- **Products and Materials:** It is recommended to install an automatic weather station with a GPRS transmission system next to the leachate storage basin to alert the operator to the microclimate of the site and to know the direction of the flights and odors to be able to judge the relevance of certain complaints.
- **Installation of ramps fitted with Hydragel plates:** Another Westrand product that has proven itself in Moroccan landfills and WWTPs are NV hidragel plates. These are gel plates fixed in a support mounted on wooden or iron poles 2.30 m high and must be located at 3 meters from the leachate basins and around the cells in operation.
- **Installation of automatic pulverizer in the compactor:** Compaction is one of the sources of odor in the CET. To neutralize the smell upstream, automatic sprayers of Airhitone SD could be installed, so that the driver activates it during the last pass.
- **Installation of a withdrawal station to inspire biogas:** The age of the landfill is currently 6 years old, the quantity of biogas generated by this center will undoubtedly increase with the increase in the quantities of waste that has escaped and with the advancement of the age of the CET. An installation of a draw-off station to inspire the biogas is mandatory. This will send the biogas to the recovery unit such as the generator or to the disposal unit such as the flare.

Conclusion

This study allowed us to:

- Understand the mechanisms of dispersion of olfactory nuisance-

es around the controlled landfill of Al-Hoceima. This phenomenon is strongly influenced by climatic factors, the most important of which are wind (speed and direction) and atmospheric turbulence.

-Determine the main sources of odors at the controlled landfill, namely:

- Storage lockers for household waste (uncovered waste, dumping of fresh waste, etc.).
- The leachate storage basins are bacteriologically and especially chemically charged, both mineral and organic, which promotes the release of bad odors.
- Escape of biogas into the air.
- Dysfunction of the operating mode especially compaction.
- Finally, measures must be taken to minimize odor nuisance, especially improving the way the landfill is operated, improving Odor treatment, and capturing the biogas produced at this CET. This will reduce the dispersion of odors to protect local populations from olfactory nuisances.

References

1. M Vrijheid (2000) Environment Health Perspectives. Flight 108: Supplement 1.
2. BD Shusterman, J Lipscomb, R Neutra, K Satin (1991) Environmental Health Perspectives. 94: 25-30.
3. GF Bennett, Waste Hazard (1987) Materials. 4: 119-138.
4. Ph Thoumelin, Ch Bazin, MC Girod (2005) Study "Assistance in the identification of CMR (Carcinogenic, Mutagenic and toxic for Reproduction) risks for waste treatment sectors", RECORD 04-0660/2A.
5. H Dolk and All (2004) Environmental Health Perspectives. 112: 3.
6. (2008) National Household Waste Program (PNDM) State Secretariat for Water and the Environment Department of the Environment (Morocco).
7. B Allouah (2013) End-of-study project. National School of Applied Sciences of Al-Hoceima.
8. (2008-2012) Precipitation of AL Hoceima source: Direction of National Meteorology.

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