

## The Study of Correlation Between Acute Respiratory Infections and Oil Mills Pollution in Fez Rural (Morocco)

Adil Essahale<sup>1,2\*</sup>, Hicham Benbaqqal<sup>1,3</sup>, Iahcen Karrouch<sup>4</sup>, Mohieddine Moumni<sup>4</sup>

<sup>1</sup> Department of Biology-Geology, Ecole Normale Supérieure (ENS), Sidi Mohammed Ben Abdellah University (USMBA), Fez, Morocco

<sup>2</sup> Biotechnology, Environment, Agri-Food and Health Laboratory (LBEAS), Faculty of Sciences Dhar El Mehraz, USMBA, Fez, Morocco

<sup>3</sup> Laboratory of Geosciences, Environment and Associated Resources (LGERA), Faculty of Sciences Dhar El Mehraz, USMBA, Fez, Morocco

<sup>4</sup> Department of Biology, Faculty of Sciences Meknès, Morocco Moulay Ismail University, BP11201 Zitoun, Meknès, Morocco

\* Corresponding author's e-mail: [adil.essahale@usmba.ac.ma](mailto:adil.essahale@usmba.ac.ma)

### ABSTRACT

In order to evaluate the impact of olive activities on the population health in Fez rural, which is affected by air pollution, a retrospective study of acute respiratory infections (ARI) and chronic was studied (about ten years) in the commune of Ain Taoujdate (30 km of Fez center), known by its strong pollution particularly that of the air caused by industrial activity. Method using was the examination of medical records from 2004 to 2015. Analyzing the evolution of respiratory infections at Ain Taoujdate, we noticed a remarkable and repetitive increase, during olive tree campaign and in the spring (in each year), following the air pollution in the commune and abundance of pollen (pollinosis). Very high cases of pneumopathies recorded during the month of December 2004 and which reached 305 and 124 cases successively and which corresponds to the most important triturating activity during these twelve years of study. On the other hand the asthma crisis of Ain Taoujdate, shows a very large value in olive oil milling season. The main cause seems to be air pollution of Ain Taoujdate, since a large oil mill that releases a huge amount of fume is installed close to the population. Statistical analyzes using principal component analysis (PCA) and ascending hierarchical classification (HAC), were able to show an eventual correlation. This work excludes microbial infections; its limitation is the absence of air quality data and was the consequences to take stock of the impact of air pollution caused by oil mills on respiratory health

**Keywords:** respiratory infections, oil mills, Fez rural, Ain Taoujdate, Morocco, air pollution.

### INTRODUCTION

Protecting the environment is one of the pillars of sustainable development, which is a major challenge for the future of man and the planet. Air pollution is the first comprehensive and current account of the science of air pollution and its impact on human health [Robert et al., 1999]. The quality of the air we breathe induces short-term health effects such as allergies, asthma and other respiratory and long-term diseases of cardiovascular disease and lung cancer. WHO through

global air quality guidelines provide guidance on the limits of key air pollutants that pose health risks, including particulate matter (PM) which are indirect indicators of air pollution and consist of two components; particles with a diameter not exceeding 10 microns (PM<sub>10</sub>), which penetrate the lungs and particles with a diameter not exceeding 2.5 microns (PM<sub>2.5</sub>) are even more harmful to health. Ozone (O<sub>3</sub>) is also one of the main risk factors for morbidity and mortality related to asthma; carbon monoxide (CO) and nitrogen dioxide (NO<sub>2</sub>) and sulphur dioxide (SO<sub>2</sub>) which can also affect

asthma, bronchial diseases, pulmonary inflammation and impaired lung function [WHO, 2021].

Industrial activities are one of the main risk factors that influence not only personal and in this case called occupational diseases, but also the adjacent population [Andujar and Nemery, 2009]. In other words, occupational asthma, which is a type of asthma caused by certain chemical or biological agents present in the workplace, is considered to be the most common occupational respiratory disease, especially in industrialized countries [Ameille and Escatha 2004].

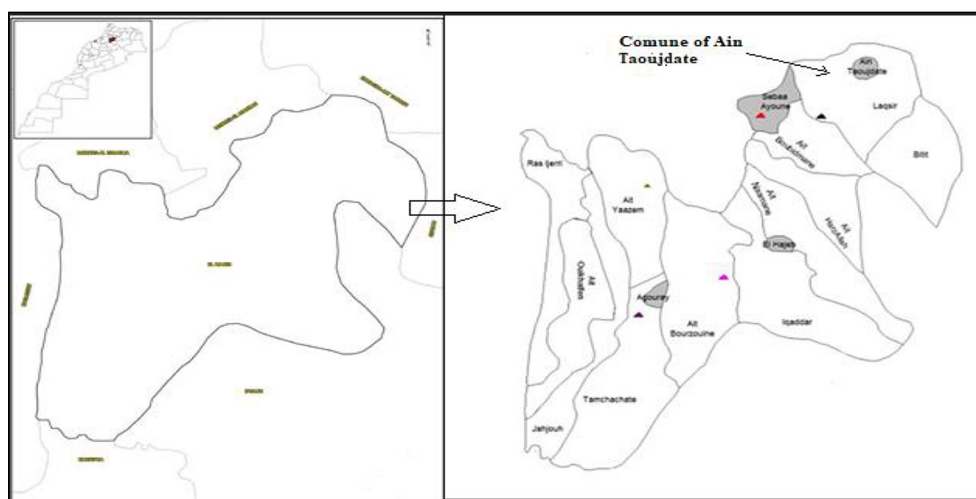
Among the industrial activities that generate air pollution is the olive sector, which is based on the extraction of olive oil. This extraction is carried out according to the following steps; the grinding which is carried out by millstones, the mixing which makes it possible to release the maximum of oil by mixers, the separation of the phases and finally the decantation [Essahale and Karrouch 2015]. Two types of processes are used: the industrial one, which is generally based on a continuous extraction system comprising a horizontal centrifugation which can separate the dough into three phases (oil, vegetation waters and solids) or two phases (oil and wet paste), if there is little or no water injection, followed by vertical centrifugation. The second, known as traditional, is done by discontinuous extraction often by pressure and gives two phases, the liquid is then filtered and precipitation allows the oil to be obtained [Benyahia and Zein, 2003]. Vegetation waters which are by-products of trituration, if they are not treated, have very harmful effects on the quality of water. The solid which is also

produced during this process is often dried leading, in order to reduce the humidity to around 10 to significant air pollution [International Olive Council guide, 2006].

FEZ is affected by air pollution, population living which has an impact on the health and living conditions industrial areas [Antouh and ElQandi, 2018]. This activity is important economic source in Ain Taoujdate and neighboring, because the olive tree is grown on about 8,060 ha of area with an average yield of 2 to 2.8 tons / ha [PDA-El Hajeb, 2010]. It generates alarming pollution, particularly in Ain Taoujdate, which is a commune located about 30 km from the city of Fez, and whose population is about 27,000 inhabitants [HCP-Fes-Meknes, 2019]. Several olive processing units are installed in the municipality and are well known for their air pollution in particula [Essahale, 2016]. This retrospective study aims to evaluate acute respiratory infections and asthma for about 10 years in the population of Ain Taoujdate, through the analysis of the registers of medical consultants at the level of the centers of health, and to correlate the causes and effects of these diseases with the air pollution of the oil olivier mills installed in this commun. Note that these observations are descriptive and require further analysis of the air to definitively establish a causal link

## Study area

The study is conducted in commun of Ain Taoujdate (the El Hajeb province, Fez, Meknes Region) (Figure 1).



**Figure 1.** Geographical location of the study sites in Fez region

## Patients and methods

The method using in this study was the examination of medical records from 2004 to 2015, to identified acute respiratory infections and correlate it with industrial activity extracting olive oil. The data were obtained by Tuberculosis and Respiratory Disease Diagnostic Center Provincial Delegation of Health in El Hajeb (Fez-Meknes region, Morocco). The diagnosis is made by general medecins to the health centers of Ain Taoujdate, and who are focal points trained in the respiratory health program. It should be noted that some patients have been referred to pulmonologists in the province as needed. All patients diagnosed in health centers as suffering from ARI or asthma (including asthma attack) are compulsorily declared under cover of the hierarchy, and the databases are analyzed, in accordance with the Helsinki Charter. Monitoring and evaluation are carried out periodically to ensure that the information collected perfectly.

It should be noted that the sample studied corresponds to the symptomatic cases presented daily to the health centers for a routine consultation, these are new declared cases, the number of which depends on the epidemiological and climatic conditions with the average of about twenty cases per day per health center, in a population of about 30,000 inhabitants and a number of children under five of about 5,000. Inclusive and exclusive criteria – Exlued on this study microbial (bacterial and viral) Pneumonia

## Statistic data analysis

In order to establish a typology of the study area, the statistical analysis of the data and in particular the principal component analysis (PCA), ascending hierarchical classification (AHC) and descriptive analysis were performed out using version 22 XLSTAT-2022 software. These methods have been widely used in many fields related to the environment and health to highlight associations between individuals and/or variables and to identify seasonal and anthropic influences on the environment and health [DeLagarde.1995; Vega et al. 1998; Parinet et al. 2005]. The Pearson correlation coefficient was used to establish correlations between ARI and asthma variables, and the t-test was used to compare variations in ARI parameters between different study periods (Jan 2004 to Dec 2015).

## RESULTS AND DISCUSSION

### Analysis of medical records consulting

By analyzing the evolution of ARI for the Ain Taoujdate from 2004 until 2015 in children under 5 years old (Figure 2a), We noticed almost the same shape of the curve repeated from year to year, with two very identifiable peaks. The first peak appears from November to the end of January, during the olive oil milling season (olive campaign), and the second corresponds to the spring season, which is known for hay fever due to the abundance of different types of pollen.

Indeed, the agriculturale of the commun is very famous for the olive-growing activity which plays an important role in the agricultural economy at the local level, thanks to the support of the agricultural development fund, within the framework of the Green Morocco Plan. Several oil mills are installed and are well known for their pollution, especially air pollution [Essahale, 2016], but also for their impact on aquatic environments [Bouaouine, 2020]. In this context, environmental pollution control commissions have raised concerns about violations, particularly regarding air pollution in Ain Taoujdate caused by some oil mills, they have issued fines and required the owners of these units to implement mitigation measures [Essahale, 2016; Study environnement d'huilerie Lousra, 2016], Despite this, pollution remains alarming. Studies have indicated significant health risks due to exposure to particulate matter, as well as ozone ( $O_3$ ), nitrogen dioxide ( $NO_2$ ), and sulfur dioxide ( $SO_2$ ), including acute lower respiratory tract infections, cardiovascular diseases, chronic obstructive pulmonary disease, and lung cancer [WHO. 2021; Vikram et al.2020]. Indeed, hydrogen sulfide ( $H_2S$ ), for example, has the characteristic, at low concentration, of being odorous and above all of causing corrosion phenomena and irritating respiratory and ocular mucous membranes, knowing that ARI are a major cause of morbidity and mortality worldwide [Mansbach, Camargo, 2012]. Repeated exposure to this gas can also cause irritative bronchitis and skin irritation [Bouzaza et al., 2003]. Cliffe and Patumsawad found a significant correlation between the percentage of olive oil extraction waste and carbon monoxide emissions [Cliffe and Patumsawad 2001]. They noted that for all tests, carbon monoxide emissions ranged from 100 ppm to 350 ppm (114.561 to 400  $mg/m^3$ ), while the WHO recommends a value that should not exceed 4  $mg/m^3$  [WHO. 2021]. Other researchers

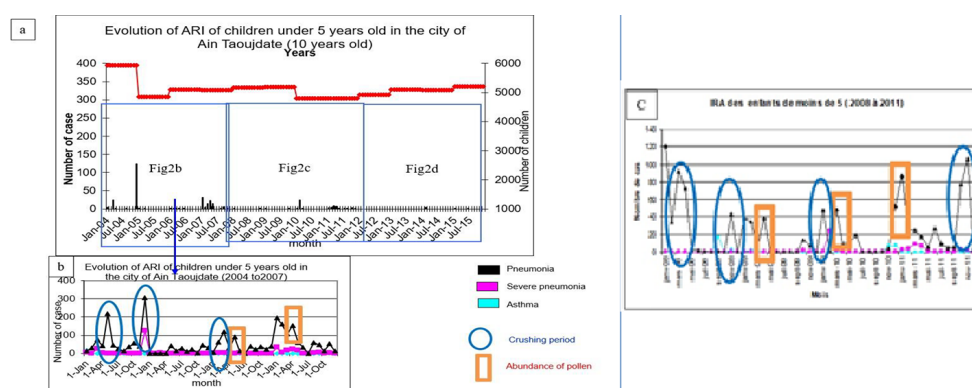
have confirmed the presence of toxic gases in atmospheric emissions from solids pyrolysis. For example, Blanco Lopez et al. 2002. found high levels of nitrogen ( $N_2$ ), oxygen ( $O_2$ ), carbon oxides ( $CO$  and  $CO_2$ ), and light hydrocarbons ( $CH_4$ ,  $C_2H_4$ , and  $C_2H_6$ ) [Blanco-López et al., 2002].

As part of the data analysis, we found that the month of December 2004 was marked by a surprising increase in pneumonia and severe pneumonia among children under 5 years of age, reaching 305 and 124 cases, respectively (Figure 2b), this coincides remarkably with the most important olive harvest campaign, which set a world record for olive oil production at around 3 174 000 tons t [International Olive Council, 2011]. A slight decrease in ARI occurred starting from 2009 with no new cases observed during certain periods, for example, between May 2009 and September 2009, and between July 2010 and October 2010 (Figure 2c). This decrease in ARI cases can be explained by a slight reduction in the impact of oil mills on the environment, after the

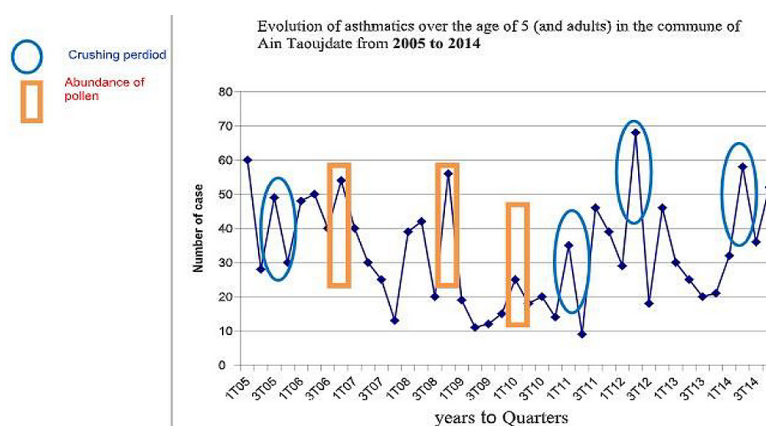
creation of the provincial committee for industrial pollution control. Indeed, Essahale have shown that the number of polluting oil mills, which was 93.75% in 2005, reached 51.51% in 2014, which is certainly one factor among others that explains this decrease.

Asthma were studied during the same period (2004–2015) for subjects over 5 years old (and adults). Figure 3 shows a remarkable correlation between asthma attacks and olive oil activity, on one hand, and the presence of high pollen concentrations in the air on the other hand. There is a sequential increase in asthma attacks at the end of the fourth quarter and the beginning of the first quarter of each year studied, which corresponds to the period of olive oil processing.

The increase in asthma crises is also observed during the spring period due to the abundance of pollen in the air. During the spring season, the concentration of pollen in the air is high, as the vegetation cover of the region is dominated by cereal crops and fruit tree plantations, notably olive trees [Essahale,



**Figure 2.** a) Evolution of ARI of children under 5 years old in the city of Ain Taoudjate (10 years old), b) Evolution of ARI of children under 5 years old in the city of Ain Taoudjate (2004–2007), c) Acute respiratory infection (IRA) in children under 5 years old of ain Taoudjate (2009–2010)



**Figure 3.** Evolution of asthma crises in individuals over 5 years old in the city of Ain Taoudjate between 2005 and 2014



2016], The pollination of this plant occurs around the month of May, which coincides remarkably with the second peak of respiratory infections. During this time, the plant releases large quantities of pollen. Studies on its pollen and recombinant allergens have currently shown 10 recombinant allergens [SETE, 2018]. Similar results were found by Alaoui Yazidi and Bartal Gaussorgues [Alaoui and Bartal, 2000], who studied skin sensitization to the olive tree (*Euro-paea*) in 640 subjects consulting for the first time for asthma and/or rhinitis and/or conjunctivitis across several regions of Morocco. They showed that the prevalence was high in regions where the olive tree is implanted, and that in Meknes (a city located about 50 km away from Ain Taoujdate) and its regions (including Ain Taoujdate), it represented 40% of the cases [Alaoui and Bartal 2000]. The commune of Ain Taoujdate is known by oil mills that release a huge amount of smoke [Essahale, 2016].

The concerns regarding the impact of air pollution have led governments and local authorities to regulate it. Air pollution is regulated by regulations regarding classified installations for the protection of the environment. According to Articles 2, 4, and 5 of Decree No. 2-09-286 setting the air quality standards and the methods for air monitoring [Decree n° 2-09-631, 2010], mainly the air quality index (the overall air quality of an agglomeration), the limit value for health protection for hydrogen sulfide ( $H_2S$ ), and sulfur dioxide is  $125 \mu g/m^3$ , 99.2 percentile of daily averages, and PM10 should not exceed a total of  $50 mg/m^3$  [Decree n° 2-09-631, 2010]. Despite all the efforts of the state to minimize air pollution, the impacts of olive activities on health remain very significant, especially during the milling period. In Fez the damage due to air pollution and noise pollution takes into account the negative impacts on health [Antouh and ElQandi, 2018].

## Statistical analysis

The results of descriptive statistical analysis are summarized in Table 1. We note that the high standard deviation values for the majority of variables indicate a large dispersion of their distributions. These standard deviations may be due to temporal and seasonal variations (climate change) as well as anthropogenic factors (impact of air pollution). Table 2, which summarizes the results of Pearson correlation tests, indicates that the majority of the respiratory parameters show significantly high correlations (calculated significance level  $P < 0.05$ ). Asthma is negatively correlated with the other respiratory variables. Severe pneumonia and pneumopathy are fairly strongly correlated with each other ( $r_{\text{severe pneumonia-pneumopathy}} = 0.634$ ).

Principal component analysis (PCA) performed on the data matrix for the three variables are shown in Figures 4 and 5. The correlation circle (Fig. 4) clearly shows that of the respiratory variables (Severe Pneumo and Pneumonitis) are positively correlated with the first main component (F1 54.62%), unlike Asthma which is negatively associated with this axis. This axis (F1) allows the identification of the enrichment of the variables described above in relation to the anthropogenic contributions to Ain Taoujdate mainly during olive-growing companion.

The PCA results (Fig. 5) show that the first two factor axes (F1 and F2) contribute to explain more than 87.85% of the total variation. In the general case, a better representation of point cloud in this factorial plane is shown by much of the inertia [DeLagarde, 1995]. We will observe in particular the regular and significant increase in the scattering of the points along component 1 (component of the respiratory variables: Severe Pneumo and Pneumonitis) The analysis is not done in

**Table 1.** Descriptive statistics

Variable	Observations	Minimum	Maximum	Average	Standard deviation
Asthma	144	0.000	20.000	0.773	2.884
Severe pneumo	144	0.000	124.000	2.333	11.254
Pneumonitis	144	0.000	305.000	31.444	43.917

**Table 2.** Pearson correlation matrix (n)

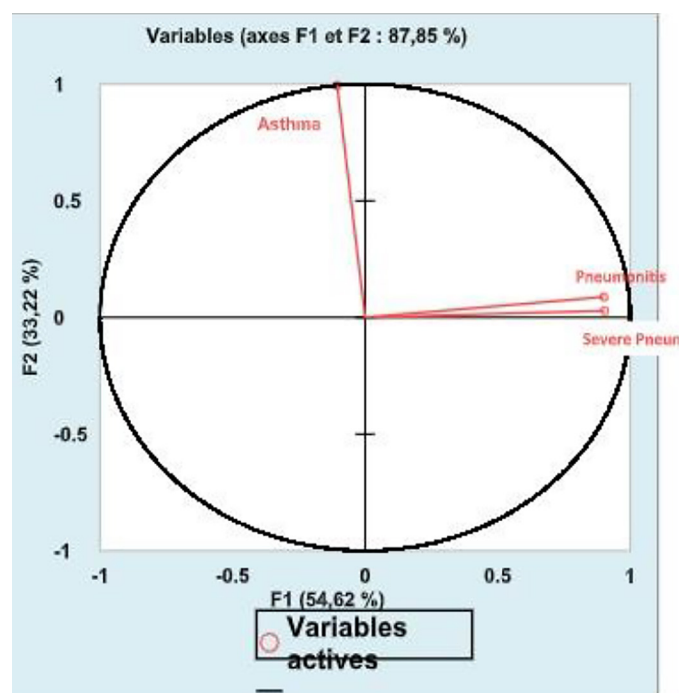
Variables	Asthma	Severe pneumo	Pneumonitis
Asthma	1	-0.019	-0.056
Severe pneumo	-0.019	1	0.634
Pneumonitis	-0.056	0.634	1

relation to the center of gravity of the cloud of points in space  $R_n$ , but in relation to the origin. Indeed, all the variable points are on a sphere, of radius 1 centered at the origin of the axes [DeLagarde, 1995]. Concerning the distribution of the Ain Taoujdat surveys on the F1 X F2 projection plane (Figure 5), all the points occupy positions consistent with what is known from their environment. Indeed, the CPA shows that the measurements periods for months 1 and 2 of 2004 and 2007 were positively coordinated on component 1 (the evolution is mainly according to component 1). This shows the importance of anthropogenic emissions (olive processing plants) on the evolution of respiratory diseases during this period and that the measurements in 2004, 2007, 2012, and 2014 have the largest amplitudes. This is entirely consistent with what was mentioned in Figure 3 and derived from the epidemiological data of the Ain Taoujdat municipality.

The temporal evolutions of asthma during the study period for both Ain Taoujdat were evaluated by the dispersion of the point cloud corresponding to the different samplings. The results of the PCA (Figure 5) show that the first two factorial axes (F1 and F2) explain 100% of the total variation. We can particularly observe the regular and significant increase in the dispersion of the points along component 1 as we move in the direction of the  $-45^\circ$  linear bisecto.

PCA was supplemented by a HAC. This classification was performed using the same quantitative variables used for the PCA (data matrix). The results of the HAC allowed the discrimination of 5 classes (Figure 6):

- Class 1: This class is composed of 72 records. The barycenter of class 1 is composed of severe pneumopathy. The identities of the closest observations to the center of gravity of the class or “exemplars” are characterized by mean parameters lower than the overall average.
- Class 2 and Class 3: These two classes are composed of 64 surveys. They contain 45% of all the surveys studied. On the principal component 1 (Axe 1), these relevés have positive coordinate. The individuals in these classes are characterized by high variability during the study period, specifically in the months of January 2004, January-February-March 2007, and December 2012. These statistically raised peaks significantly coincide with periods of olive crushing and pollen abundance. Indeed, this is reflected in an increase in the number of cases of pneumonia (class centroids).
- Classe 4: It is formed by 4 records. This class is characterized by a very high intra-class variance (1113.14) compared to class 1 (50.94). The centroid of this class is formed by Asthma (newly declared cases of asthmatics).The



**Figure 4.** Correlation circle of the respiratory variables (asthma, serve pneumo and pneumonitis)

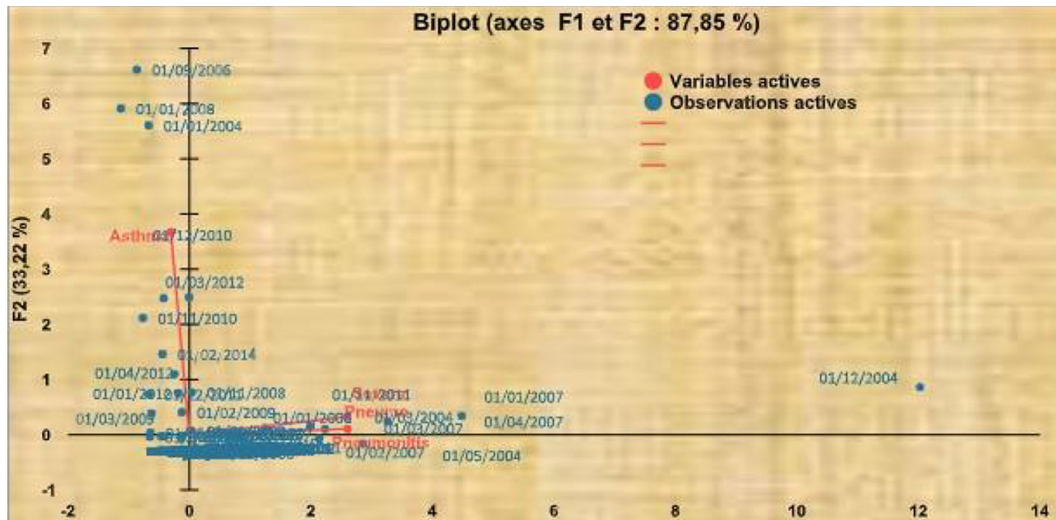


Figure 5. Principal component analysis (PCA)

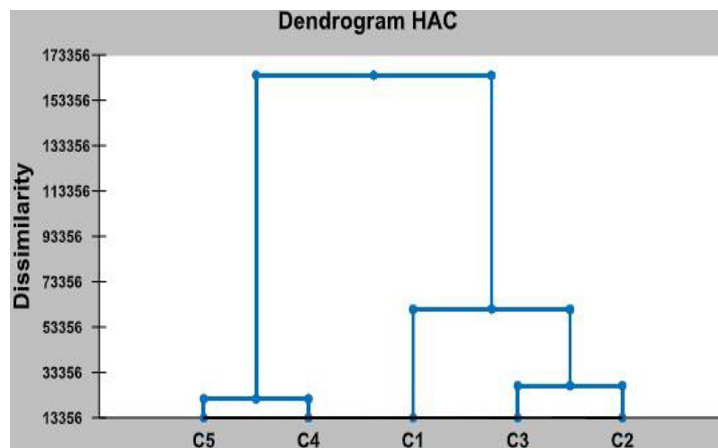


Figure 6. Hierarchical ascending classification (HAC) of Ain Taoujdate surveys

relèves closest to the center of gravity of this class group together the measurements taken during the olive harvest seasons.

- Class 5: This class consists exclusively of an observation taken in December 2004 (01-12-2004, see Figure 5). This class is distinguished by a strong correlation with the axis 1 and a very large distance from the barycentres of the other classes. The most logical explanation may be the effect of air emissions during the drying of olive marc, which increases at the beginning of the olive season.

By referring to many subsequent studies, which prove the strong pollution caused by oil mills and correlating with statistical studies; we can only make the link between air pollution in the municipality and respiratory diseases. Above all there are no other sources of air pollution mentioned in the bibliography during the study period.

## CONCLUSIONS

In conclusion after monitoring the evolution of acute respiratory infections and chronic respiratory diseases (especially asthma) in the Ain Taoujdate community for 10 years, an increase in cases of these infections during olive harvesting seasons and in the spring due to the presence of large quantities of pollen, which can cause hay fever, has been observed. This could be due to air pollution from crushing units installed within the perimeter of the municipality. The statistical analyses using PCA and HCA confirmed our assumptions and allowed the correlation of causes/effects between the studied lung diseases and pollution from the olive crushing sector. Quantitative studies of different types of air pollutants are possible to prove this correlation.

## Acknowledgements

We thank the health personnel at the Delegation of the Ministry of Health and Social Protection of Fez and El Hajeb, for all the efforts made to carry out this work.

## REFERENCES

1. Ameille J., Escatha A. 2004. Occupational asthma. *Presse Med.* 33, 882–90.
2. Andujar P., Nemery B. 2009. Acute and subacute respiratory diseases of toxic origin. *Rev. Mal. Respir.* 26, 867–85 <https://doi.org/10.1019/20094111>
3. Antouh B. and El Qandi M. 2018. Environmental impacts and cost of degradation-remediation of air pollution and noise pollution of the urban community of Fez (Morocco) *Advances in Science, Technology and Innovation* Pages 1979–1980.
4. Yazidi A.A, Bartal M. 2000. Prevalence of skin sensitivity to olives in Morocco: multi-center study. *Journal of Allergy and Immunology*; (in French) 40(4), 481–488.
5. Benyahia N., Zein K. 2003. Contribution spéciale de Sustainable Business Associates (Suisse) à l'atelier, Enjeux de pollution et de développement dans le bassin méditerranéen, 2nd International Conference on Swiss Environmental Solutions for Emerging Countries (SESEC II) du 28–29, Lausanne, Suisse.
6. Blanco-López M.C., Blanco C.G., Martinez-Alonso A., Tascou J.M.D. 2002. Composition of gases released during olive stones pyrolysis. *Journal of analytical and applied pyrolysis.*, 65, 313–322.
7. Bouaouine O. Bourven I. Khalil F. Baudu M. 2020. Reuse of olive mill wastewater as a bioflocculant for water treatment processes. *Journal of Cleaner Production.* 246.
8. Bouzaza A. Marsteau S. Laplanche A. Garrot B. 2003. Hydrogen sulfide adsorption on activated carbon fiber Tests on Parisian subway Pollution Atmosphérique. 178.
9. Cliffe K.R., Patumsawad S. 2001. Co-combustion of waste production with coal in fluidised bed. *Waste Management*; 21, 49–53.
10. Decree No. 2-09-631 of 6 July 2010 setting the limit values for the release, emission or discharge of pollutants into the air from fixed sources of pollution and the procedures for their control (in French).
11. DeLagarde, J. 1995. Introduction to data analysis. 1995, (in French); 3<sup>ième</sup> Edition, Dunod, Paris.
12. Essahale A. and Karrouch L. 2015. Contribution to the study of oil mills impact on the environment in El Hajeb province. *Archives des Maladies Professionnelles et de l'Environnement.* 76, 355–365. <https://doi.org/10.1016/j.admp.2015.05.004>
13. Essahale A. 2016. Impact of oil mills in the province of El Hajeb (Morocco) on the environment; monitoring and recommendations. Ed. Universitaires européens.
14. HCP-Fes-Meknes. 2019. High Commission for Planning Regional Direction Fès-Meknès, monograph of the province of El Hajeb.
15. High Commission for Planning Morocco HCP- report 2014. The social indicators of Morocco legal deposit: 172/1997.
16. International Olive Council Guide. 2006. Olive Pomace Oil Extraction Industry Quality Management Guide. Conseil oléicole international T33–1/4.
17. International Olive Council (IOC). 2011. Economie, science et technique OLIVÆ/N° 115.
18. Mansbach, J.M., Camargo, C.A. 2012. Acute Respiratory Infections. In: Litonjua, A. (eds) *Vitamin D and the Lung.* Respiratory Medicine, 3. Humana Press, Totowa, NJ. [https://doi.org/10.1007/978-1-61779-888-7\\_9](https://doi.org/10.1007/978-1-61779-888-7_9)
19. Parinet, A., Boukari, S.O.B. and Adima, A. 2005. Evaluation of the state of river water by multidimensional analysis using some characteristic parameters of dissolved organic matter. *Journal of Water Sciences*, (in french). 18, 133–163.
20. PDA- El Hajeb. 2010. (Direction of Agriculture El Hajeb). Study day on the olive sector theme «The olive tree in the province of El Hajeb State of play and development prospects in the framework of the Green Morocco Plan 2010.
21. Robert M., Stephen H., Hillel K., Jonathan S. 1999. *Air Pollution and Health.* 1st Edition – Academic Press -April 21, 1999. eBook.
22. SETE (Society for Technical and Environmental Studies) 2018. Environmental impact study of a project to establish an olive crushing unit in the municipality of Laqsir circle Ain Taoujdate.
23. Study report environnement d'huilerie Lousra; 2016. Environmental impact study of a wastewater treatment plant project and environmental upgrade strategy for the Lousra oil mill.
24. Vega, M., Pardo, R., Barrado, E. and Deban, L 1998. Assessment of Seasonal and Polluting Effects on the Quality of River Water by Exploratory Data Analysis. *Water Research.* 32, 3581.
25. Vikram R. William V. Particulates Matter. 2020. Impact, Measurement, and Remediation of Airborne Pollutants. 1st Edition ELSVIER eBook. <https://www.sciencedirect.com/book/9780128169049/particulates>
26. World Health Organization. 2021. WHO air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide. Policy Brief.