EJMHR ISSN 2786-8524
EUROPEAN JOURNAL OF MEDICAL AND HEALTH RESEARCH
OPEN ACCESS
PEER REVIEWED

# Integrated Approach for the Assessment of Real Risk of Population Exposure in Industrial Areas

**Mario Negrone**
Local Health Authority of Potenza - Prevention Department, Italy
**Michele Greco**
University of Basilicata - Engineering School, Italy
**Carmine Serio**
University of Basilicata - Engineering School, Italy
**Guido Masiello**
University of Basilicata - Engineering School, Italy
**Angela Cerosimo**
University of Basilicata - Engineering School, Italy
**Francesco Arbia**
University of Basilicata - Engineering School, Italy
**Antonio Sinisgalli**
ATS Brescia - Food Hygiene and Nutrition Service, Italy

## Abstract
Research goal is to identify an integrated approach for assessing real risk exposure of population located in areas of extractive industries. We focused on environmental data evaluation (diffusion model), figures and contextual analysis of active health surveillance data of the population (questionnaire, chemistry panel, spirometry and activation of a biobank). Environmental exposure data crossed with the calculation of the AQI (Air Quality Index) did not highlight any critical issues. A cohort of 600 locals subjected to health surveillance was analysed by calculating risk perception; a questionnaire aimed at assessing risk perception was administered to the population sample.All data (environmental and clinical) were georeferenced and analysed using GIS (Geographic Information System) software; study of contaminant distribution was carried out using a Q-GIS software shows average exposure conditions well below regulatory limits, with minor exceptions relative to concentrations of finer particulate matter (PM 2.5) and with reference only to the major urban centers; analysis of risk perception evince "incorrect" perception, with little confidence in relation to the environmental monitoring of the Regional Agencies.

## More Information
**How to cite this article:** Negrone M, Greco M, Serio C, Masiello G, Cerosimo A, Arbia F, Sinisgalli A. Integrated Approach for the Assessment of Real Risk of Population Exposure in Industrial Areas. Eur J Med Health Res, 2024;2(5):58-66.

**DOI:** 10.59324/ejmhr.2024.2(5).06

**Keywords:**

Environment,
pollution,
study population,
active health surveillance,
extractive district



## Introduction
Environmental epidemiology studies aim to assess the effect of environmental factors on human health, encompassing both the physical environment (physical, chemical and biological agents) and the social environment. As early as the 1950s, epidemiology determined a fundamental contribution in the study from disease development to environmental determinants. However, only since the 1980s an organized development of this specific branch has been determined. In the working routine all types of observational and experimental epidemiological studies are used in the field of environmental epidemiology (with inclusion of some nearly experimental and experimental, community-based study designs) [1,2,3,4]. The validity of an epidemiological study lies in producing correct estimates of the measures of interest, whether they are measures of frequency, such as prevalence, rates or risks, measures of association such as relative risks or odds ratios, or measures of impact, such as attributable risks and proportions [5,6,7]. The major critical issues associated with these types of studies relate primarily to the estimation of the measure of exposure (either the study factor or other factors that may play a role in the determinism of disease), cohort selection,

measures of association and effect. The objective of the present research is to define an integrated approach in the assessment of exposure risk through the analysis of environmental [27] and health data and concomitantly through the implementation of active health surveillance on population groups. The aim is to evaluate the health status of the population sample in question from not only the purely clinical aspect but also with an insightful and ample analysis on aspects such as environmental risk perception, social and health integration.

## Research Objective

The objective of the study was to carry out an epidemiological survey and assess the health status of the population residing in the region with high anthropogenic pressure (municipalities of the Agri Valley and areas near extractive industries) in relation to exposure to the main sources of air pollution. The effects of environmental exposures, after taking into account the social, economic level, were studied using a residential cohort approach, which, in the context of observational studies, is the one that best assesses the association between" an exposure", in this case exposure to industrial pollutants, and its effect (mortality/morbidity) [8] on the health of a resident population exposed. As suggested by the European Environment Agency [9,25] for the estimation of individual-level exposure, pollutant dispersion models provided by ARPAB and the School of Engineering of the University of Basilicata were used; allowing considering the mechanisms involved in air pollutants dispersion and taking into account also the meteorology and orography of the surveilled area. To each individual in the cohort, based on the address of residence, were assigned indicators of exposure to sources of pollution existing in the area, estimated using atmospheric dispersion models. For each resident, exposure level was restored by analyzing annual emissions and meteorological conditions from 2006 to 2020. The reconstruction of emission scenarios for the various industrial sources was developed through collected and structured data on a digital platform.

## Methods

### Environmental Profile

The assessment of the environmental profile [10] was carried out on the basis of data provided by ARPA Basilicata and derived from five control units located on the territory and from reference data published on institutional sites. Air quality monitoring is carried out through the use of five fixed control units, one of which is pre-existing (named Viggiano - Industrial Zone and in operation since 2006) and four newly installed (named Viggiano 1, Grumento Nova, Masseria De Blasiis, Costa Molina Sud 1, installed on November 16, 2011 and transferred in ownership to ARPA Basilicata on September 4, 2012), located around the Val d'Agri Oil Center. At the Viggiano 1, Grumento Nova, Masseria De Blasiis and Costa Molina Sud monitoring stations, acquisition of the following concentration values is carried out: sulfur dioxide ($SO_2$), ozone ($O_3$), carbon monoxide (CO), nitrogen monoxide (NO), nitrogen dioxide ($NO_2$), nitrogen oxides ($NO_x$), atmospheric particulate matter with aerodynamic diameter less than 10 µm ($PM_{10}$), atmospheric particulate matter with aerodynamic diameter less than 2.5 µm ($PM_{2.5}$), hydrogen sulfide ($H_2S$), methane ($CH_4$), non-methane hydrocarbons (NMHC), total hydrocarbons (THC - Total Hydrocarbons), Volatile Organic Compounds (VOCs): benzene ($C_6H_6$), toluene, ethylbenzene, m,p,o-xylenes (BTEX); sulfur-mercaptan compounds; Radon gas concentration measurement.The air quality index [11,12,13] is a quantity that makes it possible to represent in synthetic manners the state of air quality by simultaneously considering data from several air pollutants. The indicator, associated with a scale of air quality judgments, represents a simple and immediately readable tool, untethered from units of measurement and to legal limits [18]. This index varies depending on the number of pollutants screened and the air quality standards established by Legislative Decree 155/2010 (D.lgs). In calculating the air quality index (AQI), the following six pollutants were taken into account, whose potential impact on human health in industrialized areas has been highlighted in the scientific literature

1- Particulate matter ($PM_{10}$), a collection of solid and liquid substances with a diameter of less than 10 microns. They result from emissions from motor vehicles, industrial processes, natural phenomena/environmental phenomena.

2- Particulate matter ($PM_{2.5}$) set of solid and liquid substances with diameter less than 2.5 microns. They result from industrial processes, combustion processes, motor vehicle emissions, natural phenomena.

3- Carbon monoxide (CO), gaseous substance formed by incomplete combustion of organic material, e.g., in motor vehicle engines and industrial processes.

4- Ozone ($O_3$), it occurs naturally in small amounts in Earth's atmosphere or is produced under certain conditions by the photochemical reaction between nitrogen oxides and hydrocarbons in the lower atmosphere called ground-level ozone and considered a major air pollutants.

5- Nitrogen dioxide ($NO_2$), a toxic gas formed in high-temperature combustion. Its main sources are combustion engines, thermal plants, and thermal power plants.

6- Sulfur dioxide ($SO_2$), an irritant gas, its largest source is burning of fossils by power plants, fuel with a high sulfur content or copper smelting.

Calculation was performed using the following formula:

$$AQI = \frac{\text{measured concentration}}{\text{legislative limit}} \cdot 100$$

Once the AQI for each pollutant has been determined, the worst quality index, i.e., the numerically highest of those measured, is considered.The Air Quality Index (AQI) classifies air quality into different categories based on health implications as following:

- Good (0-50): Air quality is satisfactory, posing little or no risk.
- Moderate (51-100): Acceptable, but some pollutants may concern sensitive individuals.
- Unhealthy for Sensitive Groups (101-150): Sensitive groups may experience health effects.
- Unhealthy (151-200): Everyone may experience health effects.
- Very Unhealthy (201-300): Health warnings; entire population at risk.
- Hazardous (300+): serious health effects; everyone should avoid outdoor exertion.

The urban areas surveyed in this study did not present an AQI beyond the baseline values set by D.Lgs 155/2010. Exception in a few circumstances. primarily related to exceeded of particulate matter concentration in the municipalities of Grumento Nova and Viggiano.

**Social Profile**

The social profile of the cities in this study was assessed based on available ISTAT (National Institute of Statistics) [26] data, focused on social-economics indicators. These data consisted of: income level, education level, and employment rate. All these factors gave an image of the standard of living for the population involved and identified questionable/doubtful aspects that could potentially influence the health outcome subject of this research.

**Statistical Analysis**

The statistical analysis was performed using multivariate models and assessed the correspondence between exposure to pollutants and health outcomes. The models were adjusted for potential confounders, including age, gender, socio-economic status, and other environmental exposures. The exposure measures were obtained from the pollutant dispersion models.

## Results

**Environmental Data**

The air quality monitoring data showed that Viggiano and Grumento Nova had the highest levels of particulate matter, nitrogen dioxide, and sulfur dioxide. These findings were consistent with the emission sources identified in the area and were primarily related to industrial activities and vehicular traffic.

The annual average concentrations of pollutants were compared to the legal limits set by D.Lgs 155/2010. In several instances, the concentrations of PM10, PM2.5, NO2, and SO2 exceeded the legal thresholds, particularly in industrial zones.

**Calculation of Air Quality Index**

The calculation of daily AQI values indicated "good" evaluation class values (e.g., for Grumento and Costa Molina stations) and/or "excellent-good" evaluation class values (e.g., for Masseria De Blasis and Viggiano1 stations) as shown in fig. 1 and fig. 2.

**AQI – daily**

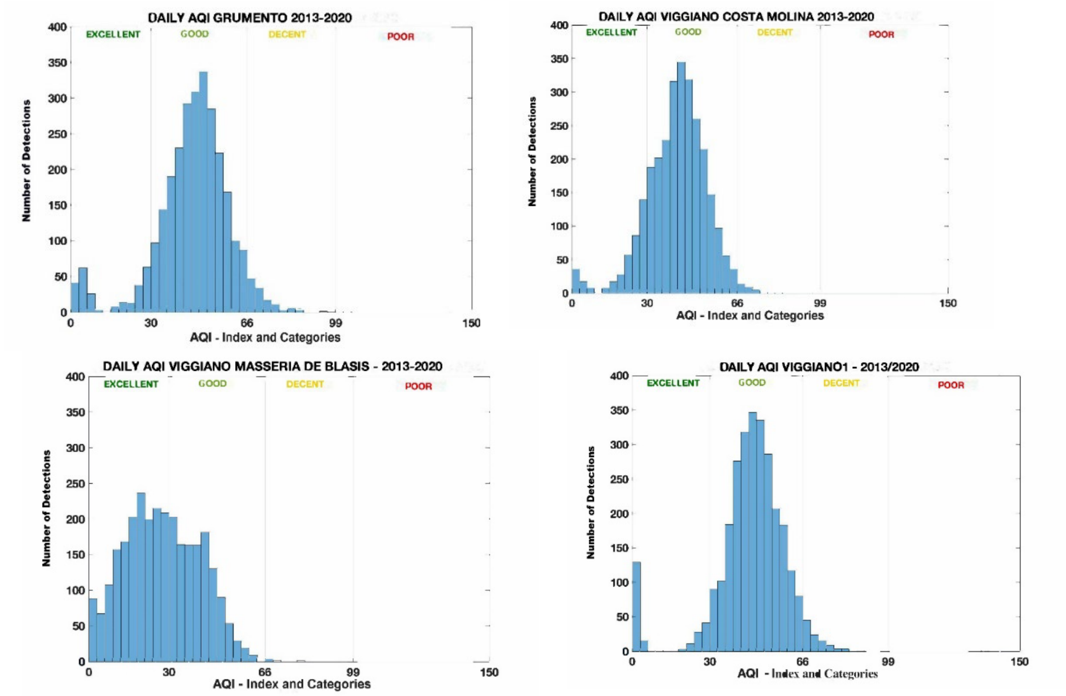



Figure 1: AQI Calculation - Daily Values

Similarly, calculation of monthly AQI values indicated "good" evaluation class values (e.g., for Grumento and Costa Molina stations) and/or "excellent-good" evaluation class values (e.g., for Masseria De Blasis and Viggiano1 stations).

**AQI – monthly**

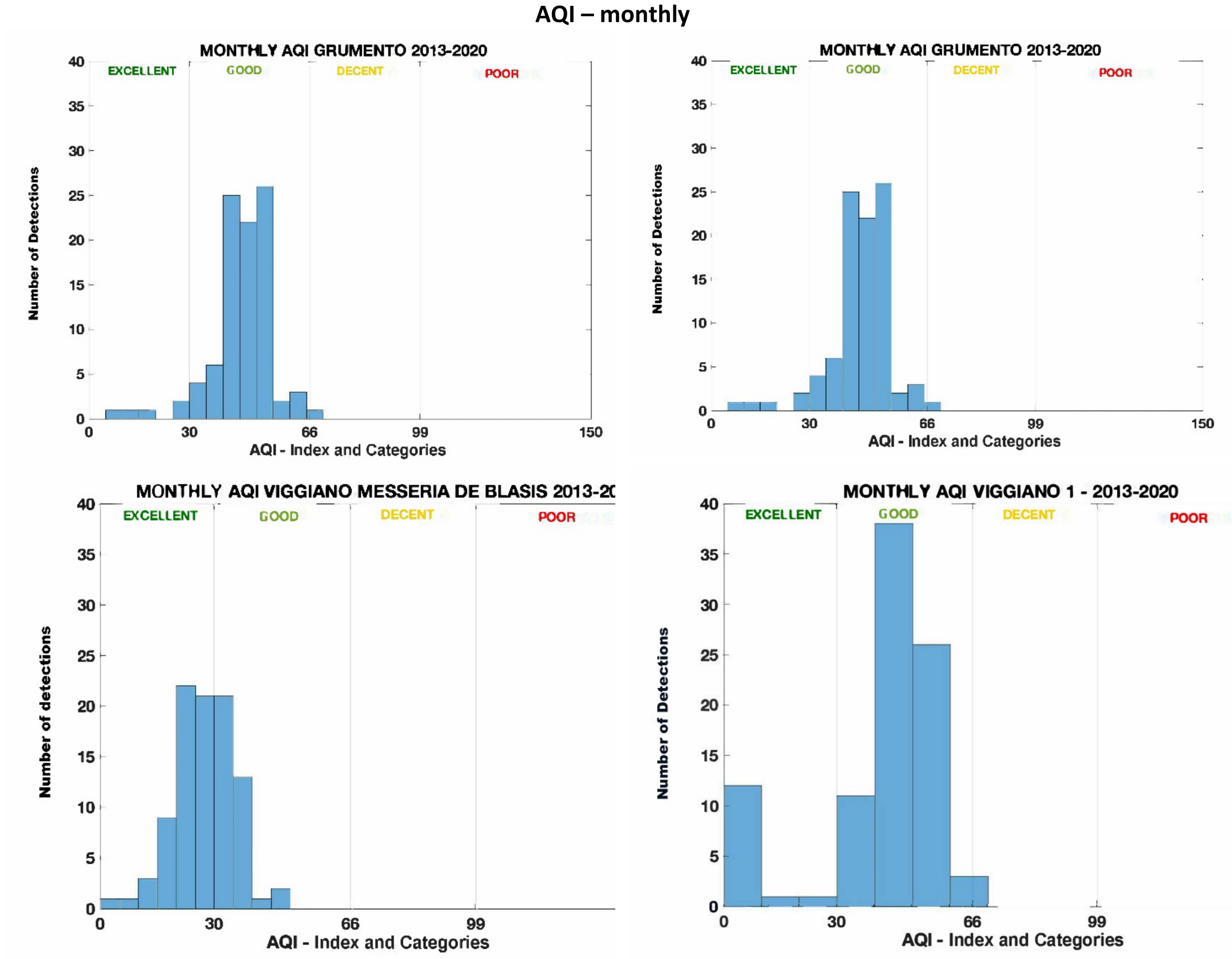



**Figure 2: AQI Calculation - Monthly Values**

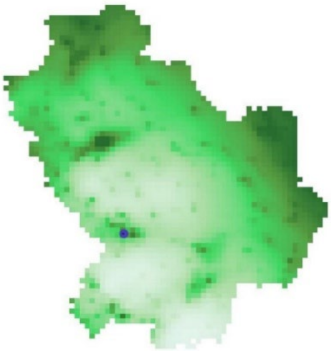
**Individual Contaminants –Models-sourced by ARPAB Station Data**

The study of contaminant distribution was carried out using a software and Q-GIS version 3.16.7 with Grass 7.8.5. The graphical representation of the data shows average exposure conditions well below regulatory limits, with minor exceptions relative to concentrations of finer particulate matter (PM 2.5*) and with reference only to the cities of Potenza and Matera.

Particularly in the municipalities within the Val d'Agri area, the average values of all contaminants were in the medium-low average ranges compared to the regulatory limit, as represented in fig.3 and 4. The concentration gradients shows, on a regional scale and for most of the contaminants studied, increases in concentration (although within normal ranges) in areas with higher population and/or industrial density with higher values near the regional capitals and in areas near the border with the province of Taranto and the industrial area of San Nicola di Melfi.

**Limit value according to D.Lgs 155/2010 and subsequent amendments (Annex XI, paragraph 1; Annex XIV, paragraphs 3 and 4).*

C6H6



**Concentration level ($\mu g/m^3$)**

| | | | |
|---|---|---|---|
| | | | 0-4 $\mu g/m^3$ |
| | | | 4-5 $\mu g/m^3$ |
| | | | >5 $\mu g/m^3$ |

● Oil Center Val d'Agri

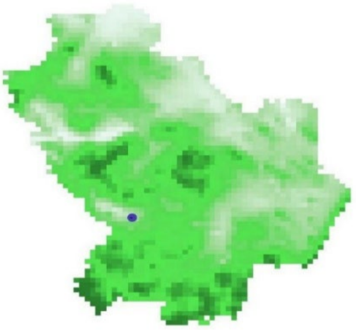
O3

**Concentration level ($\mu g/m^3$)**

| | | | |
|---|---|---|---|
| | | | 0-100 $\mu g/m^3$ |
| | | | 100-120 $\mu g/m^3$ |
| | | | >120 $\mu g/m^3$ |

● Oil Center Val d'Agri

PM 10



**Concentration level ($\mu g/m^3$)**

| | | | |
|---|---|---|---|
| | | | 0-40 $\mu g/m^3$ |
| | | | 40-50 $\mu g/m^3$ |
| | | | >50 $\mu g/m^3$ |

● Oil Center Val d'Agri

**Figure 3: Pollutant Dispersion Model (C6H6,O3,PM10)**

NO2

**Concentration level ($\mu g/m^3$)**

| | | | |
|---|---|---|---|
| | | | 0-150 $\mu g/m^3$ |
| | | | 150-200 $\mu g/m^3$ |
| | | | >200 $\mu g/m^3$ |

● Oil center Val d'Agri

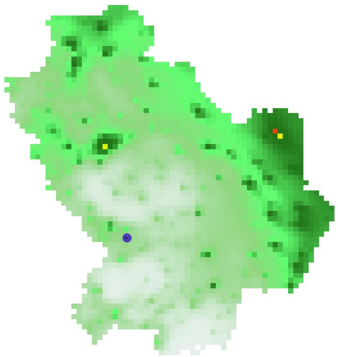
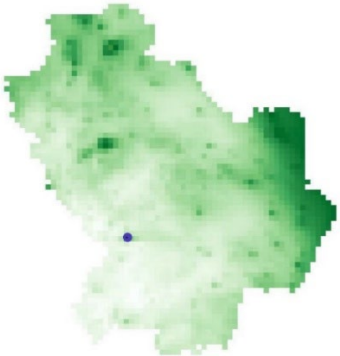
| PM 2,5 | |
|---|---|
|  | **Concentration level ($\mu g/m^3$)**<br>0-20 $\mu g/m^3$<br>20-25 $\mu g/m^3$<br>>25 $\mu g/m^3$<br>● Oil center Val d'Agri |
| SO2 | |
|  | **Concentration level ($\mu g/m^3$)**<br>0-100 $\mu g/m^3$<br>100-120 $\mu g/m^3$<br>>125 $\mu g/m^3$<br>● Oil center Val d'Agri |

**Figure 4: Pollutant Dispersion Model (NO2,PM 2,5,SO2)**

**Active Surveillance on Population Groups - Epibas Model**

The study approach of populations potentially exposed to anthropogenic pressure, based on active population surveillance [21,22,29] has taken place, as evidenced in the literature [14,15,16,17], with the aim of measuring on cohorts of potentially exposed individuals, indicators of health [23,24] and in some cases even molecular ones used for early diagnosis( eg mesothelin for mesothelioma diagnosis)

The Epibas study, in particular, aims to enhance the knowledge and link between Environment and Health in the area affected by extractive concessions in Basilicata [23-24], Val d'Agri (started in 1996 and became operational in 2001) and Gorgoglione (started in December 2019) and to acquire the "zero point" in the Tempa Rossa area (Gorgoglione). The study of health status of population residing in the proximity of the industries was based on the evidence of three separate actions:

- Active Health Surveillance
- Geographic Epidemiology
- Study of the Reference Environmental Profile

The reference study was designed considering the correlation of data collection emerged after the completion of the three actions, two assigned to health indicators (Health surveillance and Geographical Epidemiology) one allocated to the environment [28] (Definition of the environmental profile of the territories under study).

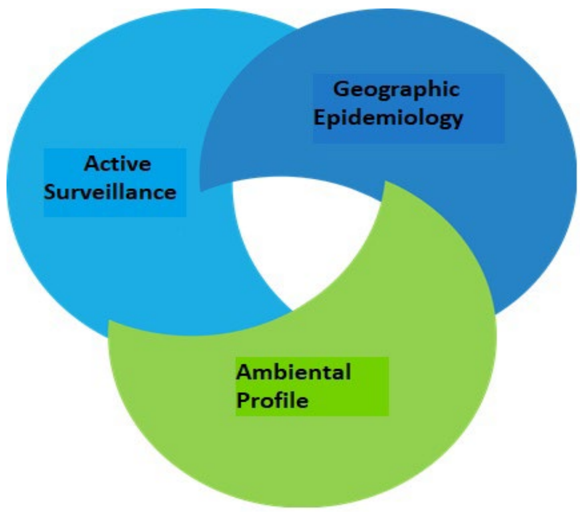



**Figure 5: Integrated Study Model Scheme – (source: Epibas-FARBAS Project Technical-Scientific Report Phase 1)**

**Graphical Representation of Results**

Subsequently, the responses to the questionnaire were mapped; initially, the address of each of 600 subjects who answered were converted into geographic coordinates in the WGS84 reference system. These were integrated using GIS (Geographic Information System) and created a point shapefile. This way, the spatial distribution of all surveyed individuals was obtained and categorized based on provided or non-provided responses. Data analysis was conducted on the base of territory distribution.

**Table 1: Sample Characteristics**

| | classification | N | % |
|---|---|---|---|
| sex | Female | 438 | 71 |
| | Male | 179 | 29 |
| qualification | None | 1 | <1 |
| | Bachelor's degree | 19 | 3 |
| | Master's degree | 87 | 14 |
| | Primary School | 57 | 9 |
| | Secondary School | 205 | 33 |
| | High school | 248 | 40 |
| distribution by municipality | Corleto Perticara | 66 | 11 |
| | Gorgoglione | 32 | 5 |
| | Grumento Nova | 55 | 9 |
| | Guardia Perticara | 33 | 5 |
| | Marsicovetere | 95 | 15 |
| | Moliterno | 98 | 15 |
| | Montemurro | 41 | 7 |
| | Sarconi | 35 | 6 |
| | Spinoso | 40 | 6 |
| | Tramutola | 5 | 1 |
| | Viggiano | 117 | 20 |

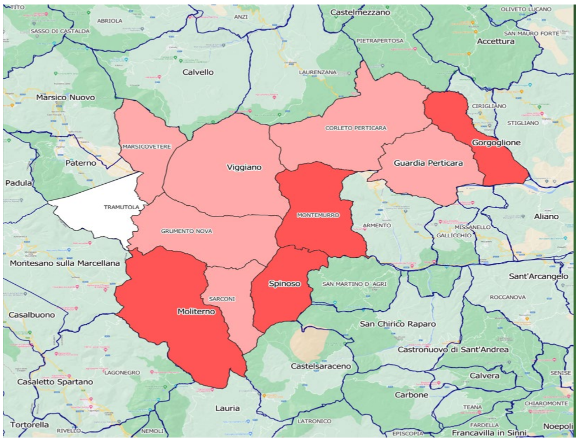



**Figure 6: Distribution of Responses to Question No. 1: Are there one or more sources of environmental pollution in the area where you live?**

**Note:** Percentage (%) of affirmative response

0 - 50 | 50 - 75 | 75 - 100

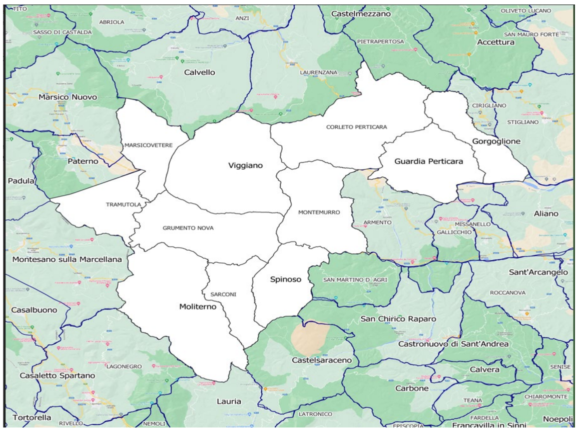



**Figure 7: Distribution of Responses to Question No. 5: Do you think there is soil pollution in the area where you live?**

**Note:** Percentage (%) of affirmative response

0 - 50 | 50 - 75 | 75 - 100

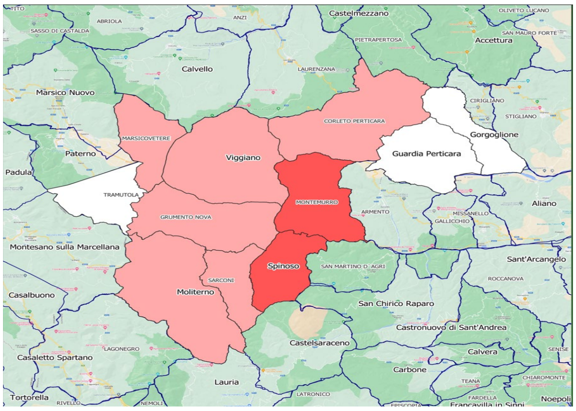



**Figure 8: Distribution of Responses to Question No. 6: Do you think there is food pollution in the area where you live?**

**Note:** Percentage (%) of affirmative response

0 - 50 | 50 - 75 | 75 - 100

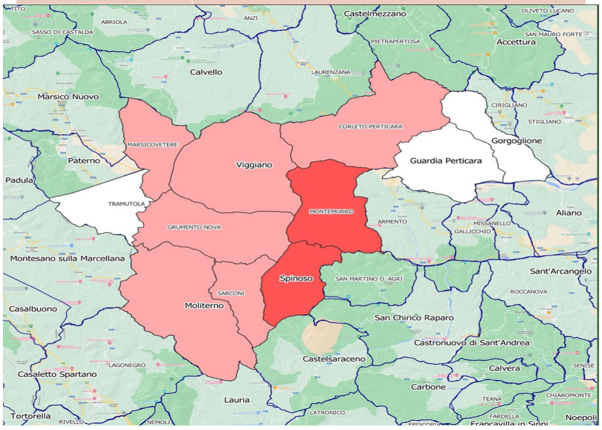



**Figure 9: Distribution of Responses to Question No. 7: In the area where you live, do you perceive industrial smells?**

**Note:** Percentage (%) of affirmative response

0 - 50 | 50 - 75 | 75 - 100

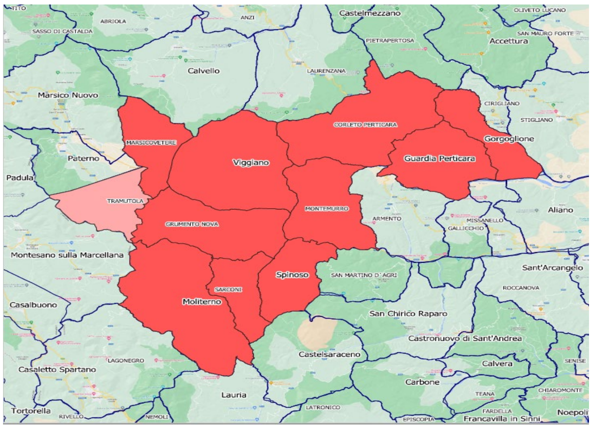



**Figure 10: Distribution of Responses to Question No. 8: Does oil extraction pose a health risk?**

**Note:** Percentage (%) of affirmative response

0 - 50 | 50 - 75 | 75 - 100

The graphical analysis (fig. 6-10) of the responses highlights a risk perception strongly skewed towards the effects of anthropogenic activities on human health, in response to the insufficient awareness of the potential pollution of the three main environmental resources (air, water, and soil).

**Socio-Economic Factors**

Socio-economic survey revealed that cities with the highest pollution levels had lower average income level and higher unemployment rate. These factors were considered in the multivariate analysis of the effect of pollution on health outcomes [20].

## Discussion

The findings of this study highlight the significant impact of air pollution on public health in the "Val d'Agri region".

The study also emphasizes the importance of social-economics factors in environmental health research. Low social-economics condition can make vulnerable the population exposed to the pollution in the area subject to this analysis.

## Conclusions

The integrated approach to risk assessment used in this study provides a comprehensive understanding on health impact by environmental exposures. Integrating environmental data with health surveillance and social-economics analysis, the study offers valuable insights for policymakers and public health officials to regarding environmental health challenges in the Val d'Agri region.

Future research should focus on long-term health monitoring and the implementation of effective pollution control measures to protect health residents of affected areas with particular focus on biomarkers [19].

**Conclusions - Risk Perception**

From the analysis and processing of 600 collected questionnaires, a moderately risk perception was highlighted in all cities, with specific higher concentration in particular geographic areas.

## Recommendations

Based on the study findings, the following recommendations were proposed:

- Reinforcement of air quality monitoring procedures: enhance the existing monitoring network to ensure comprehensive coverage and timely detection of pollution levels.
- Implement pollution reduction strategies: develop and enforce regulations to limit emissions from industrial and vehicular sources, particularly in high-risk areas.
- Promote public awareness: educate residents about the health risks associated with air pollution and encourage behaviour that reduce exposure.
- Limit/narrow social-economics disparities: implement social and economic policies to improve the living conditions and health outcomes of vulnerable populations.
- Conduct further research: support ongoing research to monitor health variables and evaluate the effectiveness of intervention measures.

## Conflict of Interests

Authors declare no conflict of interest

## Acknowledgements

The Regional Agency for Environmental Protection Basilicata for the provision of environmental data.

## References

[1] Cauzillo G, Becce G, Saponara C, et al. Statistical survey on mortality. Regional Atlas - Graphics Paternoster s. n. c. - Matera: Basilicata Region; 2005. Printed in June 2005. [DOI не доступен]

[2] Vitullo F, Tognoni G, Montagano G. Health Report. Epidemiological Observatory – Basilicata Region. Technical-scientific and training support project for the development of the Basilicata Region Epidemiological Observatory. Basilicata Region Agreement - Mario Negri South Consortium n. 4859 of 07/09/99. Resolution G.R. n. 1645 of 07/20/99.

[3] ISS collaboration agreement - Basilicata Region contribution from the ISS Statistics Office. The description of the health profile of the populations of Val d'Agri through the study of current health data.

[4] Bianchi et al. Sample survey on respiratory function. Project for the implementation of a health impact assessment in the municipalities of Viggiano and Grumento Nova in Val d'Agri. Roberto Pini Institute for the Study of Ecosystems-CNR (ISE-CNR soil physics and chemistry working groups).

[5] Institute of Clinical Physiology of the CNR (IFC-CNR). Creation of a health impact assessment in the municipalities of Viggiano and Grumento Nova in Val d'Agri, Basilicata. 2017.
[6] Comba P, Bianchi F, Iavarone I, et al. Impact on health of polluted sites: Methods and tools for research and evaluations. ISTISAN Reports 2007/50. Guidelines for VIS Biomarkers. Rosini M, ed. Fos environmental diagnosis and prognosis tools. 2000.
[7] Erspamer L, Ranzi A, Lauriola P, et al. ISTISAN Reports 2007/41. Guidelines for VIS Biomarkers.
[8] Duggento A, Toschi N, Pietroiusti A, et al. A novel approach for geographical risk mapping of morbidity and mortality rates: The case of Val D'Agri, Italy. Sci Rep. 2019;9:10348. doi: 10.1038/s41598-019-46893-2.
[9] European Environment Agency. Air quality in Europe. EEA; 2016. Available from: https://www.eea.europa.eu/publications/air-quality-in-europe. Accessed November 5, 2023.
[10] Mangia C, Cervino C, Trini S, et al. Simulation of the dispersion of effluents from chimneys of the Val d'Agri olive oil center for the purposes of exposure assessment – Epibas Project Progress Report. Available from: www.epibas.it.
[11] Cerosimo A, Derio C, Masiello G. TROPOMI NO2 Tropospheric Column Data: Regridding to 1 km Grid-Resolution and Assessment of their Consistency with In Situ Surface Observations. Remote Sens. 2020;12:2212. doi: 10.3390/rs12142212.
[12] Carmine S, Masiello G, Cerosimo A. NO2 pollution over selected cities in the Po valley in 2018–2021 and its possible effects on boosting COVID-19 deaths. Heliyon. 2022 Aug;8(8). doi: 10.1016/j.heliyon.2022.e09882.
[13] Priti K, Prashant K. A critical evaluation of air quality index models. Environ Monit Assess.
[14] Bortoletto M, Chermaz E, Bolzan S, et al. Correlation between air quality and health indicators. Evaluation analysis derived from the PM10 values in four municipalities in the Province of Treviso.
[15] Ivaldi C, Carnà P, Romeo D. Historical cohort study on the health status of residents in the municipality of Saluggia, home to a nuclear site. ARPA Piemonte; 2023.
[16] Fano V, Michelozzi P, Ancona C, et al. Epidemiological survey among the population residing in Falconara Marittima and neighboring municipalities. Occup Environ Med. 2004;61:757–763. doi: 10.1136/oem.2003.010231.
[17] Bianchi F, Comba P. Impact on health of polluted sites: Methods and tools for research and evaluations. ISTISAN Reports 2007/50.
[18] Fujita EM, Campbell DE. Review of current air monitoring capabilities near refineries in the San Francisco Bay Area - Final Report. San Francisco, CA: Environ; 2013.
[19] Erspamer L, Ranzi A, Lauriola P, et al. ISTISAN Reports 2007/41. Guidelines for VIS Biomarkers. Environmental diagnosis and prognosis tools. Rosini M, ed. 2000.
[20] Powers M, Saberi P, Pepino R, et al. Citizens' concerns regarding the economic, environmental, health and social impacts of unconventional natural gas drilling operations. Media New York: Springer; 2014.
[21] Miller M, Newby DE. Air pollution and cardiovascular disease: Car sick. Cardiovasc Res. 2020;116:279-294. doi: 10.1093/cvr/cvz231.
[22] Health Examination Survey CUORE Project - Epidemiology and Prevention of Cardiovascular Diseases. Istituto Superiore di Sanità, Department of Epidemiology of Cerebral and Cardiovascular Diseases, National Center for Epidemiology, Surveillance and Health Promotion, National Association of Hospital Cardiologists. Cardiovascular epidemiological observatory 2008.
[23] Basilicata Health Report. Available from: http://www.sanita.basilicata.it/DNNSanita/Dati_Sisr/Collaboratori/Utenti/Documentazione/RelazioneSanitaria/Relazione.html. Accessed November 5, 2023.
[24] Basilicata Region - Single SEZ for Southern Italy - Territory. Available from: http://www.regione.basilicata.it/giunta/site/giunta/. Accessed November 5, 2023.
[25] European Environment Agency. Available from: https://www.eea.europa.eu/it. Accessed November 5, 2023.
[26] ISTAT - Higher Institute of Health. Available from: https://www.istat.it/it/archivio/278177. Accessed November 5, 2023.
[27] Higher Institute of Health - WHO. Country by country, the impact of the environment on health. Available from: https://www.epicentro.iss.it/ambiente/ambiente_oms. Accessed November 5, 2023.
[28] ISPRA - Higher Institute for Environmental Protection and Research. Available from: https://www.isprambiente.gov.it/it. Accessed November 5, 2023.
[29] ISS - The Heart Project. Available from: http://www.cuore.iss.it/. Accessed November 5, 2023.