Indicators of Waste Exposure in an Area of Campania (Southern Italy) Characterized by Numerous Dumping Sites

Stefania Trinca¹, Giovanna Martini², Luciana Cossa¹, Fabrizio Falleni¹, Marzia Matteucci², Augusta Piccardi¹, Loredana Musmeci¹, ‘Environmental characterization’ working group³

Abstract
As a task assigned by the Department of Civil Protection of the Italian Government, a working group including WHO, CNR, ISS, OER and ARPA Campania has been established in order to check whether and how waste treatment in Campania Region could have repercussions on territory and resident population. To assess health risks from the presence of storage, treatment, disposal and illegal dumping sites of hazardous and non-hazardous waste, a number of data dating back to period 1997-2003 and coming from various administrations have been implemented in an apposite geo-database. By means of arcGIS software-platform a territorial analysis has been performed in terms of sites and municipalities. As a result, ‘synthetic descriptive indexes’ have been obtained in order to measure position-variability of such sites and of their potential health impact in the Provinces of Naples and Caserta. Our results represent a base for exposure assessment in epidemiological studies now in progress.

1. Introduction
As of late, Campania, a Region of Southern Italy, has been a scene of controversy concerning waste disposal and treatment. Resident people and health authorities are more and more worried, while a heavy demand for new plants is in progress. Indeed, the regional administration is dealing with a rearrangement of waste-disposal system following recent emergencies among other things. Moreover, the regional territory houses some areas which have to be reclaimed as requested by a ministerial decree; precisely, in Agro Aversano and along Domitia-Flegrea seacoast various sites of uncontrolled waste-abandonment have been identified and assessed by the Campania Region’s Environmental Protection Agency (ARPA Campania) (1, 2); many of them contain industrial hazardous substances. Here spreading of unauthorized dumping sites has started in the ‘80s and goes on and on (Figure 1).

So one important issue in environmental matters is waste disposal (3, 4, 5, 6, 7). Accordingly it is desirable to start assessing possible consequences from population exposure to emissions from unauthorized dumping sites and plants for disposal and treatment of urban solid waste (RSU) and hazardous substances.

A working group including World Health Organization (WHO), National Research Council (CNR), Istituto Superiore di Sanità (ISS), Department of Civil Protection (DCP), Campania Regional Epidemiologic Observatory (OER) and Campania Region’s Environmental Protection Agency (ARPA Campania) has been assigned by DCP the task of checking whether and how waste treatment in Campania could have adverse effects on environment and public health. Its work has partly dealt with epidemiological investigations on mortality and congenital anomalies in municipalities belonging to the

---

¹ Istituto Superiore di Sanità (ISS), Rome, Italy
² Department of Civil Protection, Rome, Italy
³ ‘Environmental characterization’ working group: ISS: Mirella Bellino, Cinzia Carboni, Pietro Comba, L. Cossa, F. Falleni, Loredana Musmeci, A. Piccardi, S. Trinca; Dept of Civil Protection: Marco Leonardi, Giovanna Martini, Marzia Matteucci Luisa Madeo; ARPA Campania: Gabriela Angrisani, Massimo Menegozzo, Marinella Vito; APAT: Angelo Felli
Provinces of Naples and Caserta. At the same time, risk and exposure assessment relative to the presence of storage, treatment, illegal disposal and dumping sites of hazardous and urban waste has been worked out by implementing data from the period 1997-2003 and coming from various administrations in an apposite geo-database (8, 9), so to extract ‘synthetic descriptive indexes’ measuring position-variability of such sites and of their potential health impact.

Figure 1: Waste disposal sites in Campania Region

The described approach has been used in many geographical-epidemiological studies relative to health effects from waste presence; it consists in evaluating people’s exposure on the base of their distance from landfills. Recent specialized literature suggests the range of influence considered varies from 2 to 4 km (3, 4, 5). But these studies are about dumping sites containing either hazardous or special large-sized waste. We rather aim to analyze an ensemble of sites, diversified in nature and dimensions, sometimes very close to each other, in an area characterized by either a high or very high population density. Therefore, our choice criterion has just selected population really living close to the sites, according to a common epidemiological approach to high-risk groups. As a result, an area 1 km in range around each site has been chosen since it ensures an adequate statistical power all the same.

Outcomes from the above analysis, performed on all 196 municipalities in the Provinces of Naples and Caserta, represent a base for recent epidemiological studies (10, 11) in order to assess adverse effects on environment and resident population from waste presence.
2. **Data and the geo-database structure**

A number of information layers describing the entire regional area in its demographic, housing and environmental aspects have been acquired and organized by means of GIS software-platform. The resulting geo-database represents a powerful tool to characterize the area under examination, to identify elements which are exposed and sensitive to contamination and to analyze links to further natural and technological hazards.

Data have been filed according to the following macro-topics, each representing a single geo-database:

- **environment**: data dealing with waste disposal and treatment in the Provinces of Naples and Caserta dating back to the period 1997-2003 (1, 13)
- **population and housing resources**: Provinces, municipalities, built-up areas, census tracts and connected data about population and housing resources (14)
- **infrastructures**: road and railway infrastructures (15)
- **territory**: protected areas, environmental bonds, geological and hydro-geological information, soil exploitation, pits, etc.
- **health**: epidemiological data

3. **Methods**

Analysis of influence of polluting sources on territory and people has been organized into the following steps.

3.1. **Search for information, data validation, site selection**

Data about both authorized and unauthorized waste-disposal sites, collected 1997 to 2003 (1, 13) by various environment agencies of Campania, have been carefully compared, validated and checked as well in terms of correct location by means of ortho-photo maps picked up during Italia2000 fly, IGM 1:25.000 scale and Teleatlas road graph. Then, 140 sites in the Province of Caserta and 86 in the Province of Naples have been selected on the base of their features and information completeness.

3.2. **Characterization of waste disposal and abandonment sources and assignment of a hazard index (HI) to sites**

Selected sites have been further classified on the base of their dangerousness (HI hazard index) taking into account site nature (either authorized or non-authorized sites), typology (dumping and storage sites, slagheaps, submerged waste, uncontrolled waste abandonment, etc), waste volume and type and pollutant emission-mode.

The assignment criterion rested mainly upon environmental impact on water, air and soil of storage-treatment-disposal-abandonment typologies concerning hazardous and urban waste.

The grade consists of an alpha-numeric code where the number increases with hazard and the letter goes A to G at the decreasing of it (A = max hazard; G = min hazard). In a few words, the number identifies danger magnitude, while the letter is a multiplication factor related to waste intrinsic dangerousness.

Table 1 shows HIs for various waste disposal/treatment and/or abandonment typologies.
Table 1:
Hazard indexes for various waste disposal/treatment and/or abandonment typologies

<table>
<thead>
<tr>
<th>TYPOLOGY</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submerged waste (lakes)</td>
<td>4 A</td>
</tr>
<tr>
<td>Slagheaps</td>
<td>3 B</td>
</tr>
<tr>
<td>Hazardous waste storage and disposal</td>
<td>3 B</td>
</tr>
<tr>
<td>Abandonment of metal drums</td>
<td>3 B</td>
</tr>
<tr>
<td>Pit slagheaps containing hazardous waste</td>
<td>3 B</td>
</tr>
<tr>
<td>2nd class – type B dumping sites (special/industrial waste)</td>
<td>2 B</td>
</tr>
<tr>
<td>Car wrecking and scrapping plants</td>
<td>1 D</td>
</tr>
<tr>
<td>Plants for electric and electronic waste reclaim</td>
<td>1 D</td>
</tr>
<tr>
<td>Temporary storage of non-hazardous waste</td>
<td>1 D</td>
</tr>
<tr>
<td>Plants for chemical – physical treatment of waste</td>
<td>1 D</td>
</tr>
<tr>
<td>Non-hazardous waste reclaim</td>
<td>1 D</td>
</tr>
<tr>
<td>Plants for treatment (storage) of special waste</td>
<td>1 D</td>
</tr>
<tr>
<td>Special waste incineration and oil reclaim plants</td>
<td>1 D</td>
</tr>
<tr>
<td>Uncontrolled RSU dumping sites</td>
<td>1 F</td>
</tr>
<tr>
<td>Pit large-volume (&gt; 10000 cc) non-hazardous slagheaps</td>
<td>1 F</td>
</tr>
<tr>
<td>Large-volume (&gt; 10000 cc) non-hazardous slagheaps</td>
<td>1 F</td>
</tr>
<tr>
<td>Controlled RSU dumping sites – Authorized inert waste sites</td>
<td>1 F</td>
</tr>
<tr>
<td>Composting plants</td>
<td>1 F</td>
</tr>
<tr>
<td>Plants for refuse – Derived Fuel (RDF) selection and production</td>
<td>1 F</td>
</tr>
<tr>
<td>Refluent – water depuration plants</td>
<td>1 F</td>
</tr>
<tr>
<td>Industrial slagheaps</td>
<td>1 F</td>
</tr>
</tbody>
</table>

Precisely:

- **A**: potential hazardous or very hazardous submerged waste
- **B**: hazardous waste
- **C**: potential hazardous emissions from industrial special waste
- **D**: potential hazardous emissions from non-hazardous waste
- **E**: uncontrolled non-hazardous waste
- **F**: controlled non-hazardous waste

### 3.3. Criterion identification and application procedure to describe environmental-impact areas – assignment of a composite hazard index (CHI)

By means of arcGIS software-platform, opportunely customized through Python and Avenue programming languages, a territorial analysis has been performed in terms of sites and municipalities.

Site-analysis has identified and characterized sources, calculating their ‘fallout areas’ (buffer strips of 1 km from sites). On the other hand, analysis on a municipality-scale needs an identification and characterization of areas influenced by more than one site, so to avoid counting population living in one area more than one time; at the same time, a specific coefficient is needed to describe global danger to
them. Therefore, a script has been worked out to pass from ‘fallout areas’ to ‘environmental impact areas’; its logic steps are summarized in Figure 2.

Figure 2: Logic steps to identify impact areas

Selecting a buffer strip 1 km in range around any potential polluting source, fallout areas have been identified. These latter have been assigned HIs from corresponding sites; then, each area influenced by more than one site has been attributed a multi-code (CHI) consisting in a series HIs from single sources lying in the examined area (Figure 3).

Figure 3: Characterization of impact areas through CHI codes

3.4. Computation of a municipal hazard index (MHI)

A potential hazard index (PHI, numeric parameter) has been associated with each CHI (alpha-numeric parameter); this way a classification of hazard values has been performed. Consequently, if impact-area typologies and surfaces (S) are known for each municipality, then a municipal hazard index (MHI) can be derived.

As a result, the following function has been implemented:

\[
MHI = \sum_{i=1}^{n} S_i \cdot PHI_i
\]

\(n\) being the number of impact areas in the municipality under examination.
3.5. Computation of population living in each impact area to assess risk from exposure

Then a further hazard index has been introduced, taking into account information about the distribution of potential exposed population; at this aim, population falling in each impact area have been computed, extracting them from ISTAT 2001 census tracts.

Analysis steps follow:

1. computation of population density in census tracts – population density in each tract has been obtained dividing resident people by tract surface;
2. intersection of census tracts and impact areas – the two layers have been intersected, so deriving new polygons. This way attributes associated with the two layers have been spacially combined as well;
3. computation of people living in polygons of the new layer – population falling in each new polygon has been computed multiplying population density by polygon surface.

3.6. Computation of a synthetic waste risk index (SWRI)

A synthetic waste risk index (SWRI) has been derived multiplying surfaces of impact areas falling in a specific municipality by their PHIs and population living in each area (E) and then summing over the number n of areas included in the municipality under examination:

\[
SWRI = \sum_{i=1}^{n} S_i \times PHI_i \times EP_i
\]

In each CHI, frequencies of numbers and letters have been assigned different statistical weights.

4. Results

So far our approach has allowed us to describe geographical distribution of waste disposal sites in terms of their PHIs, in order to identify and characterize, by means of GIS, those areas apt to waste contamination, which gather between inshore municipalities and those falling north-east of Naples. Mapping of impact areas (Figure 4) by means of their CHIs has enabled us to select those zones lying in the two Provinces, which are under waste pressure most.
A SWRI has been computed for each of the 196 municipalities under examination, thinking of resident population as a target of contamination. As shown by the geographical distribution of SWRIs (Figure 5), municipalities on the border between the Provinces of Caserta and Naples and those lying along the Tyrrhenian coast are exposed to risk most. According to epidemiological studies, high mortality by cancer and frequent congenital anomalies are typical of such areas as well (11). A correlation study is in progress in order to assess connection among SWRI, mortality rates from specific causes and congenital anomalies.
5. Conclusions

The goal of this analysis was trying to give geographical-epidemiological studies a contribution, using waste-disposal data collected in Campania to derive an exposure index based not only on distance from dumping sites, but also on characterization of neighboring areas depending on territorial significant elements, as allowed by GIS features.

As a first result, some municipalities along the coast and north of Naples have proved to be characterized by high-risk impact areas, which represent top targets for reclamation procedures and further analytical epidemiological studies.

So far, only population living in impact areas around potential polluted sites (computed by means of population density of census tracts) have been taken into account as a possible target, but, as a second step, further environmental and territorial factors (hydrological data, soil exploitation, socioeconomic conditions, etc) are going to be included into the computation of SWRI.

Geographical distribution of SWRIs is consistent with outcomes from epidemiological studies performed so far. Anyway, many other factors (extensive agriculture, industrial activities, socioeconomic conditions, high population density, health conditions) influence this territory from an environmental point of view and have to examined in the context of a multivariate analysis.

Acknowledgements

We want to sincerely thank P. Comba (ISS), M. Martuzzi e F. Mitis (WHO European Centre for Environment and Health), F. Bianchi (CNR Pisa), R. Pizzuti (OER Campania), M.Menegozzo (ARPA Campania), for their contribution to the present work.


Lang L. – GIS for Health organizations – ESRI press – 1-879102-65-x


TeleAtlas road graph and RFI railway map
