Waste processing and health. A position document of the Italian Association of Epidemiology (AIE) - May 2008

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Summary. This is a position document of the Italian Epidemiological Association (AIE) on the health hazards of waste disposal. The main objectives of the document are: 1) to support the decision makers on the safety of the existing waste treatment and disposal plants and of the planned new plants; b) to recommend protective actions in favour of populations exposed to toxic agents linked to illegal waste treatment and disposal; c) to signal circumstances that require the adoption of surveillance plan or ad hoc studies in order to unveil possible health effects associated to the environmental exposure to toxic agents derived from waste treatment and disposal. The evaluations presented in this document are based on the available scientific literature. AIE recommends the adoption of preventive policies to contain both the production of waste and the need to dispose it. AIE also recommends the participation and involvement of the population in all phases of waste management, from the decisional to the operational ones.

Key words: waste treatment and disposal, disposal plants, incinerators, health hazard, environmental exposure.

Riassunto (*Trattamento dei rifiuti e salute. Posizione dell'Associazione Italiana di Epidemiologia, AIE)*. Il documento esprime il giudizio dell'Associazione Italiana di Epidemiologia (AIE) sulla nocività per la salute delle diverse modalità di trattamento dei rifiuti. Gli obiettivi del documento sono: a) favorire le scelte dei decisori in merito alla sicurezza degli impianti legalmente in uso e di quelli in programmazione; b) dare indicazioni in merito alla opportunità di adottare azioni di protezione della popolazione esposta ad agenti nocivi provenienti da siti di smaltimento non autorizzati; c) identificare le circostanze in cui è necessario l'avvio di indagini mirate e di piani di sorveglianza per evidenziare possibili effetti prodotti dall'esposizione ambientale a tossici derivanti dal trattamento dei rifiuti. Le considerazioni espresse derivano dalla valutazione delle conoscenze disponibili in letteratura scientifica. L'AIE raccomanda che le politiche connesse alla gestione dei rifiuti siano prioritariamente orientate ad azioni di prevenzione e al coinvolgimento delle popolazioni interessate in ogni fase del processo decisionale

Parole chiave: trattamento dei rifiuti, discariche, inceneritori, effetti sanitari, esposizioni ambientali.

BACKGROUND AND SCOPE OF THE DOCUMENT

Waste production – the undesired by product of the production and consume of goods – is growing in Italy both in quantity (0.54 t/year per capita in 2005) and in the variety of chemicals. It is therefore relevant the concern about its adverse impact on the environment and population health.

The most important actions aimed at preventing the potential hazards from wastes should consist in the reduction, differentiation, re-use and rationalisation of waste processing according to the latest EU Directive on this issue (2006/12/UE).

The present Italian legislation (DL.vo 152/06) classifies wastes on the basis of their origin into *urban wastes* (mostly domestic) and *special wastes* (mostly from industrial productions), and, on the basis of their level of danger, into toxic wastes (containing metals and other toxic substances – Directive 91/689/CE), and non toxic wastes (all the others). The Italian legislation requires separate processing according to the different categories.

After the recycling phase, in the areas where this has been activated, residual wastes are processed, in agreement with the present Italian legislation, with two different approaches: conveyance to a controlled landfill (48%) or incineration (10%) with partial energetic re-use. There are, however, frequent situations in which authorized landfills do not follow strictly the rules (in particular as far as leachate and biogases are concerned) or toxic wastes are illegally dumped into landfills authorized for conveyance of urban wastes.

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Finally, illegally operated landfills, illegal dumping sites, and uncontrolled combustions of mixed and toxic wastes should also be considered.

The major aim of this document is to provide an evaluation, based on the available evidence, of the health hazards associated with legal waste treatment in order to provide the necessary information to public authorities in charge of the safety aspects of the existing waste treatment and disposal plants and of the planning of new plants. A secondary goal is to evaluate the health effects from illegal waste treatment and suggest, if necessary, actions to protect the exposed population or, in case of inconclusive epidemiological evidence, *ad hoc* studies or surveillance activities to ascertain the potential health effects.

The evaluations presented in this document have been elaborated by the Secretariat of the Italian Association of Epidemiology (AIE) based on the available scientific literature.

HEALTH HAZARDS FROM LANDFILL SITES

Authorized landfill sites

The common toxic substances known to be present in landfills are:

- chlorinated solvents (tri- and tetra ethylene chloride, bi- and tri- chloroethane);
- metals (zinc, mercury, cadmium, chromium, arsenic, lead);
- polycyclic aromatic hydrocarbons (benzene, toluene, methylene);
- polychlorinated biphenyls (PCB);
- vinyl chlorides.

Possible routes of exposure include inhalation, ingestion (water and contaminated agricultural products) and dermal contact.

The two main questions concerning the potential health impact of landfills operating in agreement with the regulations are:

- Do landfills generate exposures which cause an increased morbidity in the general population?
- Have excesses of any disease been registered among the population living in the proximities of landfills?

The latter question has been addressed more frequently due to the limited knowledge on the former.

Most of the epidemiological studies have not been conducted in Italy and are multicentric or multisites [1-7]. These studies are mainly characterized by a large sample size, a good control of confounding and provide a solid background for strategic decisions. There are however weaknesses mainly due to the presence of combined exposure to several toxic agents and to the lack of differentiation between urban and toxic landfills in the national legislations at the time when the studies were conducted. Actually, it should be noticed that in most of the international studies no distinction is made between solid urban wastes and toxic wastes; therefore observations in the literature refer to the combined exposure as separate analyses are not feasible.

These studies are geographical investigations in which exposure, defined as the distance between the source of exposure and the residence, is poorly characterized. Also in the multicentric case control study EUROHAZCON [7, 8], in which information on potential confounders has been collected by individual questionnaire assuring a good control of confounding, the level of exposure has been estimated by the distance between the landfill and the address of residence. Some studies used a more precise assessment of the exposure [9-12], but they suffer from low statistical power, limited control of confounding and possible recall bias.

With these limitations, the considered studies detected a 10% excess risk of congenital malformations (in relation to landfills with conveyance of toxic substances), in particular defects of neural tube and cardiovascular system [7-8], gastroschisis and palatoschisis [9-10]. Furthermore, multisite studies found an increased risk of low birth weight (relative risk (RR) ranging from 1.03 to 1.06) and of different types of tumours (leukemia, colon-rectum, lung, bladder, and liver cancers), with RRs between 1.02 and 1.20. Some studies, however found no adverse pregnancy outcomes excess risks [10-15].

Overall, the evidence from these studies is limited. Among other studies with a more solid methodological design, some indicate small excesses while others do not. In the majority of the studies, a role of confounding and exposure misclassification cannot be excluded. Very few studies have been carried out on possible effects of urban wastes only while most of the evidence concerns toxic wastes.

In conclusion, as far as landfills with conveyance of toxic wastes are concerned, there is evidence of a small but statistically significant excess of congenital malformations and more consistent evidence of an increased risk of low birth weight. There is no convincing evidence of an increased risk of cancer, mainly due to incomplete residential histories and consequent problems to control for the latency period between the exposure and the disease.

Epidemiological research has only marginally investigated potential risks from landfills with conveyance of urban wastes only, due to the prevailing concern from exposure to toxic wastes and to an *a priori* evaluation of null or low risk from urban wastes landfills which most likely follow legal and technological requirements.

Illegal landfill sites

We should include in this category illegal landfills, authorized landfills storing substances which were not allowed in that specific site and landfills not complying with the rules concerning emissions and the processing of the leachate. These landfills involve various exposure pathways.

Since 2000, several studies involving illegal landfills have been conducted in Italy, particularly in Campania, providing a relevant, although not con-

clusive, contribution to the characterisation of the potential health risks from this type of sites [16-23]. Most of the studies are spatial investigations using a classical ecological approach, not always conducted with an adequate time span. They considered different endpoints, including mortality, hospital discharges, congenital malformations and, in a few cases, cancer incidence.

One ecological study used a specific exposure index at the municipality level, based on the distance from the source of exposure and on the characterisation of the toxicity of the wastes [24].

The results from these studies, which have considered both authorized and illegal landifills, show a relationship between the exposure index and overall mortality, cancer mortality (all types, liver, lung, and stomach cancer among men), mortality for cardiovascular diseases, respiratory diseases, diabetes and liver cirrhosis and prevalence of some malformations of the nervous system and the genital-urinary tract.

After taking into account that ecological design cannot assess the causality of the association, the authors of these studies consider however the results indicative of an increased risk related to the environmental pollution from the existing landfills in the area. The interpretation of the results in causal terms is complicated by three main aspects:

- the studies considered both authorised and illegal landfills with well documented presence of toxic substances without separating the potential effects of the different types of landfills;
- although an effort has been made to control for the possible confounding effect from social and economical status by using a deprivation index, residual confounding cannot be excluded. For some causes of death, *e.g.* malignant neoplasms of kidney and bladder, the deprivation index resulted to be the most important risk factor;
- proximity to the landfill has been indicated by the authors as the main explanation of the excess found, but other possible contributing causes cannot be excluded: a) the high prevalence of hepatitis, in relation to liver cancer; b) occupational exposures, in relation to mortality excesses limited to males; c) the low level of diagnostic and therapeutic activities in relation to cardio-respiratory diseases and diabetes.

Notwithstanding the above mentioned limitations, the results are suggestive of possible health hazards in the population resident near illegal landfills, which result in environmental pollution and consequent population exposure to a mix of toxic substances through different pathways (air, water, soil and food).

Although not conclusive the results are supported by the biological plausibility and the consistency of the effects across gender and age. Overall, the weaknesses due to the study design and the lack of control of confounding do not detract from a causal interpretation.

Health hazards deriving from waste incineration

The major chemical substances released by incinerators, considered as a potential health hazard to humans, are:

- metals (cadmium, thallium, zinc, mercury, chrome, arsenic, lead, cobalt, manganese, nickel, vanadium);
- polycyclic aromatic hydrocarbons (PAH);
- fine and ultra-fine particulate;
- acids (fluoridric, chloridric);
- gases (SO_2, NO_2, CO)
- polychlorinated products (polychlorinated biphenyls PCB, dioxins, furans).

Identified routes of exposure are: inhalation (gases, particulate, PAHs), ingestion (PCB) and dermal contacts (metals, PAH).

Incineration of waste is largely used to reduce the volume and the toxic and infective properties of urban, toxic, and hospital wastes. In Italy, 50 incinerator plants, prevalently located in the North and the Centre (13 in Lombardy, 9 in Emilia and 8 in Tuscany), are currently operating.

Whether incineration is an appropriate and safe waste treatment is still in debate in our country, with focal interest on the potential health hazards to humans linked to emissions of pollutants from the incinerating process. Some of these (dioxins, metals and ultrafine particles) are known carcinogenic and toxic agents. Although the effects have been observed at much higher concentrations of those produced by incinerator plants, it is still unclear whether, due to possible molecular stability of the mentioned substances, cumulative exposure over time could result into increased risks for the exposed populations.

With regards to intensity of exposure, a clear distinction must be made between old and new generation plants, since the allowed levels of emissions, up to the introduction of EU Directive 2000/76/CE, were 3-6-fold higher for the main parameters and several-hundreds-folds for dioxins and furans.

Old generation incinerator plants

Between the years 1960 and 1980, several epidemiological studies have been conducted in the populations residing in the proximities of incinerator plants. In addition, an Italian systematic review [25] of the literature, reporting general assessments of hazards from old generation incinerators, and a recent technical report published by the World Health Organization [26] are available on the same topic.

Old generation incinerators have certainly caused to the residing populations environmental exposure to higher levels of toxic substances. Therefore, potential effects have been investigated with regard to respiratory diseases [27-29], sex ratio at birth [30-32], congenital malformations [33-37], and tumors – lymphoma, soft tissue sarcoma, and larynx, lung and liver cancer [38-44].

Methodologically robust and validated studies have highlighted tumor excesses associated with dioxins exposure [38, 39, 42, 43]; these results may

be explained by the high concentrations, permitted until recently, of these substances in the emissions released by incinerators. However, the interpretation of results concerning other effects is more uncertain. It should be noted that also these studies, as those described in the previous sections, lack in controlling for potential confounding factors related to socio-economic status.

In conclusion, there is convincing evidence of an association between exposure to emissions from old generation incinerators (dioxins, in particular) and increased frequency of malignancies at various sites. Although it is possible that these emissions may have produced other effects (carcinogenic or not), the available data are not sufficient to corroborate the hypothesis.

New generation incinerator plants

After the restrictions imposed by the European Community on allowed emissions (Directive 2000/76/EC, adopted in Italy in 2005), the concentrations of many toxic substances have been notably reduced. In particular, the maximum permitted concentrations of dioxins, in our country, have been lowered from 4000 ng/m^3 (DM 12/7/1990) to 0.1 ng/m^3 (DL.vo 11/5/2005) (toxicity equivalent values of the sum PCDD+PCDF referred to 2,3,7,8, TCDD). Due to the short time since the adoption of *best available technologies* (BAT) incinerators, enforced by the EU, and because of the difficulties in conducting sufficiently large studies to assess the possible effects of the new concentrations of emitted toxic substances, no clear evidence of risk linked to new generation incinerator plants has been highlighted so far.

The frequent presence, within the areas where incinerators are located, of other industrial sites, heavy traffic highways and residential areas whith socially and economically disadvantaged populations causes new problems – difficult to overcome with traditional epidemiological studies – in the assessment of the specific health effects due to the environmental load of new incinerators.

New generation incinerator plants release toxic substances known to be unsafe, but not at any different concentrations of – and in some cases inferior to – those deriving from other sources within the same area (road traffic, industrial sites). The new (still unsolved) problems concern the quantification of the additional harm to the territory that these plants may cause. Given the difficulty in highlighting low exposure risks, which are at the boundaries of (and perhaps beyond) the epidemiological ability to solve, and given the uncertain cost-benefit association of conventional epidemiological studies, the research is turning to risk assessment methodologies [45], which need, however, to be further strengthened. The same considerations apply to the use of biomarkers of exposure; though, so far, they have not generally highlighted significant alterations [46-50].

CONCLUSIONS

The ever growing national trend in waste disposal is, in our country, source of anxiety in relation to economic, environmental, social, and health issues; also taking into account the tension and concerns caused to the population residing in areas surrounding waste treatment plants and to their local authorities. Focal points, in a prevention-oriented policy, are waste reduction, regulation of packaging, differential collection, and recycling, re-use, and recovery of materials. Today, recycling in Italy does not exceed 24% – with great differences between geographic areas: higher proportions in the North compared to the South and the Islands, with relevant exceptions in both areas – even if waste is, in many cases, a highly energetic resource (for instance: aluminum, steel, glass, paper), which can valuably substitute raw materials in the production of consumers goods. The two types of waste disposal at the closing stages of separate collection – conveyance to a controlled landfill and incineration –are not antithetic, but are comprehensive of a safe and efficient management. Reasserting the priorities of preventive actions (*i.e.*, reduction, recovery, separate collection), the European Community recommends preferably [51] incineration rather than conveyance to controlled landfills. In some Italian areas, where the sites available to landfills are coming to an end (this is the case for the provinces of Naples and Caserta), finding alternative solutions to incinerations does not appear easy; born in mind the importance of increasing recovery of materials and differential collection of waste.

Although inconclusive, the presently available epidemiologic knowledge suggests that waste conveyance to controlled landfills, built and directed in agreement with National and European regulations, does not cause a risk to the environment and to the health of populations residing in the proximities of these plants. Likewise, the few available epidemiologic surveys have assessed that waste management by incineration in new generation plants built with BAT do not increase the risk to human health. This conclusion is supported mostly by the extremely low concentrations of toxic substances in the emissions of the new incinerators. However, a realistic measurement of the volumes of toxic substances released by the chimneys in the environment is a critical factor in judging safety of new plants, which needs the conduction of accurately planned observations. In large installations, the low concentrations of toxic substances in the emissions may be overcome, at least in theory, by the high quantities in volume of emissions in unit of time. Indeed, this type of plant may interfere with policies of waste recycling in the surrounding areas, because large moving-grate plants need large volumes of waste and low caloric index fuel for a perfect control of combustion temperatures. Other technologies (fluid bed, gasification), activated in smaller installations, are more suitable for a waste cycle that considers also recycle and re-use.

The literature, insufficient and not conclusive also in this case, shows that the major health hazards are associated to emissions from illegally operated landfills and illegal dumping sites, incinerator plants with obsolete technologies, and from uncontrolled waste combustions.

Recommendations

Safeguarding the health and the environment requires the adoption of preventive policies to contain both the production of waste and the need to dispose it.

The conveyance to controlled landfills and the incineration by BAT are the waste treatment methods that minimize the impact on the environment and health. Possible alternative methods should not be dismissed *a priori*, while should be carefully evaluated, also in terms of cost-benefits, before they are implemented. All other approaches of waste treatment – illegal or guaranteed by any departure from administrative laws – should be interrupted for violation of current laws until the presence of risk conditions associated with the procedure in use is verified.

Programs should be implemented to monitor emissions and the health of populations residing in the proximities of authorized landfill sites and of incinerators built with BAT or planned. Analytical studies, instead, should be initiated to research health effects in populations that have been exposed to other waste disposal procedures.

To overcome the limitations of the studies conducted so far, the following recommendations should be adopted: application of advanced models for dispersion of pollutants based on most recent *geographical information system* (GIS) technologies; activation of prospective studies, possibly multicentre ones, with particular attention to systematic control for confounding factors; implementation of bio-monitoring procedures, especially in the most susceptible groups (*e.g.*, children, pregnant women, chronically ill people); testing of risk assessment studies.

It is recommended that surveillance programs and analytical studies derive from guidelines written by boards of experienced experts in the absence of conflicts of interest. Such boards should be responsible for project design, verification of field work and dissemination of results.

As stated by the Aarhus European Convention and by the Aalborg Chart, the participation and involvement of the population should be encouraged in all phases of waste management, from the decisional to the operational ones.

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