

Human health and pollution due to solid waste incinerators (SWI): a selection of two recent well conducted studies

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Abstract

Incinerators reduce the volume of visible waste, turning it into ashes and smoke which can cause local and global environmental pollution due to particulate matter (PM), dioxins, furans, hydrochloric acid, hydrocarbons, heavy metals, sulfur and nitrogen dioxides. In order to describe cancers and non-neoplastic diseases in populations exposed to incinerator pollution, the scientific literature available since 1987 has been selected on the basis of the best epidemiological evidences. In Italy, women who lived for at least 5 years in areas that were likely to be the most polluted by heavy metals, showed increased risk of death from all causes (relative risk, RR=1.07-1.17) and all cancers (RR=1.17-1.54). In France, an incidence study found increases in all cancer risks both in males (RR=1.03) and females (RR=1.06) who resided in areas where dioxin pollution was estimated to be higher than it was in the referent areas (less dioxin polluted).

Introduction

According to Italian law, solid waste incinerators (SWI) are classified as insalubrious industries belonging to class 1 and they produce several hundreds of different pollutants [1] independently of the technology involved. The formation of these pollutants depends on the type of materials being burned, on how these materials can combine together by chance in the furnaces, on the operating temperatures of the SWI and above all on the variations of these temperatures in the different compartments [2]. The main categories of pollutants emitted include: inhalable (PM₁₀), fine (PM_{2.5}) and ultrafine (PM_{0.1}) particulates, heavy metals, dioxins, volatile organic compounds, nitrogen and sulphur oxides. These substances exert their harmful effects following inhalation, dermal contact or ingestion

of contaminated food. Many of these substances are toxic, mutagenic and carcinogens in humans [3]. They can act as persistent and bioaccumulative endocrine disruptors. Mutagenesis tests conducted on SWI emissions, have shown an equivalent or higher activity than that of other types of combustion-related emissions [4-5]. SWI are also a non negligible source of particulate matter: a study carried out in a Swedish city estimated that a modern incinerator produces between 17% and 32% of urban PM_{2.5} [6]. Another study which was performed in Paris found that the incinerator, along with domestic heating and traffic, is one of the three main sources of particulates [7]. The consequences of particulate pollution on human health have been known for some time, the smaller the diameter of the particulate matter, the more severe they are; "modern" SWI are a major source of ultrafine particles [8] because they operate at high temperatures. The consequent damages are oxidative stress, generalized state of inflammation, increased blood viscosity, alteration of the most delicate cell functions [9]. Living in proximity to an incinerator has already been associated with an increased risk for cancer: in a review published in 2004 and conducted on 46 selected studies, significant exposure disease associations are reported by two thirds of the findings concerning cancer (mortality, incidence or prevalence) [10]. Statistically significant evidence was observed for all tumors and specific cancers: lung cancer, stomach cancer, colon-rectal cancer, liver cancer and childhood cancer [11-13].

Statistically significant evidence, confirmed also by studies recently conducted, was observed for soft tissue sarcoma [14-17] and non-Hodgkin's lymphoma (NHL) [18-22]. NHL, particularly, is a well known dioxin-related neoplasm, as clearly shown by the 25 years follow-up of the Seveso accident (Italy, 1976) and many other studies [23-26]. In addition to cancer, also non-neoplastic diseases are associated with SWI fumes exposure because some of the contaminants may have a role as endocrine disruptors [27], may interfere with estrogen metabolism [28], may lead to multiple births and an abnormal sex ratio of newborns [29], may be linked with birth problems (congenital anomalies, prenatal deaths, low birth weight, [30-31] and health damage in adolescents and children [32, 33]. Aim of this work is to describe the best scientific evidence related to cancer and non-neoplastic diseases in populations exposed to incinerator pollution.

Materials and Methods

We reviewed experimental and epidemiologic studies published between 1987 and 2009 found in the PUBMED database of the National Library of Medicine and recently produced by public agencies. We selected well conducted papers, excluding studies, even recent ones, which are limited to a too simple study design based only on distance analysis from SWI. This “rings analysis” does not take into account either specific orographic or weather conditions and may therefore seriously underestimate both the true and overall health risks of the exposed population. Consequently this article examines two main studies called the Italian study [34] and the French study [35] which, in our opinion, correctly analyze the health effects - neoplastic and non-neoplastic diseases - attributable to SWI after estimating the correct environmental pollution levels. *Italian study (Coriano, 2007)*. Valutazione dello stato di salute della popolazione residente nell'area di Coriano (Forli) [34].

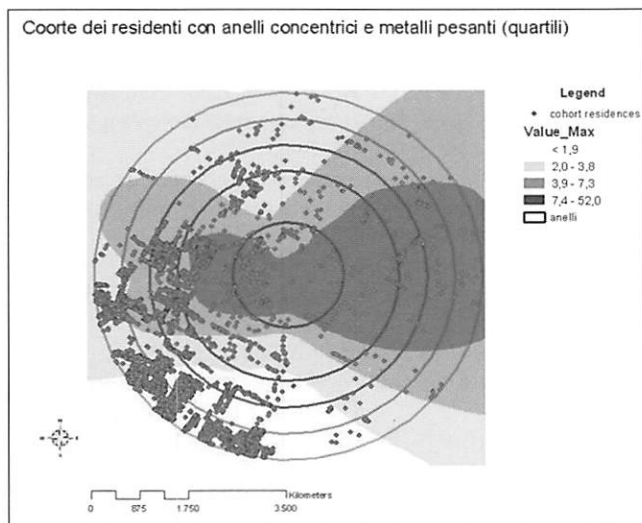


Figure 1. Italian study: map with heavy metals distribution (quartile) and related concentric rings [34]

In this study, called Enhance Health, exposure to heavy metals such as cadmium, nickel, mercury, aluminium, chromium and lead, was used as a proxy for exposure to all pollutants emitted by two closely located (municipal solid waste and hospital waste) SWI in Coriano (Forli). Pollution was evaluated according to a dispersion model in the air, four increasing levels of pollution were compared to the lowest one. Georeferencing of the resident population was also performed. Fig. 1 shows a map with the geographical distribution of both the resident population and heavy metal pollution. In the study the relative risks (RRs) for different levels of pollution were calculated with respect to the area and population with the lowest level of exposure. *French study (2008)*. Study of the incidence of cancers close to municipal SWI in France [35]. This is an ecological spatial study which was performed to assess the relationship between the exposure to emissions from municipal solid waste SWI and incidence of cancers in adults [35]. Estimate of the intercensus population in 1995: the total

population of individuals over the age of 14 years in the four departments studied was estimated to be 2,487,274 for 1995. It was based on cancers diagnosed in the three districts between 1990 and 1999: 135,567 cancer cases were reported over almost 25 million person-years. The exposure of each statistical unit to one of the 16 SWI during the 1970s and 1980s was quantified by modeling atmospheric dispersion and cumulative surface of dioxin deposition (Fig. 2). The atmospheric release from 16 SWI for the study of solid cancers between 1972 and 1984 covered 23% of this study population. Results are expressed as relative risks (RR), comparing the risks of cancer occurrence in areas with high and low levels of exposure.

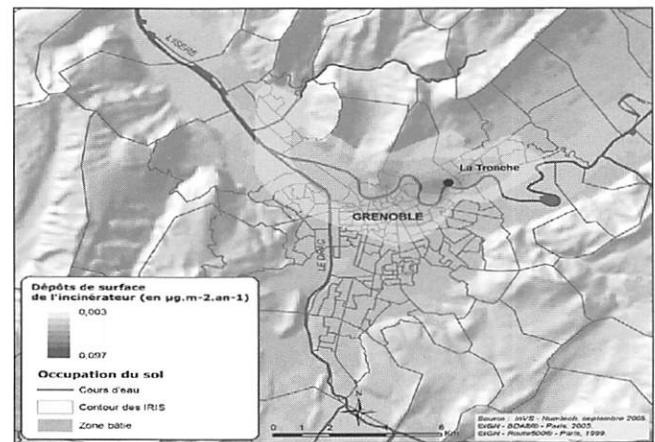


Figure 2. France study: Example of the modelling of surface deposits of dioxins between 1972 and 1984 around incinerator of La Tronche, Isère [$\mu\text{g}/\text{m}^2/\text{year}$] [35].

Results

Italian study (Coriano, 2007). This study shows the risk of death from all causes for women resident for at least 5 years from 1990 to 2003 in areas with different levels of exposure within 3.5 km of two incineration plants. Increased risks were observed for all causes of deaths and for all cancers. On the whole, also if the area under study was small, the methodology of the study makes these results particularly reliable among females. In that study other health effects and different damages were investigated using SDOs (hospital discharge records). Statistically significant (SS) increases in hospital admissions for respiratory diseases, kidney diseases, heart diseases, diabetes and spontaneous abortions were observed in the areas with highest risk levels of exposure; increased breast, gastric and colon-rectum tumors were also observed. Increasing (from 7% to 17% SS) relative risks (RR) for all – cause mortality were observed in females resident in the three main areas exposed to heavy metals (more than in the first level, taken as a reference). All cancers combined are more closely related to the three exposure levels as the risks are increased by 17%, 26% and 54%, respectively. We estimated that there were about 116 more deaths (including 73 tumors) among women residing for at least 5 years in the three exposed areas. This estimate is

relevant because it is based on a large number of cases observed only in the 1990-2003 period (358 and 166 cases were residents in the exposed and unexposed areas, respectively). These results, not shown in the cancer incidence study, may be underestimated because the reference population was likely exposed to heavy metals ranging between 0.61 and 1.9 ng/m³, whose harmlessness is still to be proven. In conclusion, it can be suggested that the largest number of health effects on women may be a result of the fact that they spend more time in the most exposed area.

French study (2008). A statistically significant relationship was found between exposure to incinerator emissions and the incidence, in women only, of all types of cancer combined (RR=1.06; CI95%=1.01-1.12), breast cancer (RR=1.09; CI95%=1.01-1.18) and non-Hodgkin's lymphoma (RR=1.18; CI95%=1.01-1.38). A significant relationship was also found for malignant non-Hodgkin's lymphoma in both men and women (RR=1.12; CI95%=1.00-1.12) and for multiple myeloma in men only (RR=1.23; CI95%=1.00-1.52). Close to the conventional level of statistical significance are also sarcomas (RR=1.22; CI95%=0.98-1.22), liver tumors (RR=1.16; CI95%=0.99-1.37) and multiple myeloma (RR=1.16; CI95%=0.97-1.40) in both sexes. If in addition to this evidence on females, we also consider male residents in a polluted area (RR=1.03), this study provides additional epidemiological evidence of a negative health impact of incinerator emissions.

Discussion

In some studies the simple distance from the incinerator was used as a proxy for exposure (analysing municipalities and concentric rings around the pollution source). In our opinion, a more correct study design should be selected, i.e. studies which used the emission characteristics of the source and meteorological and orographic data to estimate dispersion models for pollutants (analysis of exposure levels). In any case today there is sufficient agreement on recognition of the health damages, especially cancer related to old SWI. This is attested by the position of the Italian Association of Epidemiology (AIE) according to which: "older generation SWI have of course exposed resident populations to high levels of toxic substances [...]. Methodologically robust studies which cannot be easily contested have highlighted the presence of excesses of cancers ascribable to dioxin exposure" [36]. Instead the debate is ongoing on the risks of new SWI, but no good epidemiological data is available at this moment [37]. For these reasons, in order to avoid past mistakes, we believe that the prevention and precautionary principles ought to be applied privileging the reduction of waste production and fostering the recycling of materials.

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