



Food contamination by PCBs and waste disposal crisis: Evidence from goat milk in Campania (Italy)



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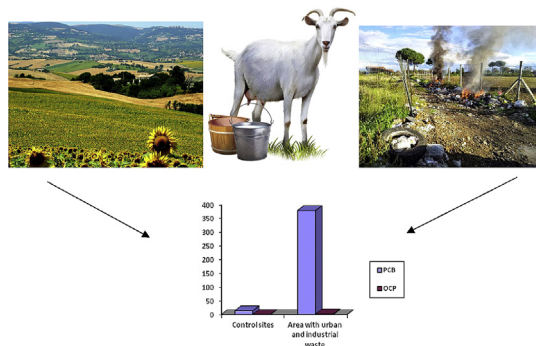
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HIGHLIGHTS

- High PCB concentrations in goat's milk from area with illegal waste disposal.
- Indicator PCB concentrations above the MRL fixed by EU.
- PCB concentrations negatively related to lipid content.

GRAPHICAL ABSTRACT



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ABSTRACT

Aim: The study aims at investigating whether, and if so, to what extent the strong presence of urban and industrial waste in a territory may cause PCB contamination in goat milk produced therein.

Methods: We compared PCB concentrations in goat milk from three different locations in the Campania region (Italy). One of the three locations, together with its surrounding area, has long suffered from illegal waste disposal and burning mainly by the so-called Ecomafia. The other locations, not involved in these illegal activities, allowed us to create a control group of goats with characteristics very similar to those of main interest.

Results: In milk from the waste contaminated area we identified high PCB concentrations (six indicator PCBs amounted to 170 ng g^{-1} on lipid weight, on average), whereas there was an almost total absence of such pollutants in milk from the control group. Concentrations of the six indicator PCBs were above the current European maximum residue limit fixed by the EU. At the same time, we found a lower average value of lipid content and a negative relationship between lipid content and PCB concentrations.

Conclusion: Evidence indicates the potential health risk for consumers living in areas involved in illegal dumping of waste.

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1. Introduction

During the 1990s a vast area of the provinces of Caserta and Naples (Campania, Italy) was involved in a dramatic emergency

concerning waste dumping. As revealed by a whistleblower, formerly a boss of the mafia group known as Casalesi, since the 1980s the network of criminal organizations known as Ecomafia had been organizing the illegal dumping of toxic urban and industrial waste produced all around Italy. The area concerned became the end point of such illegal activity. Here the waste was buried or dumped in illegal landfills or spilled into sewage systems, rivers and the sea (Dipartimento della Protezione Civile et al., 2007; Greyl et al., 2010). At the same time, the overloading of legal waste treatment facilities in the region also resulted in large amounts of civic waste being abandoned across the countryside or along the suburban streets, particularly where there was high population density. One of the most affected areas is nowadays known as *Terra dei Fuochi* (literally Land of Fires) because of the many episodes of waste being burnt in the open. The acknowledged environmental degradation prompted the national Italian authorities to include a number of municipalities within the area among the sites of national interest destined for remediation.

According to many authors, the prolonged and diffuse practice of illegal waste disposal, and the open-air burning of solid waste, including agricultural refuse, determined the release of organic as well as inorganic chemical contaminants (see Brambilla et al., 2004; US EPA, 2006). For instance, De Felip et al. (2014) found the presence of a number of highly toxic persistent contaminants in blood, serum and human milk samples from the province of Caserta. Giovannini et al. (2014) found dioxin concentrations in breast milk sampled in the highly contaminated municipalities of Caserta and Naples to be up to 1.5 times the maximum contamination recorded in Milan by Ulaszewska et al. (2011). Protracted living in such degraded environments may have an impact on health. A positive correlation across municipalities between the rise in mortality rates for stomach and liver cancer, which increased by up to 19% in some areas, or urogenital tract malformations, and an index of the vulnerability of the territory because of contaminated sites, indeed suggested a negative effect of such sites on health (Comba et al., 2006; Dipartimento della Protezione Civile et al., 2007; Martuzzi et al., 2009). In addition, groundwater from the Campania region has been found to contain hazardous chemicals, such as nitrate (Corniello et al., 2007).

Organochlorine compounds (OCs) are endocrine disruptors, which impair the normal functioning of the endocrine system of both animals and humans, thus inducing reproduction disorders and, at the worst, cancer (Mnif et al., 2011; Annamalai and Namasivayam, 2015; Polanco et al., 2017a, 2017b). They are also indicated as responsible for other toxic effects such as teratogenicity and immunotoxicity (see Annamalai and Namasivayam, 2015 for a recent survey). Malisch and Kotz (2014) reported that more than 90% of human exposure to OCs occurs in food, mainly that of animal origin. Moreover, in developing countries, where organochlorine pesticides (OCPs) are still employed in agriculture and cattle treatment, exposure may also occur via drinking water (Polanco et al., 2015).

Milk and dairy products, which are basic foods in the human diet, are among the main sources of exposure to OCs. Characteristics of lactating animals, such as age and the stage of lactation, as well as their diet and livestock rearing, together with environmental pollution, determine milk contamination with these chemicals (Krokos et al., 1996; Mamontova et al., 2007; Chen et al., 2017). In particular, when the animals are in pastures, the involuntary ingestion of soil, whose OC contamination is generally equal to, or higher than, that of grass can represent a major concern (Gworek et al., 2013). Several authors have detected higher OC concentrations in milk produced near waste incinerators or motorways or steel smelters (Ramos et al., 1997; Rychen et al., 2008; Turrio-Baldassarri et al., 2009; Desiato et al., 2014; Bertocchi

et al., 2015).

In the present study, we investigated whether waste of urban and industrial origins may be responsible for food contamination, by looking at PCBs (mainly non-dioxin-like PCBs) in goat milk. While several studies have been conducted on samples of cow and sheep milk, the literature on PCBs reveals little evidence regarding goat milk, which was obtained under experimental conditions (Costera et al., 2006; Esposito et al., 2010; Ounnas et al., 2010; Feidt et al., 2013; Fournier et al., 2013). Goat milk is consumed as a substitute for cow milk and for producing traditional cheeses and other milk-based products. Italy stands among the four main Mediterranean countries producing such milk (Escareño et al., 2013).

Its high percentage of fats (more than 4%) causes goat milk to accumulate lipophilic xenobiotics (such as PCBs and OCPs). The identification of the linkage between PCBs and waste was based on three main circumstances. Firstly, our sample units of milk came from farms managed by pastoralists and smallholders who adopted the extensive production system, whose main characteristic was that goats usually grazed freely around the farm and thus they might also feed of waste, as well as grass and soils. Secondly, some sample units were related to goats grazing inside the area affected by the waste emergency, while the rest of the sample came from two different locations in Campania neither of which were in the least involved in the emergency. Thirdly, we measured concentrations of PCBs as well as those of OCPs which, unlike PCBs, should not be linked to urban and industrial waste. Accordingly, we did not expect to find any difference between the two sub-samples. In making the analysis, we ascertained whether the pollutant concentrations were above the limit value for human consumption established by the European Commission legislation. Finally, we looked at the relationship between the pollutants and lipid content.

2. Materials and methods

2.1. Sampling sites and milk collection

Because of the activity of the Ecomafia as well as the overloading of treatment facilities, by 2005 it was estimated that there were as many as 2551 possibly contaminated sites in the Campania region, Italy (Fig. 1A). The provinces of Caserta and Naples registered about 80% of the total number of sites in the region (see Fig. 1B); in particular, 661 out of 766 uncontrolled waste disposal sites in the Campania region were located there (Table 1). However, as Fig. 1C clearly reveals, even within these two provinces the contaminated sites were not uniformly distributed.

The area of main concern for our analysis, namely the core area, is that identifiable through the exposure to the contamination index established by the Dipartimento della Protezione Civile et al. (2007). This area consisted of municipalities in the north-east of Naples and south-west of Caserta, where the average value of the contamination index was about four (the index ranges from one, for the lowest exposure, to five), with very slight variability across municipalities. Within the core area, the percentage of territory affected by the potential negative impact of legal and illegal waste sites was varied between 50% and 70%. Strong growth in the number of cancer patients among people living in this area during 1994–2001 is also reported by the Dipartimento della Protezione Civile (see also Comba et al., 2006; Martuzzi et al., 2009).

Milk sample units were collected from 4 farms, one farm located within the core area and three farms located outside the provinces of Caserta and Naples, two in the south of the Campania region, while the other one was in the north of it. Managed by herders or smallholders, farms were far from the maritime coast and the mountainous territory of the region, very close to urban

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