# Plant biomonitoring around waste incinerators

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## Introduction

Since the mid-nineties new waste incineration plants have come into operation in various agricultural regions in the Netherlands. Burning of municipal waste and biomass can result in the emission of potentially toxic compounds including heavy metals and organics such as dioxins and polychlorinated aromatic hydrocarbons. The incineration plants must comply with strict conditions concerning emission control and state-of-the-art technologies are used to remove gases and fly ash. However, public concern on the possible impact of emissions from waste incineration on human health and the environment still exists. Biomonitoring has shown to be very suitable tool to monitor the real impact of these emissions on agricultural crops and to communicate with all stakeholders.

## Material and methods

Standardized biomonitoring programmes were set up around three waste incineration plants to determine the possible effects of emissions on quality of agricultural and horticultural products (De Temmerman *et al*., 2004; Tonneijck *et al.*, 2002). Depending on time of year, kale (*Brassica oleracea* L.) and spinach (*Spinacia oleracea* L.) plants were cultivated for use as accumulators of cadmium (Cd), mercury (Hg) and polychlorinated aromatic hydrocarbons (PAHs). Trends in fluoride contents are followed by sampling field-grown pasture grass. Cow milk was sampled at different dairy farms to determine the concentrations of dioxins. Gladiola plants (*Gladiolus gandavensis* L.) were used for the assessment of visible injury by ambient fluoride in one programme only.

To determine possible effects of emissions from waste incineration plants, measurements at the sampling points at 3-4 km distance from each incinerator were compared with those from a reference point in the same area. Concentrations were also compared with the rural background levels (if known) and compared to standards for consumption (EC, 2006) or animal feed quality (Gezondheidsraad, 1990).

## Results and discussion

Results from two biomonitoring programmes between 2001 to 2011 around incinerators with a capacity of approx. 800 kton per year (Incin. 1, 2) are presented. A third programme was started in 2010 around a new incinerator with a capacity of approx. 250 kton per year (Incin. 3).

### *Cadmium and mercury*

Cadmiun levels in spinach and kale were comparable with the corresponding background level of approx. 95 and 30 µg $kg^{-1}$ fresh weight respectively (Figure 1). Mercury levels were relatively low (not shown). In a large number of samples mercury was not detectable. For both components no clear differences in concentrations were found at the sampling points around the incinerators and the corresponding reference point and appears that neither cadmium nor mercury was related to emissions from the incinerators. The maximum allowable level for cadmium in leaf vegetables of 200 µg $kg^{-1}$ fresh weight was not exceeded over the years. For mercury no maximum allowable level is set for leaf vegetables.

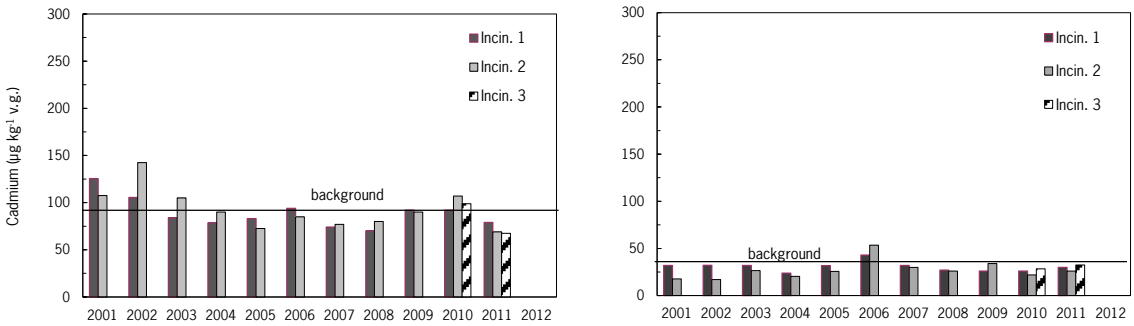


Fig. 1. Cadmium (µg $kg^{-1}$ f.w.) in spinach (left) and kale (right) exposed to ambient air in the immediate vicinity of three different waste incinerators from 2001 till 2011. The line indicates the background level.

## *Fluorides*

In general fluoride levels in grass follow a seasonal pattern with higher levels in autumn and winter and lower levels in the summer. Standing crop and surface roughness are important factors for this season fluctuation (Van der Eerden, 1991). In spring and summer, the levels around the incinerators and the reference points are corresponding to the seasonal pattern (= background level). The specific fluoride induced leaf-tip injury of the gladioli around Incin. 1 was relatively small during summer periods, also indicating a background load.

In autumn and winter of most years levels at the sampling points near incinerators 1 and 3 were somewhat higher than expected based on the seasonal pattern. On several days a significant relationship was seen between the fluoride concentration and the frequency of wind (hours) coming from the incinerators. Although a causal relationship was not proven but a contribution of the emissions to the levels found could not be completely excluded.

Annual mean fluoride concentrations were comparable with the background level of 5 µg $g^{-1}$ d.w (Figure 2). Almost every year one or several exceedances of the standard for animal feed of 25 µg/g were found, mainly at the sampling points north east of incinerators 1 and 3 (prevailing wind). In absolute terms, these levels were of little significance in relation to the risk for cattle. The fluoride levels around Incin. 2 were relatively low and no exceedances of the standard were found.

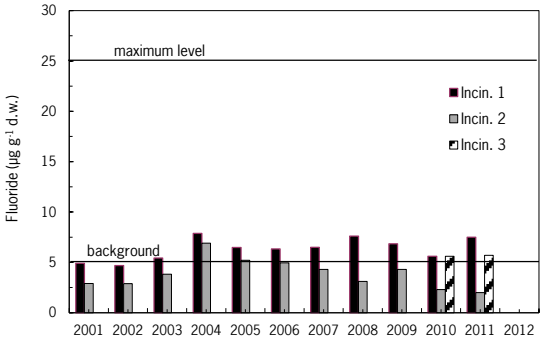


Fig. 2. Fluoride (µg $g^{-1}$ d.w.) in pasture grass harvested in the immediate vicinity of three different waste incinerators from 2001 till 2011. The line indicates the maximum allowable level for animal feed.

## *PAHs*

The long term PAH (sum of 13 polycyclic aromatic hydrocarbons) measurements in spinach and kale showed various levels of PAH, both between sampling points and over the season. In general the concentrations did not exceed the corresponding background level (Figure 3). No clear differences were found in PAH concentrations at the sampling points in the vicinity of the incinerators and the corresponding reference points. This was also the case in 2004 when

PAH levels in spinach were higher than the background level near incinerator 2. There was a significant correlation between the PAH concentrations and the frequency of wind coming from the incinerator. For PAH no maximum allowable level is set for leaf vegetables.

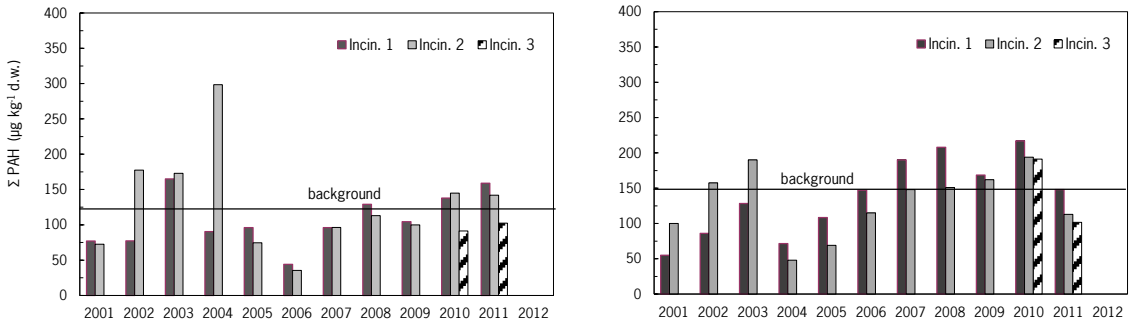


Fig. 3. PAH levels (µg $kg^{-1}$ d.w.) in spinach (left) and kale (right) exposed to ambient air in the immediate vicinity of three different waste incinerators from 2001 till 2011. The line indicates the background level.

## *Dioxins*

The levels of dioxins in milk from the dairy farms in the immediate vicinity of the incinerators did not exceed the national background level of 0.64 pg TEQ $g^{-1}$ fat (WHO-TEQ; Van den Berg et al., 1998), and thus do not apprear to be related to emissions from the incinerators. The dioxins-like PCBs content in milk fat from dairy cattle was determined in addition to the dioxins (Figure 4). The levels of dioxins and the sum of dioxins and PCBs remained well below the maximum permissible level for milk and milk products of 3 and 6 pg TEQ $g^{-1}$ fat respectively (EC, 2006). The results show that there is no potential risk with respect to the consumer quality of the examined milk.

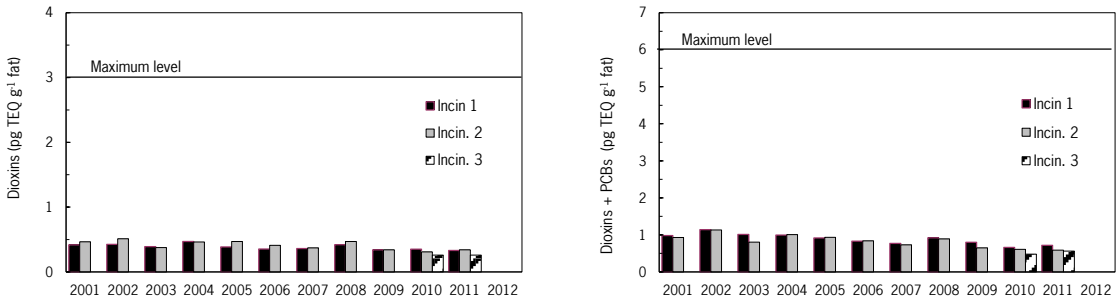


Fig. 4. Levels of dioxins (left) and dioxins+PCBs (right) in milk from dairy cattle in the immediate vicinity of three different waste incinerators in The Netherlands (pg TEQ $g^{-1}$ fat; mean of 4 samples per year). The line indicates the maximum level for milk en dairy product (EC, 2006)

# Conclusion

Long term results of biomonitoring showed that the emissions of the waste incinerators did not affect the quality of crop produce and cow milk. Concentrations of the various components in these products were generally similar to background levels and did not exceed standards for maximum allowable concentrations. Almost every year some exceedances of the fluoride standard for cattle feed were found in the maximum deposition area of two incinerators. A contribution of the emissions to the levels found near incinerator 1 could not be completely excluded. In absolute terms, these levels are of minor significance with respect to the risk to livestock.

The biomonitoring programs have also contributed to a better relationship between the companies involved and the farmers. Farmer's representation in the advisory commissions made it possible to discuss points of criticism and concerns. The predominantly positive results from the biomonitoring programs and open communication about it, resulted in the disappearance of farmer's resistance against waste incineration installations.

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