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DE SÉCURITÉ SANITAIRE
DES ALIMENTS

Maisons-Alfort, 27 July 2009

Opinion
of the French Food Safety Agency on soil contamination by dioxins and dioxin-like PCBs and the possible use of these soils with respect to any health-related repercussions on certain agricultural products

THE DIRECTOR GENERAL

1- CONTEXT OF THE REQUEST AND QUESTIONS RAISED

On 2 April 2009, the Directorate General for Food requested that the French Food Safety Agency (AFSSA) issue an opinion on soil contamination by dioxins and dioxin-like PCBs[1] (PCB-DLs), and the possible use of these soils with respect to any health-related consequences on agricultural products.
On 21 August 2008, a fire at the Vitale Recyclage wooden pallet recycling plant in Saint Cyprien (Loire département) led to smoke emissions over a period of some three months. Analyses of samples from within a five-kilometre radius of the affected area revealed contamination by dioxins and PCB-DLs of the air, soil, crops, silage, milk and live animals. It is very likely that the damaged land had previously been contaminated by Polycyclic Aromatic Hydrocarbons (PAHs), heavy metals and PCBs.

Given this context, management measures were taken in the approximately ten farms within one kilometre of the affected area, where dioxin and PCB-DL levels in milk and meat exceeded the maximum tolerated level. These included:

- a ban on the movement of animals exceeding the maximum tolerated level of dioxins and PCB-DLs,
- a ban on the collection and sale of milk from these animals,
- a ban on feeding animals from fodder produced within a five-kilometre radius of the damaged area,
- the destruction of the remains of hay and silage produced after the fire,
- ploughing any crops and plants at the end of the winter into the ground,

Before putting cattle out to pasture in the municipality of St Cyprien, AFSSA was requested to investigate:

1. the risk of contamination of the food chain resulting from farming activities on contaminated soil, whether pastures or crops used for animal fodder,
2. the influence of farming practices (whether crop growing or breeding practices) on the risk of contamination of the food chain originating in the soil.

After analysing the bibliographical data available and the results of analyses on samples from animals, fodder, milk and soil in the affected area, the Scientific Panels on Chemical and Physical Residues and Contaminants, and Animal Feed, met on 2 and 7 July 2009, respectively, and formulated the following opinion.

2 RESULTS OF ANALYSES OF SAMPLES FROM THE AFFECTED AREA

2.1 Results of analyses of soil and plant samples from areas in the vicinity of the fire

[1] PCB refers to polychlorinated biphenyls, chlorinated aromatic compounds belonging to a family of 209 compounds or congeners

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The initial results of analyses on samples from the affected area, sent to AFSSA between 8 April and 16 June 2009, reveal:

- soil contamination by dioxins and PCB-DLs much greater than usual 'background' levels, the maximum reaching 9600 pg TEQ/g dry weight at the site of the fire (Table 1), and contamination of grass and plant cover (fodder) differing in relation to distance from the site of the fire,
- results cannot exclude the possibility of pollution by PCBs and other persistent organic pollutants previous to the fire.

Table 1: Concentrations measured in soil samples within five kilometres of the fire (pg TEQ/g dry weight)

Sample site	PCDD/F TEQ	PCB-DL TEQ	Total TEQ
Area of fire	**7000**	**2600**	**9600**
Plot 2bis	*50*	*30*	*80*
Plot 2	*8*	*6*	*14*
Plot E1	*7.3*	*4.3*	*11.6*
Plot E3	*11*	*3.5*	*14.5*
Plot E5	*6.2*	*0.7*	*6.9*
Plot E6	*4.7*	*5.4*	*10.1*
Plot E7	*1.8*	*0.8*	*2.6*
Plot E9	*2.6*	*1.1*	*3.7*
Plot b	*7*	*2.3*	*9.3*
Plot d	*6.4*	*1.1*	*7.5*
Plot n	*2.4*	*0.6*	*3.0*
Plot Q	*2.7*	*0.7*	*3.4*
Plot v	*1*	*0.3*	*1.3*

Results provided by INERIS

2.2 Results of samples from animals near the fire

The few samples of fatty tissue and milk taken from animals on farms within five kilometres of the fire at St Cyprien reveal:

- Dioxin and PCB-DL contamination levels in fatty tissue two to 50 times higher than the tolerated level[2], in all the sheep and cattle analysed. The highest levels were found in suckling cows;
- heterogeneous contamination of milk samples (n=12), with seven samples that do not comply with regulations.

These results cannot be generalised to the whole affected area because there were too few analyses and too few repetitions for each parameter.

3. SYNOPSIS OF BIBLIOGRAPHICAL DATA AVAILABLE

Experimental research and observations currently available show that:

- particles of dioxins and PCB-DLs can be deposited near sources of emission but also up to several kilometres from the source,
- numerous factors, such as environmental conditions, plant characteristics and physico-chemical properties can influence the level of plant contamination by dioxins and PCB-DLs,

[2] Maximal value of 6 pg TEQ/g of fat for milk and 4.5 pg TEQ/g of fat for beef/veal or mutton/lamb; Commission Regulation EC 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs (OJEU of 20.12.2006, L364)

- the involuntary ingestion of soil by grazing animals usually represents less than 10% of dry matter ingested by sheep and less than 2% of that ingested by cattle (**Annex 1**). This is explained by the possibility of soil on fodder or the ingestion of plants with some roots attached, for example when grass tufts are pulled up. The risk of involuntary ingestion of soil by herbivorous animals increases:

  - with the species' prehension (tearing of fodder from the ground) and their ability to graze short grass, which means they are more likely to ingest soil. This is more often the case for sheep than for cattle,

  - when vegetation is short (during winter grazing or drought, for instance),

  - when animals are in particular need of food and seek grass even when it is short,

  - as density of grazing animals increases (risk of overgrazing).

- soil-to-plant carry-over (grass and pasture legumes) is usually limited (Collins *et al.*, 2006). In the case of the Saint Cyprien fire, this would indicate that there would be little contamination of fresh spring grass in 2009 and, more generally speaking, fodder produced once dioxins and PCB-DLs had stopped being released. However, contamination by dust particles from nearby contaminated soil cannot be excluded,
- taking into account the particularly long half-life of PCB-DLs and dioxins, which can reach 100 years in certain soils according to the US Environment Protection Agency (US EPA, 1997), it is of no advantage to bury plants in the subsoil to protect the food chain. When they decompose, the pollutants are likely to pass from the plants into the soil and thus increase the concentration of pollutants in surface soil,
- the mean dioxin levels measured in the soil of different French regions reveal reference values of between 0.02 and 1 pg TEQ/g dry weight in rural areas, 0.2 to 17 pg TEQ/g dry weight in urban areas and 20 to 60 pg TEQ/g dry weight in industrial areas (INSERM, 2000).

4. ESTIMATION OF THE RISK OF FOOD CHAIN CONTAMINATION BY ACTIVITIES HELD ON CONTAMINATED SOILS

To date, France has no regulations on the use of soils contaminated by dioxins or PCB-DLs. Some European countries have, however, proposed 'tolerable' soil contamination levels for dioxins and PCB-DLs with respect to certain activities:

- In Germany (Bundesrats-Drucksache, 1992), classification values based on dioxin contamination levels of soils were proposed to help implement management measures. It is thus recommended, should dioxin concentrations in soil lie between 5 and 40 pg I-TEQ/g[3] dry weight, to systematically test foodstuffs. Above 40 pg I-TEQ/g dry weight, a restriction on crops should be considered,

- In France, AFSSA proposed in 1999 a table indicative of soil use depending on dioxin contamination (Table 2).

Table 2: Grid indicating use of dioxin-contaminated soils – AFSSA 1999[4]

Indicative target values #	Dioxins in pg TEQ/g dry weight
Contaminated soil	>5

[3] Unit I-TEQ defined by NATO in 1989, later changed by the WHO

[4] Proceedings of the meeting of 2 August 1999: contamination of kaolin by dioxin, AFSSA, 11 August 1999.

Animal grazing stopped	>40
Use of soil for agricultural purposes stopped	>100
Soil to be decontaminated	>1000

[#] *These indicative values do not take into consideration contamination levels of non dioxin-like PCBs in particular (PCB-NDLs).*

To estimate the dioxin and PCB-DL concentration not to be exceeded in the soil (in pg TEQ/g dry weight) and, in the case of the St Cyprien fire in particular, to allow "uncontaminated" animals brought from outside the area to graze safely, various simulations and contamination hypotheses were proposed as shown below. An initial contamination level of 1 pg TEQ/g of fat (background) was selected for these animals.

Soil was considered the only reservoir of significant contamination for dioxins and PCB-DLs. Fodder was considered contaminant-free, given the absence of elements needed to quantify the volatilisation of PCB-DLs from soil and their adsorption on the lower side of leaves.

The simulations took the regulatory limit of 6 pg TEQ/g of fat for milk and 4.5 pg TEQ/g of fat for beef/veal and mutton/lamb into account (Commission Regulation EC 1881/2006) for the total amount of dioxins and PCB-DLs.

The estimation of the amount of soil ingested by grazing animals depended on the species in question and was based on available research data (**Annex 1**).

The carry-over rate (COR) of dioxins and PCB-DLs into fat is not known for all animals and varies according to the type of dioxin or the considered PCB-DL congener. Among dairy cattle, documented data suggest a COR into milk fat of the most abundant congeners found at St Cyprien of around 40% (**Annex 2**). However, as a conservative measure and in the absence of data applicable to all animals, a COR of 100% was chosen.

4.1 Estimation of dioxin and PCB-DL contamination levels in soil to avoid non-conformity of meat in sheep grazing for six months

The following hypotheses were used:

- sheep with a live weight of 60 kg including 9 kg of fatty tissue (15% of body weight),
- daily soil ingestion of 75 g or 150 g corresponding to 5 or 10% of ingested dry matter (1.5 kg/day),
- a two-box model was used, one being possible elimination through milk and the other accumulation in fatty tissue,
- 100% bioavailability,
- animals imported from outside the affected area: initial contamination of fatty tissue of around 1 pg TEQ/g of fat, so an initial load of 9000 pg TEQ,
- 90 days of lactation,
- production of 1 kg of milk per day corresponding to 60 g of fat excreted per day,
- level of contamination of milk fat identical to the concentration in fatty tissue.

The maximal levels for dioxins and PCB-DLs tolerated in soils to avoid any non-conformities in the meat of grazing sheep are estimated respectively at **4 and 8 pg TEQ/g dry weight depending on which hypothesis is used for the ingestion of contaminated soil (5 or 10% of dry matter ingested)**.

4.2 Estimation of dioxin and PCB-DL contamination levels in soil to avoid non-conformity of meat in young cattle grazing for six months

The following hypotheses were used:

- young cattle with a live weight of 300 kg including 44 kg of fatty tissue, imported from outside the affected area,
- initial contamination of fatty tissue of around 1 pg TEQ/g of fat, whence the maximal value of 44,000 pg TEQ,
- growth of 1000 g per day when grazing, whence a live weight of 480 kg after six months (including 95 kg of fatty tissue),
- daily soil ingestion of 160 g or 320 g corresponding to 2% or 4% of 8 kg of dry matter ingested per day.

The maximal levels for dioxins and PCB-DLs tolerated in soils to avoid any non-conformities in the meat of young grazing cattle are estimated respectively at **13 and 7 pg TEQ/g dry weight depending on which hypothesis is taken for the ingestion of contaminated soil (2 or 4% of dry matter ingested)**.

4.3 Estimation of dioxin and PCB-DL contamination levels in soil to avoid non-conformity of milk in dairy cattle

The following hypotheses were used:

- daily production of 25 kg or 35 kg of milk with 4% fat and 6 pg TEQ/g of fat, which is the maximum allowed under current regulations,
- dairy cow imported from outside the contaminated area,
- daily ingestion of 16 kg of dry grass matter, corresponding to 320 g or 640 g of soil assuming soil ingestion of 2 or 4%
- the animals' daily ration is complemented using variable quantities of (uncontaminated) concentrated feed depending on their production,
- COR of 100% or 40% (determined on the basis of documented data on dairy cattle - **Annex 2**).

The maximal levels for dioxins and PCB-DLs tolerated in soils to avoid any non-conformities in milk are estimated at **between 9 and 68 pg TEQ/g dry weight depending on the hypotheses chosen** (Table 3).

Table 3: Tolerable soil contamination (pg TEQ/g dry weight) to avoid non-conformities in the milk fat of dairy cows

	Concentrations in soil (pg TEQ/g dry weight)			
Daily soil ingestion	40% COR into milk		100% COR into milk	
	Milk production hypothesis Low	High	Milk production hypothesis Low	High
	25 kg with 4% fat	35 kg with 4% fat	25 kg with 4% fat	35 kg with 4% fat
320 g	**47**	**68**	**18**	**26**
640 g	**24**	**34**	**9**	**13**

4.4 Estimation of dioxin and PCB-DL contamination levels in soil to avoid non-conformity of meat in lactating meat-breed cattle

The following hypotheses were used:

- lactating meat-breed cow with a live weight of 900 kg including 120 kg of fatty tissue,
- lactating meat-breed cow from an uncontaminated area,
- daily soil ingestion of 260 g or 520 g, i.e. 2% or 4% of 13 kg of dry matter ingested[5],
- grazing during lactation estimated at 180 days,
- daily production of 7 kg of milk per day i.e. 280 g of fat containing a maximal limit of 4.5 pg TEQ/g of fat,
- concentration of pollutants (dioxins and PCB-DLs) in milk fat identical to that of fatty tissue,
- a two-box model was used, one being possible elimination through milk and the other accumulation in fatty tissue
- 100% bioavailability of pollutants.

The maximal levels for dioxins and PCB-DLs tolerated in soils to avoid any non-conformities in the milk and meat of lactating cows are estimated respectively at **6 and 11.5 pg TEQ/g dry weight depending on which hypothesis is used for the ingestion of contaminated soil (2 or 4% of dry matter ingested)**.

If the lactating cow continues to ingest 2% of soil (11.5 pg TEQ/g dry weight) after drying off, dioxin and PCB-DL concentrations in milk and fatty tissue are likely to exceed the maximal regulatory value of 4.5 pg TEQ/g of fat when next calving because contaminants will accumulate in fatty tissue rather than being excreted in milk as the cow is no longer lactating.

4.5 Dioxin and PCB-DL contamination in grazing suckling calves ("broutards") weaned at six months,

The following hypotheses were used:

- grazing suckling calves ("broutards") consuming 7 kg of milk per day from cows outside the contaminated area and grazing on contaminated soil with 11.5 pg TEQ/g dry weight,
- suckling period of 180 days,
- initial contamination of the dam's milk 1 pg TEQ/g of fat, then progressively richer and greater contamination up to 4.5 pg TEQ/g of fat after 180 days[6]
- suckling calf of 300 kg live weight, including 44 kg of fatty tissue at the age of six months,
- ingestion of 4 kg of dry grass matter during the first three months of suckling,
- ingestion of soil (contaminated with 11.5 pg TEQ/g dry weight) taken to be 2% of the quantity of grass ingested, i.e. 900 pg TEQ per day for the last three months prior to weaning.

After six months, dioxin and PCB-DL concentrations in the fatty tissue of suckling calves could be higher or equal to the maximal regulatory limit of 4.5 pg TEQ/g of fat, which would mean they would be unfit for sale and consumption at this stage. However, if the calves are put out to graze on uncontaminated soil or fattened up off-land (bullocks), contamination should be lower.

5. Conclusions and Recommendations

[5] The needs of lactating meat-breed cows in terms of ingested dry matter are below those of dairy cows because they produce less milk

[6] Maximal limit chosen for lactating suckler cows for meat and milk taking the hypothesis of dioxin/PCB-DL pollutant concentration identical in milk fat and fatty tissue

Considering

- the complexity of cross-over modalities for organic pollutants persisting in the food chain,
- the difficulty in exploiting results of soil analysis due to possible interpretation biases linked to the site's history and soil farming
- the partial nature of data currently available from St Cyprien concerning the quantity and spatial distribution of contamination,
- a dioxin and PCB-DL carry-over rate into fat of 100% in the absence of bibliographical data for all the species in question,

the French Food Safety Agency considers that tolerable soil contamination levels to avoid the risk of non-conformities in meat and/or milk from animals having grazed in the contaminated area lie **between 4 and 20 pg TEQ/g dry weight** depending on the different categories of investigated animals (Table 4).

Table 4: Estimation of dioxin and PCB-DL concentrations in soil that could lead to exceeding the maximal regulatory limits in animal products consumed (milk, meat) in the absence of any other source of contamination (as pg TEQ/g dry weight)

Species		C_{Soil} depending on the quantity of ingested soil (as a % of dry matter ingested)*	
		Low	High
Dairy cow	Poor producer	**9**	**18**
	Good producer (complemented)	**13**	**26**
Suckler cow		**6**	**11.5**
Young cattle		**7**	**13**
Sheep		**4**	**8**

* % of dry matter ingested by cattle: High = 4%, low = 2%, % of dry matter ingested by sheep: High = 10%, low = 5%

On the basis of these estimates, the maximal limit of 5 pg TEQ/g dry weight may be considered as a trigger value requiring the implementation of complementary measures consisting in:

i) confirming the spatial representativeness of the area's contamination by complementary soil analyses,

ii) applying grazing practice recommendations described in **Annex 3** when the mean level of soil contamination has been confirmed as: i) above 10 pg TEQ/g dry weight for cattle, or ii) above 5 pg TEQ/g dry weight for sheep, due to their higher ingestion rates,

iii) implementing a plan to monitor animal products for human consumption (milk, meat and offal), as well as soil and plants from the affected area.

AFSSA also points out that these recommendations cannot, under any circumstances, be generalised to sites subject to ongoing atmospheric pollution because the initial hypothesis for these simulations is that soil is the only means of contamination of animals imported from outside the contaminated area.

6 Bibliography

Collins C., Fryer M,, Grosso A. 2006. Plant Uptake of Non-Ionic Organic Chemicals. *Environm. Sci. Technol. 40, 45-52*

US EPA 1997. Test methods for evaluating solid wastes. SW-846. Final Update 3. *Office of solid waste and emergency response. Washington D.C.*

Abrahams P.W., Steigmajer J. 2003. Soil ingestion by sheep grazing the metal enriched floodplain soils of Mid-Wales. *Environm. Geochemistry and Health* 25, 17-24

Beyer N., Connor E.E., Gerould S., 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage. 58, 375-382.*

Bundesrats-Drucksache 24/92 (1992): Bericht der Bundesregierung zur Entschließung des Bundesrates zur Aufstellung einheitlicher Bewertungskriterien für Umweltbelastungen mit Dioxinen und Furanen (Bundesrats-Drucksache 140/90), Bonn 8.1.92

Collins C., Fryer M., Grosso A. 2006. Plant Uptake of Non-Ionic Organic Chemicals. *Environ. Sci. Technol. 40, 45-52*

Costera A., Feidt C., Marchand Ph., Le Bizec B., Rychen G. 2006. PCDD/F and PCB transfer to milk in goats exposed to a long-term intake of contaminated hay. *Chemosphere 64, 650-657*

Field AC, Purves D 1964. The intake of soil by grazing sheep. *Proc. Nutrit. Soc.* 23, 24

Firestone D., Clower M. Jr, Borsetti A.P., Teske R.H., Long P.E., 1979. Polychlorodibenzo-p-dioxin and pentachlorophenol residues in milk and blood of cows fed technical pentachlorophenol. *J. Agric. Food Chem. 27, 1171-1177.*

Fries G.F., Marrow G.S., 1982. Soil ingestion by dairy cattle. *J. Dairy Sci. 65, 611-618*.

Fries G.F., Paustenbach D.J., Mather D.B., Luksemburg W.J., 1999. A congener specific evaluation of transfer of chlorinated dibenzo-p-dioxins and dibenzofurans to milk of cows following ingestion of pentachlorophenol-treated wood. *Envir. Sci. Technol. 33, 1165-1170*.

Fries G.F., Paustenbach D.J., Luksemburg W.J., 2002. Complete mass-balance of dietary polychlorinated dibenzo-para-dioxins and dibenzofurans in dairy cattle and characterization of the apparent synthesis of hepta- and octachlorodioxins. *J. Agric. Food Chem*. 50, 4226-4231.

Fürst P., Krause G.H.M., Hein D., Delschen T., Wilmers K., 1993. PCDD/PCDF in cow's milk in relation to their levels in grass and soil. *Chemosphere* 27, 1349-1357.

***Healy* W.B., 1968**. Ingestion of soil by dairy cows. NZ. *J. Agric. Res. 11, 487-499.*

Healy W.B. et Ludwig T.G., 1965. Wear of sheep's teeth. I. The role of ingested soil. *N.Z.J. Agric.* Res. 8, 737-752.

Healy W.B., Drew K.R., 1970. Ingestion of soil by hoggets grazing swedes. *N.Z.J. Agric. Res.* 13, 940-944

INSERM, *Dioxines dans l'environnement - Quels risques pour la santé? Expertise collective – 2000*

Kirby D.R., Stuth J.W., 1980. Soil-ingestion rates of steers following brush management in central Texas. *J. Range Manage*. 33, 207-209.

Kreulen DA, Jager T. 1984. The significance of soil ingestion in the utilization of arid rangelands by large herbivores, with special reference to natural licks on the Kalahari pans. *In: Herbivore nutrition in the Subtropics and Tropics. Ed. Gilchrist FMC & Mackie RI, Science Press Johannesburg, 204-221*

Mayland H.F., Florence A.R., Rosenau R.C., Lazar V.A., Turner H.A., 1975. Soil ingestion by cattle on semiarid range as reflected by titanium analysis of feces. *J. Range Managm. 28, 448-452*

McGrath D., Poole D.B.R., Fleming G.A., Sinnott J., 1982. Soil ingestion by grazing sheep. *Ir. J. Agric. Res. 21, 135-145*.

McKay D., Fraser A., 2000. Bioaccumulation of persistent organic chemicals: mechanisms and models. *Environ. Pollut. 110, 375-391*.

McLachlan M.S., 1994. Model of the fate of hydrophobic contaminants in cows. *Environ. Sci. Technol. 2, 2407-2414*.

McLachlan M.S., 1995. Accumulation of PCDD/F in an agricultural food chain. *Organohalogen Compounds 26, 105-108*.

McLachlan M.S., Thoma H., Reissinger M., Hutzinger O., 1990. PCDD/F in an agricultural food chain. Part I : PCDD/F mass balance of a lactating cow. *Chemosphere 20, 1013-1020.*

Olling M., Derks H.J., Berende P.L., Liem A.K., Jong A.P., 1991. Toxicokinetics of eight ^{13}C-labelled polychlorinated dibenzo-p-dioxins and -furans in lactating cows. *Chemosphere 23, 1377-1385.*

Robert JC, Casteille 1990. INRA *Prod. Anim. 3, 243-252*

Sample B.E., Suter G.W. II, 1994. Estimating exposure of terrestrial wildlife. *Draft. ES/ER/TM-125.*

Sample, B.E., Aplin M.S., Efroymson R.A., Suter G.W. II, 1997. Methods and Tools for estimation of the exposure of terrestrial wildlife to contaminants. *Environmental Science Division Publications n°4650. ORNL/TM-13391, October 1997*

Slob W., Olling M., Derks H.J., de Jong A.P., 1995. Congener-specific bioavailability of PCDD/Fs and coplanar PCBs in cows: laboratory and field measurements. *Chemosphere 31, 3827-3838*.

Sweetman A.J., Thomas G.O., Jones K.C., 1999. Modelling the fate and behaviour of lipophilic organic contaminants in lactating dairy cows. *Environ. Pollut. 104, 261-270*.

Thomas G.O., Sweetman A.J., Jones K.C., 1999. Metabolism and body-burden of PCBs in lactating dairy cows. *Chemosphere* 39, *1533-1544*.

Thornton I., Abrahams P., 1983. Soil ingestion – a major pathway of heavy metals into livestock grazing contaminated land. *The Science of the Total Environment 28, 287-294*

Tuinstra L.G., Roos A.H., Berende P.L., van Rhijn J.A., Traag W.A., Mengelers M.J., 1992. Excretion of polychlorinated dibenzo-p-dioxins and -furans in milk of cows fed on dioxins in the dry period. *J. Agric. Food Chem*. 40, 1772-1776

Key words: Dioxins, PCB-DLs, soil, animal feed, contamination, cattle

Annex 1

Soil ingestion by grazing ruminants – bibliographical synopsis

The following table provides a synopsis of the literature on soil ingestion by grazing ruminants.

Most of this research focuses on sheep, which may ingest up to 15% of soil (Abrahams & Steigmeier, 2003) although a more usual level would be below 10% of dry matter ingested (Field & Purves, 1964) even though ingestion levels of up to 35% have been reported in extreme winter grazing conditions (Healy & Drew, 1970).

There are fewer studies on cattle and they show that involuntary soil ingestion among cattle does not exceed 4% of ingested dry matter in good grazing conditions and usually remains below 2% (Fries *et al.,* 1982).

Extreme values of 16% of dry matter (Kirby & Stuth, 1970) or 2.4 kg of soil (Thornton & Abrahams, 1983) have been reported in very unfavourable grazing conditions but it does not appear possible to generalise these statistics.

Species	Country	Season	Presence of other food	Ingested soil (g/day)			Weight gain (g/kg LW)	Weight gain (g/g of feed)	References
				Mean	Max	Min			
Sheep	NZ	Winter	No	60	150	5	1.2	0.060	Healy & Ludwig (1965)
	NZ	Autumn	No	4	10	0	0.1	0.005	Healy & Ludwig (1965)
	NZ	04/10	No	63	108	1	1.2	0.060	Healy *et al.* (1967)
	NZ	07/08	Yes	>1	>1	-	-	-	Healy *et al.* (1967)
	NZ	08/10	No	90	-	-	1.8	0.090	Healy *et al.* (1967)
	NZ	08/10	Yes	35	-	-	0.7	0.035	Healy *et al.* (1967)
	NZ	Winter	No	83	125	43	1.7	0.085	Healy & Drew (1970)
	NZ	Winter	Yes	48	68	26	1.0	0.050	Healy & Drew (1970)
	NZ	Winter	No	30	41	21	0.6	0.030	Healy & Drew (1970)
Cattle	NZ	All year	No?	770	2070	260	1.9	0.063	Healy (1968)
	GB	04/08	?	310	2400	27	0.7	0.022	Thornton & Abrahams (1983)
	USA	07/11	No	400	1500	100	1.1	0.055	Mayland *et al.* (1975)
	USA	05/11	Yes	113	146	83	0.4	0.019	Fries *et al.* (1982a)
	USA	Summer					0.3 to 0.84		Kirby & Stuth (1980)

Annex 2

Bibliographical data used to estimate carry-over rates (COR)
for milk fat from dairy cows

For dioxin- and furan-like congeners, the chosen values come from bibliographical references based on the distribution of contaminated fodder in experimental conditions or field conditions.

Table 1: Cross-over rate for PCDD/Fs from feed into milk – Synopsis of data from documented dioxin research

Congeners	Firestone *et al.* (1979)	McLachlan *et al.* (1990)	Olling *et al.* (1991)	Tuinstra *et al.* (1992)	Fürst *et al.* (1993)	Slob *et al.* (1995)	Fries *et al.* (1999)	Costera *et al.* (2006)
Milk (kg/day)	*14*	*28*	*-*	*23*	*-*	*28*	*26*	*2.2*
BF content (kg/day)	*0.5*	*1.4*	*-*	*1.2*	*-*	*1.0*	*1.1*	
2,3,7,8-TCDD		**35**	**30**	**34**	**9.3**	**15**	**35**	**38.8**
1,2,3,7,8-PeCDD		**33**	**28**	**55**	**6.5**	**10**	**28**	**34.3**
1,2,3,4,7,8-HxCDD		**17**		**28**	**3.0**	**5.6**	**18**	**24.1**
1,2,3,6,7,8-HxCDD	**16**	**14**	**27**	**37**	**5.3**	**6.4**	**16**	**22.7**
1,2,3,7,8,9-HxCDD		**18**		**12**	**1.5**	**3.1**	**12**	**14.1**
1,2,3,4,6,7,8-HpCDD	**1.7**	**3**	**1.6**	**2.5**	**2.0**	**0.6**	**1.8**	**5.0**
OCDD	**0.3**	**4**		**0.6**	**0.3**	**0.1**	**0.3**	**1.5**
2,3,7,8-TCDF					**0.6**			**8.2**
1,2,3,7,8-PeCDF					**0.3**			**14.3**
2,3,4,7,8-PeCDF		**25**	**36**	**24**	**5.1**	**12**	**18**	**28.1**
1,2,3,4,7,8-HxCDF			**18**	**26**	**3.7**	**4.3**	**5.7**	**22.0**
1,2,3,6,7,8-HxCDF		**16**		**30**	**2.7**	**3.6**	**11**	**17.8**
1,2,3,7,8,9-HxCDF								**4.4**
2,3,4,6,7,8-HxCDF		**14**		**25**	**3.5**	**4.2**	**8.4**	**13.0**
1,2,3,4,6,7,8-HpCDF		**3**	**1.7**	**1.9**	**0.7**	**0.4**	**1.4**	**2.9**
1,2,3,4,7,8,9-HpCDF		**8**				**0.5**		**3.1**
OCDF	**0.1**	**1**		**0.0**	**0.2**	**0.0**	**0.1**	**0.9**

Table 2: Mean COR into milk estimated for dioxins on the basis of research by Firestone *et al.* (1979), McLachlan *et al.* (1990), Olling *et al.* (1991), Tuinstra *et al.* (1992), Fries *et al.* (1999) and Costera *et al.* (2006).

Congener	Mean COR	COR standard deviation	*COR chosen (mean +1.96 SD)*
2,3,7,8-TCDD	34.6	3	**40.7**
1,2,3,7,8-PeCDD	35.7	11	**57.6**
1,2,3,4,7,8-HxCDD	21.8	5	**32.0**
1,2,3,6,7,8-HxCDD	23.3	9	**41.5**
1,2,3,7,8,9-HxCDD	14.0	3	**19.6**
1,2,3,4,6,7,8-HpCDD	2.8	1	**5.4**
OCDD	1.6	2	**4.9**
2,3,7,8-TCDF	8.2		**8.2**
1,2,3,7,8-PeCDF	14.3		**14.3**
2,3,4,7,8-PeCDF	26.2	7	**39.1**
1,2,3,4,7,8-HxCDF	17.9	9	**35.1**
1,2,3,6,7,8-HxCDF	18.7	8	**34.5**
1,2,3,7,8,9-HxCDF	4.4		**4.4**
2,3,4,6,7,8-HxCDF	15.1	7	**28.9**
1,2,3,4,6,7,8-HpCDF	2.2	1	3.6
1,2,3,4,7,8,9-HpCDF	5.6	3	12.3

Table 3: Estimated COR into milk for PCB-DLs

There are far fewer published data on PCB-DLs. The chosen values are based on personal communications (Ounnas *et al*., 2009, to be published) and the reprocessing of data from Costera *et al*. (2006).

PCB	chosen COR (%)
PCB 77	8
PCB 81	83
PCB 105	67
PCB 114	50
PCB 118	68
PCB 123	30
PCB 126	62
PCB 156	73
PCB 157	72
PCB 167	57
PCB 169	71
PCB 189	49

Annex 3

Good grazing practices

To reduce soil ingestion when grazing to a minimum, it is recommended that:

i) animals be put out to graze when mean grass height is equal to or greater than 10 cm,

ii) animals be removed when grass has been grazed down to a mean height of 5-6 cm, excluding refused areas,

iii) pastures not be overgrazed,

iv) prolonged grazing be avoided in Autumn and that animals not be allowed to graze in winter,

v) the cutting blade be raised when preparing grass silage,

vi) feed or feed complements not be put directly on the ground.