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Dioxin and PCB levels in milk

The place of milk in consumers' exposure to PCDDs, PCDFs and Dioxin-like PCBs

A document based on replies to IDF questionnaire 3002/SCRCC – Dioxin/PCB levels in milk

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1. Background

1.1. The issue

PolyChlorinated Dibenzo-Dioxins (PCDDs) and Dibenzo-Furans (PCDFs) (both referred to as dioxins) and dioxin-like PCBs (dl-PCBs) are lipophilic molecules. Due to their aerial dispersion and their lipophilic nature, these molecules enter the food chain through various routes. They are also found in the dairy section of the food chain.

Since 1998, market basket based surveys have been carried out in different parts of the world in order to determine the dietary exposure of humans to these compounds and to establish the basis for an evaluation and management of risks to public health. Milk and dairy products appear to be one of the significant contributors of the dietary exposure to the PCDDs, PCDFs and dl-PCBs.

Dioxins are formed as unintentional by-products and the main sources of emissions identified in many industrialized countries are particularly poorly controlled combustion processes. Manufacture of dl-PCBs and their use have been banned in most countries in 1987. The predominant sources of PCBs are now the environmental reservoirs from past release.

Some sources of PCDDs, PCDFs and/or dl-PCBs are listed below:

- Incineration of industrial, hospital and municipal waste
- Burning of household wastes
- Metal recycling and refining
- Drying processes for feed
- Ball clay (geogenic dioxins)
- Forest fires, volcanic eruptions
- Burning of fuels (such as wood, coal, gasoline or oil
- Chlorine bleaching of pulp and paper
- Electrical transformers and condensers
- Paints, wax, ink, plasticizers, lubricants, non-inflammable agents, adhesives...

An extensive inventory of PCDDs, PCDFs and dl-PCBs sources is reviewed in the "Code of Practice for the Prevention and Reduction of Dioxin and Dioxin-like PCB Contamination in Foods and Feeds" published by Codex Alimentarius (1).

Further reading:

- "Community strategy for dioxins, furans and polychronated biphenyls" by the Commission of the European Communities (2).
- "Stantardized toolkit for identification and quantification of dioxin and furan releases" by the United Nations Environment Programme (3).
- "Dioxin and furan inventories" National and regional Emissions of PCDD/PCDF by the United Nations Environment Programme (4).

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-"Guidelines for the identification of PCBs and materials containing PCBs" by the United Nations Environment Programme (5).

The chemical and toxicological behaviour of dioxins has quite extensively been described in review or position papers by groups such as JECFA (Joint FAO/WHO Expert Committee on Food Additives) (6), the EU SCF (European Union Scientific Committee on Food) and the US EPA. The 1st Scientific Report on Dioxins of the European Food Safety Authority (EFSA), which was meant to set methodologies and principles for setting tolerable intake levels for dioxins, furans and dl-PCBs, contains very valuable information as well (7). (Active links to websites with comprehensive information can be found on page 8).

1.2. The policies

EU SCF and JECFA have set Tolerable Intakes and compared these with calculated intakes. Based on these values, it appears that a proportion of the population exceeds the tolerable intake.

The policy developed by EU has been to establish a coherent set of Maximum Levels (ML) in food and feed based on Tolerable Intake values and on the technological possibilities, taking into account the range of background levels in the EU. The ML for milk and milk products is 3 pg WHO-PCDDs/PCDFs TEQ/g fat (8). The ML for compound feeding stuffs is 0.75 ng WHO-PCDDs/PCDFs TEQ/kg (9). The EU regulation n°1881/2006, that was implemented by 4 November 2006 integrates dl-PCBs. The ML set for milk and milk products is 6 pg/g for the sum of PCDDs/PCDFs and dl-PCBs. Moreover, action levels are tools for competent authorities and operators to identify a source of contamination and to take measures for its reduction or elimination. The action threshold for PCDDs/PCDFs as well as action level for dl-PCBs is 2 pg TEQ/g fat in milk and milk products (Recommendation 2006/88/EC (10)).

This enables guidance (Good animal feeding practice, Good manufacturing practice, etc...) and measures to be implemented in order to effectively reduce the content of dioxins and dl-PCBs in feeding stuffs.

1.3. Background of the issue at Codex Alimentarius Commission

The 32nd session of the Codex Committee on Food additives and Contaminants (CCFAC) decided that a Position Paper on dioxins and dl-PCBs should be elaborated on basis of a discussion paper from the Netherlands (11). This Position Paper would include the potential range of levels in the food (and feed) products of interest, information on available methods of analysis, and exploration of the arguments for and against setting maximum limits. At its 35th session, the CCFAC decided to discontinue the consideration of methods of analysis of dioxins and dl-PCBs, as that issue was being addressed by the Codex Committee on Methods of Analysis and Sampling.

At the same session, the CCFAC also requested the Netherlands to collect information on background levels of dioxins and dl-PCBs in food and feed, to support the development of possible maximum levels. Meanwhile, at its 32nd session, CCFAC had agreed that Germany would lead a drafting group to develop a "Proposed draft Code of Practice for source-directed measures to reduce dioxin contamination of foods". At the 36th session of CCFAC, the Committee noted that the Position Paper had provided the information that had been requested, that the delegation of the Netherlands would update the paper in the light of the comments received for future consideration, but agreed to discontinue the consideration of the Position Paper as regards to the development of maximum limits. At the 37th session of the CCFAC, it was decided to change the title to "Code of Practice for the prevention and reduction of dioxin and dl-PCB contamination in foods" (12). At the 39th session, a new section covering data on feed led to a document entitled "Code of Practice for the Prevention and Reduction of Dioxin and Dioxin-like PCB Contamination in Foods and Feeds".

The evolution of the requests of the CCFAC shows the evolution of the issue from the late 90's to 2006. Due to the knowledge collected on the considered persistent organic pollutants (POPs), namely their long persistence in the environment, the best way to tackle the whole issue is to work out a Code of Practice to act on sources and to prevent existing reservoirs from contaminating the food chain.

During its 36th session, the CCFAC encouraged Codex members to submit data on dioxins and dl-PCBs in foods to the WHO GEMS/Food database.

With the view of implementing its policy on assessing and managing risk, the European Commission recommended its member states to participate in its 2004-2006 EC monitoring programme for the background presence of dioxins, furans and dl-PCBs in foodstuffs via the Commission Recommendation 2004/705/EC (13). Other countries took similar decisions (see links on page 10). These monitoring programmes are still in place.

1.4. The issue for the dairy sector

As reported in the Position paper CX/FAC 04/36/32, compared to other food samples, many data are available for cow's milk and dairy products. During the initial phase of the dioxin crises linked to the concomitant findings on the toxicity of the dioxins and their release by industrial activities and namely waste incinerators, much of the monitoring programmes have been focused on milk and dairy products.

In this phase, the health and the environmental priorities have been mixed up: milk was considered by governmental bodies as a convenient indicator for health impact and as an indicator for environmental monitoring. This is understandable in a first phase of the issue management. But it should be clear to governments that for health and environmental monitoring purposes, milk is a biased and rather late indicator.

As it has been related above, market basket surveys that started in the late 90's have given a more realistic image of the contribution of various foodstuffs to human exposure to dioxins and dl-PCBs. Since the presence of dioxins in milk is mainly linked to aerial releases and to a lesser extent to reservoirs in the environment, it proved important to show the effects of the measures taken to decrease the releases of the main aerial sources on the dioxin level recorded in milk. For the milk industry, it is important to show that once the aerial sources are reduced, the relative contribution of milk and dairy products to exposure rapidly decreases.

During its meeting of 28 November 2001 in London, the IDF Standing Committee on Residues and Chemical Contaminants (SCRCC) decided to collect data from member states in order to detect if ML settings had already had an impact on actual values detected in milk and milk products and to see whether a trend curve could be drawn. It was intended that the resulting report draw discussion on whether or not MLs setting plays a role in managing dioxin levels in milk. A second goal of the report was to shape an IDF view on the "Contribution of milk to global exposure of the consumer to dioxins and related compounds". Further outcomes could be to initiate future work by IDF on the management of dioxin related issues.

2. IDF questionnaire 3002/SCRCC – Dioxin/PCB levels in milk

2.1. Questionnaire

To collect data, a questionnaire (see annex 1) was sent in 2002 to the 36 IDF full members and to 5 IDF associate member countries. None of them abstained but 22 countries did not reply to the survey (17 full members and the 5 associate member countries). 19 countries did respond (46%), the majority from Europe (particularly from the European Union).

2.2. Results

Among the 19 answers, some were incomplete or showed some incoherence, particularly for the qualitative part of the questionnaire. A synthesis and comments on the qualitative form are given in annex 2. A synthesis and comments in the quantative form are given in annex 3.

No supplementary data were yielded after the two meetings of the SCRCC of 14 November 2003 (Brussels) and of 1 March 2004 (Cape Town). No breaking new results or trends on milk or dairy products were found in the proceedings of "Dioxin 2003", the 23rd International Symposium on Halogenated Environmental Organic Pollutants, Boston, in "Dioxin 2004", the 24th International Symposium, Berlin or in "Dioxin 2005", the 25th International Symposium, Toronto. The results of the various national monitoring programmes that were communicated during these Symposia have not been integrated in the results hereunder. They do not modify the conclusions and trends.

The latter surveys included some new molecule monitoring like polybrominated flame retardants (polybrominated diphenylethers - PBDE) that could later be accounted in the total TEQ values (14).

2.3. PCDDs/PCDFs

Total PCDD/PCDF trends during the last years (1999-2002) could be assessed from the data received from four responding countries (all industrialised countries). All recorded an overall trend of more than 10% decrease per year in the 5-8 years after implementation of emission control measures (figure 1). After this initial phase, the PCDD/PCDF values expressed in WHO-TEQs reach an average plateau at 0.3 – 0.5 pg TEQ/g fat (but with a regional and seasonal variation) in the historically most industrialised countries. These are somewhat lower in the lesser industrialized countries. The results available in 2003 and 2004 (not covered at the time the questionnaire was sent) show the same trend.

Areas or countries with a less industrialised background can reach a lower plateau 0.1 – 0.3 pg TEQ/g without dl-PCBs (0.3 – 0.5 with dl-PCBs).

2.4. Dioxin-like PCBs

Data are scarce. It is too early to draw conclusions on the time trend of dl-PCB values. Although the origin of PCDDs/PCDFs and dl-PCBs differ, it seems that the various emission control measures also have an impact on decreasing the dl-PCB levels in milk, but to a lesser extent. More values became available in 2003 and 2004 that confirm the decrease in dl-PCBs.

Figure 1 shows a typical evolution of milk contamination by PCDDs/PCDFs in an industrialized country where emission control measures have been implemented recently. When the main sources of airborne contamination are suppressed, as has occurred in some industrialised countries, the level of milk contamination rapidly decreases. The "plateau" level depends on the present pressure of diffuse sources and the "history" of the areas. The same occurs for PCBs, albeit at a slower rate.

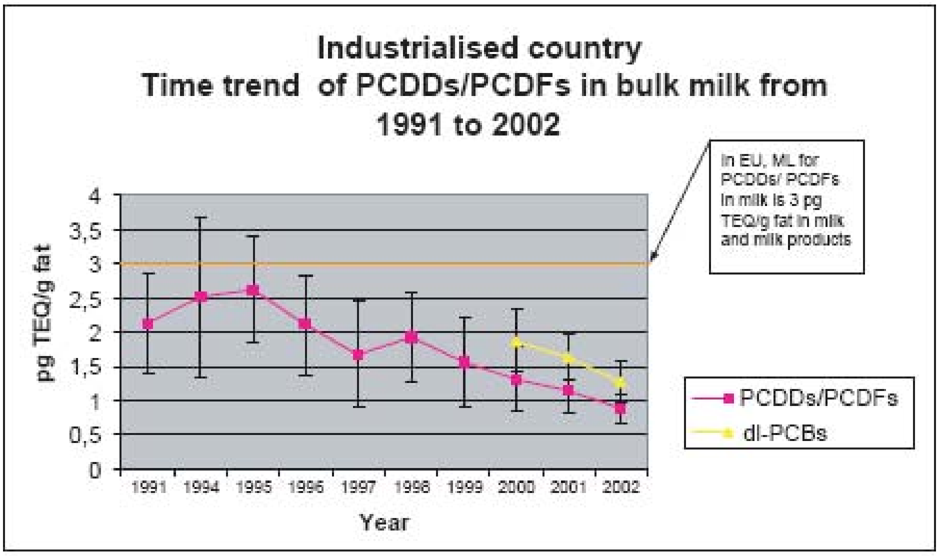

Figure 1. Example of time trend of PCDDs/PCDFs in bulk-milk in an industrialized country.

Figure 2 shows the same kind of trend but in a situation where corrective measures on sources began earlier (in the Netherlands). One should know that before 1989, there was no legal limit on dioxins. Between 1989 and April 2001, the maximum limit for PCDDs/PCDFs set at a national level was 6 pg TEQ/g fat and between April 2001 and May 2002, it was reduced to 5 pg TEQ/g fat. From June 2002, the maximum limit has been set at the EU level at 3 pg TEQ/g fat. This figure illustrates quite well the fact that the measures taken on emission sources are much more effective than the measures taken on food.

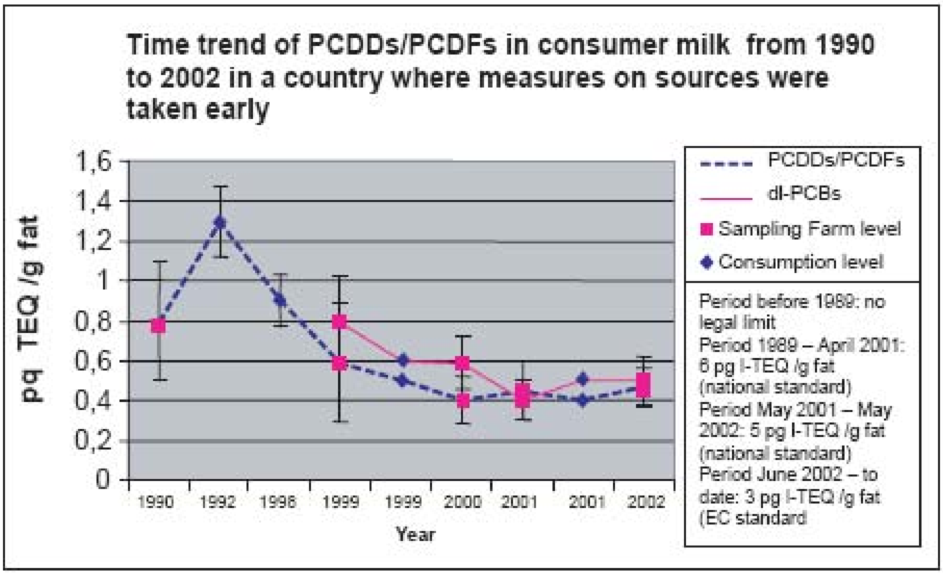

Figure 2. Time trend in an industrialized country where emission control measures were implemented early.

Figures 3 and 4 that follow are drawn from a paper by Baumann R.A. et al. at the International Symposium on Dioxins, Dioxin 2003, Boston and are worth examining.

Figure 3 gives the total level of PCDDs/PCDFs and dl-PCBs in monthly pooled samples of farm milk in the Netherlands (Note : in the new EU legislation, the maximum limit for the sum of PCDDs/PCDFs and dl-PCBs is set at 3+3 pg TEQ/g of fat). It confirms the results mentioned previously, with a better focus on the 1997 to 2002 period. It shows the importance of surveying and monitoring sources of halogenated compounds, since a single accident can dramatically affect the content in milk (e.g., the 1997 event with the presence of high levels of dioxins in citrus pulp from Brazil, used in feed). It also shows the plateau reached in 2000-2001, in a country where emission control measures were taken early.

Figure 4 shows that the relative contribution of PCBs (and in particular PCB 126) gradually increases over the years, indicating that the emission control measures have rapid impact on PCDDs/PCDFs, and a lesser impact on PCBs.

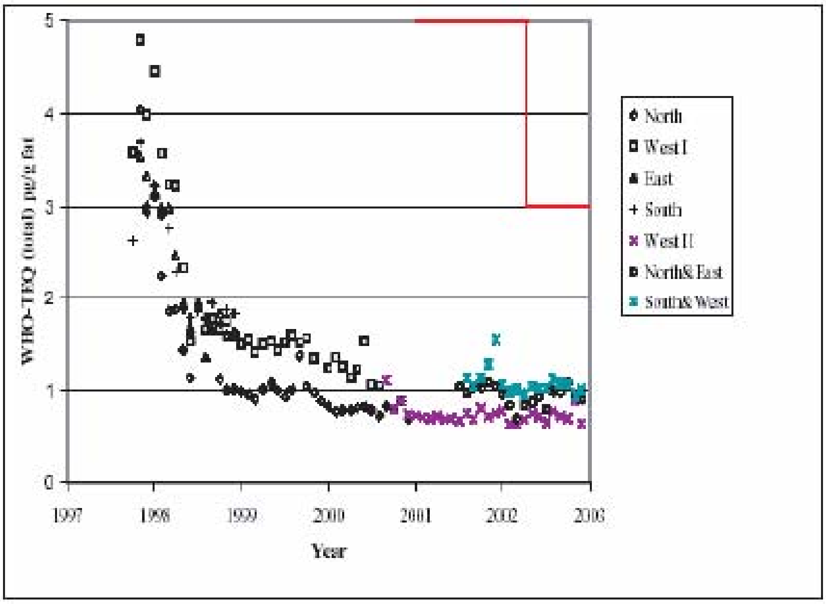

Figure 3. Level of WHO-TEQ's (sum of PCDDs/PCDFs and dl-PCBs) in monthly pooled samples of farm milk in country where national ML's exist since 1989. ML's are shown in red line. From 1989 to April 2001, ML's for PCDDs/PCDFs were set at 6 pg I-TEQ/g fat

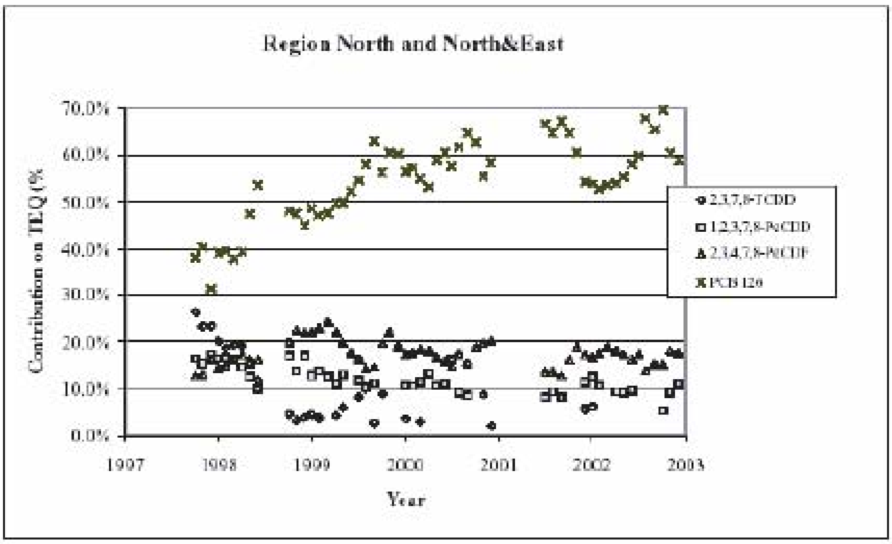

Figure 4. Level of WHO-TEQ's (sum of PCDDs/PCDFs and dl-PCBs) in monthly pooled samples of farm milk in a country where national ML's exist since 1989.

3. Discussion

Since the health concerns peaks of the late 90's, the dioxin and related compounds issue has evolved in most of the developed countries. Due to its rapid transfer to the food chain, the key to reduce human exposure to PCDDs/PCDFs is to reduce the releases into the environment. Through regulation and voluntary efforts, releases of dioxin to the environment have been dramatically reduced.

Based on the European experience where ML on food and feed exist and apply, it appears that broadly applied environmental measures and legal emission limits are most effective in reducing the dioxin content of milk. These measures result in a rapid reduction of PCDDs/PCDFs and, at a lower rate, dl-PCBs. Legal limits for dioxins in milk are a stimulant for applying the legally required environmental measures in areas with extreme emission and are an effective management tool in case of contamination incidents in the food chain. However, these milk related measures add little to the reduction of the average dioxin level of milk. This is also true when the limits in milk are further reduced as it appears from figures 2 and 4.

The dairy industry should be aware that:

- An essential prerequisite for a low contamination of milk and dairy products is the elimination of the emission sources of dioxins and dl-PCBs.
- The food sector, and particularly the dairy sector, has paid a high price for complying with existing or future standards; the key point is that the sectors concerned with emission/source of halogenated compounds comply to their own standards. ML's for food and feed products prove to be an effective tool for the management of incidents in which extreme emissions and/or contaminations from other sources occurred. However, as there is a tendency to set these standards at a low level, the resulting measures are mainly at the expense of the food industry, which often has been handled as a hostage between the lack of environmental rules and enforced on the one hand and strictly applied food legislation standards on the other hand.
- The key point to further reduce the presence of halogenated compounds in food is to introduce an environmental legislation, which is attuned to the potential contamination of the food and the tolerable intake of these compounds. The regulations should be enforced by surveying, controlling and monitoring the potential (emission) sources. The authorities should associate industries concerned with the emission source to the integrated food chain management approach and, in the scope of a risk assessment, to establish Performance Objectives for them. This work has partially been implemented for PCDDs/PCDFs, has only begun for PCBs and is not yet underway for PBDEs.
- Once the initial phase of reduction of airborne dioxin and dioxin-like compounds has occurred, the next step is to prevent the "accidents" and to avoid remobilisation of the deposits in the environment. A complete inventory of "deposits" or potential sources to be eliminated, monitored or surveyed should be established. The POP convention, Annex C, Part II and III describes the potential sources but this is not yet an inventory.
- It is not only important that inventories be established, but also that databases with pattern of congeners of sources of dioxins – PCBs be created so as to enable tracking the origin of contamination. The availability of carry-over coefficients is of uppermost importance. See the IDF paper by Heeschen and Blütghen (15).
- Milk can be considered as one of the food products of which the dioxin content is a general indicator of the quality of the environment. However, it should not be used as a "gold indicator or monitoring standard" for environmental or sanitary measures. In both cases, it is a late and non-specific indicator. Sources should be monitored directly.
- Paradoxically, milk is still being used as the multipurpose indicator because of its commodity of use, though the results that were collected indicate that milk is less sensitive to the remobilisation of historical deposits than other foods. It should be stressed however that, in regions where PCB and dioxin levels in soil are very high, altered climatic conditions can

cause milk contamination to occur. It also appears that main causes of soil pollution are linked to past dysfunction of waste incinerators and sewage sludge.

- More knowledge has to be obtained on the origin of PCB's found in milk.
- When considering standards at each step of the food chain (Performance Objectives) they should not be too stringent or unrealistic in order to avoid defaults of real compliance. Namely, the presence of relatively high PCDD/PCDF and PCB levels in soils should not be an exclusion factor for milk producing provided that the production is performed according to a code of practice.

4. Current issues and future prospects

Health bodies in the US and EU consider the general intake of dioxins and related compounds to be too high. The EU has introduced a step -and iteration- wise process to lower exposure. By 31, December 2008, provisions established in EU regulation n°1881/2006 and Recommendation 2006/88/EC should be re-examined, and the distinct maximum level for dioxins could be deleted. The policy that is adopted is to progressively decrease exposure while not impacting more than 5% of the products from the market. The EU relies on combined MLs and ALs, subject to revision to continuously decrease the dioxin burden. These new considerations will only be based on technical possibilities.

Based on the trend that has been shown, the dairy industry will be able to comply. In consideration of the "integrated milk chain" it is important that the measures be taken at the right place in the chain so as to avoid recurrent, inefficient and costly actions.

Milk and milk products will still contribute partially to the total exposure of the consumer to the dioxins and dl-PCBs. This contribution will progressively decrease due to the fact that milk is less sensitive than other products to the remobilisation of historical deposits.

Longer-term prospects would be to coordinate research on how milk nutrients could counteract deleterious effects of dioxins. Until now risk is only assessed based on the cumulative effects of individual toxicants. The nutrients can antagonise the effects of toxicants by binding to receptors to which toxicants are ligands. The most potent antagonist of dioxin to the Arh receptor is 7-keto cholesterol, which is found in high amounts in milk (16); there is a whole area of research that is still unravelled on which the dairy sector should focus.

5. Links

- Stockholm convention on Persistent Organic Pollutants (POPs):
  http://www.pops.int/
- European Commission - persistent organic pollutants :
  http://europa.eu.int/comm/environment/pops/index_en.htm
- European Commission (DG Health and Consumer Protection) – Dioxins in feed and food:
  http://europa.eu.int/comm/food/food/chemicalsafety/contaminants/dioxins_en.htm
- US Environmental Protection Agency - resources on dioxins and related compounds:
  http://www.epa.gov/nceawww1/dioxin.htm
- WHO - factsheet on dioxins:
  http://www.who.int/inf-fs/en/fact225.html
- Chlorine Chemistry Council - facts on dioxins:
  http://c3.org/chlorine_issues/understanding_dioxin/dioxin_index.html
- European Commission - waste incineration page:
  http://europa.eu.int/comm/environment/wasteinc/index.htm
- Australian Government National dioxins program:
  http://www.deh.gov.au/settlements/chemicals/dioxins/index.htm

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