Prepared by Dioxin, PCBs and Waste Working Group of the International POPs Elimination Network (IPEN) Secretariat, ENVILEAD (Kenya) and Arnika Association (Czech Republic)

Contamination of chicken eggs near the Dandora dumpsite in Kenya by dioxins, PCBs and hexachlorobenzene

ARNIKA

ENVILEAD

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"Keep the Promise, Eliminate POPs!" Campaign Report

Prepared by Dioxin, PCBs and Waste WG of the International POPs Elimination Network (IPEN) Secretariat, ENVILEAD (Kenya) and Arnika Association (Czech Republic)

Nairobi - Prague (March-16-2005)

Executive Summary

Free-range chicken eggs collected near the Dandora dumpsite outside Nairobi showed high levels of dioxins and PCBs. Dioxin levels exceeded background levels by almost 18-fold and were more than six times higher than the European Union (EU) dioxin limit for eggs. Levels of PCBs exceeded proposed regulatory limits by more than four-fold. To our knowledge, this study represents the first data about U-POPs in chicken eggs from Kenya.

The most obvious potential source of POPs releases at the site is the burning of chlorine-containing waste products such as commonly-found PVC plastics. The high levels of U-POPs represent a concern for wider contamination since the Nairobi River passes below the dump and eventually drains into the Indian Ocean.

The toxic substances measured in this study are slated for reduction and elimination by the Stockholm Convention which holds its first Conference of the Parties beginning 2 May 2005. Kenya is a Party to Convention since it ratified the Treaty in September 2004. The Convention mandates Parties to take specific actions aimed at eliminating these pollutants from the global environment. We view the Convention text as a promise to take the actions needed to protect Kenyan and global public's health and environment from the injuries that are caused by persistent organic pollutants, a promise that was agreed by representatives of the global community: governments, interested stakeholders, and representatives of civil society. We call upon Kenyan governmental representatives and all stakeholders to honor the integrity of the Convention text and keep the promise of reduction and elimination of POPs.

Recommendations

1) More POPs monitoring in Kenya is needed;

2) More publicly accessible data about U-POPs releases from all potential sources in the region are needed to address them properly;

3) Stringent limits for U-POPs emissions and levels in waste should be introduced into national legislation.

4) PVC-containing waste should not be burned and preferably other materials that do not contain chlorine should be substituted for products currently using PVC.

Introduction

Persistent organic pollutants (POPs) harm human health and the environment. POPs are produced and released to the environment predominantly as a result of human activity. They are long lasting and can travel great distances on air and water currents. Some POPs are produced for use as pesticides, some for use as industrial chemicals, and others as unwanted byproducts of combustion or chemical processes that take place in the presence of chlorine compounds. Today, POPs are widely present as contaminants in the environment and food in all regions of the world. Humans everywhere carry a POPs body burden that contributes to disease and health problems.

The international community has responded to the POPs threat by adopting the Stockholm Convention in May 2001. The Convention entered into force in May 2004 and the first Conference of the Parties (COP1) will take place on 2 May 2005. Kenya ratified the Convention in September 2004.

The Stockholm Convention is intended to protect human health and the environment by reducing and eliminating POPs, starting with an initial list of twelve of the most notorious, the "dirty dozen." Among this list of POPs there are four substances that are produced unintentionally (U-POPs): polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) The last two groups are simply known as dioxins.

The International POPs Elimination Network (IPEN) asked whether free-range chicken eggs might contain U-POPs if collected near potential sources of U-POPs named by the Stockholm Convention. The Dandora dumpsite near Nairobi was selected as a sampling site since open burning of PVC plastic and other chlorine-containing items are known to produce dioxins and furans. Chicken eggs were chosen for several reasons: they are a common food item; their fat content makes them appropriate for monitoring chemicals such as POPs that dissolve in fat; and eggs are a powerful symbol of new life. Free range hens can easily access and eat soil animals and therefore their eggs are a good tool for biomonitoring of environmental contamination by U-POPs. This study is part of a global monitoring of egg samples for U-POPs conducted by IPEN and reflects the first data about U-POPs in eggs ever reported in Kenya.

Materials and Methods

Please see Annex 1.

Results and Discussion

U-POPs in eggs sampled near the Dandora dumpsite

The results of the analysis of a pooled sample of 6 eggs collected near the Dandora dumpsite are summarized in Tables 1 and 2. Pooled sample fat content was measured at 11.5%.

Levels of dioxins found in sampled eggs from the Dandora dumpsite in Table 1 were more than six times higher than the EU dioxin limit for eggs. In addition, the samples exceeded the proposed limits for PCBs (in WHO-TEQs) by more than four-fold.

Table 1: Measured levels of POPs in eggs collected near the Dandora dumpsite close to Nairobi per gram of fat.

	Measured level	Limits	Action level
PCDD/Fs in WHO-TEQ (pg/g)	22.92	3.0[a]	2.0[b]
PCBs in WHO-TEQ (pg/g)	8.10	2.0[b]	1.5[b]
Total WHO-TEQ (pg/g)	31.02	5.0[b]	-
PCB (7 congeners) (ng/g)	31.1	200[c]	-
HCB (ng/g)	4.40	200 (10)[d]	-

Abbreviations: WHO, World Health Organization; TEQ, toxic equivalents; pg, pictogram; g, gram; ng, nanogram.

[a] Limit set up in The European Union (EU) Council Regulation 2375/2001 established this threshold limit value for eggs and egg products. There is even more strict limit at level of 2.0 pg WHO-TEQ/g of fat for feedingstuff according to S.I. No. 363 of 2002 European Communities (Feedingstuffs) (Tolerances of Undesirable Substances and Products) (Amendment) Regulations, 2002.

[b] These proposed new limits are discussed in the document Presence of dioxins, furans and dioxin-like PCBs in food. SANCO/0072/2004.

[c] Limit used for example in the Czech Republic according to the law No. 53/2002 as well as in Poland and/or Turkey.

[d] EU limit according to Council Directive 86/363/EEC, level in brackets is proposed new general limit for pesticides residues (under which HCB is listed) according to the Proposal for a Regulation of the European Parliament and of the Council on maximum residue levels of pesticides in products of plant and animal origin, COM/2003/0117 final - COD 2003/0052.

Table 2 shows that the level of dioxins in eggs expressed as fresh weight exceeded the limit for commercial eggs in the USA by 1.5 fold. The US Food and Drug Administration estimates a lifetime excess cancer risk of one in 10,000 for eggs contaminated at 1 pg/g ITEQ. The samples collected near the dumpsite at Dandora exceeded this cancer risk level.[a]

Table 2: Measured levels of POPs in eggs collected near the Dandora dumpsite close to Nairobi per gram of egg fresh weight.

	Measured level	Limits	Action level
PCDD/Fs in WHO-TEQ (pg/g)	2.64	1[a]	-
PCBs in WHO-TEQ (pg/g)	0.93	-	-
Total WHO-TEQ (pg/g)	3.57	-	-
PCBs (7 congeners) (ng/g)	3.58		
HCB (ng/g)	0.51	-	-

Abbreviations: WHO, World Health Organization; TEQ, toxic equivalents; pg, pictogram; g, gram; ng, nanogram.

[a] U.S. Department of Agriculture Food Safety and Inspection Service [Memo 8 July 1997] Advisory to Owners and Custodians of Poultry, Livestock and Eggs. Washington, DC:U.S. Department of Agriculture, 1997. FSIS advised in this memo meat, poultry and egg product producers that products containing dioxins at levels of 1.0 ppt in I-TEQs or greater were adulterated. There is an even more strict EU limit at level of 0.75 pg WHO-TEQ/g of eggs fresh weight for feeding stuff according to S.I. No. 363 of 2002 European Communities (Feedingstuffs) (Tolerances of Undesirable Substances and Products) (Amendment) Regulations, 2002.

To our knowledge, the measurements of U-POPs in this study represent the first data on U-POPs in chicken eggs ever reported in Kenya. The surprising high-levels of U-POPs observed in the egg

[a] was estimated (using a cancer potency factor of 130 (mg/kg-day)-1 and rounding the risk to an order of magnitude) for consumption of 3-4 eggs per week (30 g egg/day) contaminated at 1 ppt ITEQ[a, a]

samples support the need for further monitoring and longer-term changes to eliminate chlorinated materials that serve as donors for dioxin formation in the dump.

Comparison with other studies of eggs

The dioxin levels in eggs in this study exceed background levels by more than 18-fold (0.2 - 1.2 pg WHO-TEQ/g of fat).

We compared the levels of PCDD/Fs measured in this study in eggs from the Dandora dumpsite with data from other studies that also used pooled samples (Please see Annexes 2 and 3.) The data for eggs described in this report follow on the heels of a similar study in Slovakia released 21 March 2005.[1] Dioxin levels in the eggs sampled from the Dandora dumpsite in Kenya were almost two-fold higher than those observed in eggs collected in Slovakian villages downwind of the Koshice municipal waste incinerator.

Other studies showing high levels of dioxins include samples near an old waste incinerator in Maincy, France [2] and an area affected by a spread mixture of waste incineration residues in Newcastle, UK.[3] The mean dioxin values observed in these locations in pooled samples were even higher than the values observed in this study at 42.47 pg WHO-TEQ/g and 31 pg WHO-TEQ/g respectively.

It is clear that dioxins represent the most serious contaminant in the sampled eggs from the Dandora dumpsite. PCDD/Fs contribute almost 75% of the whole TEQ value in eggs as visible from graph in Annex 5. Despite this substantial contribution of dioxins, levels of PCBs and HCB are not negligible as shown in Annex 4 for PCBs and in Annex 6 for HCB. PCBs levels expressed in WHO-TEQs are lower than those found in Lysa nad Labem from Czech Republic,[4] but higher than for example levels found in Uzbekistan[5] and/or in Dutch organic farms.[6]

Possible U-POPs sources

The high levels of U-POPs in free range chicken eggs in these samples provoke the question of possible sources. The most obvious potential source of POPs releases at the site is the burning of chlorine-containing waste products such as commonly-found PVC plastics. Burning is common at the dump and there are several likely exposure pathways for such POPs contamination. One would be through the consumption of free-range chicken eggs or other products from animals (such goats, pigs and cows) that feed and drink from the surrounding area. Another would be through the consumption of vegetables grown along the banks of the river that passes around the edge of the dump. The direct inhalation of fumes from site would be the other likely pathway. The predominant wind direction is north westerly.

The Dandora dumpsite

The Dandora dumpsite is located in the Eastlands suburb of Nairobi (1°15'' South, 37 ° East). It is at an altitude of 2000 metres, and has a population density of over 100 persons per square kilometer. Passing below the dumpsite is the Nairobi River (as seen on the pictures), which eventually drains to the Indian Ocean. The soils that are found on this site are usually well-drained to moderately well-drained which means that chemical compounds such as dioxins and furans in the ash can easily find their way to the ground water sources and therefore end up in the river. Rain can also wash POPs-contaminated ash into the Nairobi River.

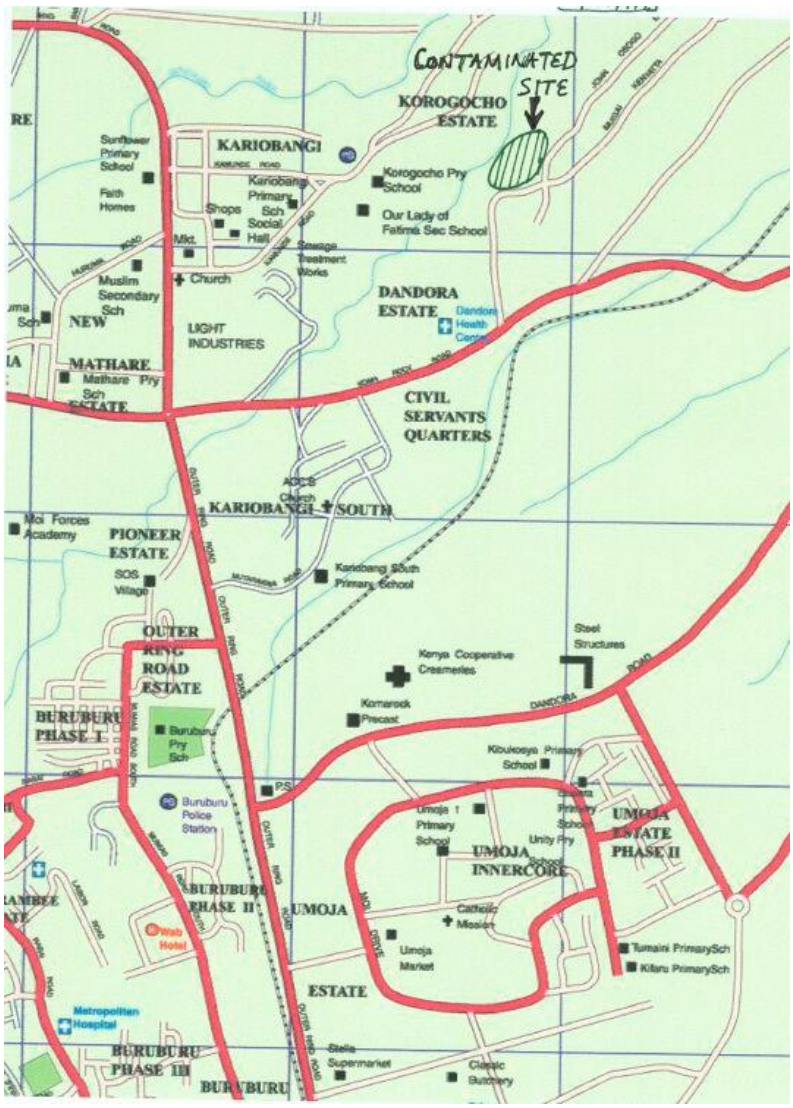
Annex 1. Materials and Methods

Sampling

For sampling in Kenya we have chosen dumpsite Dandora dumpsite located in the Eastlands suburb of Nairobi, the capitol city of Kenya. The eggs were collected from two sites bordering the Dandora dump. One was from the western border of the dump, within the Dandora estate, and the other from the northern border, within the Ngomongo slum. The hens from which the eggs were picked were between 6 months and one year old, and were all free-range although occasionally provided with shop-bought food supplements. The hens do not feed directly from the dump, but live at the edge where ash from the dump is easily deposited.

Sampling was done by members of ENVILEAD at place about 30 meters from the edge of the dump (see map in Picture 1) at December - 18th 2004. Two chicken fanciers supplied 10 eggs from their free range chickens. The eggs were kept in cool conditions after sampling and then were boiled in Kenya by ENVILEAD for 7 - 10 minutes in pure water and transported by express service to the laboratory at ambient temperature.

Picture 1: Map of the Dandora dumpsite and surrounding area.



Analysis

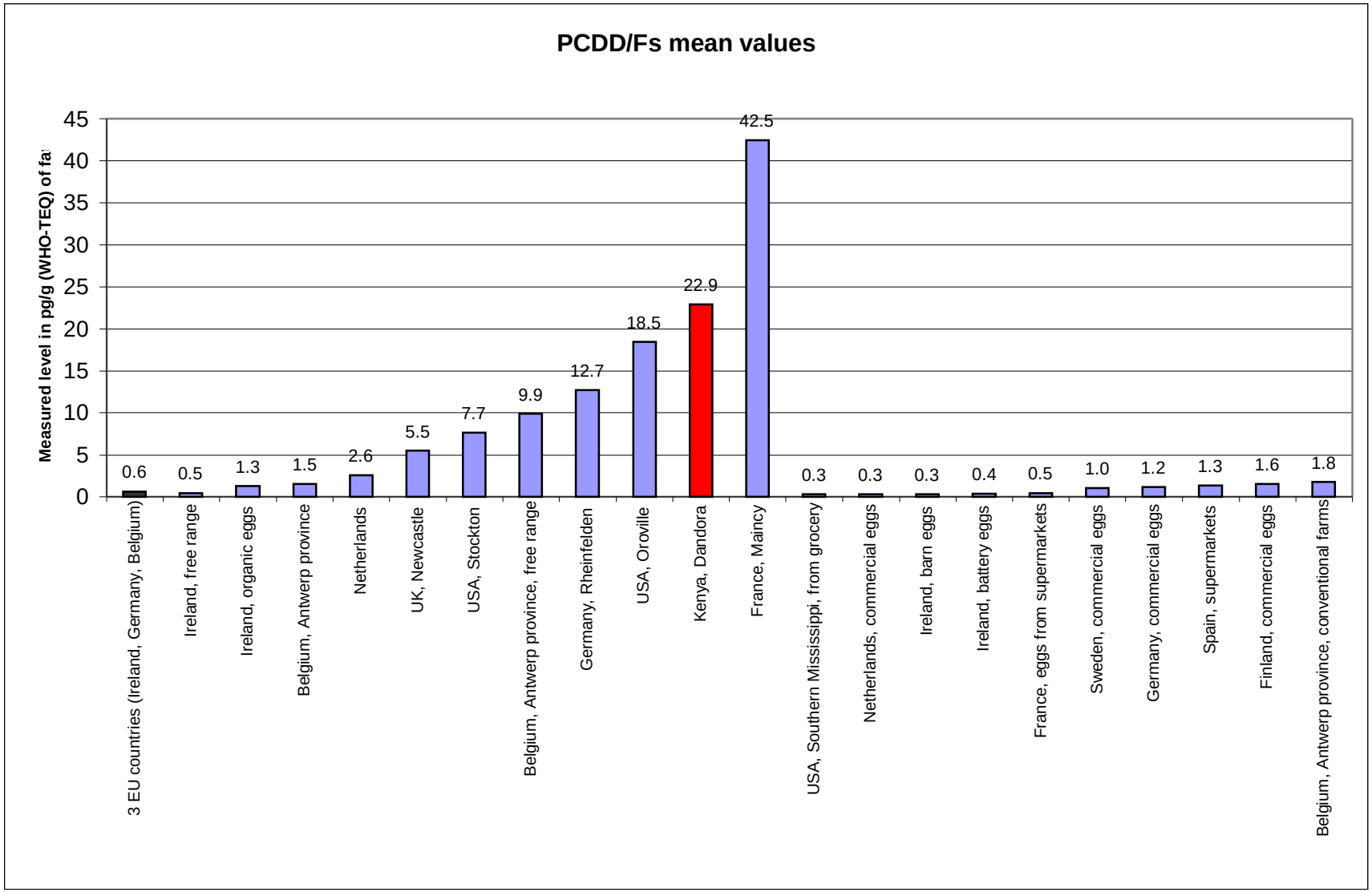
After being received by the laboratory, the eggs were kept frozen until analysis. The egg shells were removed and the edible contents of 6 eggs were homogenised. A 30 g sub-sample was dried with anhydrous sodium sulphate, spiked by internal standards and extracted by toluene in a Soxhlet apparatus. A small portion of the extract was used for gravimetric determination of fat. The remaining portion of the extract was cleaned on a silica gel column impregnated with H_2SO4, NaOH and $AgNO_3$. The extract was further purified and fractionated on an activated carbon column. The fraction containing PCDD/Fs, PCBs and HCB was analysed by HR GC-MS on Autospec Ultima NT.

Analysis for PCDD/Fs, PCBs and HCB was done in the Czech Republic in laboratory Axys Varilab.

Laboratory Axys Varilab, which provided the analysis is certified laboratory by the Institute for technical normalization, metrology and probations under Ministry of Industry and Traffic of the Czech Republic for analysis of POPs in air emissions, environmental compartments, wastes, food and biological materials.[a] Its services are widely used by industry as well as by Czech governmental institutions. In 1999, this laboratory worked out the study about POPs levels in ambient air of the Czech Republic on request of the Ministry of the Environment of the Czech Republic including also soils and blood tests.

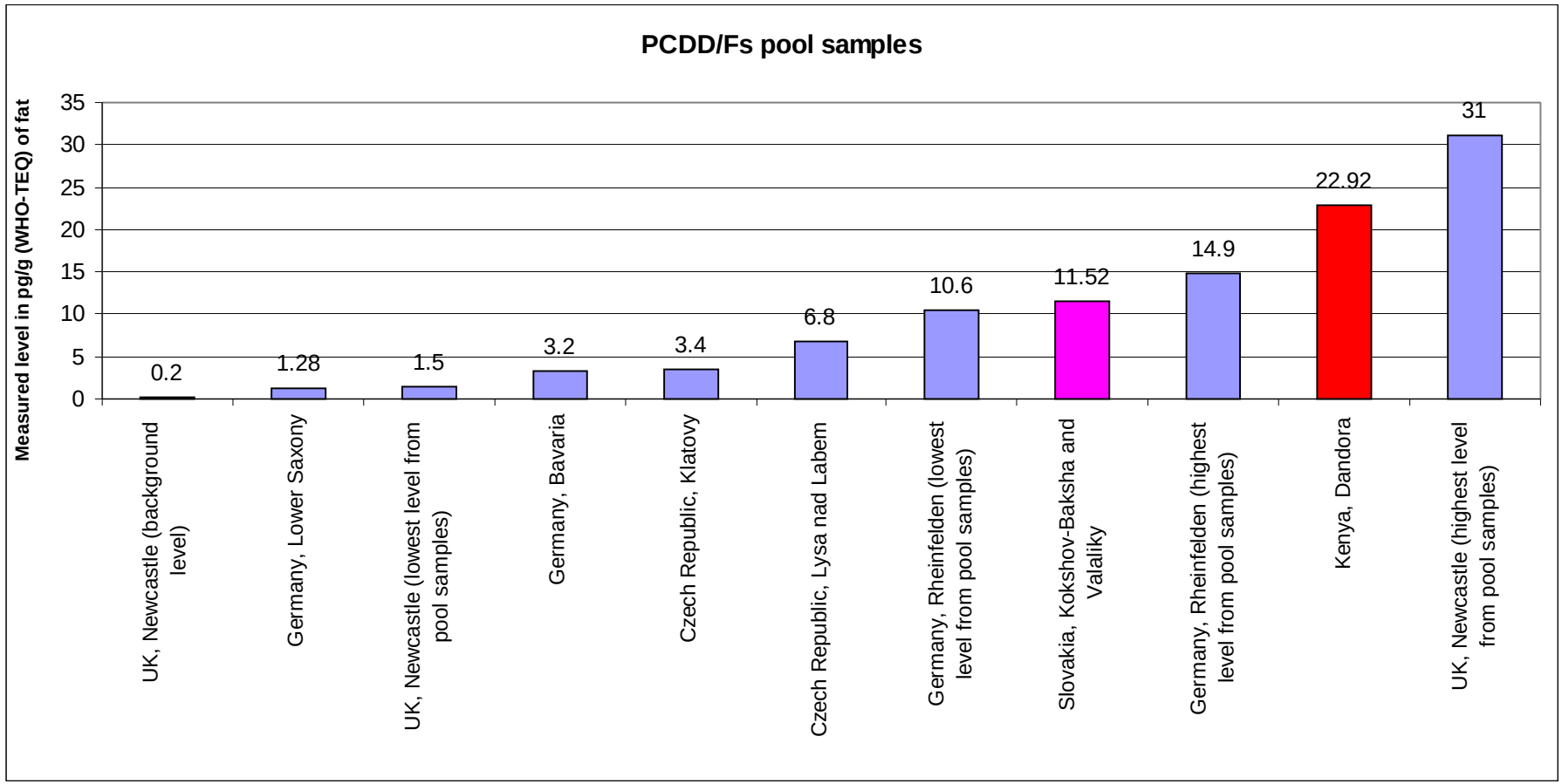
Annex 2: Mean values found within different groups of eggs from different parts of world

Country/locality	Year	Group	Measured level in pg/g (WHO-TEQ) of fat	Source of information
3 EU countries (Ireland, Germany, Belgium)	1997-2003	both	0.63	DG SANCO 2004
Ireland, free range	2002-2005	free range	0.47	Pratt, I. et al. 2004, FSAI 2004
Ireland, organic eggs	2002-2005	free range	1.3	Pratt, I. et al. 2004, FSAI 2004
Belgium, Antwerp province	2004	free range	1.5	Pussemeier, L. et al. 2004
Netherlands	2004	free range	2.6	SAFO 2004
UK, Newcastle	2002	free range	5.5	Pless-Mulloli, T. et al. 2003b
USA, Stockton	1994	free range	7.69	Harnly, M. E. et al. 2000
Belgium, Antwerp province, free range	2004	free range	9.9	Pussemeier, L. et al. 2004
Germany, Rheinfelden	1996	free range	12.7	Malisch, R. et al. 1996
USA, Oroville	1994	free range	18.46	Harnly, M. E. et al. 2000
Kenya, Dandora	2004	free range	22.92	Axys Varilab 2005
France, Maincy	2004	free range	42.47	Pirard, C. et al. 2004
USA, Southern Mississippi, from grocery	1994	not free range	0.29	Fiedler, H. et al. 1997
Netherlands, commercial eggs	2004	not free range	0.3	Anonymus 2004
Ireland, barn eggs	2002-2005	not free range	0.31	Pratt, I. et al. 2004, FSAI 2004
Ireland, battery eggs	2002-2005	not free range	0.36	Pratt, I. et al. 2004, FSAI 2004
France, eggs from supermarkets	1995-99	not free range	0.46	SCOOP Task 2000
Sweden, commercial eggs	1995-99	not free range	1.03	SCOOP Task 2000
Germany, commercial eggs	1995-99	not free range	1.16	SCOOP Task 2000
Spain, supermarkets	1996	not free range	1.34	Domingo et al. 1999
Finland, commercial eggs	1990-94	not free range	1.55	SCOOP Task 2000
Belgium, Antwerp province, conventional farms	2004	not free range	1.75	Pussemeier, L. et al. 2004


PCDD/Fs mean values
Measured level in pg/g (WHO-TEQ) of fa
45
40
35
30
25
20
15
10
5
0
0.6
0.5
1.3
1.5
2.6
5.5
7.7
9.9
12.7
18.5
22.9
42.5
0.3
0.3
0.3
0.4
0.5
1.0
1.2
1.3
1.6
1.8
3 EU countries (Ireland, Germany, Belgium)
Ireland, free range
Ireland, organic eggs
Belgium, Antwerp province
Netherlands
UK, Newcastle
USA, Stockton
Belgium, Antwerp province, free range
Germany, Rheinfelden
USA, Oroville
Kenya, Dandora
France, Maincy
USA, Southern Mississippi, from grocery
Netherlands, commercial eggs
Ireland, barn eggs
Ireland, battery eggs
France, eggs from supermarkets
Sweden, commercial eggs
Germany, commercial eggs
Spain, supermarkets
Finland, commercial eggs
Belgium, Antwerp province, conventional farms

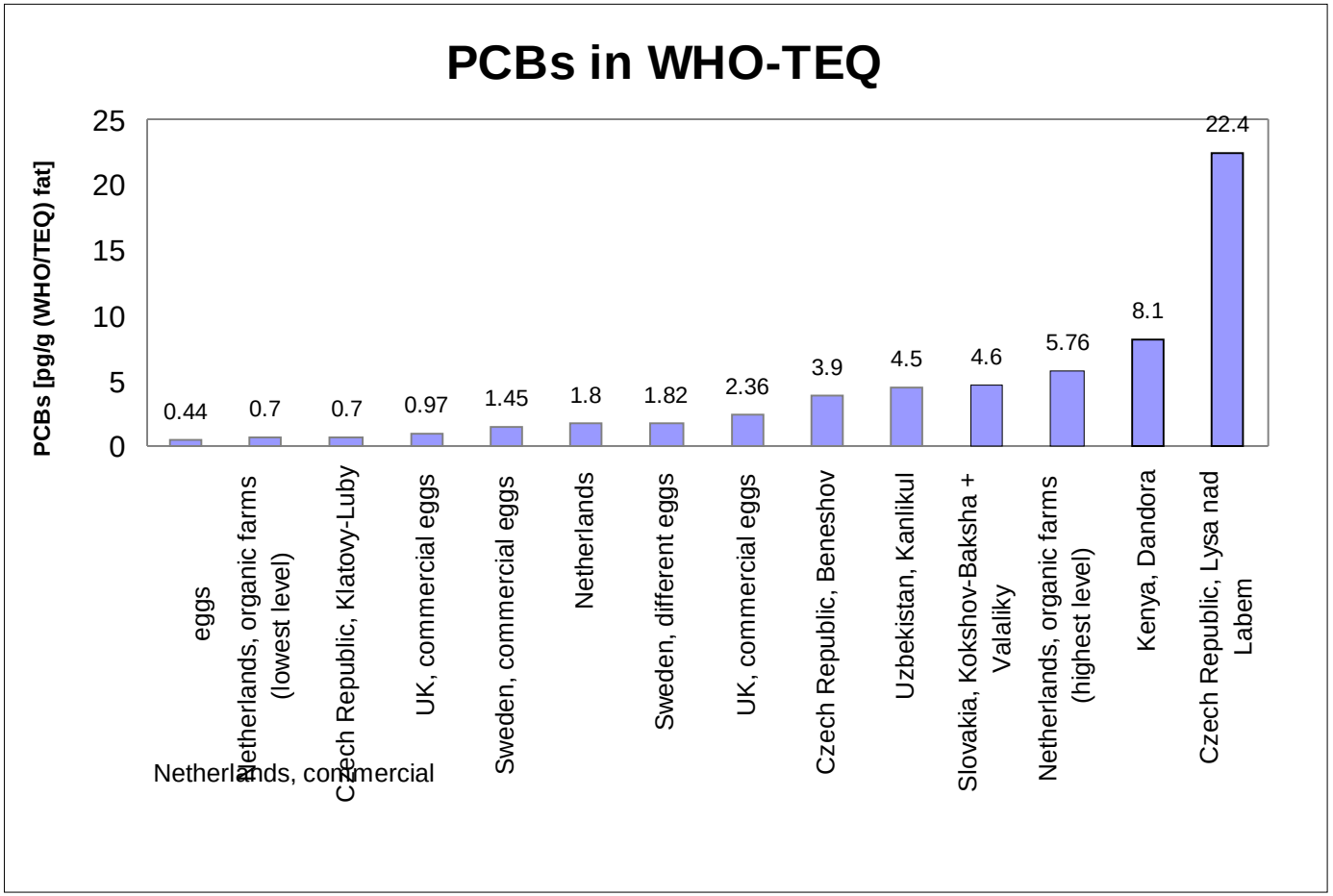
Annex 3: Levels of dioxins (PCDD/Fs) in different pool samples from different parts of world

Country/locality	Year	Group	Number of eggs/measured samples	Measured level in pg/g (WHO-TEQ) of fat	Source of information
UK, Newcastle (background level)	2000	free range	3/1 pooled	0.2	Pless-Mulloli, T. et al. 2001
Germany, Lower Saxony	1998	free range	60/6 pools	1.28	SCOOP Task 2000
UK, Newcastle (lowest level from pool samples)	2000	free range	3/1 pooled	1.5	Pless-Mulloli, T. et al. 2001
Germany, Bavaria	1992	free range	370/37 pools	3.2	SCOOP Task 2000
Czech Republic, Klatovy	2003	free range	12	3.4	Beranek, M. et al. 2003
Czech Republic, Lysa nad Labem	2004	free range	4	6.8	Petrlik, J. 2005
Germany, Rheinfelden (lowest level from pool samples)	1996	free range	-	10.6	Malisch, R. et al. 1996
Slovakia, Kokshov-Baksha and Valaliky	2005	free range	6/1 pooled	11.52	Axys Varilab 2005
Germany, Rheinfelden (highest level from pool samples)	1996	free range	-	14.9	Malisch, R. et al. 1996
Kenya, Dandora	2004	free range	6/1 pooled	22.92	Axys Varilab 2005
UK, Newcastle (highest level from pool samples)	2000	free range	3/1 pooled	31	Pless-Mulloli, T. et al. 2001


PCDD/Fs pool samples
Measured level in pg/g (WHO-TEQ) of fat
35
30
25
20
15
10
5
0
0.2
1.28
1.5
3.2
3.4
6.8
10.6
11.52
14.9
22.92
31
UK, Newcastle (background level)
Germany, Lower Saxony
UK, Newcastle (lowest level from pool samples)
Germany, Bavaria
Czech Republic, Klatovy
Czech Republic, Lysa nad Labem
Germany, Rheinfelden (lowest level from pool samples)
Slovakia, Kokshov-Baksha and Valaliky
Germany, Rheinfelden (highest level from pool samples)
Kenya, Dandora
UK, Newcastle (highest level from pool samples)

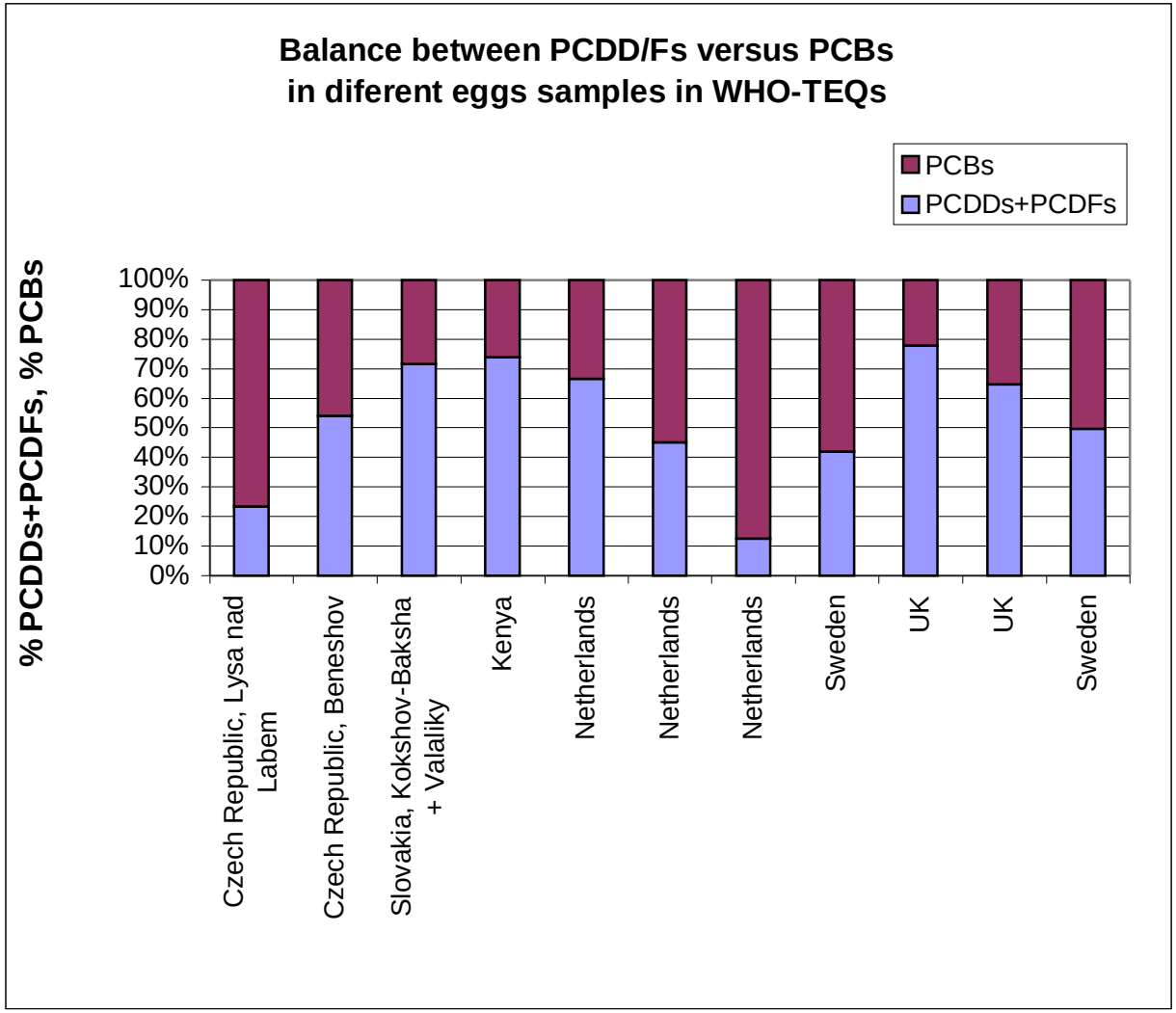
Annex 4: Levels of PCBs in WHO-TEQ in different chicken eggs samples from different parts of world

Country/locality	Year	Group	Number of measured samples	Specification	Measured level in pg/g (WHO-TEQ) of fat	Source of information
Netherlands, commercial eggs	1999	not free range	100/2 pools	pool, nonortho-PCBs	0.44	SCOOP Task 2000
Netherlands, organic farms (lowest level)	2002	free range	6	pool	0.7	Traag, W. et al. 2002
Czech Republic, Klatovy-Luby	2003	free range	free range	individual	0.7	Beranek, M. et al. 2003
UK, commercial eggs	1992	not free range	24/1 pool	pool	0.97	SCOOP Task 2000
Sweden, commercial eggs	1999	not free range	32/4 pools	pool	1.45	SCOOP Task 2000
Netherlands	1990	mixed	8/2 pools	pool, nonortho-PCBs	1.8	SCOOP Task 2000
Sweden, different eggs	1993	mixed	84/7 pools	pool	1.82	SCOOP Task 2000
UK, commercial eggs	1982	not free range	24/1 pool	pool	2.36	SCOOP Task 2000
Czech Republic, Beneshov	2004	free range	4	pool	3.9	Axys Varilab 2004
Uzbekistan, Kanlikul	2001	free range	-	individual	4.5	Muntean, N. et al. 2003
Slovakia, Kokshov-Baksha + Valaliky	2005	free range	6/1 pool	pool	4.6	Axys Varilab 2005
Netherlands, organic farms (highest level)	2002	free range	6	pool	5.76	Traag, W. et al. 2002
Kenya, Dandora	2004	free range	6/1 pool	pool	8.1	Axys Varilab 2005
Czech Republic, Lysa nad Labem	2004	free range	4	pool	22.4	Petrlik, J. 2005


PCBs in WHO-TEQ
PCBs [pg/g (WHO/TEQ) fat]
25
20
15
10
5
0
0.44
0.7
0.7
0.97
1.45
1.8
1.82
2.36
3.9
4.5
4.6
5.76
8.1
22.4
Netherlands, commercial eggs
Netherlands, organic farms (lowest level)
Czech Republic, Klatovy-Luby
UK, commercial eggs
Sweden, commercial eggs
Netherlands
Sweden, different eggs
UK, commercial eggs
Czech Republic, Beneshov
Uzbekistan, Kanlikul
Slovakia, Kokshov-Baksha + Valaliky
Netherlands, organic farms (highest level)
Kenya, Dandora
Czech Republic, Lysa nad Labem

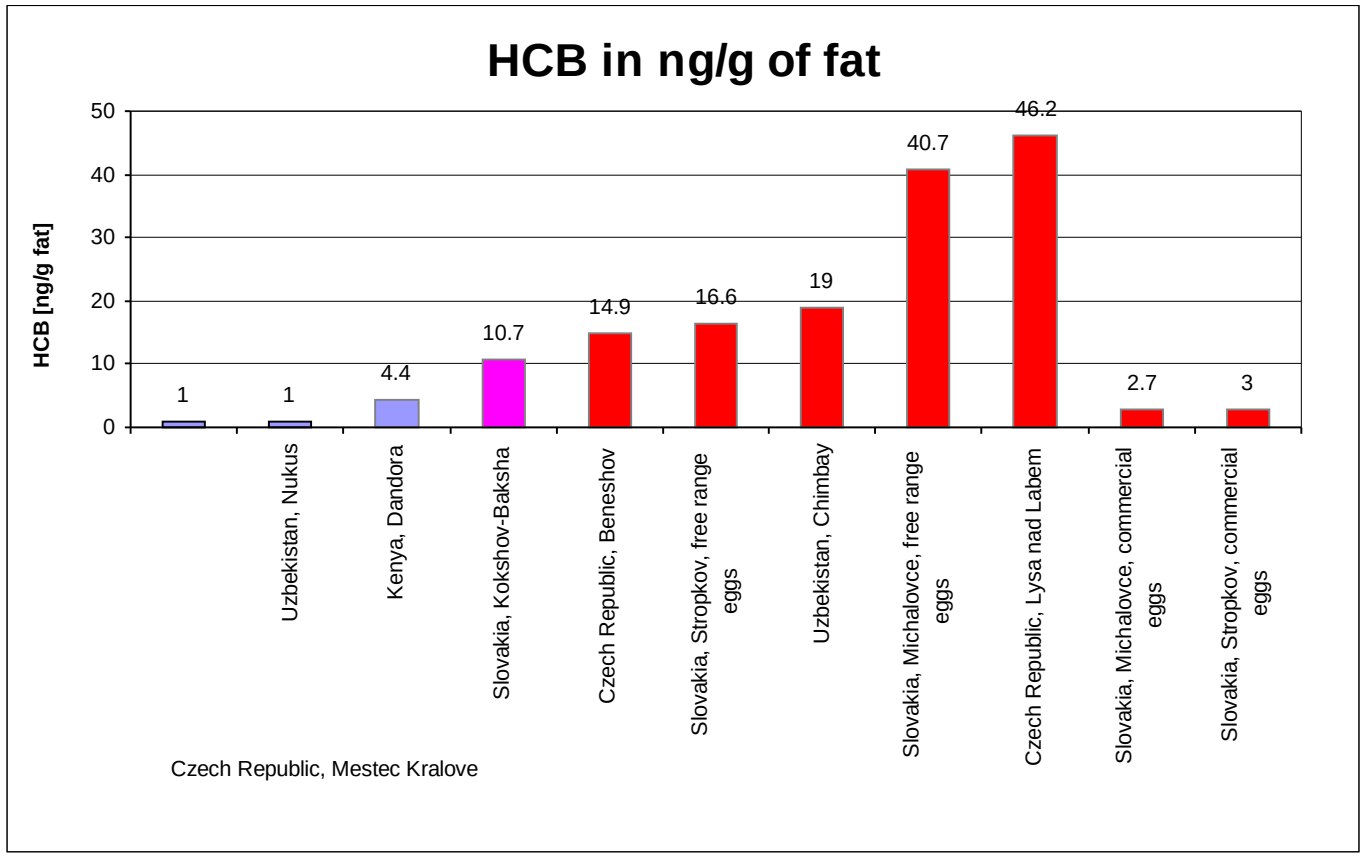
Annex 5: Balance between PCDD/Fs versus PCBs in diferent eggs samples in WHO-TEQs

Country/locality	Year	Group	PCDD/Fs	PCBs	Total WHO-TEQ	Source of information
Czech Republic, Lysa nad Labem	2004	free range	6.80	22.40	29.20	Petrlik, J. 2005
Czech Republic, Beneshov	2004	free range	4.60	3.90	8.50	Axys Varilab 2004
Slovakia, Kokshov-Baksha + Valaliky	2005	free range	11.52	4.60	16.12	Axys Varilab 2005
Netherlands	2002	free range	3.01	1.52	4.53	Traag, W. et al. 2002
Netherlands	2002	free range	4.74	5.76	10.50	Traag, W. et al. 2002
Netherlands	2002	free range	0.70	4.89	5.59	Traag, W. et al. 2002
Kenya	2004	free range	22.92	8.1	31.02	Axys Varilab 2005
Sweden	1993	mixed	1.31	1.82	3.13	SCOOP Task 2000
UK	1982	not free range	8.25	2.36	10.61	SCOOP Task 2000
UK	1992	not free range	1.77	0.97	2.74	SCOOP Task 2000
Sweden	1999	not free range	1.43	1.45	2.48	SCOOP Task 2000


Balance between PCDD/Fs versus PCBs
in diferent eggs samples in WHO-TEQs
PCBs
PCDDs+PCDFs
% PCDDs+PCDFs, % PCBs
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Czech Republic, Lysa nad Labem
Czech Republic, Beneshov
Slovakia, Kokshov-Baksha + Valaliky
Kenya
Netherlands
Netherlands
Netherlands
Sweden
UK
UK
Sweden

Annex 6: Levels of HCB in ng/g of fat in different chicken eggs samples from different parts of world

Country	Date/year	Specification	Number of measured samples	Measured level in ng/g of fat	Source of information
Czech Republic, Mestec Kralove	2003	free range	3	1.0	SVA CR 2004
Uzbekistan, Nukus	2001	free range	-	1.0	Muntean, N. et al. 2003
Kenya, Dandora	2004	free range	6/1 pool	4.4	Axys Varilab 2005
Slovakia, Kokshov-Baksha	2005	free range	6/1 pool	10.7	Axys Varilab 2005
Czech Republic, Beneshov	2004	free range	4/1 pool	14.9	Axys Varilab 2004
Slovakia, Stropkov, free range eggs	before 1999	free range	1	16.6	Kocan, A. et al. 1999
Uzbekistan, Chimbay	2001	free range	-	19.0	Muntean, N. et al. 2003
Slovakia, Michalovce, free range eggs	before 1999	free range	1	40.7	Kocan, A. et al. 1999
Czech Republic, Lysa nad Labem	2004	free range	4/1 pool	46.2	Petrlik, J. 2005
Slovakia, Michalovce, commercial eggs	before 1999	not free range	1	2.7	Kocan, A. et al. 1999
Slovakia, Stropkov, commercial eggs	before 1999	not free range	1	3.0	Kocan, A. et al. 1999


HCB in ng/g of fat
HCB [ng/g fat]
50
40
30
20
10
0
1
1
4.4
10.7
14.9
16.6
19
40.7
46.2
2.7
3
Czech Republic, Mestec Kralove
Uzbekistan, Nukus
Kenya, Dandora
Slovakia, Kokshov-Baksha
Czech Republic, Beneshov
Slovakia, Stropkov, free range eggs
Uzbekistan, Chimbay
Slovakia, Michalovce, free range eggs
Czech Republic, Lysa nad Labem
Slovakia, Michalovce, commercial eggs
Slovakia, Stropkov, commercial eggs

Annex 7: Photos

Dandora dumpsite. Photo by: Paul Maina.

This is the Western edge of the Dandora dumpsite. Some of the chickens in the sampling exercise live in a homestead to the left of the storey buildings, and scavenge from the area shown above. Photo by: Rachel Wambui.

An aerial view of part of the Dandora dumping site. At the far end, smoke from burning activity can be seen blowing towards the living quarters.Photo by: Paul Maina.

This is the sampling site in Dandora where the chicken live. Photo by: Rachel Wambui.

Dandora dumpsite. Notice the smoke in the background which is always present. The houses in the background are part of the Ngomongo slums, one of the sampling sites. Photo by: Rachel Wambui.

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