UNDERSTANDING THE PROBLEM

THE NUMBERS GAME

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Ruth Stringer,
Greenpeace QMW,
School of Biological Sciences,
Queen Mary & Westfield College,
Mile End Road,
London E1 4NS.

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There are 75 polychlorinated dibenzo-p-dioxins and 135 polychlorinated dibenzofurans. Their concentrations in the environment varies tens and hundreds of millions of times, depending on the sample you are looking at. The toxicity of these compounds varies by nearly as much.

To understand and interpret the research data available, therefore, involves juggling a sometimes dizzying array of numbers. There are also over a dozen different ways of summarising and reporting these results that are being used by different researchers.

The units used are summarised below.

milligram	mg	$1x10^{-3}g$	0.001g
microgram	ug	$1x10^{-6}g$	0.000001g
nanogram	ng	$1x10^{-9}g$	0.000000001g
picogram	pg	$1x10^{-12}g$	0.000000000001g
femtogram	fg	$1x10^{-15}g$	0.000000000000001g
attogram	ag	$1x10^{-18}g$	0.000000000000000001g

parts per million	ppm	mg/kg	ug/g	mg/l	ug/ml
parts per billion	ppb	ug/kg	ng/g	ug/l	ng/ml
parts per trillion	ppt	ng/kg	pg/g	ng/l	pg/ml
parts per quadrillion	ppq	pg/kg	fg/g	pg/l	fg/ml

In addition, results may be reported on a wet weight basis (foods and fish), dry weight (soils and sediments), fat basis (tissue or milk samples) or even an area basis (sometimes used for soils).

It is usual for analysis results to be reported for between a dozen and twenty different congeners. This is just not manageable, and it is necessary to summarise the data so that individual samples can be directly compared. There are three simplified measures in use; total PCDD/F, 2,3,7,8-TCDD and toxicity equivalents (TEQs).

Each system has its advantages and disadvantages. To sum all the different congeners gives an easily used figure but gives no understanding of the toxicity that figure represents. Analysing and reporting only 2,3,7,8-TCDD lifts a great burden from the chemists and has superficial attractions for legislators, who must finance a large proportion of these analyses. However, it gives a far from complete picture as 2,3,7,8-TCDD usually represents only a small fraction of the total PCDD/F toxicity in any given sample. More recently, as the toxicity of the different congeners has been more clearly identified, the concept of toxicity equivalents (TEQs) has come to the fore. This concept will be more fully

explained below, but it must be remembered that this system is only as good as the toxicological data on which it is based. Differing opinions on the relative toxicity of the congeners means that there are some ten or eleven schemes in existence. Any of the factors may need to be reassessed as more data is collected. The five most important TEQ systems are Eadon, BGA (German), NATO/I-TEQ, US Environmental Protection Agency (EPA) and the Nordic system. All work in the same way. Using a variety of toxicological measures, each congener's toxicity is assessed as a fraction of that of 2,3,7,8-TCDD. This is the congener's toxicity equivalence factor. To obtain the TEQ, multiply the concentration of each congener by its TEF, then sum the results.

The five main toxicity factor systems are given below.

DIOXIN AND FURAN TOXICITY EQUIVALENT FACTORS (TEFs)

COMPOUND	I-TEQ	EPA	BGA	NORDIC	EADON
2378-TCDD	1	1	1	1	1
OTHER TCDD	0	.01	.01	0	0
12378-PeCDD	.5	.5	.1	.5	1
OTHER PeCDD	0	.005	.01	0	0
123478-HxCDD	.1	.04	.1	.1	.03
123678-HxCDD	.1	.04	.1	.1	.03
123789-HxCDD	.1	.04	.1	.1	.03
OTHER HxCDD	0	.0004	.01	0	0
1234678-HpCDD	.01	.001	.01	.01	0
OTHER HpCDD	0	.00001	.001	0	0
OCDD	.001	0	.001	.001	0
2378-TCDF	.1	.1	.1	.1	.33
OTHER TCDF	0	.001	.01	0	0
12378-PeCDF	.05	.1	.1	.01	.33
23478-PeCDF	.5	.1	.1	.5	.33
OTHER PeCDF	0	.001	.01	0	0
123478-HxCDF	.1	.01	.1	.1	.01
123678-HxCDF	.1	.01	.1	.1	.01
123789-HxCDF	.1	.01	.1	.1	.01
234678-HxCDF	.1	.01	.1	.1	.01
OTHER HxCDF	0	.0001	.01	0	0
1234678-HpCDF	.01	.001	.01	.01	0
1234789-HpCDF	.01	.001	.01	.01	0
OTHER HpCDF	0	.00001	.001	0	0
OCDF	.001	0	.001	.001	0

(after Maisel, B.E. & Hunt, G.T. (1991) Chemosphere 20(7-9): 771-778)

The disadvantage of all three simplified measures; total PCDD/F, 2,3,7,8-TCDD and TEQs is that they give very different numbers for the same sample results and so cannot be directly intercompared. This is illustrated by the example of fly ash results from a municipal incinerator. All results are in ng/g (ppb).

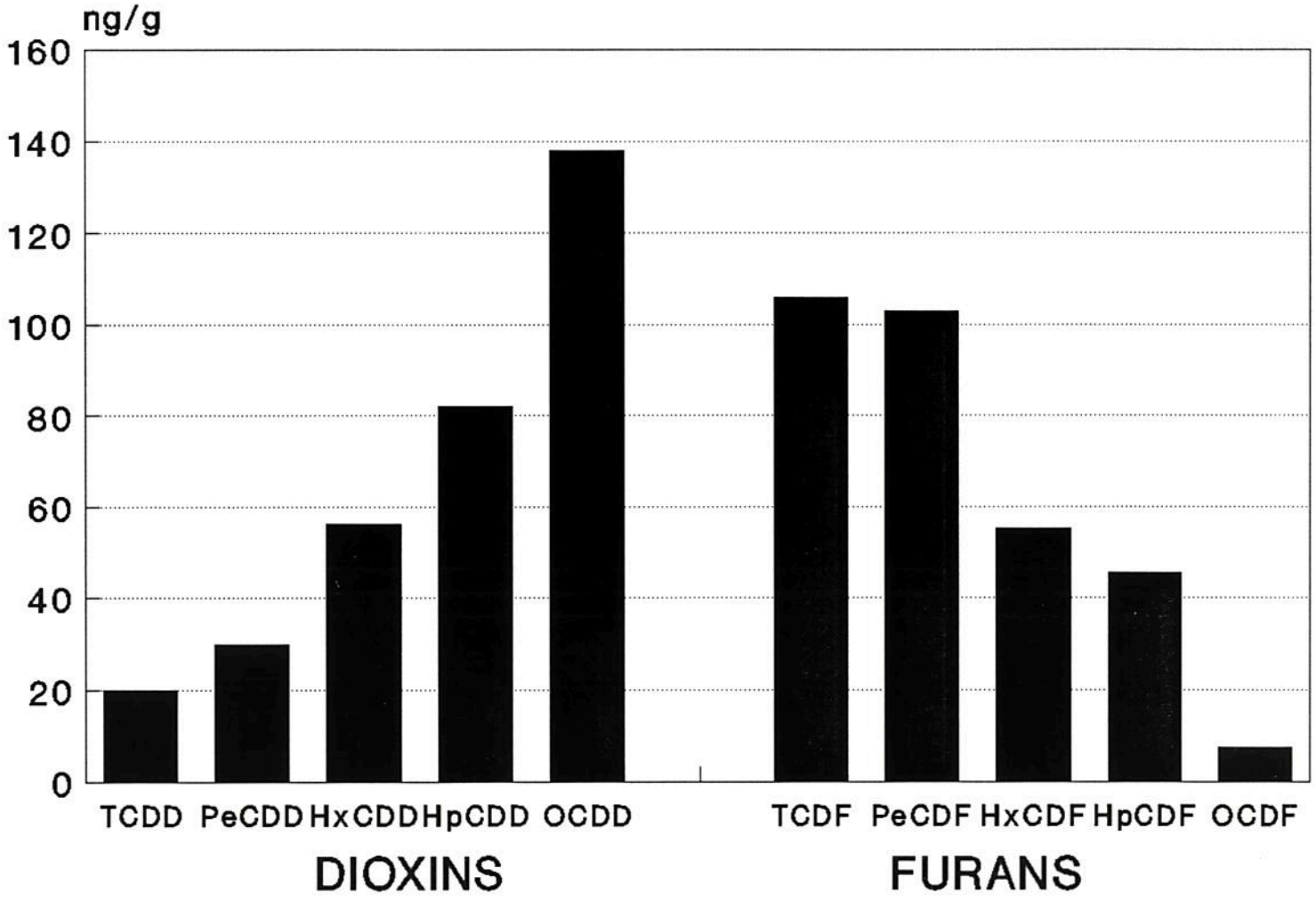
MUNICIPAL FLYASH

			----------TEQs----------				
Total	PCDD/F	2,3,7,8-TCDD	Eadon	BGA	I-TEQ	Nordic	EPA
643		0.52	8.1	9.7	9.3	9.1	4.2

(All results in ng/g)

Further, one loses the pattern of congeners produced by different industries and processes which gives a "fingerprint" that can clearly identify the source of the contamination. For example, the congener profile for the aforementioned flyash sample is typical of its type. Only the full data sets can be properly compared and so it is vital that writers report full results as well as the summary measures.

CONGENER PROFILE- FLYASH



DIOXINS IN SEDIMENTS

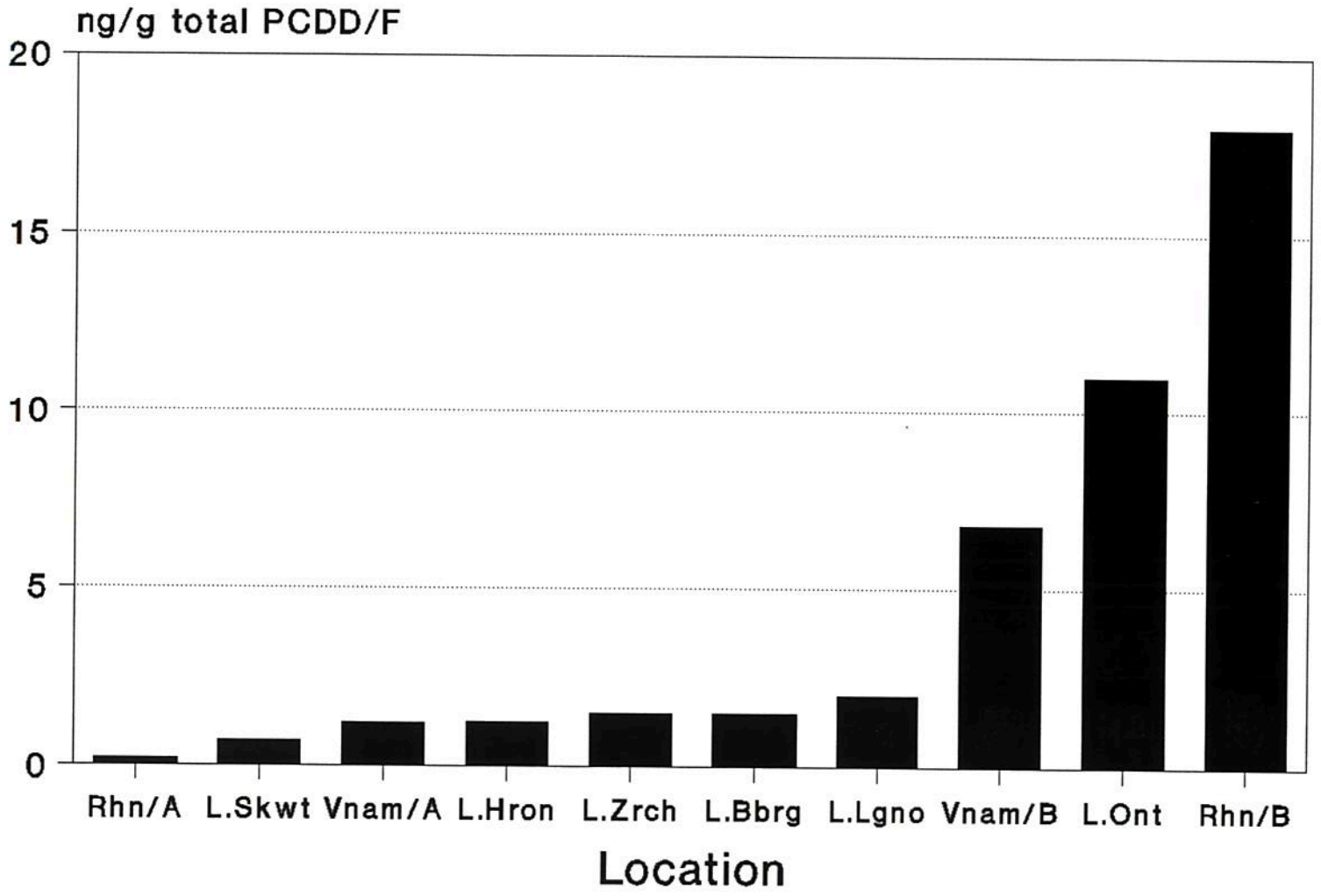
Location	Concentration (ng/g total PCDD/F)
Rhine (upper part)[b]	0.2
Lake Siskiwit[a]	0.73
Vietnam (Agent Orange sprayed area)[a]	1.2
Lake Huron (average figure)[a]	1.24
Lake Zurich (average figure)[a]	1.5
Lake Balberg (average figure)[a]	1.5
Lake Lugano (average figure)[a]	2.0
Vietnam (industrial area)[a]	6.8
Lake Ontario (pentachlorophenol contamination?)[a]	11.0
Rhine (lower part)[b]	18.0

References

[a] Schecter, A., Eitzer, B.D. & Hites, R.A. (1989) Chlorinated dioxin and dibenzofuran levels in sediments collected from rivers in Vietnam 1984-6
Chemosphere 18(1-6): 831-834

[b] Evers, E.H.G., Ree, K.C.M. & Olie, K. (1988) Spatial variations and correlations in the distribution of PCDDs, PCDFs and related compounds in sediments from the river Rhine- Western Europe
Chemosphere 17(12): 2271-2288

DIOXINS IN SEDIMENTS



DIOXINS IN SOILS

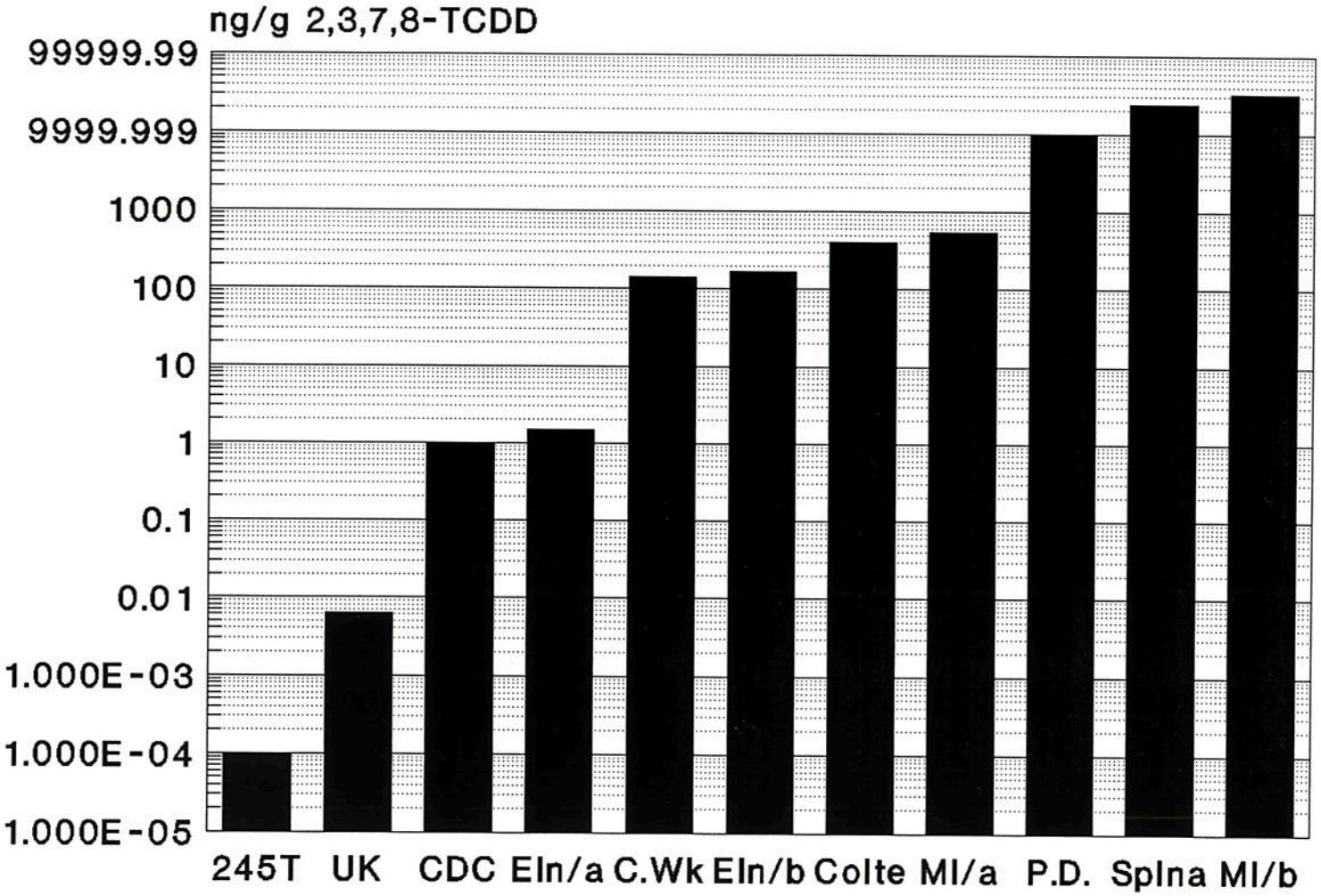
Location	Concentration (ppb TCDD)
Rural England[a]	<0.0005
After 2,4,5-T spraying (1lb/acre,100ppb TCDD)[b]	0.0001
Near Manchester UK[a]	0.0064
CDC level for concern in soil[a]	1.0
Elgin AFB, Florida (Agent Orange spill)[b]	1.5
Chemie Werk, Linz, Austria (2,4,5-T production)[b]	140
Elgin AFB, Florida (Agent Orange spill)(localised)[b]	170
Coalite, Manchester, UK (trichlorophenol accident)[b]	400
Horse arena C (Missouri)(Waste oil application)[b]	540
Phillips Duphar, Amsterdam (trichlorophenol accident)[b]	10,000
Spolana, Czechoslovakia (trichlorophenol production)[b]	24,200
Horse arena A (Missouri)(Waste oil application)[b]	32,000

References

[a] H.M. Inspectorate of Pollution (1989) Determination of polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in UK soils. Publ: Her Majesty's Stationery Office, 50pp

[b] IN: Chlorinated dioxins and related compounds: impact on the environment, Hutzinger, Frei, Merian & Pocchiara, Eds, (1982) Pergamon Series on Environmental Science Volume 5, Pergamon Press, 658pp

2,3,7,8-TCDD IN SOILS



BACKGROUND CONTAMINATION

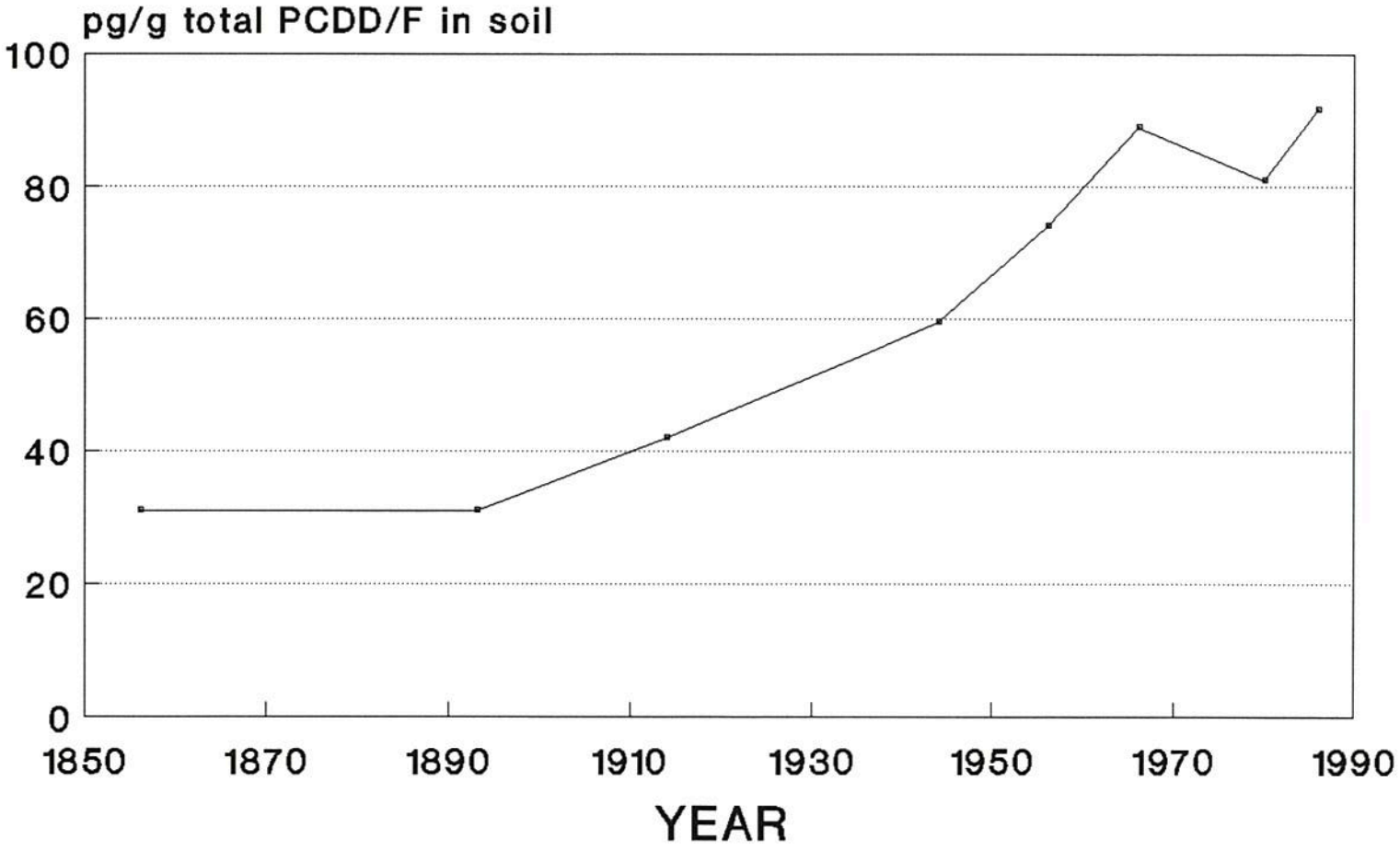
INCREASE WITH TIME

Date	Concentration (pg/g total PCDD/F)
1846 (anomolous due to differing conditions; corr-	61(29)
1846 -ected figures in brackets; omitted from graph)	54(29)
1856	31
1893	31
1914	42
1944	62
1944	57
1956	74
1966	89
1980	81
1986	95
1986	88
1986	92

Reference

Kjeller, L.-O., Jones, K.C., Johnston, A.E. & Rappe, C. (1991)
Increases in the polychlorinated dibenzo-p-dioxin and -furan content of soils and vegetation since the 1840s.
Environ. Sci. Technol. 25: 1619-1627

BACKGROUND CONTAMINATION
INCREASE WITH TIME



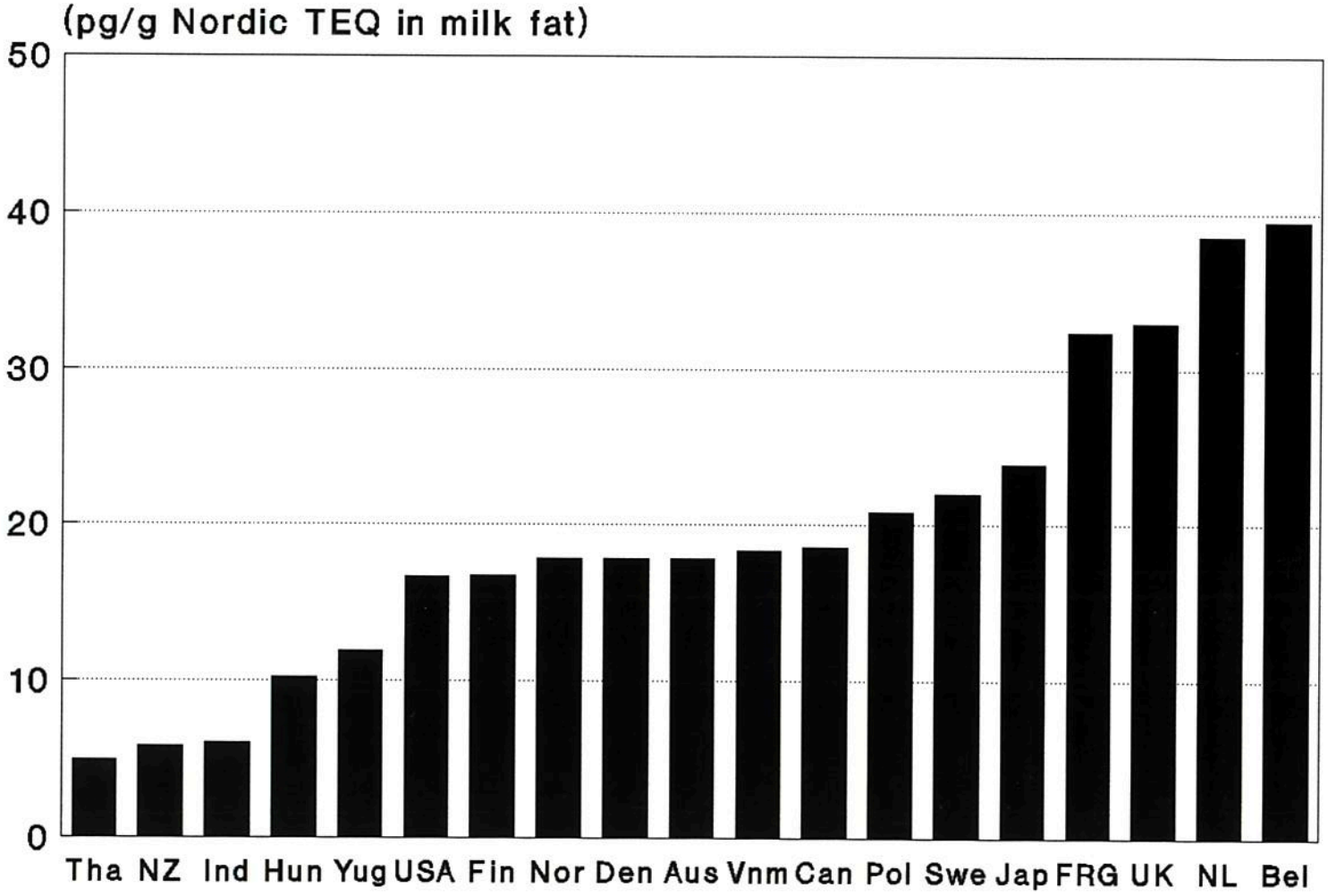
DIOXINS IN HUMAN MILK

Average figures around the world

Country	Concentration (pg/g Nordic TEQ in milk fat)
Thailand	4.9
New Zealand	5.8
India	6.0
Hungary	10.2
Yugoslavia	11.9
USA	16.6
Finland	16.7
Norway	17.8
Denmark	17.8
Austria	17.8
Vietnam	18.3
Canada	18.5
Poland	20.8
Sweden	22.0
Japan	23.9
Federal Republic of Germany	32.4
United Kingdom	33.0
Netherlands	38.5
Belgium	39.5

Tarkowski, S. & Yrjanheikki, E. (1989)
WHO coordinated intercountry studies on levels of PCDDs and PCDFs in human milk
Chemosphere 19(1-6): 995-1000

DIOXINS IN HUMAN MILK



(average figures)