REGIONAL ACTIVITY CENTRE FOR CLEANER PRODUCTION

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ANNUAL TECHNICAL PUBLICATION

SUSTAINABLE CONSUMPTION AND PRODUCTION IN THE MEDITERRANEAN

MAY 2010

Chemicals in the Mediterranean

The Stockholm and Basel Conventions and REACH

Regional Activity Centre for Cleaner Production

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Generalitat de Catalunya
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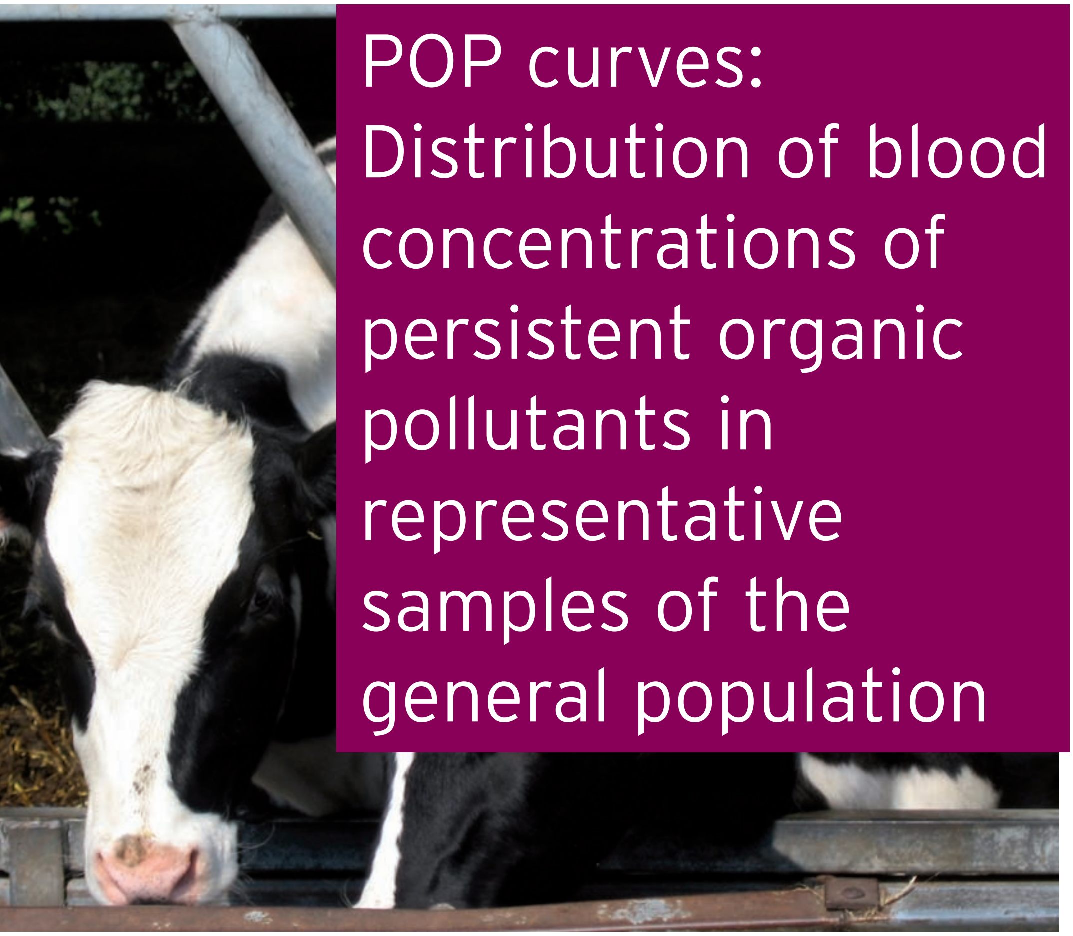
SUMMARY



POP curves: Distribution of blood concentrations of persistent organic pollutants in representative samples of the general population

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There is little as individuals we can do to decrease our personal accumulation of persistent organic pollutants (POPs). Prevention of human POP contamination cannot be treated as an individual problem; rather, population strategies are required. It is hence surprising that systems that monitor human contamination by POPs in a representative sample of the general population are so scarce worldwide, and that few efforts have been devoted to the representation and analysis of the full population distribution of POP concentrations in humans. "POP Geoffrey Rose curves" help visualize that such distributions stem from and belong to a population, and emphasize the importance of shifting the whole distribution of POP concentrations through public and private policies (e.g., policies to decrease contamination of animal feed and human food, industrial emissions and residues).

Keywords: human biomonitoring; global health; health survey; persistent organic pollutants; pesticide residues; environmental pollutants / toxicity / prevention and control; environmental exposure / adverse effects; human samples; general population.

Distribution des concentrations de polluants organiques persistants dans le sang dans des échantillons représentatifs de la population générale

À titre individuel, il y a peu à faire pour réduire notre accumulation personnelle de polluants organiques persistants (POP). La prévention de la contamination humaine par les POP ne peut pas être abordée comme un problème individuel ; au contraire, des stratégies sont nécessaires au niveau de la population. Il est dès lors surprenant que les systèmes qui contrôlent la contamination humaine par les POP dans un échantillon représentatif de la population générale soient tellement rares dans le monde, et qu'aussi peu d'efforts aient été consacrés à la représentation et à l'analyse de la distribution des concentrations de POP chez les humains dans l'ensemble de la population. « Les courbes de POP de Geoffrey Rose » contribuent à faire comprendre que ces distributions proviennent et appartiennent à la population, et mettent l'accent sur l'importance du fait de changer la distribution totale des concentrations de POP par le biais de politiques publiques et privées (par exemple des politiques visant à réduire la contamination de l'alimentation humaine et animale, les émissions industrielles et les déchets).

Distribución de la concentración en sangre de contaminantes orgánicos persistentes en muestras representativas de la población general

Poco podemos hacer las personas para reducir la acumulación de contaminantes orgánicos persistentes (COP) en nuestro organismo. La prevención de la contaminación causada por estos compuestos en las personas no puede tratarse como un problema aislado, sino que se necesitan estrategias dirigidas a la población. Por eso resulta tan sorprendente que los sistemas de seguimiento de la contaminación por COP en humanos a partir de muestras representativas de la población general sean tan escasos en el mundo y que se hayan dedicado tan pocos esfuerzos a la representación y el análisis de la distribución total entre la población humana de las concentraciones de COP. Las «curvas de Geoffrey Rose» ayudan a constatar que las distribuciones se originan en una población y son propias de ésta; además, enfatizan la importancia de modificar por completo la distribución de las concentraciones de COP a través de políticas públicas y privadas (por ejemplo, dirigidas a reducir la contaminación en los alimentos destinados a las personas y los animales, emisiones industriales o residuos).

Persistent organic pollutants (POPs) as dioxins, dichlorodiphenyltrichloroethane (DDT), hexachlorobenzene (HCB), hexachlorocyclohexanes (HCHs), and polychlorinated biphenyls (PCBs) are highly lipophilic and resistant to degradation; they thus bioaccumulate in the environment, food chains and living organisms, and are known or reasonably suspected to harm human health [1-8]. Their potential adverse effects include neurotoxicity [6,9], endocrine disruption and reproductive disorders [10-12], cardiovascular effects [4,6,13], and carcinogenicity (through a variety of mechanisms, including indirect, non-genotoxic mechanisms) [14-18]. As a consequence, many of these global and local (glocal) contaminants have been targeted for elimination or reduction by governments, and treaties as the Stockholm convention encourage countries to integrate population-based surveillance of POP levels in humans within their health monitoring schemes [3,8,19]. It is hence surprising that systems that monitor human contamination by POPs in a representative sample of the general population are so scarce worldwide [1].

In the general population, lifelong accumulation of POPs is largely the result of low-dose contamination of fatty foods [4-7,13,20-23]. There is little individuals can do to decrease personal exposure over the long term, and prevention of human POP contamination cannot be treated simply as an individual problem; rather, population strategies are required [1,24,25]. Therefore, it is also surprising that few efforts have been devoted to a rigorous representation and analysis of the full population distribution of POP concentrations in humans. It is also remarkable how little is known on the properties of such distributions.

Since the end of World War II, vast changes have occurred in human exposure to POPs in most populations worldwide: while the body burden of many compounds (e.g., some organochlorines) first increased and then decreased, levels of other POPs seem stagnant, and new synthetic chemicals as flame retardants have in recent years contaminated humans [1-7]. Surveillance of such patterns has seldom been undertaken on a nationwide, continued basis, and the generalizability of many studies is often limited [1,4,26-28]. Certainly, concentrations have been assessed in etiological studies and in some programs based on volunteers and convenience samples [1]. Surprisingly, however, only the USA and Germany regularly monitor POP concentrations in representative samples of the general population [4,7,29-36].

> “Human contamination by persistent organic pollutants (POPs) cannot be treated just as an individual problem”

Monitoring programs are useful to quantify trends and patterns of human exposure to human POPs and other environmental chemical agents, to identify highly exposed minorities [8,26,27,37], and as a framework to evaluate health impacts and the effectiveness of policies aimed at decreasing exposure to POPs [7,37,38].

Plotting the curves

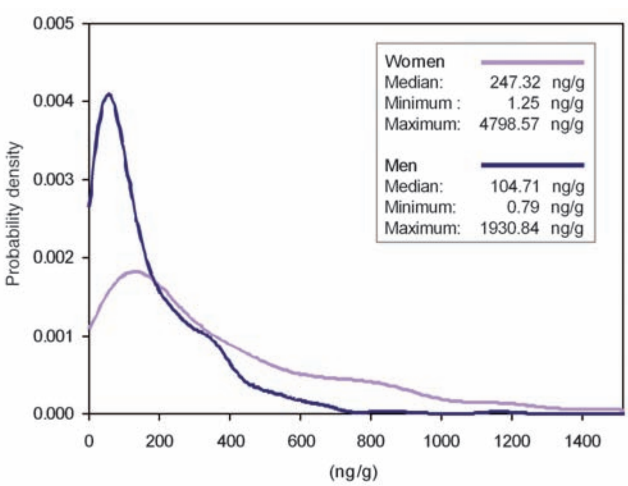
Density plots can be used to chart the distributions of POP body concentrations in the different age and sex population groups. We name these graphs "POP Geoffrey Rose curves" to emphasize the analogy with the 'population strategy' of the British epidemiologist (1926-1993) [1,24,25]. Several properties of the curves are interesting; e.g., kurtosis, skewness, and coefficient of variation. Kurtosis is a measure of the peakedness or sharpness of the peak of a distribution curve, i.e., of the extent to which the curve is flatter or more peaked. Skewness is a measure of asymmetry in frequency distributions, i.e., the degree to which frequencies trail towards extreme scores in one direction away from the majority of cases. The normal distribution is symmetric and thus has zero skewness.

In many populations wolrdwide there are huge interindividual differences in POP concentrations. In the general population of Catalonia, for instance, the highest individual concentration of p,p'-DDE (9036.01 ng/g) is over 7700 times higher than the lowest (1.17 ng/g); for HCB the corresponding values are 4798.57 and 0.79 ng/g (a 6000-fold difference), and for, β-HCH, 2716.16 and 1.35 ng/g (2000-fold). Figure 1 shows the population distribution of HCB concentrations by sex. They were significantly higher in women than men even after adjusting by age and BMI.

Figure 2 shows the distribution of p,p'-DDE by age group; with respect to older groups, the distribution of youngest individuals leans towards the left (lower DDE levels). There is a progressive flattening of the curves with increasing age. The kurtosis of each of the two younger groups is higher than that of the two older groups; i.e., in the younger groups DDE concentrations cluster more around a few values than in the older groups. Furthermore, the skewness of the distribution of the two younger groups is about twice as large than that of the two older groups. In addition, the coefficient of variation of the distribution of DDE decreases from the younger to the older groups. This phenomenon can be summarised as: curve flattening, decreasing kurtosis, decreasing skewness, and decreasing coefficient of variation in increasingly older groups.

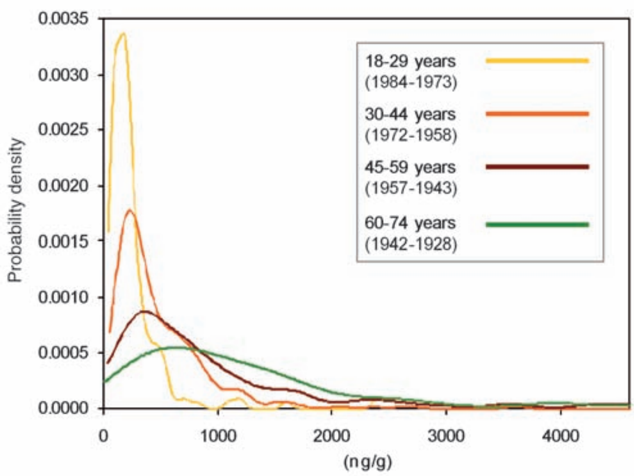
In many studies worldwide, the median, mean, geometric mean, standard deviation, maximum value, 25th percentile and 75th percentile of commonly detected POPs usually in-

Figure 1. Distribution of serum concentrations of hexachlorobenzene in Catalonia by sex



The curves include 99% of the population with lower concentrations

Figure 2. Distribution of concentrations of dichlorodiphenyldichloroethene (p,p'-DDE) in Catalonia



Figures in brackets are the corresponding birth years of each age group (number of subjects: 919) crease with increasing age group. Sometimes, a remarkable exception is the minimum value (the lower individual concentration of a POP), which may be quite similar in all age groups; i.e., among middle-aged and older subjects, a minority fails to accumulate the higher amounts of each POP that a majority accrues. This facet of the problem coexists with the fact that a vast majority of the population has much lower concentrations of POPs than a certain minority.

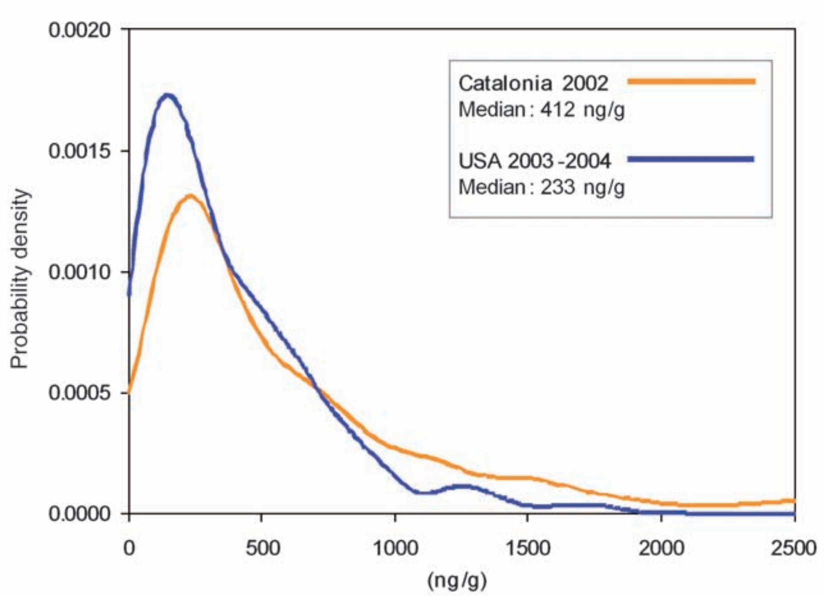
POP Geoffrey Rose curves

While several programs have yielded relevant information, there are very few reports worldwide based on a representative sample of the general population [1-8,28,32-36,41]. We suggest there is a need to focus on the whole population distributions of POP concentrations and their properties. A distribution may seem a simple representation if viewed only from a technical angle. However, as conceived, drawn and interpreted in this article, distributions of POP concentrations clearly stem from and belong to a population, they reflect the inherently population nature of the issues at stake, and thus convey pedagogically a core message: individual concentrations of POPs result from societal processes, there is little an individual can do to decrease personal exposure, and POP contamination cannot be viewed just as an individual problem. Our "POP Geoffrey Rose curves" emphasize the importance of shifting the whole population distribution of POP concentrations through public and private policies (e.g., policies to decrease contamination of animal feed and human food, industrial emissions and residues) [24,25].

When we compare POP curves of different regions it is important to remember that differences may partly be explained by subtle differences in laboratory and epidemiologic methods (e.g., the age range of participants), as well as by the ethnic composition of each country [1,7]. Although the US reports and the Germany surveys do not present the full distribution of POP concentrations, they do offer selected percentiles; from such data the distribution in the US and German populations can be estimated. Figure 3 shows the distributions of serum concentrations of p,p'-DDE in the USA and Catalonia. The shapes are remarkably similar, although the US curve trails further towards the left than the curve for Catalonia: there is a higher proportion of Americans in the zone of lower p,p'-DDE values and a higher proportion of Catalans with higher concen-

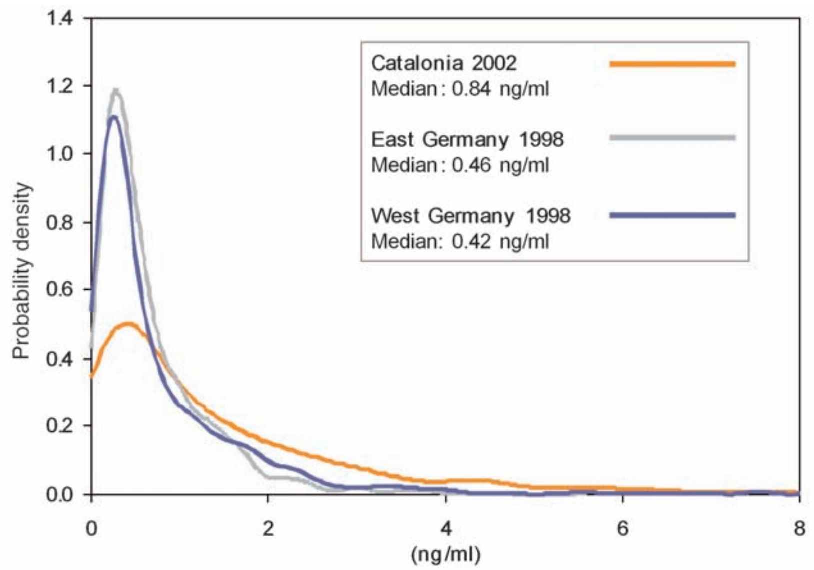
> "Shifting the population distribution of POP concentrations requires more energetic public and private policies"

Figure 3. Distribution of concentrations of dichlorodiphenyldichloroethene (p,p'-DDE) in the populations of USA and Catalonia



Catalonia: population from 20 to 74 years of age;
USA: population ≥ 20 years

Figure 4. Distribution of concentrations of hexachlorobenzene in the populations of Germany and Catalonia



All three curves refer to the population from 18 to 69 years of age

trations. As compared with the raw means or medians the curves convey much better the exposure of the whole population.

Levels of HCB and, β-HCH in Catalonia are higher than in USA and Germany. Figure 4 shows the distribution of serum concentrations of HCB in the Catalan and German (East and West) populations: the shape of the two German distributions is similar, and so is the long right tail of the three curves; with respect to the German curves, the curve for Catalonia is shifted towards higher concentrations.

Shifting the population distribution of a POP towards the left decreases the percent of the population under the right end of the tail, it lowers the mean and median values, and it may substantially decrease the percent of the population under the area of intermediate concentrations. Certainly, for many POPs the risk function is incompletely known. While the minority of the population with higher concentrations is of concern, the long-term health effects of lifelong low concentrations are not negligible [16-18].

Virtually all populations worldwide bear a body burden of environmental chemicals –with large interindividual and inter-population differences [1-6]. Programs that monitor such distributions in a representative sample of the general population are essential to establish reference levels, to analyze predictors of exposure, to increase public awareness, to stimulate prevention policies and, hence, to diminish the burden of disease that these chemicals contribute to cause.

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The **Mediterranean Action Plan (MAP)** strives to protect the environment and to foster development of the Mediterranean Basin. It was adopted in Barcelona (Spain) in 1975 by Mediterranean States and the EC, under the auspices of the United Nations Environmental Programme (UNEP). Its legal framework is made up of the Barcelona Convention (1976, revised in 1995) and seven Protocols covering certain specific aspects of environmental protection. The Action Plan is built up around an Athens-based Coordinating Unit, the MED POL Programme and six Regional Activity Centres.

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