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Chain of Contamination: The Food Link (Fact Sheet)

PHTHALATES

Background

Phthalate esters (hereafter referred to as “phthalates”) are a group of chemicals, produced in large volumes, which are widely used as additives in many plastics and consumer products (Schettler, 2006, Phthalates Information Centre Europe, 2005). Examples of phthalates include di(2-ethylhexyl)phthalate (DEHP), dibutyl phthalate (DBP), butyl benzyl phthalate (BBP), di(iso-nonyl)phthalate (DiNP) and di(iso-decyl)phthalate (DiDP).

Phthalates are ubiquitous environmental contaminants and DEHP, as it is the most commonly used phthalate, is often the predominantly detected phthalate in environmental samples (Latini, 2005, Petrovic et al, 2004). Phthalates can be found in rainwater (Guidotti et al., 2000), water (Brossa et al., 2005, Hashizume et al., 2002), soils and sediments (Gibson et al., 2005, Petrovic et al, 2004), indoor air and dust (Afshari et al., 2004, Bornehag et al., 2005, Fromme et al., 2004, Rudel et al., 2003), and fish/marine food webs (Mackintosh et al., 2004). Phthalates have also been detected in fatty foods such as meat and dairy products (MAFF UK, 1996, Sorensen, 2006), in human blood (Kato et al., 2003, Colon et al., 2000) and breast milk (Main et al., 2006) and phthalate metabolites have been detected in adult and children’s urine (Blount et al., 2000, CDC, 2005, Duty et al., 2005, Hauser et al., 2004b, Johnson et al., 2005, Koo and Lee, 2005, Koch et al., 2005).

Major uses

Phthalates are used predominantly as "plasticisers” to make plastics more flexible. In fact, 90% of phthalates produced in Europe are used to plasticise PVC (polyvinyl chloride) to make flexible PVC products (Phthalates Information Centre Europe, 2005). DEHP is the most commonly used phthalate, particularly in PVC - in Western Europe it accounts for 30% of all plasticiser usage (DEHP Information Centre, 2006). PVC is widely used for everything from kitchen flooring to medical tubing and blood bags, toys*, footwear, electrical cables, packaging, and roofing (Phthalates Information Centre Europe, 2005). Soft PVC can consist of up to 40% DEHP (Koch et al., 2006). Other phthalates are used in non-PVC applications such as paints, rubber products, adhesives, in cosmetics and personal care products (e.g. nail polish, perfumes), pharmaceutical products and printing inks (Schettler, 2006, Phthalates Information Centre Europe, 2005).

According to the UK Food Standards Agency, (FSA) the use of phthalates in food packaging is limited, mainly to the manufacture of materials such as adhesives and some printing inks (FSA UK, 2005). Conversely, the European Food Safety Authority (EFSA) recent re-evaluation of phthalate use in packaging suggests that phthalates are used in PVC food contact materials (EFSA, 2005). Recent research by Greenpeace also reveals PVC packaging used by UK food retailers contained phthalates, which can migrate into foods (meat, cheese) (Greenpeace UK, 2004). According to “FOODPLAST: A Plasticiser Information Centre (2006), phthalates are not used in plastic cling film – adipates are used as plasticizers instead. A letter to the peer reviewed journal Environmental Health Perspectives from the American plastics federation states vehemently that phthalates are not used in plastic food packaging (http://www.ehponline.org/docs/2006/8804/letter.html).

* Following the continued renewal of a temporary ban in place in Europe since 1999, the European Parliament voted in July 2005 to permanently ban the use of phthalates to soften plastic children's toys and childcare articles following health concerns. Under the new directive, DEHP, DBP and BBP will be banned outright while DINP, DIDP and DNOP will be banned from use in toys and childcare articles intended for children under three years of age and which can be put in the mouth by them - http://www.euractiv.com/en/health/permanent-phthalates-ban-toys-approved/article-142028

How do phthalates get into the environment (and food chain)?

Widespread industrial and domestic use of products containing phthalates (plastics such as PVC, toiletries, cosmetics) results in large amounts being washed down the drain, reaching sewage and wastewater systems (Fauser et al., 2003, Ishikawa et al., 2005, Marttinen et al., 2003, Palmquist & Hanaeus 2005). Wastewater and effluent from sewage treatment works can then convey phthalates to rivers, estuaries and the wider aquatic environment (Brossa et al., 2005, Cespedes et al., 2006, Fromme et al., 2002, Hashizume et al., 2002, Ogunfowokan et al., 2006). Phthalates can escape into outdoor air (Teil et al., 2006) and precipitate into the environment in rainwater (Guidotti et al, 2000). Research has shown that phthalates are also released into the atmosphere following the burning of plastics (Simoneit et al., 2005).

Sewage sludge and “biosolids” generated by sewage treatment works contain phthalates (Berset & Etter-Holzer, 2001, Fang & Zheng, 2004, Fauser et al., 2003) which can then reach the terrestrial environment and soils when applied as fertilizer to agricultural land (Gibson et al., 2005, Hu et al., 2003, Rhind, 2002, Vikelsoe et al., 2002). Phthalates present in the soil of agricultural land are then available for uptake by grazing livestock, although the extent to which this occurs is still unclear (Rhind et al., 2005).

Phthalates, and in particular DEHP, are consistently found in leachate from landfills receiving discarded consumer products and materials containing phthalates (Asakura et al., 2004, Jonsson et al 2003a, b, Marttinen et al., 2003). Landfill leachate can therefore contribute significant amounts of phthalates to the environment. Other inputs include the escape into indoor air and dust of phthalates from consumer products (Afshari et al., 2004, Bornehag et al., 2005, Rudel et al., 2003).

How are people exposed to phthalates?

Exposure to phthalates can occur directly via the use of consumer products and plastics containing them (Schettler, 2006). Children can be exposed by mouthing or chewing older PVC toys, as phthalates can leach out into their saliva (however, recent legislation has banned or restricted the use of phthalates in children’s toys - see above). Inhalation of household dust containing phthalates (particularly DEHP) from PVC flooring and building materials is another exposure route (Rudel et al., 2003, Bornehag, et al., 2005, Clausen et al., 2004).

Plasticised PVC is widely used in healthcare applications such as blood-bags and medical tubing, such that hospitalised patients undergoing haemodialysis and respiratory therapy (and also premature babies in intensive care units) can be exposed to high levels of phthalates leaching out of these devices (Schettler, 2006, Health Care without Harm, 2006). There is considerable concern about these exposure routes, given the vulnerability of the people exposed, particularly infants at critical stages of development. In 2005, the European Parliament[1] called for urgent restrictions on the use of phthalates (DEHP, DINP, DBP, DIDP, DNOP, BBP) in “domestic

[1] European Parliament resolution on the European Environment & Health Action Plan 2004-2010 (2004/2132(INI))

http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P6-TA-2005-0045+0+DOC+XML+V0//EN

products for indoor use and medical devices" in response to the Commission's Environment and Health Action Plan 2004-2010.

Phthalates can also be absorbed through the skin or inhaled following the use of perfumes, cosmetics and other personal care products containing them (Blount et al., 2000, Duty et al., 2005, Greenpeace International, 2005, Koo & Lee 2004, Schettler, 2006, Sharpe and Irvine, 2004). A study of a reference population has shown higher levels of exposure to DEP, DBP and BBP (phthalates used in personal care products) than DEHP, suggesting exposure via these products is the most important human exposure route (Blount et al., 2000). Young women (20-40yrs) were the most exposed group in the study, which is consistent with a "cosmetics" source as these phthalates are found in products such as nail polishes, perfumes and hair sprays (Blount et al., 2000). Ingestion of food containing phthalates is also an important route of exposure (see below). Ingestion of phthalates can also occur via their use in the coatings of pharmaceuticals (drugs) and nutritional supplements (Schettler, 2006, Hauser et al., 2004a). Dietary intake (from contaminated food) has been suggested as the most likely single source of phthalate exposure in the general population (Schettler, 2006, Fromme et al., 2004), although exposure via personal care products (see above) is clearly also important (Blount et al., 2000).

Phthalates in food

Phthalates are soluble in fat and therefore are commonly found in fat-containing foods (MAFF UK, 1998, Sharman et al., 1994). Phthalates can also migrate into foods (particularly fatty foods such as cheese and meat) from plastic food wrappings and possibly printing inks used on wrappers (Schettler, 2006, Greenpeace UK, 2004) although there is a lack of clarity as to the extent of the use of phthalates in food contact materials (see above). Phthalates can also enter food items during processing, quite often due to the use of PVC in food production and processing systems (Tsumura et al., 2001a,b). A number of studies of fat-containing foods have suggested that the presence of phthalates in food is due to general contamination of the environment and food chain (MAFF UK, 1998, 1996), so ingestion of phthalates in food can occur irrespective of the packaging and/or processing involved.

Information on phthalates in food is limited, but table 1 below lists some studies which have found phthalates in food items.

Food item(s)	**Reference(s)**	**Comments**
Milk/milk products	Sorensen LK. (2006). Rapid Commun Mass Spectrom., 20(7), pp1135-1143.	Determination of phthalates in milk and milk products from Denmark.
Olive oil	Stiftung Warentest (2005). "Dirty Gold". October issue, "Test" magazine http://www.bfr.bund.de/cd/6858	DEHP and DIDP found in olive oil purchased in Germany.
Turkey, chicken, cheese (brie)	Greenpeace UK (2004). The determination of additives in food products.	Phthalates (DBP, BBP & DEHP), and nonylphenol found to be migrating from PVC packaging in UK supermarket foods.
Total Diet Samples, baby food and infant formula	Petersen JH, Breindahl T. (2000). Food Addit Contam., 17(2), pp133-41.	DBP, BBP, DEHP and the adipate DEHA analysed in 29 total diet samples, 11 samples of baby food and 11 samples of infant formulae, purchased in Denmark. Phthalates detected in all samples. DEHP found most frequently.
Infant formula	MAFF UK (1998). Food Surveillance Information Sheet Number 168 -	39 samples of UK infant formulae analysed. DEHP most abundant individual phthalate

	Phthalates in infant formulae - Follow-up survey.	detected. Levels much lower than 1996 survey.
Total Diet samples (incl. meat, offal, poultry, eggs, fish, fats and oils, milk and milk products)	MAFF UK (1996). Food Surveillance Information Sheet, Number 82. Phthalates in food.	Phthalates detected in all UK total diet samples analysed. DEHP most abundant individual phthalate detected.
Milk, cream, butter and cheese	Sharman et al., (1994) Food Addit Contam., 11, pp375-385.	DEHP and other phthalates in milk, cream, butter & cheese from Norway, Spain and UK.

Table 1: Phthalates in food items – examples from the literature

What health effects are associated with exposure to phthalates?

While phthalates are of generally low acute toxicity, for some of them there are serious concerns over their endocrine disrupting properties and their potentially adverse effects on male reproductive development, with foetal animals being particularly sensitive. For example, US researchers have found that DEHP can cause malformations of the reproductive system in male rats through an endocrine-disrupting mechanism (Gray et al., 1999).

Exposure to hormone disrupting chemicals like phthalates are suspected of being one of the factors contributing to observed trends of declining fertility, increased incidence of testicular cancer and falling sperm counts in European men. In the case of phthalates, this is based on observations of their effects in rodent studies which include malformations of the reproductive system, testicular tumours and effects on sperm production (Foster, 2006, Voss et al., 2005) and the similarities of these effects to those seen in humans, such as cryptorchidism (undescended testicle), hypospadias (a birth defect of the penis), impaired spermatogenesis (sperm production) and testicular cancer (Bay et al., 2006, Fisher, 2004). These effects on the male reproductive system have been collectively termed testicular dysgenesis syndrome (TDS) (Skakkebaek et al., 2001) and it is hypothesised that they are all manifestations of disturbed prenatal testicular development i.e. they are the result of “feminisation” of the developing reproductive tract of male foetuses in the womb (Bay et al., 2006, Skakkebaek et al., 2001). It is thought that some phthalates, due to their anti-androgenic (male hormone suppressing) properties, are playing a role in this phenomenon.

Epidemiological studies in humans are limited, but relationships have been shown between reduced sperm count and motility and higher exposure to some phthalates (indicated by higher levels of phthalate metabolites in the urine) (Duty et al., 2003). More recently, a study has shown that mothers with higher exposure to some phthalates (estimated by measuring phthalate metabolites in their urine) are more likely to give birth to “feminised” boys (Swan et al., 2005). The researchers used the distance from the anus to the base of the penis or genitals as a measure of feminisation (the distance is normally twice as long in boys as it is in girls). This was used to calculate an ano-genital index (AGI) which was negatively correlated (i.e. reduced) with increasing concentrations of phthalate metabolite in the mother’s urine. Perinatal exposure to certain phthalates (based on levels of phthalates in the mother’s breast milk) has also been correlated with alteration of sex hormone levels in baby boys (Main et al., 2006).

Phthalates have also been linked with other health effects. In a recent study, 88% of new-born babies were shown to have DEHP or MEHP in their blood, and exposure to MEHP has been linked to preterm birth (Latini et al., 2003). Elevated levels of phthalates in blood have also been implicated in premature breast development in Puerto Rican girls (Colon et al., 2000). DEHP, at environmentally relevant levels, has been shown to exacerbate dermatitis-like skin lesions (Takano, et al., 2006) and phthalates in indoor air and dust have been associated with asthma, eczema, and rhinitis in children (Bornehag et al., 2004). Health concerns over the exposure of children to phthalates via PVC toys have also focused on chronic effects on the kidney and liver.

DEHP is classed as “priority hazardous substance” under the EU water Framework Directive and is classified in the EU as “toxic to reproduction”. While there is inadequate evidence in humans for the carcinogenicity of DEHP (IARC Group 3 classification for carcinogenicity), the US EPA has classified DEHP as a Group B2, probable human carcinogen. A recent EU risk assessment for DEHP has highlighted the need for more information on the risks to newborn babies posed by DEHP contaminated breastmilk[2].

How can exposure to phthalates be reduced?

Pregnant women may particularly want to reduce their exposures to phthalates. One way to reduce exposure is to avoid flexible PVC products, although this is difficult given its numerous applications, such as kitchen and bathroom flooring. Limiting the use of personal care products, cosmetics and fragrances may also reduce uptake of phthalates via the skin (Sharpe & Irvine, 2004). Regular home vacuuming can help to minimise dust build-up, and potential phthalate exposure.

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[2] http://ec.europa.eu/health/ph_risk/committees/sct/documents/out214_en.pdf

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Further information

http://www.atsdr.cdc.gov/toxprofiles
http://europa.eu.int/comm/food/food/chemicalsafety/foodcontact/legisl_list_en.htm
http://www.foodstandards.gov.uk/safereating/phthalates/
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