Risiken erkennen – Gesundheit schützen

Lead and cadmium do not belong in toys

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Lead and cadmium are heavy metals that can damage health even at low dosages. Both substances commonly occur in the environment. Humans take in both substances through different sources such as foodstuffs and drinking water as well as through contact with consumer products. A special source for the intake of lead and cadmium for children are toys that may have heavy metal-containing paints or varnishes.

Lead primarily damages the central nervous system and thus brain function, yet it can also affect the endocrine system. Unborn children, infants and toddlers react especially sensitively. According to the latest research findings, a safe threshold value cannot be defined for effects of lead on the central nervous system. The Federal Institute for Risk Assessment (BfR) thus maintains the opinion that the lead intake of children should be reduced as much as possible. Toys should therefore release no lead at all.

Cadmium damages the kidneys and accumulates in the body as a result of its long residence time. Cadmium also causes damages to bones and influences the endocrine system. According to the latest EFSA assessments, the cadmium intake of children through food alone can exceed the tolerable weekly intake (TWI), for which EFSA has just determined a lower value, by up to 100% on a regular basis. BfR thus demands that the tolerable intake levels of cadmium through toys, i.e. the migration limit values of cadmium in toys are lowered considerably in the European Community.

1 Subject of the Assessment

Lead and cadmium are classified as toxic heavy metals. Humans take in both substances through different sources such as foodstuffs and drinking water as well as through contact with consumer products. Since, for example, paints and varnishes used for toys can also contain these heavy metals such products constitute an additional possible source of exposure to children. In order to limit the exposure of children to toxic elements in toys, migration limit values for numerous heavy metals and additional elements were issued in the new European Toy Safety Directive (TSD) 2009/48/EC. The present paper constitutes a health risk assessment for the exposure of children to lead and cadmium in toys.

2 Results

Lead and cadmium are toxic heavy metals that may, for instance, be part of paints or varnishes used for toys. These substances are probably carcinogenic for humans. In regard to children, it is necessary to minimise their exposure to lead as well as cadmium. As a relevant and child-specific source of exposure, toys must hereby be taken into account as well.

The neurotoxic effects of lead must be assessed especially critically. Foetuses, infants and toddlers comprise an especially vulnerable risk group since their brains are in a particularly sensitive developmental stage. Even in the low dose range, children have been recorded to suffer from impaired intelligence, attention and reaction deficits as well as behavioural disorders and an affected endocrine system. The exposure to lead during childhood can also entail long-term effects lasting throughout adult age. A safe leffect threshold cannot be determined scientifically for these neurotoxic and endocrine effects. The concentration levels of lead detected in the blood of children in Germany are in ranges for which adverse effects

have been verified. The daily amount of lead taken up through toys that is permissible according to Directive 2009/48/EC (TSD) can constitute as much as 50% of estimated alimentary lead intake. Especially the vulnerable subpopulation of children requires exposure minimising measures that include exposure through toys. Since there is no safe effect threshold value, BfR maintains the opinion that the ALARA principle (as low as reasonably achievable) must be applied to the release of lead from toys. The former limit value should absolutely not be exceeded.

Cadmium is toxic to kidneys and accumulates in the body. EFSA recently determined a much lower tolerable weekly intake (TWI) value for cadmium of 2.5 µg/kg body weight and week. In children, dietary intake to cadmium alone exceeds the TWI value by 100% on a regular basis (EFSA 2009). The cadmium intake level permissible according to Directive 2009/48/EC through toys could account for about 20% of the TWI. If the TWI is exceeded on a regular basis, health risks can no longer be excluded for certain. EFSA thus rightly demands that current exposure to cadmium must be reduced. This must include exposure through toys. BfR suggests that in a first step, the migration limit values for cadmium in toys are promptly adjusted to the EFSA TWI value. Due to the high alimentary intake, the complete fulfilment of the TWI should in total not exceed 5% in all three toy materials defined in the TSD (dry, liquid, scraped-off).

3 Reasons

3.1 Lead

3.1.1 Hazard potential

Lead is the subject of several international (ATSDR 2007, EFSA 2004, IARC 2004, JECFA 2002, WHO 1995) and national assessments (DFG 2007). WHO/JECFA has determined a PTWI (provisional TWI) of 25 µg/kg body weight and week (corresponds to 3.5 µg/kg body weight and day) under the assumption of a safe effect threshold (JECFA 1986, 2002).

Lead accumulates in the body. The biological half-life of lead in the blood is about 35 days, yet in bones it ranges from 5 to 30 years. During certain stages of life (e.g. during pregnancy or in small children) lead can be mobilised from bones. For children it is known that the resorption of lead from the intestines is higher than for adults by a factor of 5 (ATSDR 2007).

Lead is transplacental; Newborns have the same levels as their mothers. Today, prenatal exposure is attributed greater significance than previously assumed (Ronchetti et al., 2006).

However, acute lead poisoning has become a relatively rare occurrence. Chronic lead poisoning can lead to disturbed heame synthesis (heame is the coloured component in red blood cells), peripheral neuropathy, encephalopathy, kidney damage and reproductive toxicity.

Lead induces chromosome damage and is carcinogenic in animal experiments. The Senate Commission on the Investigation of Health Hazards of Chemical Compounds in the Work Area of the DFG (German Research Foundation) classifies lead as carcinogenic in Category 2 (substances that are to be considered carcinogenic for humans; DFG 2007). IARC has also classified lead and its inorganic compounds as probably carcinogenic for humans (Group 2A) (IARC 2006).

The neurotoxic effects of lead are especially critical. Unborn children, infants and toddlers are particularly vulnerable risk groups as they are at especially sensitive stages of brain development. Children have been recorded to suffer from impaired intelligence, attention and reaction deficits as well as behavioural disorders and hearing threshold shift (WHO 1995, Chen 2007, HBM Commission 2009). Today it is an accepted fact that even low dosages, i.e. of lead concentrations < 100 µg /l in blood, impair the intellectual development of children considerably (ATSDR 2007, Chen 2007, Lanphear et al. 2005, Schnaas 2006). Relationships between hyperkinetic syndrome and low blood lead levels have been reported as well. The risk of this syndrome in children (4-15 years) was higher for blood concentrations >20 µg lead/l than for concentrations <10 µg lead/l (Brown et al. 2006, HBM 2009).

Besides affecting the central nervous system (CNS), low dosages have been reported to cause endocrine effects in humans. Evidence suggests that even at blood levels <100 µg/l lead has adverse effects on the sexual maturity of girls (delay of the first menstruation, of pubic hair growth and breast development; Selevan et al. 2003, Wu et al. 2003). An exposure to lead during childhood can also lead to long-term effects lasting throughout adulthood (CPSC 2006).

It is currently not possible to define a scientific-based threshold for the effects of lead on the CNS and the endocrine system (Schnaas et al., 2006; Lanphear et al., 2005; Canfield et al., 2003, HBM Commission 2009). Lanphear et al. concludes that "[…] existing data indicate that there is no evidence of a threshold for the adverse consequences of lead exposure […]" (Lanphear et al 2005).

Due to the lack of an effect threshold as well as the potential persistence of lasting effects of lead throughout adulthood, the "Human Biomonitoring Commission" of the German Federal Environment Agency (*Umweltbundesamt* – UBA) has deferred setting human biomonitoring values for lead in blood for children, women and men. The Commission states that "the definition of an effect threshold concerning blood lead levels is arbitrary and not justifiable" [1] (HBM Commission 2009).

EFSA is currently working on a new assessment of lead under special consideration of alimentary intake. It is likely that the WHO/JECFA will also re-evaluate its PTWI of 25 µg/kg body weight and week since this derivation was based on the assumption of a safe effect threshold (JECFA 1986, 2002).

[1] „*jedwede Festlegung einer Wirkschwelle zum Blutbleigehalt willkürlich und nicht begründbar ist*"; translation by author.

3.1.2 Exposure

Lead is ingested mainly through foodstuffs and air particles. In a number of EU Member States, the median lead intake through food for adults is in the area of 0.8 µg/kg body weight and day, which makes up about 25% of the PTWI (SCOOP 2004). For children, the alimentary intake of lead relative to body weight is greater than for adults. Younger children also have a greater alimentary lead intake than older children (SCOOP 2004). The mean lead intake of 4 to 6-year-olds was thus estimated at 1.3 µg/kg body weight and day, and the lead intake of 10 to 12-year-olds at 0.83 µg/kg body weight per day. This constitutes 35% of the PTWI. The consumption of heavily contaminated foodstuffs can produce much greater alimentary lead intake. Children who often ingest foodstuffs with high levels of lead have a greater risk to exceed the PTWI than adults (SCOOP 2004). Other sources estimate dietary lead intake in the area of 1-4 µg/kg body weight per week (equivalent of 0.1-0.6 µg/kg body weight and day), for children between 0.6 to 30 µg/kg body weight and day (equivalent of 0.1-4.3 µg/kg body weight and day) (JECFA 2006).

An additional relevant source of exposure is drinking water. The daily intake of lead through tap water is estimated at a median of 0.75 µg for children in Germany, yet at maximum of up to 1000 µg (Schulz et al. 2008). These values are based on the lead content of tap water as surveyed in the German Environmental Survey for Children. Other surveys report mean lead contents in drinking water in Germany of 26 µg/l which would lead to much higher intake amounts (Lommel et al. 2002). The use of lead releasing pottery in contact with foodstuffs can, according to BfR assessment, contribute to lead intake considerably (BfR 2005).

Exposure-relevant behaviour of children that contributes to lead intake should also be taken into account. This includes common hand-mouth contact, crawling and playing on the ground in conjunction with dust ingestion through the mouth or swallowing ground particles. House dust, ground particles and “mouthing” thus cause higher lead concentration in children’s blood than in those of older people (ATSDR 2007, UBA 2007). By swallowing lead-containing ground and dust particles, toddlers can exceed the dietary lead intake (UBA 2007).

For children, special consideration should be taken for their exposure through swallowable toy parts or other products made of lead-containing alloys. RAPEX reports continue to document cases in which the migration levels of lead in toys are greatly exceeded. The Directive 88/378/EEC for toys in force until recently limited the bioavailability of lead ingested through toys to 0.7 µg per day. In contrast the new TSD defines migration limit values for lead for three different kinds of toy materials, for each of which a maximum permitted daily lead intake of 1.3 µg can be deduced. The migration limit values were deduced based on the WHO’s deduced PTWI of 25 µg/kg body weight. If it is assumed that in a day a child plays not only with, for example, solid, but also liquid or sticky toy material (e.g. finger paints) and toys with scrapable lead-containing materials and swallows corresponding amounts of all materials, the maximum total permitted oral intake through toys would amount to 3.9 µg. According to the scenario used in the TSD 2009/48/EC (child weighing 7.5 kg), this would mean a tolerable daily lead intake amount of 0.5 µg/kg body weight and day. This is equivalent to about 50% of the estimated alimentary lead intake of children.

3.1.3 Risk characterisation

More recent research studies provide further evidence suggesting that there is no safe effect threshold for lead concerning neurotoxic and endocrine effects which must be rated particularly critical for the vulnerable subpopulation of children (Schnaas et al. 2006; Lanphear et al. 2005; Canfield et al. 2003, HBM Commission 2009). It is therefore unclear

whether or not the PTWI derived by WHO can still serve as a reliable basis for the risk assessment of lead exposure. According to the opinion of BfR, it should not be used for risk assessment and to derive limit values at this time.

Data on alimentary lead intake show that children have a higher lead intake in relation to body weight than adults do (SCOOP 2004). Due to the specific behaviour of children, other sources of exposure such as lead-containing toys, ground (soil?) and dust particles contribute to additional lead intake of this vulnerable subpopulation. Therefore, children are subject to distinctly greater external exposure in relation to body weight than adults. Furthermore, at about 50%, the rate of intestinal resorption of lead is five times higher in children as it is in adults (about 10%). As a result, considerably greater internal exposure is to be expected for children compared with adults. In conjunction with the special sensitivity to the neurotoxic and endocrine effects of foetuses, infants and children and the lack of a safe effect threshold for these effects, this can constitute a risk of neurological damage or impaired brain and endocrine function.

Data on lead concentration in the blood of three to 14 year-old children in Germany are on average 18.2 µg/l with a maximum of 100 µg/l, whereas a statistically significantly higher level has been determined for younger children (Becker 2007). For children (group aged three to 14 years) a reference value of 35 µg lead /l blood was derived from the data of the German Environmental Survey 2003/06 (GerES IV) for Children, i.e. the blood lead concentration of 5% of children in Germany exceeds 35 µg/l (HBM Commission 2009). Blood lead levels in Germany are therefore certainly in concentration ranges which have been known to produce adverse effects.

The current state of research principally allows no scientifically determined definition of a safe threshold dose for the effects of lead on the CNS and the endocrine system (Canfield et al. 2003; Lanphear et al. 2005; Schnaas et al. 2006; HBM Commission 2009). From a scientific point of view, a reliable estimation and assessment of the health risk of children associated with lead exposure is thus not possible at present. In fact, due to the detected effect on the CNS and the endocrine system as well as the special sensitivity of children, lead exposure must be minimised as much as possible.

Lead is a ubiquitous environmental contaminant. Measures to minimise exposure must therefore apply to its entry pathways in the environment as well as the use of lead in consumer products. For the vulnerable subgroup of children, the minimisation requirement should also incorporate exposure through toys. WHO has asked governments and industry to entirely eliminate substances from toys such as lead that can lead to adverse toxic effects (WHO 2007). In the BfR’s view, the ALARA principle (as low as reasonably achievable) should thus be applied to lead in toys and other consumer products.

3.2 Cadmium

3.2.1 Hazard potential

Only small amounts of cadmium are resorbed intestinally after oral intake. Resorption from the gastrointestinal tract is documented at an average of 5%. This value varies between one to 20% depending on food composition and the nutritional status of an individual (WHO 1992). The accumulation potential of cadmium is rather high, and it accumulates in the liver and especially in the kidneys. Once cadmium has been resorbed, its rate of excretion is rather low. In the kidneys, its half-life is up to 10 to 30 years. In laboratory animals as well as humans, the kidneys are considered the major target organs of sub-chronic or chronic oral cadmium exposure (JECFA 2003). Damage to proximal tubular cells causes renal dysfunction. Cadmium exposure can also lead to the loss of calcium in bones and an increased calcium excretion through the kidneys (ATSDR 1999). Further studies suggest that even relatively low exposure to cadmium increases the risk of bone demineralisation and the development of osteoporosis regardless of its effect on renal function (JECFA, 2003). Furthermore, the potential of heavy metals acting as endocrine disruptors, i.e. can affect hormone activity, is being debated. This is also true for cadmium (Iavicoli et al. 2009). In *in vitro* tests, cadmium causes an oestrogen response and is thus classified as endocrine modulating substance (Hofer et al. 2009). Evidence suggests that adverse effects of cadmium as well as lead may also be caused by epigenetic mechanisms (Baccarelli & Bollati 2009), which account for effects at low doses.

Cadmium and its compounds have been classified into Group 1 as human carcogenic substances by the International Agency for Research on Cancer (IARC) (IARC 1993). The Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area of the German Research Foundation (DFG) classifies cadmium as carcogenic substance of Category 2 (substances that are to be considered carcinogenic for humans) (DFG 2003).

The PTWI of 7 µg/kg body weight and week for cadmium was derived in 2003 by the Joint FAO/WHO Expert Committee on Food Additives (JECFA 2003). In the meantime, EFSA has re-evaluated cadmium and derived an updated, distinctly lower value for the TWI of 2.5 µg/kg body weight (EFSA 2009). This new value is based on data of urinary beta-2-microglobulin (B2M). This protein serves as biomarker to determine tubular kidney damage. Based on model calculations a critical urinary cadmium level of 1 µg per g creatinine was determined, which correlates with the development of kidney damage. The new TWI of 2.5 µg/kg body weight (daily intake of 0.35 µg/kg body weight) is meant to ensure that the critical urinary cadmium level is not reached or exceeded by the daily oral intake of cadmium. However, in its report EFSA notes that the updated TWI does not protect all population groups equally. Some groups can certainly have higher cadmium contaminations. These include children since the cadmium intake of children through foodstuffs regularly exceeds the TWI value by 100%.

3.2.2.Exposure

The main sources of human exposure to cadmium compounds are foodstuffs and cigarette smoke. Compared with non-smokers, smokers take in about twice as much cadmium per day (ATSDR 1999, EFSA 2009).

For the USA, a “total diet study” documents average dietary cadmium intake at 30 µg per day (ATSDR 1999). WHO estimates the average cadmium exposure through foodstuffs at 2.8-4.2 µg/kg body weight per week (24-36 µg/day). More recent estimates by JECFA and EFSA of average cadmium intake are in the same range. EFSA’s current estimates of adult cadmium intake are between 1.9 and 3.9 µg/kg body weight per week (median 2.3 µg/kg body weight and week) in the same area. However, it is suggested that high consumers (“total food consumption for high consumers) take in twice the amount of cadmium. A considerably higher intake of cadmium has also been documented for vegetarians. The same is true for children when the intake level is related to body weight. For children up to 12 years, EFSA has estimated cadmium intake between 0.49 and 7.9 µg/kg body weight and week (median 2.71 µg/kg body weight and week) (EFSA 2009). Intake is higher for younger children. Young children (1.5 to 4.5 years) thus exceed the cadmium intake of adults by 165% (EFSA 2009). It is therefore safe to assume that the cadmium intake through food alone can exceed the TWI value by 100% on a regular basis (EFSA 2009).

Drinking water and the use of pottery releasing cadmium in contact with foodstuffs are also relevant sources of exposure (BfR 2005; Schulz et al. 2008). House dust can also be a significant source of exposure for children (EFSA 2009).

Toy parts small enough to be swallowed constitute a relevant child-specific source of exposure. Stomach acids can release cadmium contained in these parts. The new European TSD 2009/48/EC defines migration limit values for cadmium based on the older PTWI of 7 µg/kg body weight and week for 3 different kinds of toy materials. The maximum permissible daily intake of cadmium derived from each toy material (dry, liquid, scraped-off) is 0.2 µg. If a child plays with dry as well as liquid and scrapable toys and ingests the proportionate amounts of all materials, in compliance with migration limits the child would have a total maximum oral cadmium intake of 0.6 µg per day through toys. This corresponds to 0.56 µg/kg body weight and week (a child weighing 7.5 kg according to the TSD assumption for defining migration limit values).

3.2.3 Risk characterisation

In children, dietary cadmium intake exceeds the TWI value by 100% on a regular basis (EFSA 2009). Furthermore, additional child-specific sources of exposure contribute to the cadmium intake of children. Permissible cadmium intake through toys can contribute up to about 20% to the total TWI. If the TWI is exceeded on a regular basis, health risks can no longer be excluded with sufficient certainty. EFSA is thus urging that current cadmium exposure must be reduced. EFSA’s petition in this regard should not just concern cadmium content in foodstuffs, but must include all sources. Toys can contribute just as considerably to the total exposure of children to cadmium. Yet since for children the actual TWI is exceeded even as a result of normal food intake, the exposure through toys constitutes an additional burden, which should be minimised as much as possible. Furthermore, the fact that cadmium once taken in accumulates in liver and kidneys must be taken into consideration. EFSA’s TWI is based on adult data; a possibly greater sensitivity of children was not considered. In respect to consumer health protection, it should be noted that kidney damage in children might be revealed even by low concentrations of cadmium in urine. In

addition to measures that further reduce the cadmium content in foodstuffs, specific measures aimed at reducing the exposure of children are therefore necessary. These also include toys as source of exposure as they can contribute significantly to cadmium intake.

3.3 Scope for action / measures

In regard to children, it is necessary to minimise their exposure to lead as well as to cadmium.

In addition to measures that reduce the content of these environmental contaminants in foodstuffs and therefore reduce alimentary intake, toys should be considered as child-specific source of exposure and included in measures to minimise exposure of children.

Lead:

Due to its documented low dose effects on the CNS, on intelligence and on the endocrine system as well as the special sensitivity of children, lead exposure must be minimised as much as possible. For the vulnerable subgroup of children, minimisation measures must also include exposure through toys.

Principally, consumer health protection cannot tolerate the elevation of migration limit values for lead. According to recent research findings, the migration limit values for lead from different toy materials defined in Directive 2009/48/EC on the basis of the WHO TDI value effective thus far can no longer categorically avert a risk to human health. The limit values defined in Directive 2009/48/EC allow for a permissible lead intake through toys that constitute up to about 50% of alimentary intake of children.

WHO has urged governments and industry to entirely eliminate substances in toys such as lead that can lead to adverse toxic effects. BfR supports the WHO’s demand. Due to the lack of a safe threshold for critical adverse effects, BfR is in support of applying the ALARA principle (as low as reasonably achievable) to toys and other consumer products.

Cadmium:

Children's dietary intake of cadmium exceeds the TWI value by 100% on a regular basis. Furthermore, the permissible cadmium intake of children through toys can contribute to up to about 20% of the TWI. If the TWI is exceeded on a regular basis, health risks can no longer be averted for certain. Ultimately, the exposure of children to cadmium through toys should thus be minimised and the ALARA principle applied.

Migration limit values for cadmium defined in the new TSD 2009/48/EC were derived on the basis of the old PTWI of 7 µg/kg body weight and week, which has just recently been revised and lowered by EFSA. In a first step, the migration limit values for cadmium in toys should be promptly adjusted to the EFSA TWI value of 2.5 µg/kg body weight and week.

Due to the high alimentary cadmium intake of children, the tolerable intake through all three toy materials should only contribute to a maximum of 5% of the EFSA TWI. The scenario used for the derivation of migration limit values should take into consideration that in one day, children play with dusty and dry toy materials as well as liquid and scrapable toy materials and swallow proportionate amounts.

4 References

ATSDR 1999: Toxicological Profile for Cadmium; U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry.

ATSDR 2007: Toxicological Profile for Lead; U.S. Department of Health and Human Services; Agency for Toxic Substances and Diseases Registry.

Baccarelli A, Bollati V, 2009: Epigenetics and environmental chemicals. Current Opinion in Pediatrics 2009 April; 21(2):243-51.

Becker K, Müssig-Zufika M, Conrad A, Lüdecke A, Schulz C, Seiwert M, Kolossa-Gehring M, 2007: Kinder-Umwelt-Survey 2003/06 - KUS - Human-Biomonitoring Stoffgehalte in Blut und Urin der Kinder in Deutschland. WaBoLu-Hefte 01/2007, 21-29, http://www.umweltdaten.de/publikationen/fpdf-l/3257.pdf

BfR 2005: Blei und Cadmium aus Keramik, Aktualisierte Stellungnahme Nr. 023/2005 vom 26. März 2004, URL: http://www.bfr.bund.de/cm/216/blei_und_cadmium_aus_keramik.pdf (15.09.2009)

Braun JM, Kahn RS, Froehlich T, Auinger P, Lanphear BP, 2006: Exposure to environmental toxicants and attention hyperacticity disorder in U.S.children. Environment Health Perspect 2006 December; 114(12):1904-9.

Canfield RL, Henderson CR, Cory-Slechta DA, Cox C, Jusko TA, Lanphear BP, 2003: Intellectual impairment in children with blood lead concentrations below 10 micrograms per decilitre. The New England Journal of Medicine 2003 April 17; 348(16):1517-26.

Chen A, Cai B, Dietrich KN, Radcliffe J, Rogan WJ: Lead exposure, IQ, and behavior in urban 5- to 7-year-olds: does lead affect behavior only by lowering IQ? Pediatrics 2007 March; 119(3):e650-8.

Codex 2006 Discussion paper on Thirty-eighth meeting of the Joint FAO/WHO Codex Committee on Food additives, 24-28. April, The Hague (2006)

DFG 2003: MAK- und BAT-Werte-Liste

DFG 2007: MAK- und BAT-Werte-Liste 2007, Senatskommission zur Prüfung gesundheitsschädlicher Arbeitsstoffe, Mitteilung 43; WILEY-VCH Verlag GmbH & Co. KGaA; ISBN 978-3-527-31954-1

EFSA 2004, Opinion of the Scientific Panel on Contaminants in the Food Chain on a request from the Commission related to lead as undesirable substance in animal feed (adopted on 2 June 2004) The EFSA Journal 71 (2004) 1-20

EFSA 2009: Cadmium in food – Scientific opinion of the panel on Contaminants in the Food Chain, adopted on 30 January 2009, The EFSA Journal (2009) 980 http://www.efsa.europa.eu/en/scdocs/doc/contam_op_ej980_cadmium_en_rev.1.pdf

FSA (Food Standards Agency) 2009: Survey on measurement of the concentration of metals and other elements fron the 2006 UK total diet study. Food survey Information Sheet 01/09.45, http://www.food.gov.uk/multimedia/pdfs/fsis0109metals.pdf

HBM-Kommission 2009: 2.Addendum zur „Stoffmonographie Blei – Referenz- und Human-Biomonitoring-Werte" , Bundesgesundheitsbl – Gesundheitsforsch – Gesundheitsschutz 52 (10) 983-986

Hofer N, Diel P, Wittsiepe J, Wilhelm M, Degen GH, 2009: Dose- and route-dependent hormonal activity of the metalloestrogen cadmium in the rat uterus. Toxicology Letters 2009 December 15; 191(2-3):123-31.

IARC 1993: Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol 58, Beryllium, Cadmium, Mercury, and Exposures in the Glass Manufacturing Industry, Lyon.

IARC 2004, Inorganic and organic lead, Vol 87, February 10-17, 2004 (http//:www.IARC.fr)

IARC 2006: Inorganic and organic lead compounds. IARC monographs on the evaluation of the carcinogeneic risk of chemicals to humans, Volume 87, IARC, Lyon, France

Iavicoli I, Fontana L, Bergamaschi A. The effects of metals as endocrine disruptors. Journal of Toxicology and Environmental Health Part B: Critical Reviews. 2009 March; 12(3): 206-23.

JECFA, 2002: Lead. http://www.inchem.org/documents/jecfa/jeceval/jec_1260.htm

JECFA 2003: Summary and conclusions of the sixty-first meeting of the Joint FAU/WHO Expert Committee on Food Additives, 16-18. World Health Organization, Geneva; ftp://ftp.fao.org/es/esn/jecfa/jecfa61sc.pdf [online 09.05.2006].

JECFA 2006: Discussion paper on Thirty-eighth meeting of the Joint FAO/WHO Codex Committee on Food additives, 24-28. April, The Hague (2006)

Lanphear BP, Hornung R, Khoury J, Yolton , Baghurst P, Bellinger DC, Canfield RL, et al Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis. Environmental Health Perspectives 2005 July; 113(7):894-9.

Lommel L, Dengler D, Janßen U, Fertmann R, Hentschel S, Wessel M., 2002: Bleibelastung durch Trinkwasser. Bundesgesundheitbl - Gesundhetisforsch - Gesundheitsschutz 2002; 45:605-612

Ronchetti R, Van den Hasel P, Schoeters G, Hanke W, Rennezova Z, Barreto M, Villa MP. Lead neurotoxicity in children: Is prenatal exposure more important than postnatal exposure? Acta Paediatrica 2006 October; 95(453):45-9.

Schnaas L, Rothenberg SJ, Flores MF, Martinez S, Hernandez C, Osorio E, Velasco SR, Perroni E, 2006: Reduced intellectual development in children with prenatal lead exposure. Environmental Health Perspectives 2006 May;114(5):791-7.

Schulz, C., Rapp, T., Conrad, A. Hünken, A., Seiffert, I., Becker, K., Seiwert, M. Kolossa-Gehring, M. 2008: Kinder-Umwelt-Survey 2003/06, Trinkwasser – Elemente im häuslichen Trinkwasser aus Haushalten mit Kindern in Deutschland, WaBoLu Hefte 04/08, Umweltbundesamt 2008

SCOOP 2004: Report of experts participating in Task 3.2.11. Assessment of the dietary exposure to arsenic, cadmium, lead and mercury of the population of the EU Member States, March 2004

Selevan SG, Rice DC, 2003: Blood lead concentration and delayed puberty in girls. The New England Journal of Medicine 2003 April 17;348(16):1527-36.

UBA 2007: Umweltbundesamt: Daten zur Umwelt 2007, http://www.umweltbundesamt-umwelt-deutschland.de/umweltdaten/public/theme.do?nodeIdent=2887

WHO 1992: Cadmium. Environmental Health Criteria No 134. WHO, Geneva.

WHO (1995): Inorganic lead. Environmental Health Criteria No 165. WHO, Geneva, 25-32 und 215-234.

WHO 2000: Lead in: Safety Evaluation of Certain Food Additives and Contaminants. Joint FAO/WHO expert Committee on Food Additives, Food Additives Series: 44. World Health Organization, Geneva, Switzerland.

WHO 2007: Lead exposure in children. Information note, 6 August 2007 http://www.who.int/phe/news/Lead_in_Toys_note_060807.pdf

Wu T, Buck GM, 2003: Blood lead levels and sexual maturation in U.S. girls: the Third National Health and Nutrition Examination Survey, 1988-1994. Environmental Health Perspectives 2003 May; 111(5):737-41.

Yusà V, Suelves T, Ruiz-Atienza L, Cervera ML, Benedito V, Pastor A. Monitoring programme on cadmium, lead and mercury in fish and seafood from Valencia, Spain: levels and estimated weekly intake. Food Additives and Contaminants 2008, 1-10