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Environmental exposure and preventive measures in Sweden and EU*

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Abstract

Environmental exposure to cadmium (Cd) gives rise to renal tubular dysfunction at low cumulative doses of Cd. A possible role of Cd in influencing the occurrence of diseases, e.g., bone, reproductive and cancer in the general population groups environmentally exposed to Cd has been reported from Japan, Belgium, Sweden and China. Authorities have to pay attention to this fact and to act in order to prevent serious outcomes and personal suffering in the population groups at risk. A general approach in setting recommended health based limits and to regulate the occurrence of a substance existing in food stuff is to keep low levels –better to be on the safer side than on the risk side. In the case of cadmium it should be most clear that since cadmium has a very long biological half-life of 20 years in humans, increased cadmium exposure due to human activities can never be accepted. In cases where cadmium exposure can not be avoided the approach should be to limit and decrease exposure. Presently FAO/WHO Expert Committee on Food Additives and Food has a PTWI (provisional tolerable weekly intake) value for adult persons of 7 μg/kg body weight for Cd (WHO 2003) a value corresponding to 1 μg/kg body weight for each day of a week. For children and pregnant or lactating women daily intakes should not exceed 1 μg/kg body weight.

Introduction

Cadmium is a metal that may give rise to adverse health effects in humans e.g. renal tubular dysfunction and bone effects (WHO 1992; Nordberg & Nordberg 2000, 2002). It has a long biological half-life of around 20 years in humans. In 1993 cadmium and its compounds was classified as a human carcinogen (Group 1) by IARC. Environmental exposure to cadmium gives rise to renal tubular dysfunction at low cumulative doses of Cd which is regarded as the critical effect. However, it has also been found that Cd has an influence upon the occurrence of other diseases, e.g., bone, reproductive and cancer in the general population groups environmentally exposed to Cd. Since bone effects first was reported from Japan as itai-itai disease, attention has been paid to whether bone effects can be related to cadmium exposure or not in the general population. Results obtained from studies performed in Belgium, Sweden and China supports the theory that Cd is linked to bone effects.

Since the studies in China, as well as a number of studies in the mentioned other countries, show that tubular dysfunction occurs at lower cumulative doses of cadmium than previously estimated and that also bone effects occur, authorities have to pay attention to this fact and to act in order to prevent such serious outcomes and personal suffering in the population groups at risk.

Humans are exposed to cadmium via drinking water, food and tobacco smoking. In the work environment most exposure is by inhalation of dust and fumes (oxides) in the air of the work environment. Absorption of cadmium from food is influenced by intake of protein, calcium and iron i.e. by nutritional status and iron status. Very little is known about whether genetic polymorphism can have an influence on these factors which could be necessary to take into account when setting health based exposure limits for cadmium. A general approach in setting recommended health based limits and to regulate occurrence of a substance exist-

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ing in food stuff is to keep low levels –better to be on the safer side than on the risk side. In the case of cadmium it should be most clear that since cadmium has a very long biological half-life increased cadmium exposure due to human activities can never be accepted. In cases where cadmium exposure can not be avoided the approach should be to limit and decrease exposure.

Recommendations

In 1984 WHO recommended that drinking-water guideline value should be 5 μg/l (WHO 1984). Since 1993 the guideline value for Cd in drinking water is decreased to 3 μg/l (WHO 1993)

FAO/WHO Expert Committee on Food Additives and Food set a provisional tolerable weekly intake (PTWI) of cadmium for adult persons at 7 μg/kg bodyweight (JECFA 2003) which corresponds to 1 μg/kg body weight for each day of a week. In the evaluation of JECFA 2003 (JECFA 2003) the renal tubular dysfunction was regarded as the critical effect. It was however recognized that animal experiments have indicated that neurotoxic effects in children might be the critical effect in children and thus might justify a lower PTWI value than the present one which is based on renal effects in adults. JECFA encouraged more studies in this field. Codex Alimentarius has so far not given any final recommendation but has discussed levels similar to the present EU values.

It is implicit in the PTWI that it allows a certain variation of intake during a week as long as the weekly intake is not exceeded. It may also be discussed to what extent the PTWI could temporarily be exceeded without adverse effects. A single dose of 4–14 μg/kg body weight or 3 μg/kg body weight for periods of months is considered tolerable without gastrointestinal symptoms. There should be periods of compensatory intakes lower than the PTWI in order to avoid the risk of renal dysfunction.

For children and pregnant or lactating women daily intakes should not exceed 1 μg/kg body weight (Nordberg & Nordberg 2002).

WHO (1980) recommended that 250 μg/m^3 should not be exceeded for short term exposures in the work environment, provided the recommended time-weighted average (40 h/week) of 10 μg/m^3 is respected (WHO 1980). Urine and blood concentration of cadmium should not exceed 5 μg/g creatinine and 5 μg/l of whole blood, respectively.

Table 1. Medical check up workers exposed to Cd and control blood concentration of Cd (B-Cd) (Sweden) (ASF 2000)

A. Medical examination within 6 months before start of cadmium work +	
B: Medical examination every 2nd year	
C: Control blood concentration of Cd (B-Cd)	
nmol/L	action-time interval
<50	control -six months
>50	explanation demanded
	if 3 consecutive six- months control <100, 1 year control is accepted
>100	Return to control -six months
>150	Stop work-medical examination, return to work when <100

The international organizations like WHO can only issue recommendations of exposure limits, which are based on risk assessment and evaluations of existing knowledge of each individual substance. National regulatory rules and other legislation control exposures to agents giving rise to adverse health effects in humans in order to protect human health. Member states of the European Union (EU) should follow the recommendations set by EU in order to harmonize the situation in all member states.

Sweden has an extensive experience in studying the relationship between cadmium toxicity and related health effects and is still most active in the international work to develop 'safe' Cd exposure concentration. Already in the 1970s Sweden banned the use of Cd as a pigment in plastics and paint and for plating of iron. Since there has been no regulation of intake of cadmium via food stuff, no legal restrictions existed until recently. National Board of Food Safety and administration recommended a restricted intake, i.e., a maximum intake of 1–2/week of liver and kidney depending on the age of the animal.

In Sweden the National Board of Occupational Health regulates the exposure to Cd in the work environment. A threshold limit value for respirable dust is set at 10 μg/m^3 and for total dust 50 μg/m^3 (AFS 2000:3). Cadmium is listed as a carcinogenic compound. For cadmium work medical check up is compulsory for employed workers with periodic determinations of blood cadmium (Table 1).

Table 2. Regulation of cadmium in food in the European Union: Commission Regulation (EC) No 466/2001 of 8 March 2001 setting maximum levels for certain contaminants in foodstuffs. Performance criteria for sampling and Performance criteria for methods of analysis regulated by Directive 2001/22/EC.

3.2. CADMIUM (Cd)	Concentration mg/kg wet weight
3.2.1. Meat of bovine animals, sheep, pig and poultry excluding offal	0.05
3.2.2. Horsemeat	0.2
3.2.3. Liver of cattle, sheep, pig and poultry	0.5
3.2.4. Kidney of cattle, sheep, pig and poultry	1.0
3.2.5 Muscle meat of fish. as defined in category (a), (b) and (e) of the list in Article 1 of Regulation (EC) No 104/2000, excluding fish species listed in 3.2.5.1.	0.05
3.2.5.1 Muscle meat of wedge sole, eel, European Anchovy, louvar of luvar, horse mackerel or scad, grey mullet, common two-banded seabram, European pilchard or sardine	0.1
3.2.6. Crustaceans, excluding brown meat of crab	0.5
3.2.7. Bivalve molluscs	1.0
3.2.8. Cephalopods (without viscera)	1.0
3.2.9. Cereals, excluding bran, germ, wheat grain and rice	0.1
3.2.9.1. Bran, germ, wheat grain and rice	0.2
3.2.10. Soybeans	0.2
3.2.11. Vegetables and fruits excluding leafy vegetables, fresh herbs, all fungi, stem vegetables, root vegetables and potatoes	0.05
3.2.11.1. Leafy vegetables, fresh herbs, celeriac and all cultivated fungi	0.2
3.2.11.2. Stem vegetables, root vegetables and potatoes, excluding celeriac. For potatoes the maximum level applies to peeled potatoes	0.1

Within the European Union (EU) treshold limit value for Cd in food within EU area is regulated according to Commission regulation (EG) nr 466/2001. This regulation introduces for the first time maximum levels for certain contaminants in foodstuff including maximum limits for cadmium in foodstuffs. The starting date is April 5 2002, the limits for cadmium in meat, fish and shellfish and cereals are specified in the Regulation as given in Table 2. The Member States shall, not later than 5 April 2003, bring into force the laws, regulations or administrative provisions necessary to comply with the provisions of this Directive. They shall forthwith notify the Commission thereof. The Commission Directive 2001/22/EC of 8 March 2001 defines the sampling methods and the methods of analysis for the official control of the levels of lead, cadmium, mercury and 3-MCPD in foodstuffs.

In United States of America (US) in order to protect human health, the governmental agencies like EPA, FDA, NIOSH, and OSHA make recommendations and set regulatory rules influencing human cadmium exposure. The Environmental Protection Agency (EPA) of US allows 5 parts of cadmium per billion parts of drinking water (5 ppb) (ng/g). Limits for how much cadmium can enter lakes, rivers, waste sites, and cropland is also under EPA regulation. EPA does not allow cadmium in pesticides. The Food and Drug Administration (FDA) has a limit on the amount of cadmium in food colors to 15 parts of cadmium per million parts of food color (15 ppm) (15 mg/kg). OSHA (US Occupational Safety and Health Administration) has a threshold limit value for occupational exposure via air of 100 μg/Cd/μm^3 cadmium fumes and 200 μg/Cd/μm^3 as cadmium dust. The intention is to limit all cadmium compounds to 1 or 5 μg/m^3

The National Institute for Occupational Safety and Health (NIOSH) currently recommends keeping inhalation of cadmium as low as possible. Cadmium is regulated in USA by EPA and some states under the Clean Water Act's National Pollutant Discharge Elimination System and General Pretreatment Regulations. EPA offices overseeing regulations and guidelines applicable to cadmium include the Offices of Air Quality Planning and Standards. Cadmium is listed as a toxic chemical under the Emergency Planning and Community Right-to-Know Act; estimates of cadmium releases into the air, water or land must be reported annually and entered into the national Toxic Release (ASTDR 1993).

Conclusions

Because of the toxicological properties of Cd i.e. its long biological half-life of 15–20 years in humans, only very low exposure levels can be tolerated in humans, exposures of populations in the general environment have to be kept below recommended exposure limits in order for adverse health effects to be avoided. Legislation implying considerable restrictions in use of Cd including industrial exposures has been passed in some countries. Present exposure limits are based on quantitative epidemiological data in humans concerning renal dysfunction, the critical effect of cadmium in long term exposures. If the neurotoxic effect during early postnatal life that has been seen in animal experiment, will be taken as a critical effect for children and if for adults the bone effects are considered as the critical effect in risk assessment it may be necessary to reevaluate existing exposure levels. Further international evaluations and recommendations are needed for prevention of adverse health effects of cadmium in humans.

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