COMISION NACIONAL DEL MEDIO AMBIENTE(CONAMA)
UNIDAD DE DESCONTAMINACION, PLANES Y NORMAS

Con fecha 30 de Junio de 1999 se archivó bajo el número que a continuación se indica el siguiente antecedente para la elaboración de la norma de calidad primaria para plomo en el aire:

8-NOR-3/98: Global Opportunities for Reducing the Use of Leaded Gasoline, Inter-Organization Programme for the Sound Management of Chemicals.

Patricia Matus C.
Jefe Depto. Descontaminación,
Planes y Normas

PLOMO(Pb)

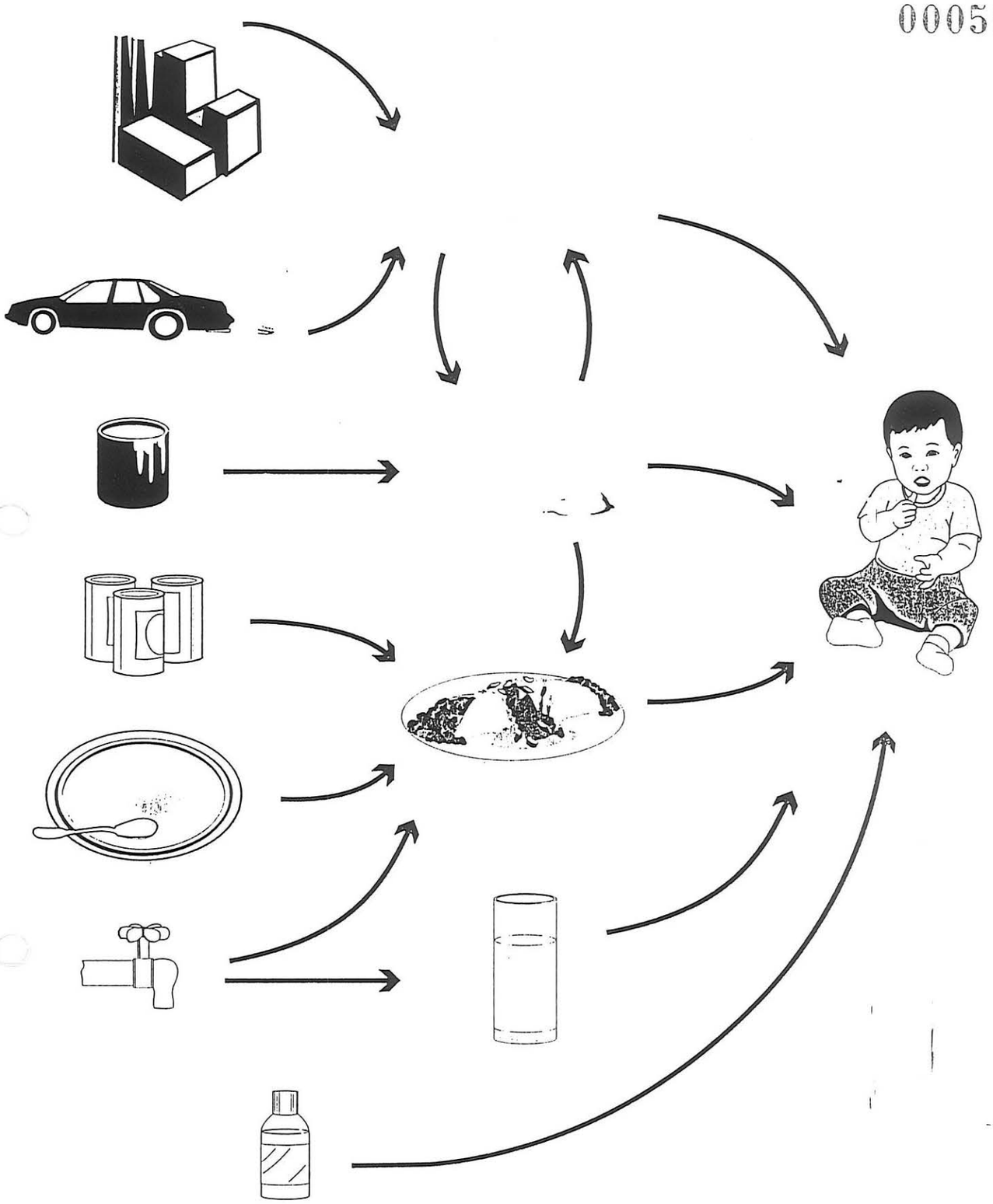
- PROPIEDADES FISICO-QUIMICAS
  - Metal
  - P.Fusión: 327.5 °C
  - P. Ebullición: 1740 °C
  - Solubilidad en agua: insoluble
- FUENTES DE EXPOSICION HUMANA
  - NATURALES (19 000 Tm/año)
    - Desgaste geológico
    - Emisiones volcánicas
  - ANTROPOGENICAS (126000 Tm/año)
    - Minería
    - Fundición
    - Uso: pilas, cables, pigmentos, aditivos de gasolina, soldaduras, tapas de botellas, esmaltes y cristalería

PLOMO(Pb)

- TRANSPORTE, DISTRIBUCION Y TRANSFORMACION
  - Aire:
    - Corto recorrido (deposición)
    - <2 µm largas distancias
  - Agua :
    - Reparto agua : sedimento
    - Aguas blandas : 30 µg/l
      » } pH >5.4
    - Aguas duras : 500 µg/l
  - Lixiviación poco importante (erosión)

- EXPOSICIÓN DE LOS SERES VIVOS
  - Directa
  - Indirecta: agua, suelo y vegetación
  - Biomagnificación (poco importante)

Figure 4 **Primary Sources and Pathways of Lead Exposure**



Other: weathering of earth's crust, deposition from air directly to food crops

PLOMO(Pb)

- NIVELES AMBIENTALES

Aire

- zonas remotas: 0.05 $\mu g/m^3$
- zonas urbanas
  - $>10\ \mu g/m^3$ (fundiciones)
  - $< 0.2\ \mu g/m^3$ (gasolina sin plomo)
- tabaco: 2.4 µg/g (5 % inhalado)

Suelo

- 10-70 mg/kg
- 138 mg/kg (carreteras)

Aguas superficiales

- Manantial: 0.02-5 µg/l

Viviendas con tuberías de plomo: > 100 µg/l

PLOMO(Pb)

- NIVELES MAXIMOS RECOMENDADOS
  - AIRE ($\mu g/m^3$)
    - Directiva UE 2.0
    - USA 1.5
    - Canadá 5.0
    - Federación Rusa 0.3

    - OMS estima que 0.5-1.0 $\mu g/m^3 \rightarrow$ Pb-H <20 $\mu g/dl$ (cada 1 $\mu g/m^3 \rightarrow$ 1.9 $\mu g/dl$)
  - AGUA ($\mu g/l$)
    - OMS 50 (pre-1993); 25 (1998); 10 (2008)
    - Japón, Namibia, SA 100
    - Directiva UE 50
    - Noruega 20
    - Canadá, Finlandia, Suecia 10
  - SUELO (mg/kg)
    - UE 300 (suelo)
      - » 1200 (lodos)

PLOMO (Pb)

ALIMENTOS (µg/g)

	USA	CANADA
Lácteos	0.003-0.083	0.001-0.082
Queso	-	0.034-6.775
Carne, pescado	0.002-0.159	0.011-0.121
Cereales	0.002-0.136	0.011-0.078
Hortalizas	0.005-0.649	0.001-0.254
Frutos y zumos	0.005-0.223	0.002-0.109
Aceites y grasas	0.006-0.073	-
Azúcares	0.006-0.073	-
Bebidas	0.002-0.041	-

PLOMO(Pb)

- ABSORCION DE PLOMO
  - INHALACION
  - INGESTION
  - CUTÁNEA (muy pequeña)

  – **AIRE**
    - Volumen: adultos: 20 m^3/día; niños: 5 m^3/día
    - Absorción respiratoria: 40-50 %

  – **ALIMENTOS**
    - adultos:10 %; niños: 50%

  – **AGUA**
    - Volumen: adultos 1 l/día; niños: 0.5 l/día
    - Absorción: adultos 10 %; niños 50 %

  – **POLVO**
    - Concentración: 1000 µg/g
    - Absorción: 50 %

  – **ABSORCIÓN**
    - Rápida en sangre y tejidos blandos
    - Lenta en huesos (acumulación)
    - Vida media en sangre: 28-36 días

PLOMO (Pb)

INGESTA DIARIA DE PLOMO EN LA ALIMENTACION (µg/día)

	ADULTOS	NIÑOS< 1 año
Reino Unido	71-110	2-3
Bélgica	96-282	-
Suecia	27	-
Finlandia	66	-
Canadá	43	-
USA	82	16-33
Japón	31	-
Alemania	61	
Croacia	15	-
Italia	140	-
China	46	-
Turquía	70	-
Nueva Zelanda	316	-
Polonia	-	225

PLOMO(Pb)

PLOMO TOTAL ABSORBIDO
(µg/día)

ADULTOS

Conc. Aire	Fuente (Pb) Aire	Alimentos	Agua	Total
0.3	2.4	10	2	14.4
2.0	16.0	10	2	28

NIÑOS

Fuente (Pb) Aire	Suelo	Alimentos	Agua	Total
0.6		25	5	30.6
4.0		25	5	34
2	12.5	25	5	44.3
2	100	25	5	132

PLOMO(Pb)

- EFECTOS EN ANIMALES
- Afecta a los sistemas:
  - Hematopoyético
  - Nervioso
  - Renal
  - Cardiovascular
  - Reproductor
  - Inmunitario
- Carcinógeno en ratas y ratones
- Deficiencias del aprendizaje y memoria
  - Ratas Pb-H: 0.72- 0.96 µmol/l (15-20 µg/dl)
  - Primates Pb-H: 0.72 µmol/l (15 µg/dl)
- Deficiencias visuales y auditivas
- Toxicidad renal en ratas
  - Pb-H : 2.88 µmol/l (60 µg/dl)
- Efectos cardiovasculares
  - Ratas (exp. crónica): Pb-H: 0.24-1.92 µmol/l (5-40 µg/dl)
- Tumores: Dosis menores de 200 mg Pb

PLOMO(Pb)

- EFECTOS EN HUMANOS
  - Sistemas:
    - Hematopoyético
    - Gastro-intestinal
    - Nervioso central y periférico
    - Renal
  - Disminuye la síntesis de hemoglobina
    - Anemia en niños a Pb-H > 1.92 µmol/l (40 µg/dl)
  - Efectos gastrointestinales:
    - Cólicos en envenenamiento agudo, Pb-H 1.92-9.6 µmol/l (40-200µg/dl)
  - Deficiencias neurocomportamentales en niños
  - Deficiencias psicológicas y neurocomportamentales en trabajadores
  - Neuropatías periféricas a niveles elevados, en trabajadores
  - Deficiencias renales
  - Reproducción: Efectos en morfología y nº de espermatozoides y en el embarazo
  - No se ha encontrado relación con el desarrollo de tumores

PLOMO(Pb)

- EVALUACION DE RIESGOS PARA LA SALUD HUMANA

  - Disminución del coeficiente de inteligencia :
    - Déficit de 0 a 5 puntos por cada 0.48 µmol/l
  - Relación causal entre el plomo y efectos en S.Nervioso :
    - Deficiencias cognitivas a niveles de 0.53-0.72 µmol/l
  - Reducción de la velocidad de conducción nerviosa periférica a partir de 1.44 µmol/l
    - Disminución de funciones sensitivomotrices 1.92 µmol/l (40 µg/dl)
    - Afección del sistema nervioso autónomo 1.68 µmol/l
  - Riesgo de nefropatía plúmbica >2.88 µmol/l
  - Ligero aumento de la presión arterial
  - Riesgo de parto prematuro
  - Insuficientes indicios de carcinogenicidad
  - Efectos en sistemas enzimáticos y bioquímicos

PLOMO(Pb)

- EFECTOS EN EL MEDIO ACUATICO
  - Toxicidad en invertebrados
    - Inorgánico: 0.78 - >500 mg/l (48h, LC_{50})
      - » Daphnia: 0.45 - 4.4 mg/l (48h, LC_{50})
      - » 0.3 mg/l (21 días, LC_{50})
    - Orgánico: 0.1 - 8.8 mg/l (96h, LC_{50})
      - » TML: NOEL 180 µg/l
      - » TEL: NOEL 25 µg/l
  - Toxicidad en peces
    - Inorgánico: 5 - 468 mg/l (48h, LC_{50})
    - Orgánico: TML: 0.1 - 84 mg/l (48-96h, LC_{50})
      - » TEL: 0.1 - 1.4 mg/l (48h, LC_{50})

PLOMO(Pb)

- EFECTOS EN ORGANISMOS TERRESTRES
  - Toxicidad en plantas
    - Inorgánico: >1000 mg/kg (LC_{50})
  - Toxicidad en aves
    - Inorgánico: >5000 mg/kg (5 días, LC_{50})
      - » >50 - >500 mg/kg 100 días, LC_{50})
    - Orgánico: TEL 107 mg/kg (aguda, LD_{50})

Lead is toxic to humans. In children continual exposure at low levels has been shown to cause mental retardation and behavioural problems.

Due to the use of lead in pipes for water reticulation, widespread use of lead-based paint, extensive use of lead additives in gasoline and other industrial uses of lead, lead has become a general environmental contaminant.

There is no safe level of lead in the body. Urgent action by local government will help prevent problems to human health and the environment.
This will involve undertaking a survey of blood lead levels of the young children in the area and then carrying out the appropriate intervention required.
When blood lead levels are above 15 µg/dl action should be taken to reduce exposure.

Lead Poisoning

- Lead is an environmental and public health hazard of global proportions. Yet, the global dimensions of lead poisoning remain poorly understood, due to the persisting lack of information. The vast majority of studies have been carried out in developed countries.
- Causes of lead poisoning are local, vary from community to community and country to country.
- Growing evidence suggests that lead in a child's body, even in small amounts, can cause disturbances in early physical and mental growth, and later in intellectual functioning and academic achievements.[4] Thus lead poisoning is not only an environmental health problem, but also a social issue.[5]
- Urban children in developing countries are most at risk. It was estimated in 1994 that over 80% of those between three and five years of age and 100% under two had average blood lead levels exceeding the threshold of 10 µg/dl set by the US Centers for Disease Control and Prevention.[6] Children abuse substances which may contain lead, for example children who live and work on the streets sometimes sniff leaded gasoline.
- Even in the world's most developed countries it is estimated that a large proportion of children suffer from lead poisoning. Even though only 28% of children between three and five years of age have average blood lead levels over 10 µg/dl, 78% of children under two exceed this threshold.[6] It is the most common, chemical related, environmental child health problem. This is especially pronounced in economically disadvantaged sections of the population. Poverty can cause malnourishment or physical stress, which intensifies disabilities caused by lead absorption.[7]
- If a pregnant women is exposed to lead, it can be carried to the unborn child and cause premature birth, low birth weight or even abortion.

II. What Is Known About Lead and Lead Poisoning?

At low levels, lead poisoning in children causes:

- reduction in IQ and attention span
- reading and learning disabilities
- hyperactivity and behavioural problems
- impaired growth and visual and motor functioning
- hearing loss

At high levels, lead poisoning in children causes:

- anaemia
- brain, liver, kidney, nerve, stomach damage
- coma
- convulsions
- death

These effects of lead poisoning on children are:

- long-term and potentially irreversible
- intensified with repeated exposure and accumulation of lead in the body

Child Vulnerability to Lead

- Behavioural characteristics
- Eating and drinking per unit of body weight
- Absorption in the G.I. tract
- Nutritional deficiencies
- Blood-brain barrier
- Low thresholds for hematological and neurological effects
- Transplacental transfer

T4

Tolerance Levels for Lead

- The more research results become available, the lower the levels become at which preventive and remedial action should be taken. Thus marker levels for tolerance for lead are unclear.
- Current toxicity studies suggest that:
  — a blood-lead concentration of *10 µg/dl* (micrograms per decilitre, indicating the amount of lead in a tenth of a litre of blood, a common way of indicating the lead stored in an individual's body) is considered as an *action* level.[9] (This can be reached when a child ingests approximately 225 ml of contaminated water per day.)
  — an amount of *45 µg/dl* demands that *treatment* begin within 48 hours;
  — more than *70 µg/dl* in blood presents a medical *emergency;*
  — over *120 µg/dl* in blood is highly toxic and potentially *lethal.*
- Studies have shown that even at 10 µg/dl blood-lead level, detrimental effects on child development and behaviour can be observed.

Further studies suggest that at any level the detrimental effects of lead on child or adult health can be detected.

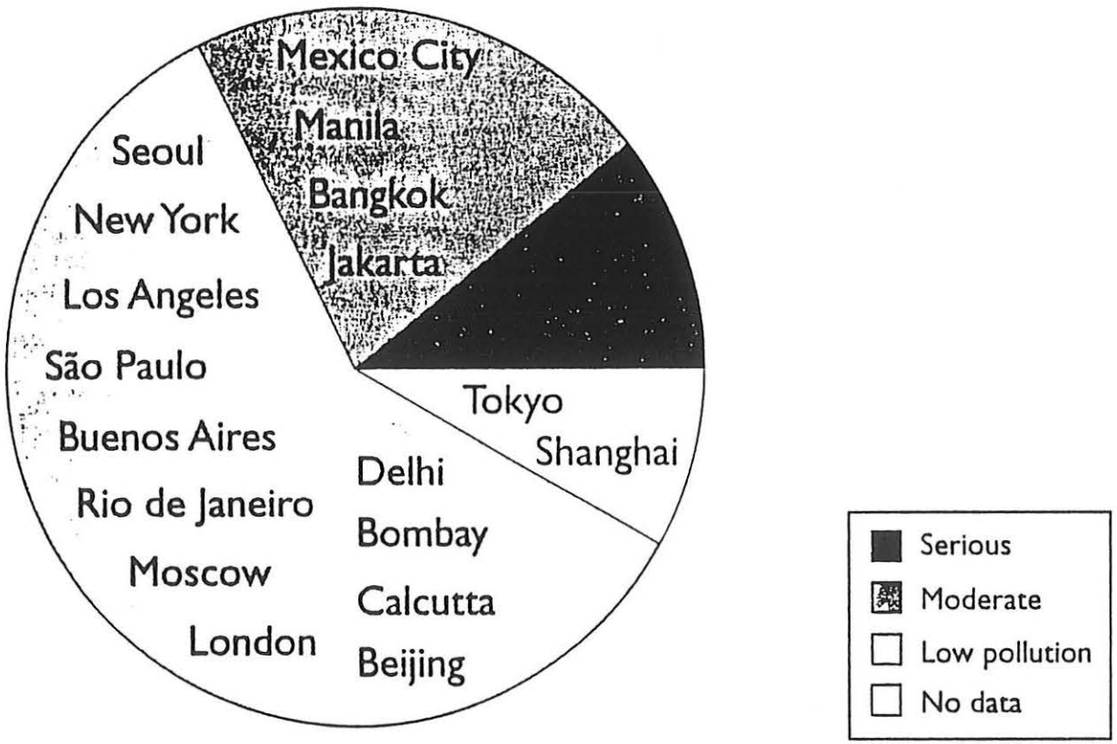
Lead Exposure

- Humans are exposed to lead through air, dust, water and food.
- Millions of children and adults are exposed to excessive levels of lead in the environment, at home, school and the workplace.
- Residents in urban areas have higher lead levels in their blood than those in rural areas.[2]
- Developing country populations, particularly children, may be under high level lead exposure due to:
  — unregulated industrial emissions and car emissions through leaded gasoline.[3]
  — lax enforcement of environmental and occupational health safety regulations.
  — 'cottage' (domestic) industries (e.g. metal polishing and smelters).

  — certain cultural practices (e.g. use of folk medicines containing lead, use of improperly glazed lead ceramic ware for cooking and food storage, use of lead-contaminated cosmetics such as surma and kohl).

FIGURE 2

Levels of lead in air in 20 mega-cities

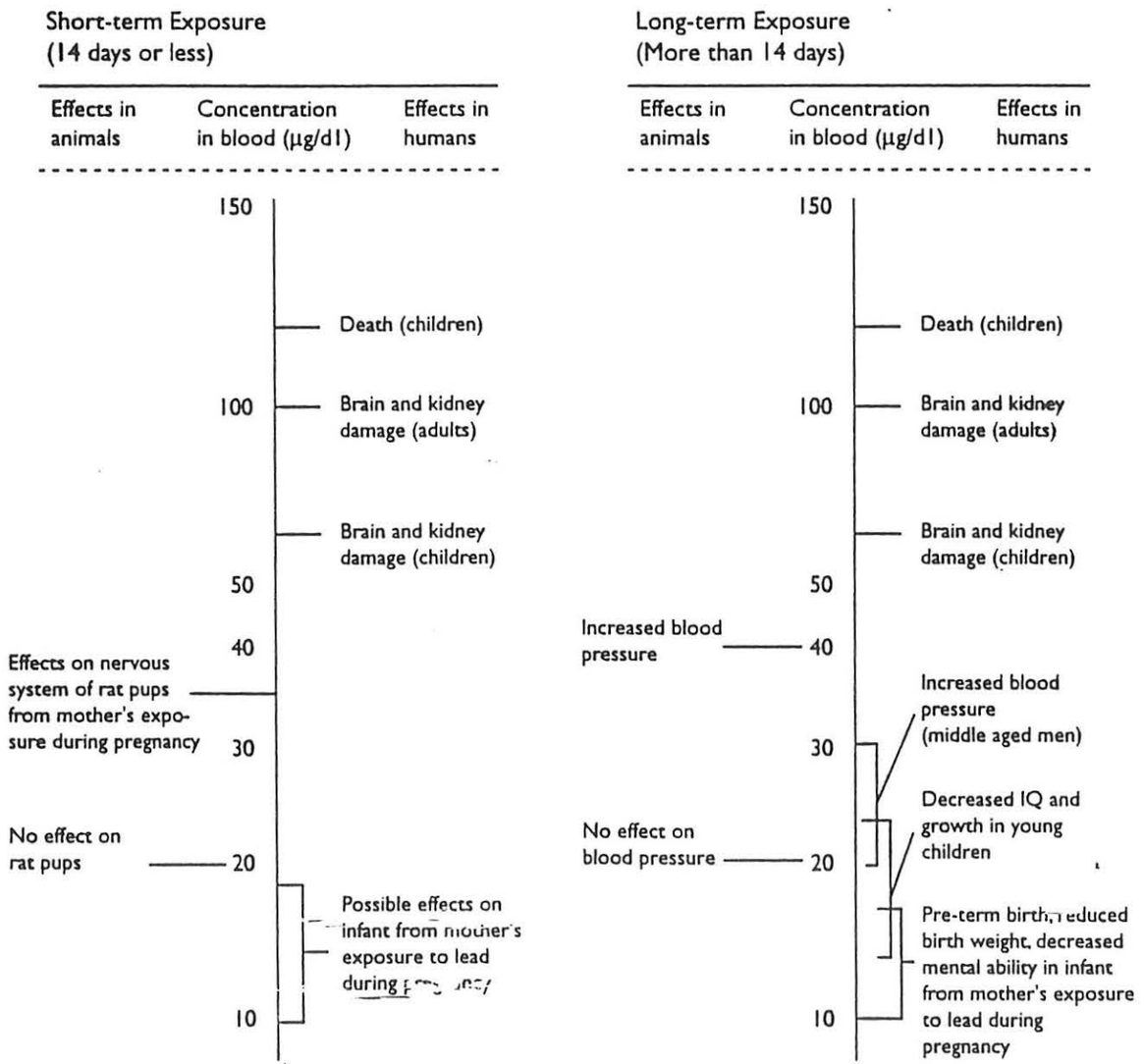


Note: "Serious" describes the situations where WHO guidelines are exceeded by more than a factor of two; "Moderate" indicates that WHO guidelines are exceeded by up to a factor of two, with short-term guidelines being exceeded on a regular basis at certain locations; "Low" suggests that WHO guidelines are normally met but short-term guidelines may be exceeded occasionally.

Source: Adapted from *Air Pollution in Mega-Cities of the World*, UNEP/WHO (1992).

FIGURE 1.

Health Effects from Ingesting and Breathing Lead



Source: US Agency for Toxic Substances and Disease Registry (1600 Clifton Rd., E-29, Atlanta, Georgia 30000, USA), April 1993

Toxicological Effects of Lead on Humans

a) Effects on haem biosynthesis and erythropoiesis
b) Effects on the nervous system
c) Effects on blood pressure and cardiovascular effects
d) Effects on kidney function

T6

Summary of lowest-observed-adverse-effect levels for lead-induced health effects in adults

Lowest-observed-effect Blood-lead-level (µg/l)	Haem synthesis haematological and other effects	Effects on nervous system
1000-1200		Encephalopathic signs and symptoms
800	Frank anaemia	
500	Reduced haemoglobin production	Overt subencephalopathic neurological symptoms, cognition impairment
400	Increased urinary ALA and elevated coproporphyrin	
300		Peripherial nerve dys-function (slowed nerve conduction velocities)
200-300	Erythrocyte protopor-phyrin elevation in males	
150-200	Erythrocyte protopor-phyrin elevation in females	

Table 1. Interpretation of blood lead test results and follow-up activities: Class of child based on blood lead concentrations

Class	Blood lead concentration (µg/dl	Comment
I	= or < 9	A child in Class I is not considered to be lead- poisoned
IIA	10-14	Many children (or a large proportion of children) with blood lead levels in this range should trigger community-wide childhood lead poisoning prevention activities. Children in this range may need to be screened more frequently.
IIB	15-19	A child in Class IIB should receive nutritional and educational interventions and more frequent screening. If the blood lead levels persist in this range, environmental investigation and intervention should be done.
III	20-44	A child in Class III should receive environmental evaluation and remediation and a medical evaluation. Such a child may need pharmacologic treatment of lead poisoning.
IV	45-69	A child in Class IV will need both medical and environmental interventions, including chelation therapy.
V	= or > 70	A child in Class V lead poisoning is a **medical emergency.** Medical and environmental management must begin **immediately**

(Adapted from CDC, Preventing Lead Poisoning in Young Children. A Statement by the Centers for Disease Control, October, 1991. U.S. Department of Health aand Human Services/Public Health Service)

Tableau 16.III : Bénéfices annuels associés à une diminution de 10 µg/l de la plombémie moyenne dans la population américaine (d'après Schwartz, 1994).

Poste	Nombre de sujets	Coût unitaire ($ 1989)	Coût total (millions $)
Enfants			
Traitement par chélation (plombémie > 250 µg/l)	145 000	1 300[1]	189
Troubles de l'apprentissage (20 % des enfants > 250 µg/l)	145 000	3 320[2]	481
Pertes de revenus induites par une baisse de QI de 0,245 point (pour les enfants de chaque tranche d'âge)	3 900 000	1 300	5 070
Décès d'enfants prématurés	380	3 millions	1 140
Soins intensifs pour enfants prématurés (symptômes respiratoires...)	1 710	39 000	67
Total			*6 947*
Adultes			
Coûts d'hospitalisation pour cause cardio-vasculaire (y compris pertes de revenus)	3 200 1 300	44 000 30 000	141 39
Coûts de traitement pour hypertension (y compris pertes de revenus)	635 000	628	400
Décès liés à l'hypertension	3 300	3 millions	9 900
Total			*10 480*
TOTAL SUR LA POPULATION AMERICAINE			17 427

[1] : Le coût est calculé par enfant dont la plombémie est supérieure à 250 µg/l (Schwartz, 1994). Le coût d'une cure de chélation en milieu hospitalier aux Etats-Unis est évalué entre 3 880 $ (Vergara et coll., 1996) et 5 000 $ (Pantell et coll., 1993)

[2] : Ce coût est calculé par enfant dont la plombémie est supérieure à 250 µg/l (Schwartz, 1994). Le surcoût est lié à l'éducation spécialisée (par rapport à l'éducation traditionnelle) est évalué à 10 000 $ pendant trois ans, selon Simon et coll. (1995)

10. RECOMMENDATIONS FOR PROTECTION OF HUMAN HEALTH

10.1 Public health measures

Public health measures should be directed towards reduction and prevention of exposure to lead by reducing the use of lead and lead compounds and by minimizing lead-containing emissions that result in human exposures. This can be achieved by:

a) phasing-out any remaining uses of lead additives in motor fuels;

b) further reducing the use of lead-based paints, with the objective of eliminating such paints;

c) development and application of methods for the safe and economical remediation of lead-painted homes and lead-contaminated soil;

d) elimination of the use of lead in food containers (e.g., in the seams of cans);

e) dissemination of information to assist with identification of glazed food containers which may leach lead into food placed, cooked or stored in the container;

f) eliminating any remaining agricultural uses of lead or lead compounds (e.g., lead arsenate as an insecticide);

g) identifying and reducing, or preferably, eliminating lead found as a contaminant or ingredient of folk remedies and cosmetics;

h) the use of materials and engineering practices to minimize plumbosolvency in water treatment and water distribution systems;

i) systematic examination of processes in which lead is used or recycled in order to identify and reduce lead exposure by means of improved engineering design, of operators, by-standers and the environment. Opportunities for technology transfer should be used whenever possible.

T15

ENVIRONMENTAL LEVELS AND HUMAN EXPOSURE

• Air. (µg/m³)

CANADA (100 stations)	0.74 (1972) ↘ 0.10 (1989)
USA (1987) non-smoking	0.1 - 0.3
smoking	0.3 - 4.0
LONDON (1914-1985)	0.50
SUFFOLK (")	0.10
NORWEGIAN ARCTIC (1983)	0.10 - 0.30 (ng/m³)
	0.3 - 9.0 (")

Average air concentration : 0.2 µg/m³ → lead intake : 0.5 µg/day infant → 4 µg/day adult.

• Water. (µg/litre)

USA : 2.8
Canada : 2.0
Glasgow : > 100 (40%)

Average drinking water concentration : 5 µg/l.
→ lead intake 3.8 µg/day infant → 10 µg/day adult

Food. (μg/day).

Daily dietary lead intakes:

Sweden	: 27.0	
Finland	: 66.0	
USA	: 23.0	(2 year old).
England (food and drink)	: 40.0	women
	30.0	children (5-7 years)
Canada	: 53.8	adolescents and adults
Belgium	: 90.0	
Mexico	: 177.0	
Some countries	: 4 to 500 μg/day.	

Wine: 73 μg/litre

Soil and Household dust.

Levels vary from < 5 μg/g to tens of mg/g.

UK intake of 42 μg/day for 2 year-old Children

Guideline Values in food and water.

Food.

JECFA (1993) → PTWI 25 µg Pb / kg bw
↑
1986

≈ 3.5 µg / kg bw / day.

for infants and children

Water.

Guideline 0.01 mg / litre