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# DETERMINATION OF HUMAN EXPOSURE USING MEASURED DATA OF Cd, As AND Pb

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## 1 INTRODUCTION

Health effects from toxic metals in the environment are closely related to the concentrations of these pollutants in the receptor organism, and can be estimated if the transport, transformation and bioaccumulation of these contaminants is known.

The present report describes the transport of a few selected metals through air, water, soil, plants, animals and diet to the human body. Mass balances and transfer factors of pollutants in the different media were estimated from measured concentrations in the surroundings of a 2000 MWe lignite-fired power plant in southern Poland. The metals selected for this study were cadmium (Cd), arsenic (As) and lead (Pb). The transfer factors obtained from the measured concentrations were compared to data from other studies (1). This work represent a basis for establishing a source oriented compartment model. The estimated total intakes from food were compared to the FAO/WHO permissible values (2,3).

## 2 DATA BASE

### 2.1 Area of study

The study area is located in the south-western part of Poland (Figure 1), close to the border of DDR and Tsjekkoslovakia in a rather montainous area. The main air pollution source in this area is the 2000 MWe lignite fired power plant at Turów. The annual consumption of lignite is $10^7$ tons, and the plant is equipped with electrostatic precipitators on each of its 4 units.

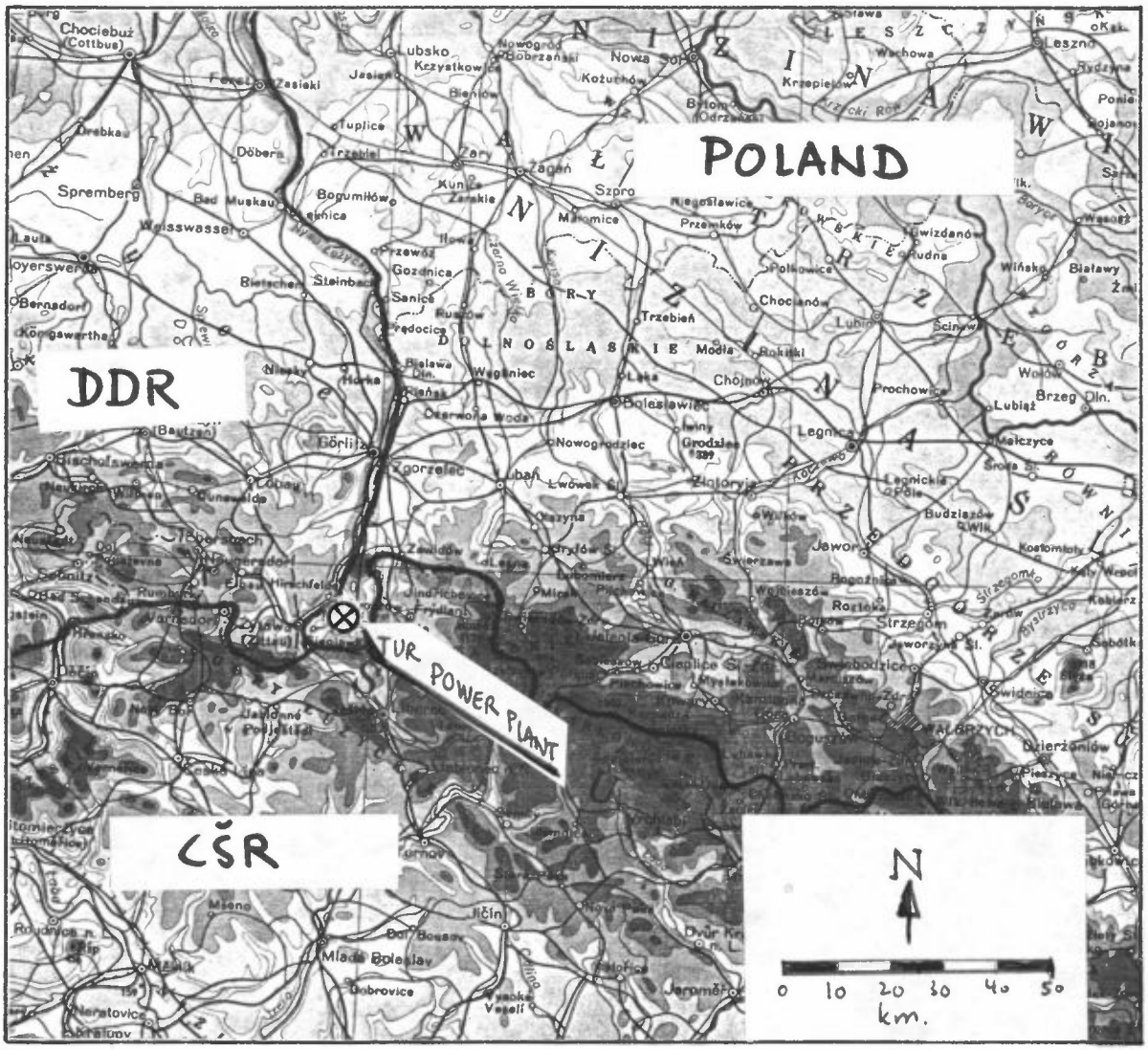


*Figure 1: Location of the study area.*

## 2.2 Measurements and sampling sites

The studies at the plant were carried out during the period 1976 to 1980. Altogether 270 samples of coal, fly-ash, bottom ash and stack dust were collected. Samples were collected every half-hour during each 3-hr sampling runs. Fly-ash and bottom-ash samples were taken at various points from hoppers and slag dumps to ensure representative sampling. Stack dust samples were collected iso-kinetically.

Ambient measurements consisted of 120 aerosol samples and 110 dust deposition samples collected at two sampling locations in the area:"Ryb" located 6.0 km from the power plant, and "Opo" located 6.2 km from the plant. Both sampling points were sited in the direction of the prevailing wind. At the same time 503 water, soil and plant samples were collected in the same area (4). When calculating the diet contamination, it was assumed that 100 per cent of the food came from the area under study.

# 3 METHODOLOGY

The simple quasi-stationary compartment model as indicated in Figure 2, was used to estimate the transfer of air pollutants to man. For each of the transfer routes a single pathway was used. Each pathway consists of a series of compartments, and equilibrium is assumed to exist between successive compartments, except between the next-to-last compartment and man. The last step in this pathway usually depends upon the dietary intake.

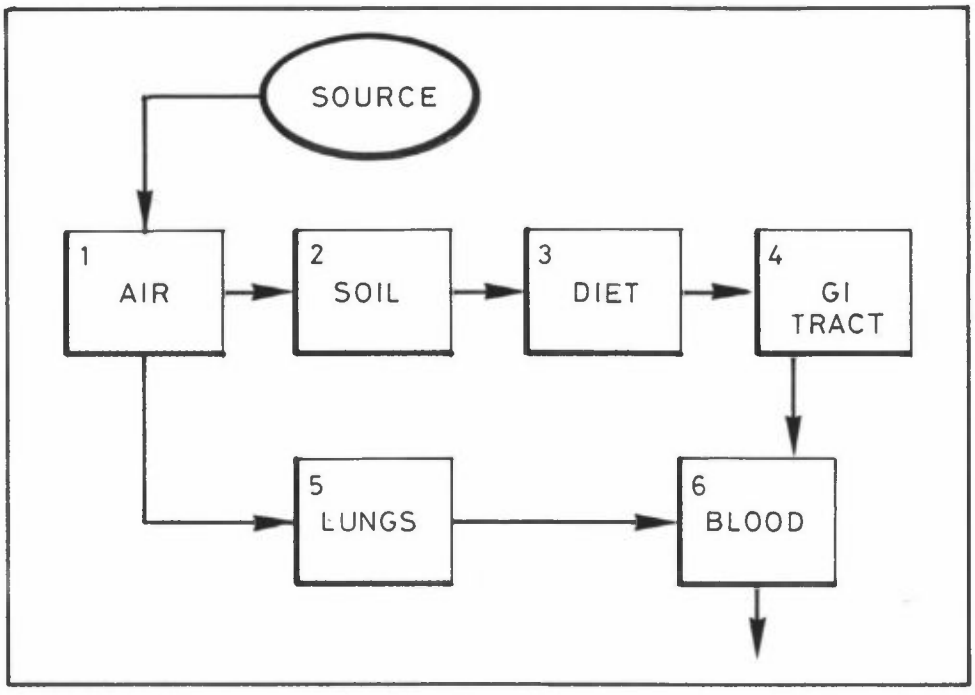


*Figure 2: The compartment model concept for transport of air pollutants to man.*

The evaluation of transfer factors from one compartment to the next is a main task with this method.

In the steady sate or equilibrium situation, the rates of pollutants entering and leaving a compartment are equal, and the concentration of the pollutant in the reference compartment does not change with time. Thus, for this case:

$$c_j^* = c_i^* \cdot f_{ij} \qquad [1]$$

where:

$c_j^*$ = the equilibrium concentration of a pollutant in a receptor food chain compartment;

$c_i^*$ = the steady-state concentration in a donor compartment i; and

$f_{ij}$ = the equilibrium transfer factor for the flow of pollutant between the donor i and receptor j compartments.

For the quasi-equilibrium model some compartments have not reached equilibrium at time t. The concentrations in these compartments will be modified compared to equilibrium values and given by:

$$c_j(t) = c_i^* \cdot f_{ij}(1-\exp(-k_2 \cdot t)) \qquad [2]$$

where:

$c_j(t)$ = the concentration of a pollutant in food chain compartment j at time t

$k_2$ = the effective first order rate constant for the loss of pollutant from food chain compartment i; and

$t$ = the time between initial exposure to the pollutant and harvest or the end of the release period.

When the effective rate constant, $k_2$, is very small with respect to t, equation [2] simplifies to:

$$c_j(t) = c_i^* \cdot f_{ij} \cdot k_2 \cdot t \qquad [3]$$

When $k_2$ is large with respect to t, equation (2) equals equation [1], and $c_j(t)$ equals $c_j^*$. Quasi-equilibrium models can be reduced to a series of multiplicative chains, and calculations with these models can be readily performed with a hand calculator.

When the exposure, which is defined as the time integral of the concentration over a specified time interval, is extended to cover the total exposure time, the quantity obtained is the exposure commitment:

$$E_i = \int_0^\infty c_i(t)dt \qquad [4]$$

The exposure commitment to blood via ingestion has been estimated in this study.

## 4 COMPONENTS OF INTEREST, MAIN PATHWAYS

The elements Cd, As and Pb were selected because of their toxicity in man and their concentrations in the environment.

Cadmium is considered to be biologically non-essential. It is toxic at higher levels of exposure. The body burden of cadmium in adults is normally 9.5 to 40 mg (1), with 40-80 per cent in kidneys and liver (5). Renal tubular disfunction may occur when the concentration is around 200 mg/kg in renal cortex (1). About 50 per cent of the cadmium in the whole body comes from ingestion, and 15 per cent from inhalation.

Arsenic has long been known as a poison and a therapeutic agent. Absorption of arsenic following inhalation is uncertain. Retention of ambient aerosols may be of the order 35 per cent (1). A large fraction is transferred from lungs to blood. Over 80 per cent of the ingested amount of arsenic is observed in the gastro-intestinal tract (1). Long-term moderate exposure to arsenic in air, diet or drinking water can result in lesions of the skin and mucous membranes, and in nervous and respiratory system damage.

Lead is an abundantly occurring heavy metal, which may cause both acute and chronic effects, mainly in the haematopoietic, nervous, gastro-intestinal and renal systems. Initial indicator changes occur at levels of 10-60 µg/dl of lead in blood (1). Blood is not the ultimate receptor organ in the body, but most reported biological effects have been correlated with lead concentrations in blood. Main pathways of lead to human body are about 50 per cent by ingestion and 30 per cent by inhalation (1). This varies however, considerably from one area to the other.

## 5 EMISSION ESTIMATES FOR THE LIGNITE FIRED POWER PLANT

During coal combustion the trace elements contained in the fuel are released. Some is retained in the bottom ash and another portion is entrained in the flue gas stream containing suspended

ash and vapors of volatile elements or compounds. It is important for the evaluation of environmental hazards from coal-fired power plant emissions, to estimate which fraction of trace metal is going into the solid wastes (both bottom and fly ashes) and which part enters the atmosphere with stack dust and vapours and then migrates through the environment.

As, Cd and Pb concentrations measured in the various fractions are given in table 1.

*Table 1: Concentrations of As, Cd and Pb in coal, bottom ash, fly ash and stack dust (µg/g).*

| Element | Coal | Bottom ash | Fly ash | Stack dust |
|---|---|---|---|---|
| As | 53.6 ±2.2 | 95.0 ±5.5 | 229.0 ±11.8 | 538.0 ±32.8 |
| Cd | 1.5 ±0.1 | 3.5 ±0.3 | 24.5 ± 2.4 | 156.2 ±10.5 |
| Pb | 14.8 ±1.2 | 24.8 ±1.6 | 62.5 ±3.7 | 370.0 ±22.8 |

It is evident from Table 1, that the concentrations of the measured metals increase as they become mobilized.

The mass balances for the metals were obtained from the flow rates of flue gas and ash streams, and from the concentration data. Table 2 shows the mass balances, including the emission rates of As, Cd and Pb from the stack.

*Table 2: Mass balances and emission rates of As, Cd and Pb at the 2000 MWe lignite fired power plant at Turów (kg/h).*

| Element | Coal | Bottom ash | Fly ash | Stack dust | Unaccounted |
|---|---|---|---|---|---|
| As | 177.0 | 25.9 | 140.1 | 3.2 | + 7.8 |
| Cd | 5.0 | 1.0 | 3.9 | 0.12 | 0 |
| Pb | 48.8 | 6.8 | 38.2 | 2.2 | + 1.6 |

The last column of Table 2 shows the differences between the concentrations of the individual metals in the burning coal and the

sum of their concentrations in the bottom ash, fly ash and stack dust samples. These data indicate, that the mass balances of As, Cd and Pb are estimated with an accuracy of 10%.

From the flow and concentration data obtained at all measuring points, the following expression is derived, which defines an enrichment ratio:

$$R_{ij} = \frac{(m_{ij}/A_j)}{(\sum_j m_{ij}/\sum_j A_j)} \qquad [5]$$

Here $R_{ij}$ is the enrichment ratio of each element i, in each outlet stream j; $A_j$ is the mass flow rate of aluminium in that stream. The value of the enrichment ratio indicates whether an element is enriched ($R_{ij} > 1$), not enriched ($R_{ij} = 1$), or depleted ($R_{ij} < 1$) in an outlet stream relative to aluminium. The calculated enrichment ratios are shown in Table 3.

*Table 3: Enrichment of As, Cd and Pb in bottom ash, fly ash and stack dust.*

| Element | $R_{\frac{\text{Bottom ash}}{\text{coal}}}$ | $R_{\frac{\text{fly ash}}{\text{coal}}}$ | $R_{\frac{\text{stack dust}}{\text{coal}}}$ |
|---|---|---|---|
| As | 0.50 | 1.00 | 2.22 |
| Cd | 0.69 | 1.03 | 3.10 |
| Pb | 0.52 | 1.12 | 6.28 |

As can be seen from Table 3, the volatile elements As, Cd and Pb are enriched relative to Al, which is in agreement with earlier findings (6).

## 6 AMBIENT CONCENTRATIONS OF ELEMENTS

The concentrations of As, Cd and Pb measured at the two sites Ryb and Opo (4) depend on dispersion and deposition. The concentrations of elements measured at the two sites were on the average almost the same, (within 10% for most of the compartments). A summary of average concentrations at the site of Ryb is presented in Table 4.

*Table 4: Average concentrations of toxic metals measured in different compartments at Ryb.*

| Compartment | Unit | Measuring site: Ryb | | |
|---|---|---|---|---|
| | | As | Cd | Pb |
| Atmosphere (aerosols) | $ng/m^3$ | 463±20 | 18±1 | 320±20 |
| Surface deposition | $kg/km^2 \cdot year$ | 112± 7 | 4.3±0.3 | 77± 6 |
| Soil concentrations | µg/g | 16.2±1.2 | 12.3±0.8 | 58.5± 5.3 |
| Grass/crop | µg/g of ash | 8.6 | 8.3 | 37.4 |

## 7 APPLICATION OF THE COMPARTMENT MODEL

### 7.1 Deposition, soil, plants

From the data on aerosols, deposition, soil and plant contamination it is possible to estimate the transfer factors for the pollutants, as they move from air through soil to plants. The migration model of the pollutants was derived from the following equation:

$$E_g(t) = f_1 D(t) + F_2 E_s(t) \qquad [6]$$

where:

$E_g(t)$ = exposure commitment of metals to grass via deposition and soil $(\frac{\mu g}{g})$ per year

$D(t)$ = deposition of metals, $(\frac{kg}{km^2})$ per year

$E_s(t)$ = exposure commitmentment of metals to soil, $(\frac{\mu g}{g})$ per year

$f_1$, $f_2$ = coefficients

The coefficients $f_1$ and $f_2$ are equal to the ratios of the annual integrated levels of pollutants in the receptor (grass in this case) and donor (deposition and soil) compartments. When several years of data are available the coefficients $f_1$ and $f_2$ can be estimated. Values of $f_1$ and $f_2$ from the Ryb area are listed in Table 5.

*Table 5: The coefficients $f_1$ and $f_2$ estimated from data at Ryb during 1976-1980.*

| Coefficient | Element | | |
|---|---|---|---|
| | As | Cd | Pb |
| $f_1$ | 0.075 | 0.480 | 0.030 |
| $f_2$ | 0.010 | 0.510 | 0.600 |

## 7.2 Deposition, soil, water

Next to be considered is the overall contamination of open waters due to:

(1) atmospheric deposition (dry and wet)
(2) contamination from the near-bank soil and bottom soil

Table 6 presents annual average concentrations of metals in the compartments mentioned above.

*Table 6: Annual deposition rates and concentrations of As, Cd and Pb in surface waters and bottom soil samples near Ryb.*

| Element | Annual deposition ($kg/km^2$) | Concentrations | |
|---|---|---|---|
| | | Surface waters $\mu g/dm^3$ | Bottom soil $\mu g/g$ |
| As | 215.5 | 20.0 | 12.0 |
| Cd | 8.6 | 8.2 | 11.0 |
| Pb | 148.2 | 30.0 | 175.0 |

A similar expression as given in equation [6] was analysed:

$$E_w(t) = f_3 \cdot D(t) + f_4 \cdot E_s^*(t)$$

where:

$E_w(t)$ = exposure commitments of metals to the open waters via deposition and soil $(\frac{\mu g}{dm^3})$ per year,

$E_s^*(t)$ = exposure commitment of metals to bottom soil and near-bank soil, $(\frac{\mu g}{g})$ per year,

$f_3$, $f_4$ = coefficients.

The coefficients $f_3$ and $f_4$ are equal to the ratios of the annual exposure commitments in receptor and donor compartments. Table 7 contains values of $f_3$ and $f_4$ calculated on the basis of 4-years of investigations near Ryb.

*Table 7: The coefficients $f_3$ and $f_4$ estimated from data measured near Ryb during 1976-1980.*

| Coefficient | Element | | |
|---|---|---|---|
| | As | Cd | Pb |
| $f_3$ | 0.086 | 0.200 | 0.190 |
| $f_4$ | 0.120 | 0.580 | 0.010 |

## 7.3 Contamination in diet

The main goal of this work was to calculate total intake of As, Cd and Pb from food on the basis of measured concentrations. Table 8 shows contamination of different food products reported in the study region influenced by the Turów power plant.

*Table 8: Contamination of As, Cd and Pb in diet in the area of Ryb.*

| Food category | Unit | As | Cd | Pb |
|---|---|---|---|---|
| Meat (including poultry excluding fish) | µg/kg | 10.0 | 21.0 | 26.5 |
| Vegetables (excluding potatoes) | µg/kg | 187.0 | 133.3 | 599.0 |
| Potatoes | µg/kg | 121.0 | 207.8 | 437.6 |
| Dairy (+ milk) | µg/kg | 10.0 | 21.0 | 14.0 |
| Grain products | µg/kg | 255.8 | 232.6 | 1081.4 |
| Fruit, sugar | - | not analysed | | |
| Fish | µg/kg | 11100.0 | 16.0 | 11.0 |
| Water (+ beverages) | µg/dm$^3$ | 20.0 | 8.1 | 30.0 |

## 7.4 Dietary intake of As, Cd and Pb

The data on food contamination and consumption makes it possible to calculate the dietary intakes of As, Cd and Pb from the food. The calculations were made for both children and adults. Estimated dietary intakes from terrestrial food are presented in Table 9 (adults) and Table 10 (children).

*Table 9: Dietary intake to adults from terrestrial food.*

| Food category | Consumption g/day | Intake As µg/day | Cd µg/day | Pb µg/day |
|---|---|---|---|---|
| Meat (including poultry, excluding fish) | 115 | 1.15 | 2.42 | 3.05 |
| Vegetables (excluding potatoes) | 224 | 41.98 | 29.93 | 134.48 |
| Potatoes | 212 | 25.65 | 44.05 | 92.77 |
| Dairy products and milk | 412 | 4.12 | 8.65 | 5.77 |
| Fruit, juices | 217 | | not analyzed | |
| Grain products | 146 | 37.47 | 34.08 | 158.43 |
| Water and beverages | 1270 | 25.40 | 10.29 | 38.10 |
| Total, daily | 2569 | 135.77 | 129.42 | 432.60 |

*Table 10: Dietary intake to children from terrestrial food.*

| Food category | Consumption g/day | As µg/day | Cd µg/day | Pb µg/day |
|---|---|---|---|---|
| Meat (including poultry, excluding fish) | 98.5 | 0.98 | 2.07 | 2.61 |
| Vegetables (excluding potatoes) | 198.5 | 37.12 | 26.46 | 118.90 |
| Potatoes | 178.0 | 21.54 | 36.99 | 77.89 |
| Dairy products and milk | 473.0 | 4.73 | 9.93 | 6.62 |
| Fruit, juices | 242.0 | | not analyzed | |
| Grain products | 121.3 | 31.03 | 28.21 | 131.17 |
| Water and beverages | 1270.0 | 25.40 | 10.29 | 38.10 |
| Total, daily | 2581.3 | 120.80 | 113.90 | 375.29 |

Values for the dietary intake from aquatic foods were also estimated. Table 11 presents these data for both adults and children.

*Table 11: Dietary intake from aquatic food.*

| | Consumption g/day | As µg/day | Cd µg/day | Pb µ/day |
|---|---|---|---|---|
| Adults | 11 | 112 | 0.2 | 0.12 |
| Children | 8 | 88.8 | 0.1 | 0.03 |

The total intake from food is given in Table 12.

*Table 12: Total intake from food.*

| Element | Daily, µg/day | | Yearly, mg/year | |
|---|---|---|---|---|
| | Adults | Children | Adults | Children |
| As | 257.9 | 209.6 | 94.1 | 76.5 |
| Cd | 129.6 | 114.0 | 47.3 | 41.6 |
| Pb | 432.7 | 375.4 | 157.9 | 137.0 |

Of the total dietary intake of As, about equal amounts come from terrestrial and aquatic foods. The dietary intake of Cd and Pb is mainly due to terrestrial foods alone. In Table 13 the total dietary intakes estimated from the measurements described above are compared with the WHO/FAO Permissible Values (2).

*Table 13: Comparison between total dietary intake and WHO/FAO Permissible Values (mg/month).*

| Element | Adults | Children | WHO/FAO limits |
|---|---|---|---|
| As | 7.84 | 6.38 | 10.0 |
| Cd | 3.94 | 3.47 | 1.6 - 2.0 |
| Pb | 13.16 | 11.42 | 12.0 |

As can be seen, the total dietary intake of Cd is twice the WHO/FAO limits. This indicates a serious potential hazard due to the Cd emission from the coal-fired power plants. The total intake of Pb is close to the WMO/FAO limits. It is, however, probable that traffic also is an important source of Pb in the area. The dietary intake of As is somewhat below the WHO/FAO limits.

## 7.5 Human exposure

Human exposure to As, Cd and Pb from both terrestrial and aquatic food ingestion was calculated, using data on dietary intakes. The following assumption were made:

- human body weight: 70 kg (7)
- blood volume: 5.2 l (1)
- total weight of kidneys: 300 g (5)
- 100 per cent of diet obtained locally
- effective mean residence time in the body for As: 8 days (from terrestrial ingestion) and 4 days (from aquatic ingestion); for Cd: 30 years, and for Pb: 23 days (1)
- absorption from diet to the gastro-intestinal tract: 100 per cent for all three metals (1)
- adsorption from gastro-intestinal tract to blood: 90 per cent for As, 5 per cent for Cd, and 10 per cent for Pb (1)
- adsorption of Cd from blood to kidneys: 33 per cent (1)

Table 14 summarizes data on human exposure to As, Cd and Pb from ingestion. The As exposure is related to 1 kg of human body, Cd to 1 g of kidneys, and Pb to 1 dl of blood.

*Table 14: Annual human exposure of As, Cd and Pb through ingestion, in the area of the Turów power plant.*

| Element | Unit | Estimated exposure | | Literature values (1) | Effects level (1) |
|---|---|---|---|---|---|
| | | Adults | children | | |
| As | $\frac{\mu g}{kg}$ of body | 14.0 | 11.4 | ~ 10.0 | 15 - 340 |
| Cd | $\frac{\mu g}{g}$ of kidneys | 60.0 | 52.8 | 14.0-16.0 | ~ 200 |
| Pb | $\frac{\mu g}{dl}$ of blood | 16.7 | 14.5 | 10.0-13.0 | 10.0-60.0 |

As seen from Table 14, the level of human exposure to Cd through dietary intake is more than three times the values cited in the literature. The data presented in the last two columns of Table 14 also include pollutants entering the human body through inhalation. Inhalation contributes to the human body about 23 per cent of Pb, 11 per cent of Cd, and 2 per cent of As (8).

## 8 COMPARISON OF TRANSFER FACTORS FROM FIELD STUDIES AND MODELLING

The total exposures of an urban population can be determined by use of models or from field studies. Field studies presented in this work were conducted on a very limited local scale. Large-scale field studies on population exposures are costly and only in the initial stages of planning at the present time. Modelling methods are less expensive for estimating the total population exposure to air pollution. In regard to further studies at NILU (9), the present report is devoted to testing Bennett's method of exposure commitment assessments of environmental pollutants (1). Two transfer factors relating exposure commitment to intake commitment are calculated:

$$F_1 = \frac{\text{Intake commitment of pollutants to soil}}{\text{Exposure commitment to air}}$$

$$F_2 = \frac{\text{Intake commitment of pollutants to diet}}{\text{Exposure commitment to soil}}$$

A comparison of the factors $F_1$ and $F_2$ on the basis of our field data are compared to the factors estimated by Bennett, in Table 15.

*Table 15: Comparison of factors $F_1$ and $F_2$.*

| Element | This study | | From Bennett (1) | |
|---|---|---|---|---|
| | $F_1$ $(\frac{\mu g \cdot m^{-2}}{\mu g \cdot y \cdot m^{-3}})$ | $F_2$ $(\frac{\mu g}{\mu g \cdot y \cdot g^{-1}})$ | $F_1$ $(\frac{\mu g \cdot m^{-2}}{\mu g \cdot y \cdot m^{-3}})$ | $F_2$ $(\frac{\mu g}{\mu g \cdot y \cdot g^{-1}})$ |
| As | $5 \times 10^3$ | $3.0 \times 10^3$ | $1.6 \times 10^5$ | $2.1 \times 10^3$ |
| Cd | $6.1 \times 10^5$ | $3.8 \times 10^3$ | $1.6 \times 10^5$ | $2.7 \times 10^4$ |
| Pb | $0.9 \times 10^5$ | $2.7 \times 10^3$ | $1.6 \times 10^5$ | $0.8 \times 10^3$ |

As can be seen from Table 15, differences between $F_1$ and $F_2$ from this study and from Bennett, varies for the different components. The best results were obtained for Pb, but the factors indicate that the exposure commitment to soil of lead is lower in this study than expected from Bennett's data. For Cd the exposure commitment to soil seems to be higher using our data from Poland.

## 9 CONCLUDING REMARKS

From these results the following comments can be made:

1. The total dietary intakes of Cd and Pb, observed in the surroundings of a coal-fired power plant in Poland are higher than the WHO/FAO limits.

2. The usefulness of establishing transfer factors between different compartments for future exposure commitment estimates has been demonstrated.

## 10. REFERENCES


(1) Bennett, B.G. — Exposure commitment assessments of environmental pollutants, Volume 1, Number 1. London, Monitoring and Assessment Research Centre, Chelsea College, University of London, 1981. (MARC Report No. 23.

(2) — Joint FAO/WHO Expert Committee on Food Additives. Genf 1967. (WHO Fechn. Rept., Series No. 373.)

(3) World Health Organization — Lead. Geneve 1977. (Environmental Health Criteria 3.)

(4) Pacyna, J.M. — Coal-fired power plants as a source of environmental contamination by trace metals and radionuclides, Habilitation thesis. Wroctaw 1980. (Techn. University of Wroctaw, No. 47.)

(5) Rupp, E.M. Parayck, D.C. Walsh, P.J. Booth, R.S. Raridon, R.J. Whitfield, B.L. — Composite hazard index for assessing limiting exposures to environmental pollutants: Application through a case study, *Environ. Sci. Technol.*, 12, 802-807 (1978).

(6) Pacyna, J.M. — Trace metal behaviour during fuel combustion in coal-fired power plants. Lillestrøm 1981. (NILU F 12/81.)

(7) National Research Council — Drinking water and health. Washington, D.C., National Academy of Sciences, 1977. 498 pp.

(8) Sivertsen, B. — Estimation of population exposure to some toxic metal air pollutants with a compartment model on micro-environments, Lillestrøm, November 1981. (Technical Note, EO-25280.)

(9) Sivertsen, B. — MIL 4. Relative bidrag av forurensninger til menneske og miljø fra forskjellige kilder (fase 1). Lillestrøm 1980. (NILU OR 50/81.)

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REFERAT (maks. 300 anslag, 5-10 linjer)

Det totale inntaket via matvarer av Cd, Pb og As er beregnet, basert på data fra et område i nærheten av et kullfyrt varmekraftverk i Polen. Bruken av compartment-modeller for beregning av total eksponering er demonstrert og sammenliknet med data fra litteraturen.

TITLE

ABSTRACT (max. 300 characters, 5-10 lines)

The dietary intake and human exposure of Cd, Pb and As were estimated based upon data taken near a coal-fired power plant in Poland. The use of compartment models for estimating total human exposure has been demonstrated, and values of transfer factors were compared with data from the literature.

**Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C