

Accidental Environmental Pollution of a Residential Quarter of Kortrijk by a Chromic Trioxide Aerosol

H. Beernaert, F. Vanderმიქსbrugge, and M. Martens

Institute of Hygiene and Epidemiology, Juliette Wytsmanstraat,
14 1050 Brussels, Belgium

Kortrijk is a town situated in the south of the Province of West-Flanders. During the week-end of 18th and 19th june 1983, the environment was polluted by a chrome plating plant. The origin of this airborne pollution was a leak in the rinsing bath. Rinsing is the final phase of the chrome plating procedure. The bath consisted of an aqueous solution containing chromic trioxide in concentrations up to 75 g/l at pH = 4. Due to a technical fault the rinsing solution entered the ventilation system of the installation. As a consequence small liquid particles were blown into the atmosphere and chemically attacked the roofs, the doors and the windows of the plant and neighbouring houses. The vegetation in the surrounding gardens were turned brown in color.

The first complaint was announced at the official services of the town on Monday the 20th of june at 9.00 hours. The police made a first inquiry and decided to stop the activities of the plant at 9.30 hours.

From a public health point of view, the most important damage appeared to be contamination of the vegetation and the soil with chromium (VI).

On the 23th of june, an inspection of the polluted zone was carried out by the services of the Department of Public Health. Since chromium (VI) was considered a toxic agent, the inspector made the decision to sample plants and soil in the gardens adjacent to the plant. The samples were sent to the Institute of Hygiene and Epidemiology and analyzed in the Food Division by direct coupled plasma emission spectral analysis (DCP).

MATERIALS AND METHODS

Direct coupled plasma emission spectrometer, model spectraspan III B, manufactured by spectrametrics, Inc. equipped with a multichannel unit, a dynamic background compensator DBC-33, a printer and a data station. Beakers of 100 ml, volumetric flasks of 100 ml, pipettes of 10 ml and 20 ml. Mettler balance of 120 g with an accuracy of 0.1 mg.

In order to detect the amount of chromium with the DCP emission spectrometer the instrument was calibrated by analyzing two standard solutions (a high and a low standard) containing known concentrations of chromium. From these data the system developed a straight line calibration curve for chromium. The curve was used to convert subsequent signal measurements into concentration values. The standard and the samples were measured in the integration mode for 10 sec. and repeated three times.

Samples were first placed in an oven at 80°C for 24 hours. After drying, the percent of dry material was calculated. The dried samples were ground into powder. Depending on the chromium content of the sample, 1 to 5 g of the homogeneized and dried product was weighed into 100 ml beakers, 40 ml 6N HCl was added and the solution was boiled for 5 minutes. After cooling the volume was adjusted to 50 ml with distilled water. The solution was centrifuged or filtered through cotton-wool. The concentration of chromium was determined using the calibration curve. To avoid chemical interferences 1000 ppm lanthanum was added to standards and samples. Chromium was detected by using the multicassette at a wavelength of 425,4 nm. At this wavelength the detection limit for chromium was 20 ppb.

RESULTS AND DISCUSSION

According to the map (Fig. 1) the polluted zone was situated on the south-west side of the chrome plating plant. The inspection service used the colour of the vegetation to locate the zone. The geographical position of this zone may be explained by the fact that during the time of the accident the direction of the wind was north-east.

In order to determine the hazard to public health, samples of plants, vegetables and soil were taken in the areas 2, 3, 4, 5 and 6 as indicated on the map (Fig. 1).

Besides samples in the grey area on the map, three samples at point 2 and a reference sample of grass material at point 7 were taken by the official inspector.

The results of the analyses are shown in Table I. The data show that the sample of grass, numbered as 7M (Table I), contains no chromium. On the basis of an instrumental detection limit for chromium of 20 ppb, we concluded that the grass sample of point 7 could be used as a reference standard.

In the polluted zone the samples contained between 263 and 931 mg Cr per kg of fresh product. This variation was attributed to the matrix effect of the materials analyzed. In fact, the influence of the material on the analysis was proved by the results obtained with samples 6J, 6K and 6L. These three samples consisting of different materials produced data with a high degree of variation (52,6 to 365,5 mg Cr per kg of fresh product). On the other side,

the three soil samples, numbered as 1B, 5H, and 6J, produced data within the same order of magnitude ($43,6 \text{ mg Cr/kg} < x < 59 \text{ mg Cr/kg}$).

From the results obtained for samples 2C and 6K, we may conclude that there was a clear reduction in pollution just beside the grey zone (Fig. 1). The low degree of pollution outside the indicated zone is illustrated by the data given for samples 2C and 2D. The result obtained for potatoes (2E) shows us that there is no contamination with chromium under the ground. The most remarkable observation was the low value of chromium in the stems of rhubarb (3F). This phenomenon may be explained by the fact that the aerosol of chromic trioxide was almost completely absorbed by the leaves of the plant.

The health hazard to be expected in this case of airborne pollution may be eye irritation, respiratory tract irritation at the moment of the emission and skin irritation caused by touching contaminated objects. Skin ulcers may develop if chromium compounds come into contact with an abrasion, a scratch, a puncture or a laceration of the skin. Solutions containing more than 5 % CrO_3 are believed to be corrosive to the skin while solutions with concentrations ranging from 0.5 % to 5 % are irritant (Directive of the Commission of the EEC, 1981). Repeated contact with materials contaminated with CrO_3 may also result in allergic contact dermatitis.

Besides the local effects of the acid CrO_3 -solution aerosol, the consumption of contaminated vegetables may pose health problems. An acceptable daily dose (ADI) may be calculated using the chromic toxicity study of MacKenzie et al. (1958). In this study no adverse effects were noted in rats treated with 25 ppm of Cr (VI) in drinking water for one year. This concentration corresponds to a daily dose of 2.5 mg/kg. Considering an uncertainty factor of 1000 and a mean human weight of 70 kg an ADI of 0.175 mg Cr (VI) per day was obtained. This corresponds roughly with the daily intake of chromium via food (American diet). To be safe the vegetables grown and eaten by people (200 g per day) within the contaminated zone should not exceed 0.9 ppm. Since the vegetables sampled in the contaminated zone (Table I) showed chromium concentrations above 0.9 ppm, it was decided that overground vegetables grown in the contaminated area should not be used for human consumption.

However it is important to emphasize that most of the Cr (VI), once in contact with the plant material, is reduced to the much less toxic Cr (III). The ADI calculated on the basis of Cr (VI) toxicity can thus be regarded as an extra safe limit. The possibility of lung cancer may be excluded in this case because airborne pollution occurred over a short period of time. Indeed, lung cancer as a consequence of chromium exposure has only been observed in humans after a long period of time (more than 6 years) and at relatively high concentrations (more than $200 \mu\text{g Cr/m}^3$). These concentrations are only encountered in the occupational environment. (Langard & Norseth, 1975; Mancuso & Hueper, 1951).

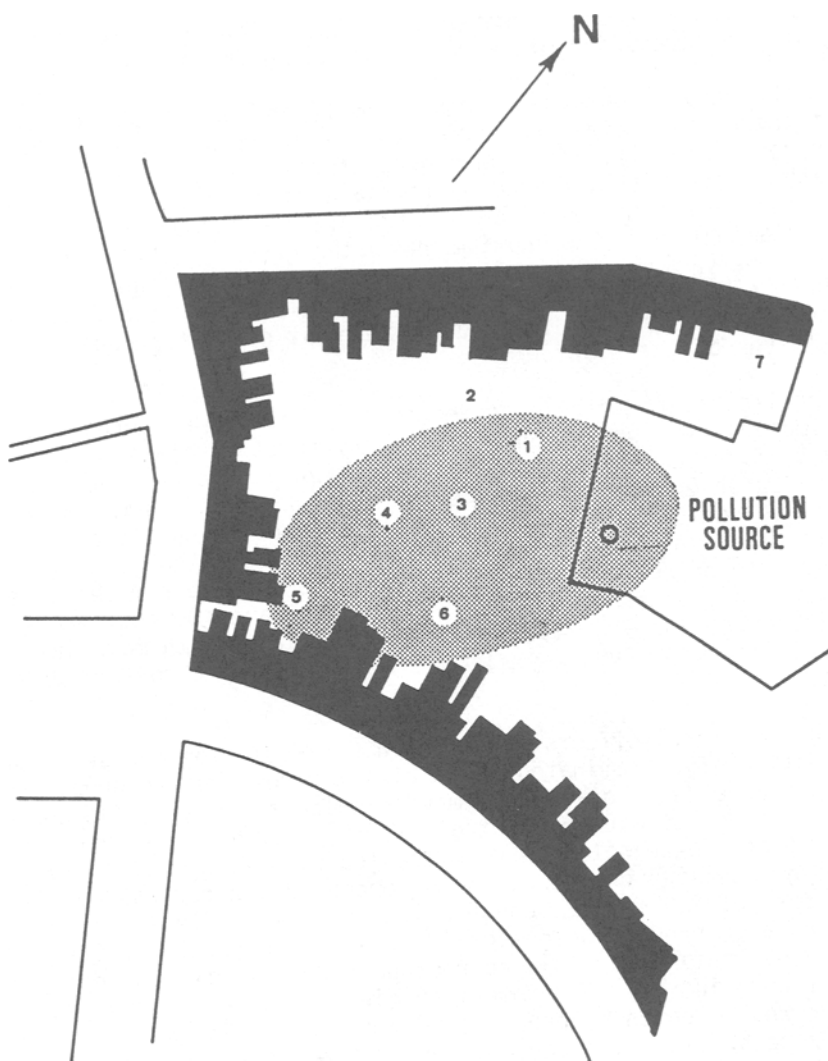


Fig. 1 : Map of the polluted zone in a residential quarter of Kortrijk

Table I. : Analysis of materials taken in the environment of a chrome plating plant for chromium.

Description of sample	Dry product	mg Cr/kg dry prod.	mg Cr/kg fresh prod.
1. STYNS, Watermolenstr. 22			
A. Leaf of onion	10.57 %	7203	761
B. Soil	88.82 %	66	59
2. BENOOT, Watermolenstr. 16			
C. Unwashed salad	5.66 %	141	7.98
D. Washed salad	4.22 %	132	5.57
E. Potatoes	22.28 %	negative	negative
3. Watermolenstr. 14, 16, 18			
F. Stems of rhubarb	4.49 %	58.6	2.63
4. KERKHOF, Izegemstr. 54			
G. Grass	23.54 %	3957	931
5. DE CRAEMER, Izegemstr. 42			
H. Soil	86.08 %	50.6	43.6
I. Piping-look	12.17 %	1444	175.7
6. DE CLERCK K. Elizabeth avenue 54			
J. Soil	87.22 %	60.3	52.6
K. Salad	6.47 %	1871	121
L. Parsley	24.29 %	1505	365.5
7. Watermolenstreet 44			
M. Grass - reference	32.2 %	negative	negative

REFERENCES

- Commission Directive of the 5th october 1981 concerning the adoption to the technical progress of Directive 77/728/EEC of the Council on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of paints, varnishes, inks, glues and related products. Official Journal of the EEC nr L 342, 28th november 1981, p 7.
- Langard, S. and Norseth, T. (1975) A short study of bronchial carcinomas in workers producing chromate pigments. Br. J. Ind. Med., 32, 62-65.
- MacKenzie, R.D., Byerrum, R.U., Decker, C.F., Hoppert, C.A. and Langham, R.F. (1958) Chronic toxicity studies II. Hexavalent and trivalent chromium administered in drinking water to rats. A.M.A. Arch. Ind. Health, 18, 232-234.
- Mancuso, T.F. and Hueper, W.C. (1951) Occupational cancer and other health hazards in a chromate plant : A medical appraisal I. Lung cancer in chromate workers. Ind. Med. Surg., 20, 358-363;

Received December 14, 1983; accepted December 28, 1983.