

# OCCURRENCE OF TETRACHLOROETHYLENE IN THE FRG

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**Abstract:** Tetrachloroethylene (PER) is detected in water, air, soil, food and human tissues in the FRG. Concentrations up to 10 µg/kg could be considered as unavoidable anthropogenic background. Drinking water is a negligible source whereas food rich in fat and indoor air play an important role. The impact of indoor air must be reconsidered.

## 1. Introduction

Tetrachloroethylene (perchloroethylene, PER,  $C_2Cl_4$ ), CAS-No. 127-18-4, is chosen as a key compound of the volatile chlorinated hydrocarbons (bp.  $<150^\circ C$ ). Source, occurrence and environmental fate of PER studied in detail will provide more understanding of this group of environmental chemicals than a shallow review of 6 or more chlorinated solvents. PER is documented well: in general (1 - 3) and in special aspects of environmental distribution (4 - 6), of occurrence in water (7, 8, 14, 23), air (12, 17, 25) and food (9, 10, 13).

PER is known since 1821 (3). The German industrial production started in 1914. Since 1945 it is used as a solvent and cleaning agent on a large scale. Production in the FRG is 157 000 tons per year with a real consumption of about 50 000 t/a (3). This amount is almost equal to the release into the environment. PER is used mainly for cleaning purposes in the metal industry, in textile industry and dry cleaning. The use in households causes relatively high concentrations in indoor air compared with ambient air (16, 17). Due to its vapour pressure, boiling point ( $121^\circ C$ ) and lipophilic character PER is an ubiquitous compound in all environmental matrices including human tissues. Air seems to be the most preferred pathway of the distribution.

## 2. Analytical techniques

Methods of analytical procedures are given in detail or summarized in the literature cited (1 - 4, 7, 9 - 11, 13, 14, 21, 23, 25). PER is detected by ECD and concentrated from liquid or solid samples (water, food, tissues, soil) by stripping, head space or solvent extraction. From air samples or stripping gases PER is concentrated on solid sorbents like active carbon, tenax or XAD by adsorption followed by thermal desorption or solvent extraction. Because of its volatility and chemical inertia PER can be chromatographed by GLC without any problems. Identity in samples of unknown origin must be assured by a second capillary column of diverse polarity or by GC-MS. Standardized procedures are available re-

fering to water (18) and edible oils (19). Determination in indoor air is in preparation (20). Principles and details of air sampling and measurement methods are well known and described (1, 4, 21). The edible-oil-method (19) had been used in various investigations of food samples 1987/88 from locations close to dry cleaning units (10).

PER is part of AOX, EOX and POX in water samples which means: adsorbed by active carbon (AOX), extracted by pentane (EOX) and purgable by air (POX). PER analyses by GLC-ECD require clean labs and permanent self-control because of its ubiquitous occurrence - even in human expired air, dry cleaned clothes or printed materials.

### 3. Occurrence

Water: PER is detected in all types of water in concentrations below 1 µg/l (1, 4 - 8, 10). Concentrations higher than 1 µg/l point at human influence of the water body i.e. to ground or drinking water. The limit is 25 µg/l in both waters set up by federal law or recommendation. In 3003 groundwater samples from North Rhine Westfalia (1983/86) 96% did not reach this limit (8). This corresponds quite well with an inquiry to water works in 1985/86 including 79% of the total groundwater in the FRG. The answers showed that 10% of the groundwater contains more than 1 µg/l and 4% more than 10 µg/l (7). In drinking water of 110 (1980) and 120 cities (1982) PER is the most abundant chlorinated solvent with mean values of 0,2 resp. 0,1 µg/l and no maximum value higher than 10 µg/l (4). The above cited inquiry of water works revealed that PER is found in 51% of German drinking waters below 0,001 µg/l, in 40% between 0,001 and 0,5 µg/l and in 9% above 5 µg/l (7).

The efficiency of water treatment processes esp. active carbon filtration to eliminate PER is very sufficient (7, 22) due to size and lipophilic capacity of the molecule. River bank filtration or slow sand filtration do not eliminate PER significantly (1, 22). Aeration techniques cause loss of PER from water bodies followed by entry into air. On the other hand washing out effects from the atmosphere are known (1, 4).

Occurrence and fate of PER in surface waters of the FRG are investigated most profoundly in the River Rhine (1, 3, 6, 7, 22 - 24). Framing a 10 years period from 1976 to 1986 it could be summarized that the mean value of PER decreased from 0,5 - 1 to 0,1 - 0,2 µg/l. This 80% reduction is caused by effective activities in producers' and users' effluents (7). Human exposure to PER via drinking water derived from surface water is therefore negligible.

Air: There is no place between the Alps and the sea without PER in the air. The mean value of 92 locations, mostly urban, in 1980 was 6,6 µg/m<sup>3</sup> (4). Daily measurements in one place result in lower average values per year: Bochum in 1981 = 2,4 (4), Hamburg in 1986/87 = 3,5 (25) and Essen in 1986/87 = 3,1 µg/m<sup>3</sup> (21). It is concluded that the distribution of PER in air refers to local and regional emissions because of its short life time in the troposphere (21). Ambient air in cities of the FRG averagely has PER concentrations between 1 and 5 µg/m<sup>3</sup> while lower amounts occur in rural areas (3, 26). In contrary to these figures indoor air is contaminated by PER up to 14 (17) or even 90 µg/m<sup>3</sup> (3) i.e. 10 times higher compared to ambient air. Special interest should be given to chloroacetic acids as degradation products of PER and the involvement of these acids and PER in the initiation of forest decline ("Waldsterben") via phytotoxic effects (26).

Soil: In soils PER is present as follows:

- unspoiled < 0,5 - 10 µg/kg
- near producers 10 - 100 µg/kg
- contaminated areas > 1000 µg/kg (3).

Food: Special concern must be given to PER in food. The overall background level caused by anthropogenic activities is thought to be below 10 µg/kg. Higher concentrations have been reported (1 - 5, 10, 13) exceeding 1 mg/kg in eggs and meat (from animals fed by PER-contaminated forage), olive oil and food rich in fat from locations close to dry cleaning units using PER (1 - 3, 10, 13). Since 1990 PER in food is limited in the FRG to 100 µg/kg by federal law.

Men: In mothers milk concentrations of PER vary between 0,1 and 4,3 µg/l (3) whereas human tissues post mortem reach 10 (muscle and lung tissues) or 20 µg/kg (liver, perinephric fat, subcutaneous adipose tissue) (11). Investigations on PER in air and blood of persons being in contact with PER at their working places are so numerous that they will not be referred in this short summary. From all data one could conclude that PER is present in humans but accumulation is not comparable to chemicals like DDT oder PCB.

#### 4. Discussion

In spite of comprehensive work done there still remain some unsolved problems of general ecological or special human aspects:

- role of PER in forest decline
- substitution of PER as an industrial solvent as well as reducing the chlorine chemistry in general to zero
- reduction of PER in indoor air and food rich in fat (neighborhood to dry cleaning units)

Little is known about human absorption rates of PER via water, air or food. Thus there is no possibility to define the real input via these matrices. Since adults' stay is preferably indoors and not in ambient air and because of an inspire of 15 - 20 m<sup>3</sup> of air per day, indoor air pollution is more important than contamination of ambient air. Therefore the role of PER from indoor air and its impact on men must be reconsidered.

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