Bull. Environ. Contam. Toxicol. (1988) 40:54–59

Bulletin of Environmental Contamination and Toxicology

Elimination of Volatile Pollutants from Water

Rolf Kroneld and Markku Reunanen

Department of Public Health, Lemminkäisenkatu 2, University of Turku, 20520 Turku 52, Finland and Laboratory of Forest Products Chemistry, University of Åbo Academy, Porthansgatan 3, 20500 Åbo 50, Finland

Several papers have dealth with the occurrence of volatile pollutants in water, air, food, blood and urine (Dowty et al. 1975, Carbon et al. 1980, Pfaffenberger et al. 1980, Bauer 1981, Reunanen & Kroneld 1982, Johnson et al. 1982, Kroneld & Reunanen 1986). Knowledge of the toxicity of, and long-term exposure of humans to volatile pollutants found in drinking water, food and body fluids is still limited (Davidsson et al. 1982). Toxicity in mice and rats has been investigated in several studies (Bowman et al 1978, Chu et al. 1982, Pyykkö 1984).

Several papers indicate the carcinogenic activity of these substances (Tardiff et al. 1978, Davidsson et al. 1982). This has led both the World Health Organization and many countries to suggest maximum limits for these substances. In its guidelines for water quality, WHO has therefore recommended maximum limit concentrations for benzene, chlorinated alkanes and alkenes, chlorophenols, polynuclear aromatic hydrocarbons, trihalomethanes and pesticides.

This paper is concerned with the possibility and methods of eliminating volatile organic pollutants of health significance.

MATERIALS AND METHODS

Distillation was found not to be efficient in eliminating volatile pollutants from water (Kroneld & Reunanen 1982). An apparatus to eliminate volatile pollutants, EVP, was developed for use during distillation (Figure 1). Gas dispersion is used as a method of increasing evaporation of fugacious organic material. A stream of gas directed against the feed-water during distillation gives more efficient elimination of volatile pollutants.

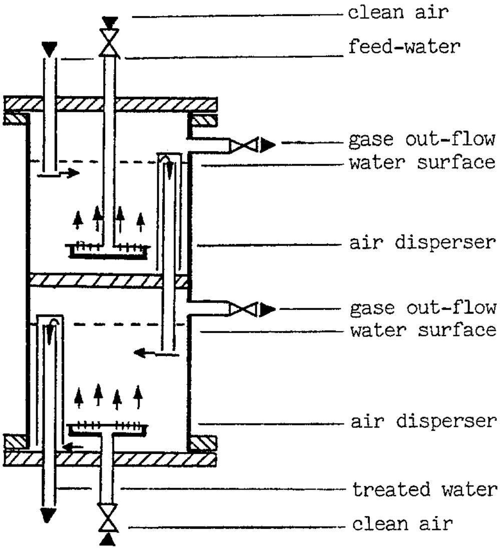


Figure 1. The two EVP apparatuses system used in the experiments of eliminating volatile pollutants from water.

The EVP apparatus was connected to the feed-water of a six-column still (Finn-Aqua, model 500-H-6, at 130 °C water temperature, 5 bar pressure and a water-to-gas ratio of 1:5. The efficiency of cooling the distillate as well as the efficiency of one and two EVP apparatuses connected to the still were tested. Test water, containing known concentrations of volatile pollutants, was used as feed-water during the tests.

Samples were collected from feed-water, from the condenser of the still, either alone or in connection with the EVP apparatus.

The analyses were performed by extraction of 300 ml of water with 2 ml carbon disulphide (CS_2), containing a known amount of 1-chlorohexane as an internal standard. The CS_2-extract was then analysed with by gas chromatograph-mass spectrometer (GC-MS), equipped with a SE-30 fused silica capillary column. The mass spectrometer operated in a selective ion monitoring mode (SIM) for quantification. Spiked water samples were used to calibrate the GC-MS system.

The Student's t-test was used to analyse the significance of the differences between feed-water, non-treated distillate and EVP-treated distillate. A probability level of $p < 0.05$ (= *) was considered as statistically almost significant, $p < 0.01$ (= **) as significant and $p < 0.001$ (= ***) as highly significant.

RESULTS AND DISCUSSION

The results of efficiency of one EVP apparatus connected to the still is described in Figure 2. The reduction for the total concentration of substances of one apparatus was 75 per cent. For two apparatuses the reduction for total concentration was 90 per cent. The reduction of non-treated distillate was only 35 per cent.

The results of the efficiency of two EVP apparatuses in elimination of different volatile pollutants are described in Figure 3.

The elimination of trichloromethane/dibromochloromethane and dichlorobromomethane was not significant, while it was highly significant compared to the feed-water after EVP treatment. Elimination of tetrachloroethene, xylene and toluene from the non-treated distillate was significant and highly significant for 1,1,1-trichloroethane and, after EVP treatment, highly significant for all four substances. EVP treatment was then highly significant in eliminating the tested volatile pollutants from the feed-water.

The toxicity, carcinogenicity and mutagenic and teratogenic activities of many volatile pollutants makes it reasonable to develop methods by which these substances can be eliminated. The myelotoxic and leucogenic effects of benzene have led to their replacement in many countries by other organic solvents such as toluene and xylene (Pyykkö 1984). Toluene, o-, m- and p-xylene were found by Ames testing to be non-mutagenic. These substances are, however, all embryotoxic with teratogenic potentials at high levels.

There are good reasons to develop guidelines for water quality and methods to improve water quality. The results of our study indicate one method of eliminating volatile pollutants from water and show that two connected EVP apparatuses give a reasonable elimination level for the tested substances.

Acknowledgments. Esko Santasalo is thanked for practical work during the tests. The English text was checked by Christopher Grapes.

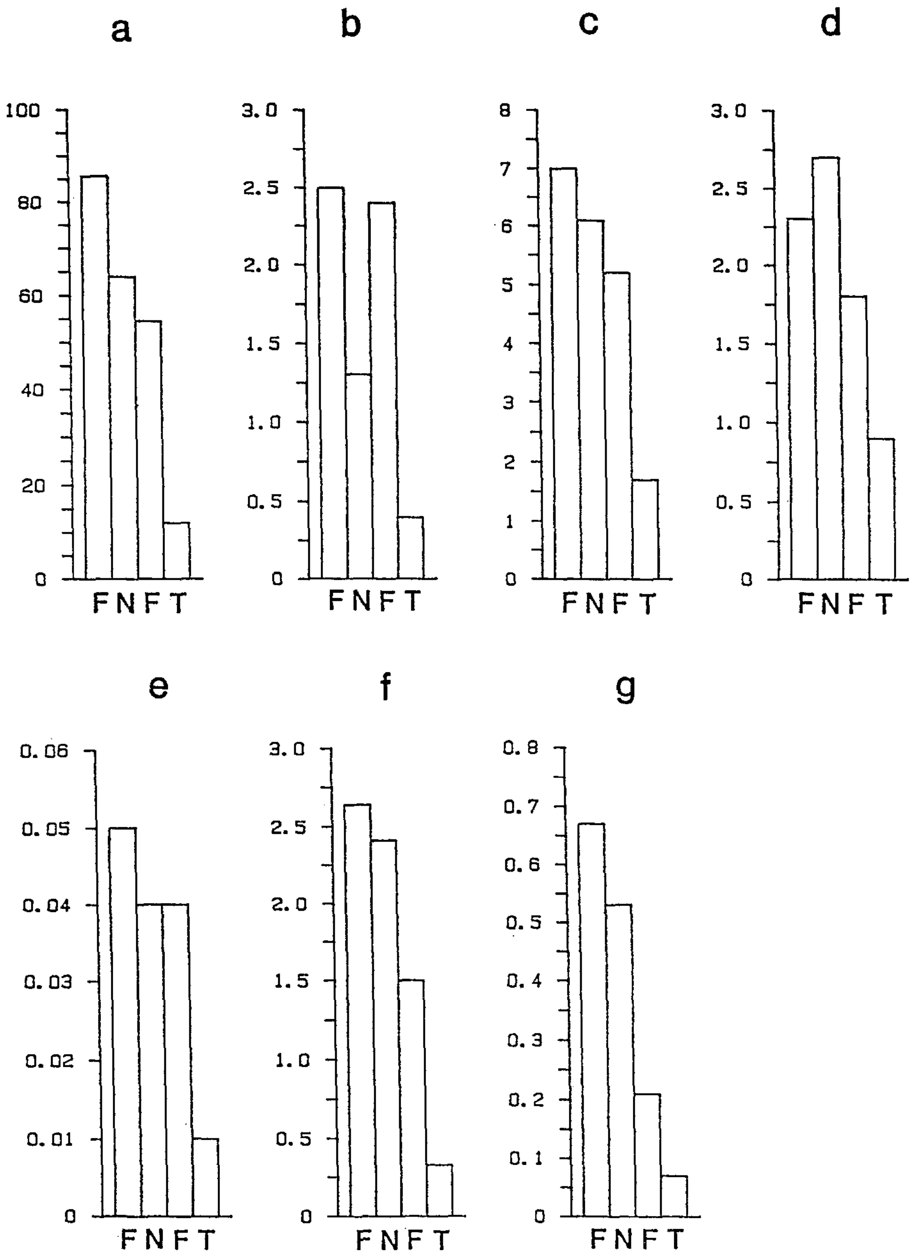
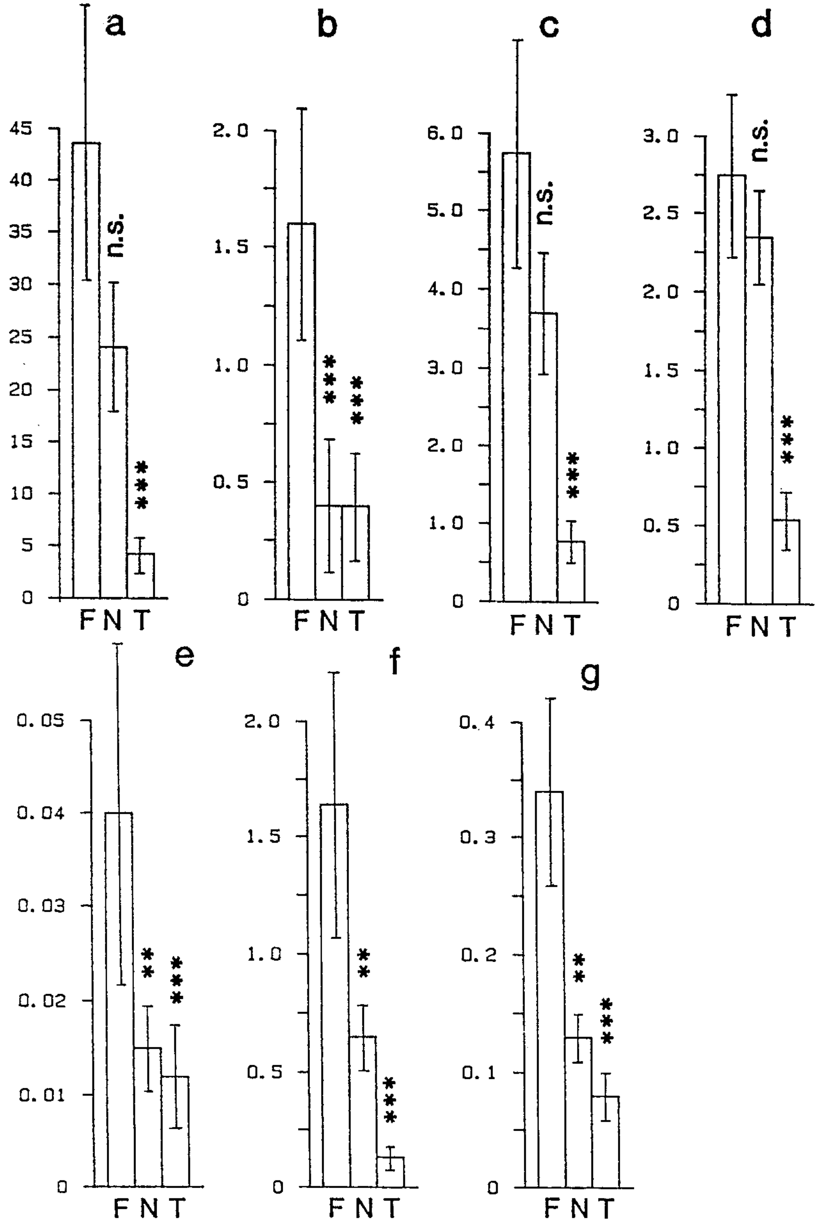


Figure 2. Diagrams showing means of EVP-treated = T (one apparatus) and non-treated distillate = N used in order to calculate the percentual reduction. Feed-water = F. a = trichloromethane, b = 1,1,1-trichloroethane, c = dichlorobromomethane, d = dibromochloromethane, e = tetrachloroethene, f = toluene and g = xylene.



P values by comparing to the initial values
n.s. = not significant

Figure 3. Diagrams showing means and standard deviations (n = 18) of EVP-treated = T (two connected apparatuses) and non-treated distillate = N and feed water = F (n = 6).
a = trichloromethane, b = 1,1,1-trichloroethane, c = dichlorobromomethane, d = dibromochloromethane, e = tetrachloroethene, f = toluene and g = xylene.

REFERENCES

Bauer U. 1981. Human exposure to environmental chemicals - investigations on volatile organic halogenated compounds in water, air, food and human tissues. III. Zol. Bakt. Hyg. (B)174, 200-237.

Bowman FJ, Borzelleca JF and Munson AE. 1978. The toxicity of some halomethanes in mice. Toxicol. Appl. Pharmacol. 44:213-15.

Carbon RM, Caple R, Oyler AR, Welch KJ, Bodenner DL and Liukkonen R. Aqueos chlorination products of polynuclear aromatic hydrocarbons. 1980. Pp. 59-76 in RG Jolley, H Gorchev and UH Hamilton, Ir. eds. Water chlorination: Environmental Impact and Health Effects, vol. 2 Ann Arbor Sci Publ. Inc., Ann Arbor, Michigan.

Chu I, Villeneuve DC, Secours VE and Becking GC. 1982. Trihalomethanes. II Reversibility of toxicological changes produced by chloroform, bromodichloromethane and chlorodibromomethane and bromoform in rats. I. Environ. Sci. Health, 3:225-240.

Davidsson IW, Sumner DD and Parker JC. 1982. Chloroform: a review of its metabolism, teratogenic, mutagenic and carcinogenic potential. Drug Chem Toxicol 5:1-87.

Dowty B, Carlisle D and Laseter JL. 1975. Halogenated hydrocarbons in New Orleans drinking water and blood plasma. Science 187:75-77.

Johnson JD, Christman RF, Norwood DC and Millington DS. 1982. Reaction products of aquatic humic substances with chlorine. Environ Health Perspect 46:63-71.

Kroneld R and Reunanen M. 1982. Volatile halocarbons in hospital and laboratory solutions. Environm and Hlth 8:598-601.

Kroneld R and Reunanen M. 1986. Volatile halocarbons in haemodialysis therapy. Bull Environ Contam Toxicol; 35: 583-592.

Pfaffenberger CD, Peoples AJ and Enos FH. 1980. Distribution of volatile halogenated organic compounds between rat blood serum and adipose tissue. Intern. J. Environ. Anal. Chem. vol. 8 pp. 55-65.

Pyykkö K. 1984. Tolune and regulation of cytochrome P-450 in the rat. Acta Universitatis Tamperensis ser. A 169:1-108.

Reunanen M and Kroneld R. 1982. Determination of volatile halocarbons in raw- and drinking water, human serum and urine by GC-ECD. J. Chromatograph. Sci. Vol. 20:449-455.

Tardiff RG, Carlson GP and Simmon V. 1978. Halogenated organics in tap water. A toxicological evaluation in: The environmental impact of water chlorination. Conf. Oak Ridge ed. Jolley R. pp. 195-210.

Received April 20, 1987; accepted June 26, 1987