Flux Model on PAHs, PCDD/Fs and PCBs in Urban Wastewater Systems of Stockholm

-Transport from the Urban Areas to the Receiving Waters, Lake Mälaren and the Baltic.

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Introduction

There is a limited knowledge about PAH, PCB and PCDD/F fluxes from urban areas. The sink of these compounds is in many cases the receiving waters, the recipients. The Stockholm Water Company, Department of Zoology/Applied Environmental Research at Stockholm University, cooperate in a study with purpose to investigate the fluxes of PAH, PCB and PCDD/F from the urban areas of Stockholm, Sweden, to the water recipients. Dominating transport paths to the water recipients are input from the duplicate and the combined wastewater systems as well as dry and wet deposition and gas exchange over the recipient surface. In the combined system wastewater and urban stormwater runoff are transported in the same sewer to the wastewater treatment plants. In the duplicate system there is separate sewers for urban stormwater runoff and wastewater. The urban stormwater runoff in the duplicate system is transported directly to the receiving waters and sedimentation magazines are the main water treatment facilities for the stormwater. Approximately 50 % of the stormwater runoff is transported in each system. About 1,5 million people live in the studied area and the main water recipients of these fluxes are Lake Mälaren and the archipelago of Stockholm in the Baltic. The study also includes an investigation of the sources of these organic pollutants. Traffic and other types of combustion are believed to be the largest sources of PAH and PCDD/F in urban areas (1). Less is known about the sources of PCB even though various products including building material are probably sources of great importance.

Material and Methods

Samples of stormwater runoff have been analysed through 1992-1996. The samples are from urban areas in the city of Stockholm and from high trafficked roads. All samples were taken during rainfall proportional to the flow in (2). Samples of incoming and outgoing water were taken at the waste water plants Bromma, Loudden and Henriksdal during 24 hour periods in 1992-1993 and in 1996. A monthly average sample of digested sludge was taken during the same periods. The sampling techniques are described in (2). Settling particulate matter (SPM) from sediment traps has been analysed from 16 different stations along the water flow transect from the city of Stockholm to the Baltic Sea. The sampling technique is described in (3). During 1991 and 1992 air samples were taken in urban areas. The technique used for sampling was performed according to LIB-norm for emission sampling near ground. All samples were collected during 24 hours (4). Air samples for PAH and PCDD/F analysis were taken at the Baltic Sea during Dec 1986 to May 1987 and April-June 1989, respectively. The sampling technique used is further described in (3). All methods of analysis used started with Soxhlet extraction in toluene and then cleanup on SiO_2 columns. The PAH analysis was carried out either by means of liquid-liquid partitioning with DMF and hexane (5) or by fractionation on an aminopropylsilica (amino) column by HPLC. This was followed by quantitative analysis on GC/MS or GC/FID (3). The PCB analysis was done using HPLC with amino column followed by quantitative analysis on GC/MS (6). The analysis of PCDD/Fs has been carried out the same way as for PCB's except for further cleanup on HPLC with PYE or carbon column before quantitative analysis on GC/MS (3).

Results and Discussion

The PAH flux per year through the wastewater system has been calculated from analytical results of stormwater runoff, incoming and outgoing wastewater and digested sludge at the wastewater treatment plants Henriksdal, Loudden and Bromma (2). The five PAH studied are Fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Benzo(ghi)perylene and Indeno(1, 2, 3-) perylene according to US-EPA's recommendation of prioritised PAHs. The results show that urban stormwater runoff and wastewater accounts for respectively 55 % and 45 % of the amounts in incoming wastewater to the plants. The outgoing amounts from the plants are to almost 100 % found in the digested sludge. The treated wastewater had a very low content of PAH. These calculations do not include the urban stormwater runoff in the duplicate system. Including this system the urban stormwater runoff and the wastewater accounts for 75 % and 25 % respectively, of incoming amounts to the total wastewater systems (duplicate and combined). The urban stormwater runoff and the digested sludge accounts for 40 % and 60 % respectively, of the outgoing amounts of PAHs from the total wastewater systems. These 40 % of the amounts of PAHs that is transported with urban stormwater runoff do not pass the wastewater plants. These calculations are preliminary and the fluxes out of the wastewater systems are found to be larger than the incoming fluxes. Although the calculations show that the urban stormwater runoff is an important transport path of PAH generated in an urban area. The flux model that will be presented has together with ecotoxicological studies of these organic compounds in aquatic ecosystems, the purpose to develop an understanding and a knowledge that will form a base for decision making about what measures to take in order to protect the water recipients in the Stockholm area.

References

1. Broman, D. (*Thesis*), Transport and Fate of Hydrophobic Organic Compounds in the Baltic Aquatic Environment, Stockholm University, 1990, ISBN 91-87272-20-2.
2. Holmgren, A. (*Master's Thesis, Swedish*), PAH, Källor, toxiska och kemiska egenskaper samt förekomst i Stockholms dagvatten, Luleå University of Technology, 1998.
3. Näf, C. (*Thesis*), Some Biotic and Abiotic Aspects of the Environmental Chemistry of PAHs and PCDD/Fs, Stockholm university, 1991, ISBN 91-87272-24-5.
4. Östman, C., Nilsson, U., Carlsson, H., Andersson, I. och Fahlgren, L., Polycykliska aromatiska föreningar (PAC) i arbetsmiljö - PAC i Stockholms gatumiljö, halter av PAH före och efter en trafikomläggning, Arbetsmiljöinstitutet, Stockholm university, 1992:35.
5. Östman, C. (*Thesis*), Isolation and Identification of Polycyclic Aromatic Compounds in Complex Matrices Utilizing Multidimensional Chromatographic Methods, Stockholm university, 1987, ISBN 91-7146557-X.
6. Axelman, J. (*Thesis*), Biological, physicochemical and biogeochemical dynamics of hydrophobic organic compounds, Stockholm university, 1997, ISBN 91-87272-52-0.