

# RELEASE OF ENDOCRINE ACTIVE COMPOUNDS INCLUDING 4-NONYLPHENOL AND BISPHENOL A WITH TREATED WASTEWATER AND SEWAGE SLUDGE TO THE ENVIRONMENT IN GERMANY

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## Abstract

Multiple samplings of raw municipal wastewater (WW), sewage sludge (SS), and wastewater treatment plant (WWTP) effluents have been carried out in Germany in order to investigate the emissions of endocrine disrupting compounds (EDCs) to the environment. In many cases, the concentrations of the natural and synthetic steroids determined were below the limit of detection. The concentrations of 4-*tert*-octylphenol (OP), 4-nonylphenol (NP), and bisphenol A (BPA) in SS dry matter (dm) amounted to up to 13.3 mg/kg dm, 560 mg/kg dm, and 32.1 mg/kg dm, in WW to 2.5 µg/l, 3.9 µg/l, and 2.6 µg/l, and in treated effluent to 0.71 µg/l, 1.8 µg/l, and 0.46 µg/l, respectively. The overall OP and BPA mass is reduced at WWTPs but NP is formed by > 20 % during SS fermentation. The overall emissions to surface waters in Germany with WWTP discharges were calculated to 6.5 t OP/a, 8.3 t NP/a, and 4.4 t BPA/a. Through the agricultural application of SS, soil is contaminated with 0.8 t OP/a, 16.5 t NP/a, and 1 t BPA/a.

## Introduction

- Endocrine disruption has become one of the most important environmental issues. One important class of hormonally active agents (HAA), also called endocrine disrupting compounds (EDC), are substances that mimic female sexual hormones (estrogens).
- Environmental occurrence and behaviour of selected natural and xenobiotic estrogens are studied at the Dresden University of Technology.
- In this study, 20 samplings at municipal wastewater treatment plants (WWTP) were carried out in Germany in the years 2000 to 2002 in order to monitor the emissions of estrogenic EDC to the environment.

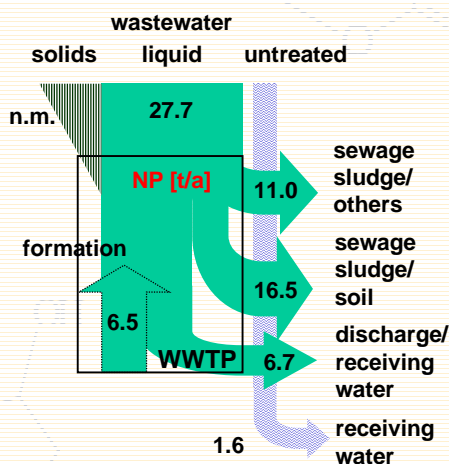


Figure 2: NP mass balance, municipal wastewater treatment in Germany, 2000

## Results and Discussion

- Max. concentration of OP, NP, BPA in WW below 12 µg/l (table 1)
- Elimination of OP, NP, BPA from WW 63 – 82 % (median, resp.)
- Very high NP concentrations in all kinds of SS; up to 560 mg/kg dm
- EDC concentrations according with literature (e.g., Wenzel et al., 1998; Meesters & Schröder, 2002)
- Increase of NP, OP, BPA concentrations in sludge during fermentation
- Quality of steroid data not satisfactory

## Additional Information

- For year 2000, respectively WW quantity : 10.6 bn m<sup>3</sup>  
Untreated WW : 0.6 bn m<sup>3</sup>  
SS to agriculture: 1.5 m t dm
- Mass balances calculated with:  
Digested sludge EDC concentrations  
Median of concentrations > LOQ  
Not considering solids/influent, solids/effluent, grit chamber, grease separator

Table 1: EDC concentrations in wastewater and sewage sludge in Germany 2000 – 2002

OP: octylphenol, NP: nonylphenol, BPA: bisphenol A, E2: 17β-estradiol, E1: estrone, E3: estriol, EE2: 17α-ethynylestradiol, ME: mestranol  
minimum - maximum, median of data > LOQ, n > LOD/total n

compound	wastewater [µg/l]		sludge [µg/kg dm]			
	influent	effluent	primary	excess	digested	dewatered
E2	n.d. - 0.029 n = 6/11	n.d. - 0.0003 n = 9/12	n.d. - 344 n = 9/12	n.d. - 71 n = 5/6	n.d. - 1,430 n = 9/10	n.d. - 1,100 n = 7/8
E1	n.m.	n.m.	n.d. - 15.9 n = 1/3	n.d. - 7.9 n = 2/5	n.d. - 99 n = 3	45 - 570 n = 3
E3	n.m.	n.m.	n.d. - 12 n = 2/3	n.d. - 29 n = 2/5	n.d. - 17 n = 2/3	n.d. - 17 n = 1/3
EE2	n.d. - 0.26 n = 7/11	n.d. - 0.065 n = 8/12	n.d. - 178 n = 4/6	n.d. - 206 n = 1/3	n.d. - 182 n = 8/10	n.d. - 281 n = 6/8
ME	n.m.	n.m.	< LOQ n = 1/3	n.d. n = 0/5	n.d. n = 0/3	n.d. - 105 n = 1/3
OP	n.d. - 4.3 n = 7/14	n.a. - 2.41 n = 14	6 - 5,99 n = 11	20 - 2,400 n = 19	33 - 13,300 n = 16	60 - 10,400 n = 13
NP	n.d. - 11.6 n = 9/14	n.d. - 7.9 n = 13/14	870 - 145,600 n = 11	500 - 48,000 n = 19	880 - 560,000 n = 16	1,200 - 493,000 n = 13
BPA	n.d. - 7.2 n = 13/14	n.d. - 2.5 n = 13/14	135 - 3,600 n = 11	60 - 1,700 n = 19	152 - 28,400 n = 16	202 - 32,100 n = 13

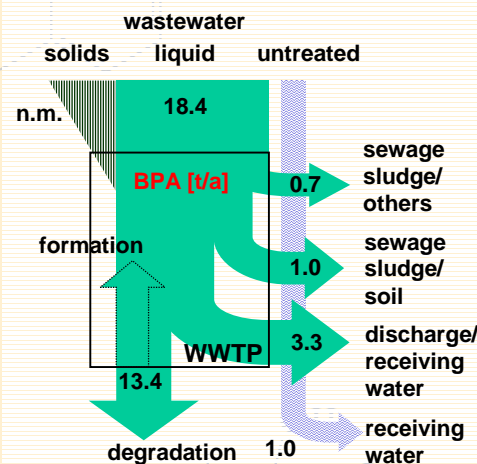


Figure 3: BPA mass balance, municipal wastewater treatment in Germany, 2000

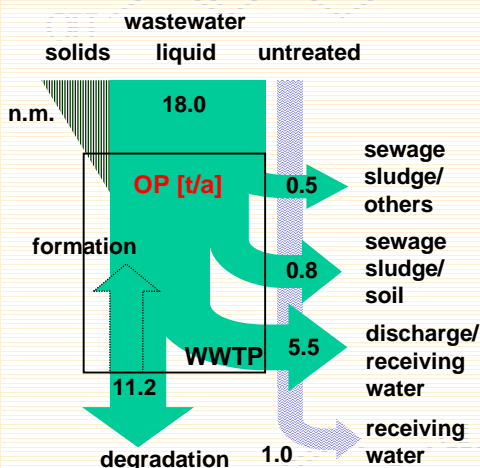


Figure 1: OP mass balance, municipal wastewater treatment in Germany, 2000

## Materials and Methods

- Analytics see Weltin et al. (in press), Gehring et al. (2003)
- Solids: freeze-drying, soxhlet, SEC; water: SPE; all : silica gel clean-up, derivatisation BSTFA, GC/MS
- Water samples filtrated 0.45 µm

## Conclusions

- OP, NP, BPA, E2 widespread contaminants of WW and SS
- EDC concentrations in accordance with literature (Wenzel et al., 1998; Meesters & Schröder, 2002)
- Run-off from SS applied land potential source for EDC pollution of receiving waters



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Wenzel A. et al. (1998). Report no. 216 02 01111, by order of Federal Environment Agency, Berlin, Germany.