



# Sewage epidemiology: Using wastewater to estimate cocaine consumption at national level

Alexander van Nuijs, Bert Pecceu,  
Lieven Bervoets, Ronny Blust,  
Philippe Jorens, Hugo Neels, Adrian  
Covaci



Toxicological Centre  
University of Antwerp  
Belgium

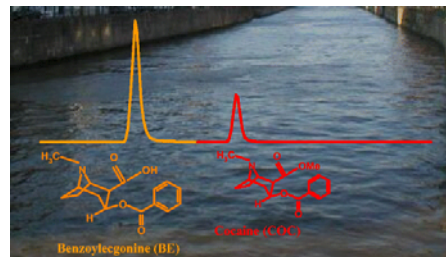


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## Content

- Introduction
- Sewage epidemiology?
- Methodology
- Calculations
- Uncertainties
- Conclusions



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# Introduction

- Cocaine is popular drug, but dangerous
- Prevalence?
- Classical (sociological) methods:
  - Interviews
  - Surveys
  - Statistics: seizures, production,...
- Disadvantages:
  - Studied population not representative for general population
  - Biased population: objectivity?
  - Time-consuming, expensive



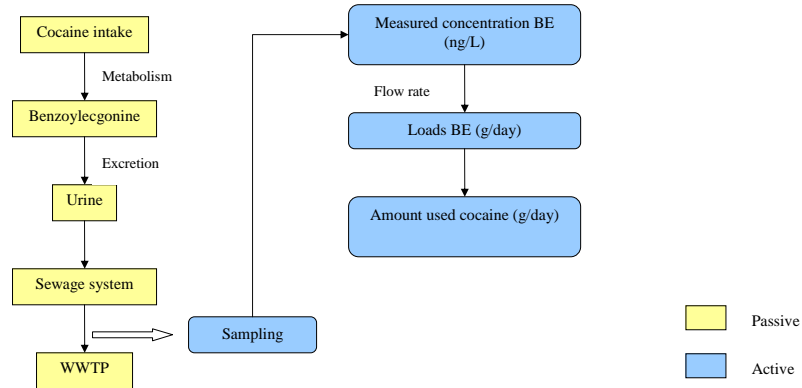
# Introduction

- 2001: Prof. Daughton (US EPA - raised theoretical idea of sewage epidemiology:
  - Objective: “giant urine test”
  - Less time consuming
  - Anonymous
- 2005: First measurements of drugs in wastewater (Zuccato et al. 2005) => SEWAGE EPIDEMIOLOGY

2006 onwards: various groups have embarked on this topic



## Sewage epidemiology?



van Nuijs et al., *Addiction*, 2009

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## Sewage epidemiology?

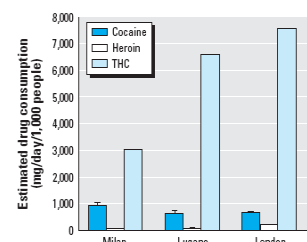
### •Important:

- Use of metabolites (to discriminate from discharge)
- Influent wastewater
- 24-h composite sampling
- Back-calculations (see further)

•Zuccato et al. (2005) for the first time at local (city) level

•Most studies looked at city level

•Possible at national level?



Zuccato et al., *EHP*, 2008

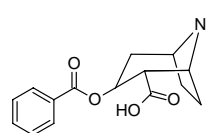
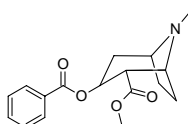
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## Methodology

- Influent wastewater samples from 41 WWTPs:
  - 24-h composite samples
  - 41 largest WWTPs spread over Belgium (3 700 000 inh)
  - After collection, samples acidified (pH2) and stored at -20°C
- Each WWTP 4 times sampled:
  - Wednesday and Sunday
  - Summer and winter
- Analyse samples for cocaine (COC) and benzoylecgonine (BE)



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## Methodology

Water samples (100 mL) filtered over glass filter  
↓  
pH adjustment to pH = 6 with NH<sub>4</sub>OH  
↓  
Addition of deuterated internal standards (BE-d<sub>3</sub>, COC-d<sub>3</sub>)  
↓  
SPE with Oasis HLB cartridges (500 mg, 6 cc)  
↓  
Elution with 2 x 4 ml MeOH  
↓  
Evaporation and reconstitution in mobile phase  
↓  
Centrifugation and filtration (0.45 µm)  
↓  
Analysis with HILIC/MS-MS (Zorbax RX-Sil)

*Gheorghe et al., Anal Bioanal Chem, 2008*

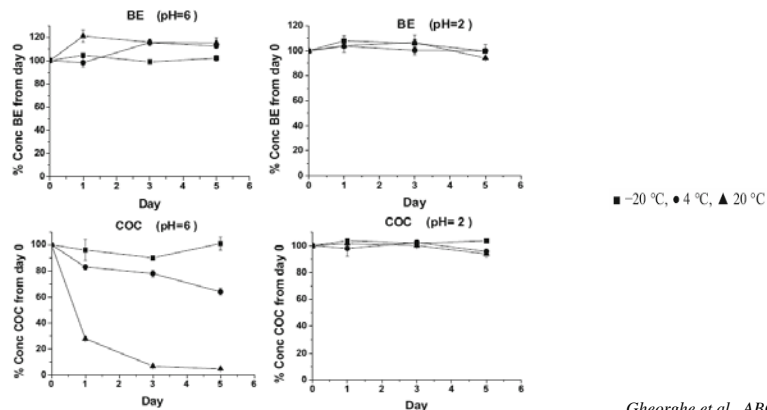
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## Methodology

- Samples stored at -20°C and at pH 2 following stability studies for COC and BE



Gheorghe et al., ABC, 2008

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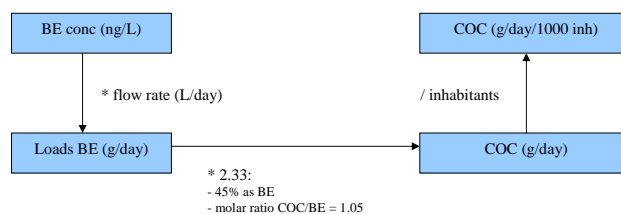
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## Calculations

- From concentrations (ng/L) to amount of used cocaine (g/day/1000 inh) for each WWTP

- Based on BE (metabolite)
- 45 % of COC dose excreted as BE, molar ratio COC/BE = 1.05
- $\text{COC} = 1.05 / 0.45 * \text{loads BE}$
- Inhabitants = capacity of WWTP



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## Calculations

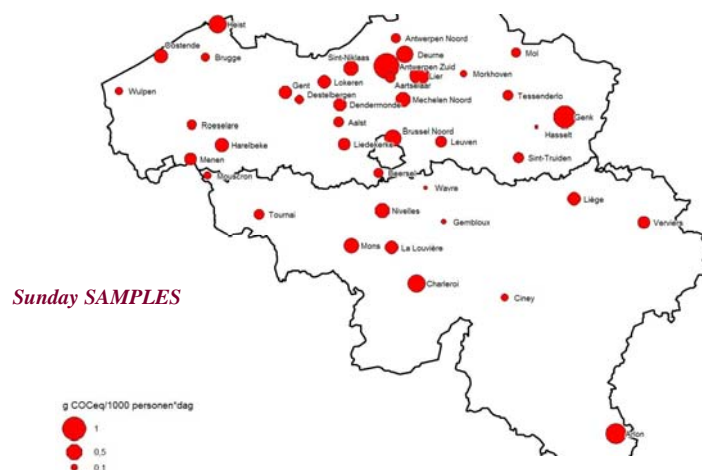
- From g/day/1000 inh to g/year for each WWTP
  - Week = 2 weekend-days and 5 weekdays
  - Wednesday sample = week, Sunday sample = weekend
  - Year = 52 weeks
- From g/year for each WWTP to g/year in Belgium
  - Sum of WWTPs
  - Extrapolation from 3 700 000 to 10 500 000 inhabitants
- From g/year in Belgium to annual prevalence
  - Average cocaine dose = 100 mg
  - Average cocaine user consumes 0.65 g/week (*Everingham, 1994; Cohen, 1994*)

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## Results (local)



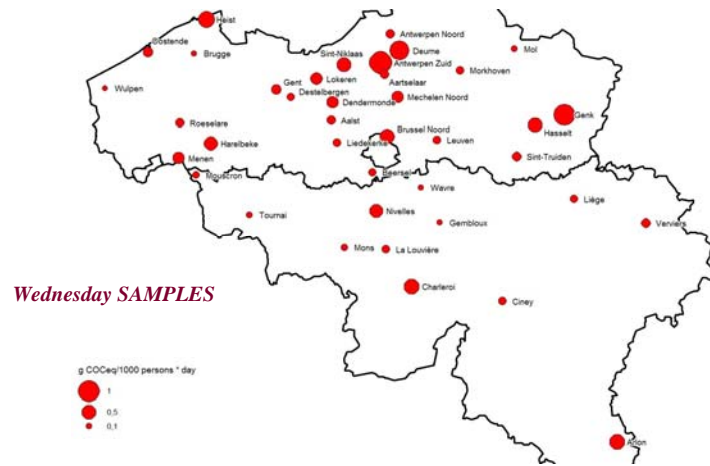
van Nuijs et al., EP, 2009

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## Results (local)



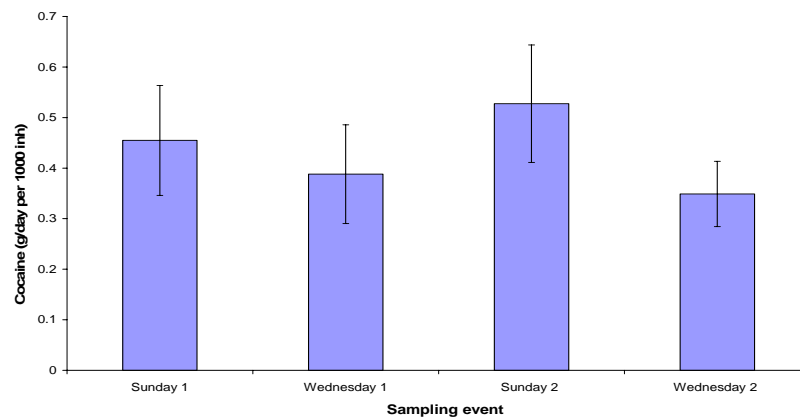
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## Results (local)

- Weekend > week



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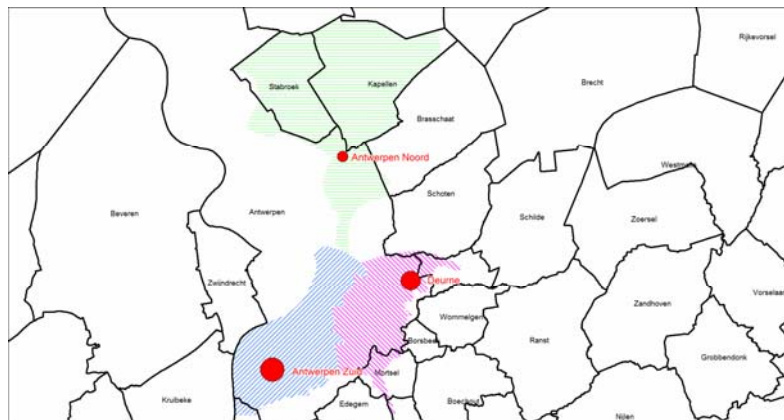


## Results (local)

- Cities > countryside
  - Antwerp: 3 WWTPs
  - 2 receive wastewater mainly from centre (Deurne and Antwerp South)
  - 1 receives wastewater from more rural areas (Antwerp North)
  - Results:
    - Deurne: 0.93 g/day per 1000 inh
    - Antwerp South: 1.4 g/day per 1000 inh
    - Antwerp North: 0.27 g/day per 1000 inh



## Results (local)



van Nuijs et al., EP, 2009

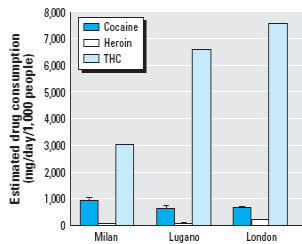




## Results (local)

- Comparison with other cities?

- in concentrations (ng/L) or use (g/day/1000 inh)?



Zuccato et al., EHP, 2008

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Results (Belgium):

Deurne: 930 mg/day per 1000 inh  
Antwerp South: 1400 mg/day per 1000 inh  
Brussels: 830 mg/day per 1000 inh

Results (Europe):

South Wales: 600 mg/day per 1000 inh  
NE Spain: 1400 mg/day per 1000 inh

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## Results (national)

- 1.88 tonnes are annually used in Belgium (Police estimation from seizures = 2.0 t)

- Annual prevalence:

- 0.53% for total population
- 0.80% for population aged 15-64
- 1.32% for population aged 15-44

- Values are in agreement with sociological studies (EMCDDA):

- In Europe: ranges from 0.1% to 3%
- In Belgium rough estimate: 0.9%

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## Uncertainties



- Stability in wastewater: degradation/adsorption
- Error on flow rate
- Pharmacokinetics of drugs
- Amount of inhabitants (cfr. Case Study: Brussels)
- Standard dose of drug
- Consumption pattern
- Ethical issues??

**=> FUTURE INTERDISCIPLINARY RESEARCH!!**



## Conclusions

- Demonstrates enormous potential for spatial and temporal trends
- Not replace sociological studies, but complementary!
- Probably less suited for prevalence
- Advantages:
  - Quick
  - Relative cheap
  - Objective
  - Selection of priority places and hot spots
- New scientific field, requires extensive optimisation



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