Practical application of sewage epidemiology to estimate drug consumption at community level
Wastewater - Based Epidemiology

This method can provide

- Evidence-based and real-time estimates of drug collective consumption

It can be used to

- Estimate **local and national** consumptions
- Estimate **spatial differences**
- Monitor **consumption changes with time**
- Estimate **temporal differences**
Local use - Weekly trends

Drug Consumption in Milan, **Italy** (2006) *(Zuccato et al., EH&P, 2008)*

- **Cocaine (g/day)**
- **Amphetamines (g/day)**
- **Heroin (g/day)**
- **THC-cannabis (g/day)**
Local use - Weekly trends

Drug Consumption in Zagreb, **Croatia** (2009)
(Terzic et al., *Environ Pollution*, 2010)
Local use - Weekly trends

Drug Consumption in Paris, France (2009)
(Karolak et al., Forensic Science International, 2010)

Study area
4 wastewater treatment plants
Local use - Weekly trends

Drug Consumption in Canada, three cities
(Metcalfe et al., Environ Pollution, 2010)
Local use – Case study in a prison

(Postigo et al., Environment International, 2011)
Cocaine detection in air

(Cecinato et al., STOTEN, 2009)

<table>
<thead>
<tr>
<th>Country</th>
<th>Site, city (year)</th>
<th>Period</th>
<th>Nicotine, (ng m⁻³)</th>
<th>Cocaine, (pg m⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ave.</td>
<td>Min–max</td>
</tr>
<tr>
<td>Italy</td>
<td>Fermi, Rome</td>
<td>Winter</td>
<td>22</td>
<td>20–24</td>
</tr>
<tr>
<td></td>
<td>Bissolati, Rome</td>
<td>Winter</td>
<td>28</td>
<td>22–38</td>
</tr>
<tr>
<td></td>
<td>Belloni, Rome</td>
<td>Winter</td>
<td>6.2</td>
<td>5.3–7.2</td>
</tr>
<tr>
<td></td>
<td>Villa Ada, Rome</td>
<td>Year</td>
<td>5.43</td>
<td>0.84–13</td>
</tr>
<tr>
<td></td>
<td>Villa Ada, Rome</td>
<td>Winter</td>
<td>6.57</td>
<td>3.2–13</td>
</tr>
<tr>
<td></td>
<td>Villa Ada, Rome</td>
<td>Summer</td>
<td>4.0</td>
<td>3.0–4.4</td>
</tr>
<tr>
<td></td>
<td>Montelibretti, Rome</td>
<td>Year</td>
<td>1.86</td>
<td>0.59–7.6</td>
</tr>
<tr>
<td></td>
<td>Malagrotta, Rome</td>
<td>Spring</td>
<td>1.67</td>
<td>1.43–1.92</td>
</tr>
<tr>
<td></td>
<td>Bari</td>
<td>Winter</td>
<td>19.4</td>
<td>14–28</td>
</tr>
<tr>
<td></td>
<td>Torre Sarca, Milan</td>
<td>Year</td>
<td>18.0</td>
<td>5.8–54</td>
</tr>
<tr>
<td></td>
<td>Torre Sarca, Milan</td>
<td>Winter</td>
<td>19.0</td>
<td>5.8–54</td>
</tr>
<tr>
<td></td>
<td>Torre Sarca, Milan</td>
<td>Summer</td>
<td>7.5</td>
<td>7.4–7.5</td>
</tr>
<tr>
<td>Portugal</td>
<td>Ermesinde, Oporto</td>
<td>Summer</td>
<td>5.1</td>
<td>2.7–7.5</td>
</tr>
<tr>
<td>Serbia</td>
<td>PHI, Pančevo</td>
<td>Year</td>
<td>34</td>
<td>26–38</td>
</tr>
<tr>
<td></td>
<td>FB, Pančevo</td>
<td>Year</td>
<td>6.7</td>
<td>1.20–13.8</td>
</tr>
<tr>
<td></td>
<td>UR, Pančevo</td>
<td>Year</td>
<td>25</td>
<td>10.3–42</td>
</tr>
<tr>
<td></td>
<td>FF, Pančevo</td>
<td>Year</td>
<td>22</td>
<td>7.2–38</td>
</tr>
<tr>
<td></td>
<td>BZ, Pančevo</td>
<td>Year</td>
<td>8.4</td>
<td>6.0–10.9</td>
</tr>
<tr>
<td>Algeria</td>
<td>Tafourah, Algiers</td>
<td>Summer</td>
<td>10.9</td>
<td>3.5–21</td>
</tr>
<tr>
<td></td>
<td>Roubia, Algiers</td>
<td>Summer</td>
<td>6.3</td>
<td>5.7–9.9</td>
</tr>
<tr>
<td></td>
<td>Reghaia, Algiers</td>
<td>Summer</td>
<td>7.8</td>
<td>2.9–11.4</td>
</tr>
<tr>
<td>Chile</td>
<td>Santiago</td>
<td>Winter</td>
<td>14.4</td>
<td>10.3–20</td>
</tr>
<tr>
<td></td>
<td>Piracicaba (2003)</td>
<td>Winter</td>
<td>2.6</td>
<td>2.5–2.7</td>
</tr>
<tr>
<td></td>
<td>Piracicaba (2007)</td>
<td>Winter</td>
<td>3.7</td>
<td>2.9–4.5</td>
</tr>
<tr>
<td></td>
<td>Araraquara (2003)</td>
<td>Winter</td>
<td>1.93</td>
<td>0.99–2.8</td>
</tr>
<tr>
<td></td>
<td>Ouro Preto (2002)</td>
<td>Winter</td>
<td>3.9</td>
<td>2.5–5.2</td>
</tr>
<tr>
<td></td>
<td>Ouro Preto (2003)</td>
<td>Autumn</td>
<td>10.1</td>
<td>7.7–12.6</td>
</tr>
</tbody>
</table>
National consumption – Spatial differences

Cocaine Consumption in Belgium (van Nuijs et al., Addiction, 2009)
National consumption – Spatial differences

Drug Consumption in the State of Oregon, USA
(Banta-Green et al., Addiction, 2009)

**Cocaine:** higher use in urban areas
**Methamphetamine:** at all municipalities
National consumption – Spatial differences

Cocaine Consumption in **Italy** (Zuccato et al., submitted)
National consumption – Spatial differences

Cocaine Consumption in France (Nefau et al., STOTEN, 2013)

Study area
25 wastewater treatment plants

Cocaine consumption (mg/day/1000 inh hab.)

Cocaine consumption (mg/day/1000 inh hab.)
European study – Regional differences

A  Cocaine consumption (based on BE loads)

B  Ecstasy loads (MDMA)

C  Amphetamine loads (AMP)
   Methamphetamine loads (METH)

D  Cannabis (THC-COOH loads)

Thomas et al., STOTEN, 2012
Spatial differences – Urban vs Regional

Drugs Consumption in Adelaide and State of South Australia

(Irvine et al., Forensic Science International, 2013)

Study area

**Metropolitan:** three wastewater treatment plants

**Regional:** ten wastewater treatment plants

---

**SA metropolitan mid-week v weekend**

![Graph showing comparison between mid-week and weekend consumption of MDMA, Meth, and BE.

**SA metropolitan v regional**

![Graph showing comparison between metropolitan and regional consumption of MDMA, Meth, and BE.](Image)
Spatial differences – Urban – Rural - Holiday areas

Drug Use in Queensland, **Australia** (Lai et al., *Addiction*, 2012)
**Spatial differences – An Island**

Drug Use in Sardinia, **Italy** (Zuccato and Castiglioni, Scientific Report, 2010)

Heroin consumption estimated from morphine (mg/d/1000 inh)

1° week: 4-10 June 2009
2° week: 27 July 2 – August 2009
3° week: 22-28 February 2010

In line with **prevalence data** provided by the Local Health Agency
Temporal trends – One year study

Drug Use in Belgium (van Nuijs et al., *Environment International*, 2011)
Heroin consumption fell 66% in 2009 (p<0.05, Tukey-Kramer HSD test)
Zuccato et al., 2011, Drugs and Alcohol Dependence, submitted.
**Trends in drug consumption (2005-2010)**

Cannabis consumption was falling from 2005 to March 2009 (*p<0.05 vs. 2005, Tukey-Kramer HSD test), rose in September 2009 (**40%, p=0.027, t-test).

Zuccato et al., 2011, *Drugs and Alcohol Dependence*, submitted.

<table>
<thead>
<tr>
<th>Year</th>
<th>Doses/1000 inhabitants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-2006</td>
<td>24.1 ± 3.8</td>
</tr>
<tr>
<td>2008</td>
<td>20.1 ± 5.8</td>
</tr>
<tr>
<td>March 2009</td>
<td>17.9 ± 7.6</td>
</tr>
<tr>
<td>September 2009</td>
<td>24.9 ± 4.7</td>
</tr>
<tr>
<td>2010</td>
<td>19.8 ± 3.9</td>
</tr>
</tbody>
</table>
Trends in drug consumption (2005-2012)

Milan, **Italy** (Zuccato et al. *Drug Alcohol Depend*, 2011)

**Cocaine**

**THC**

**Heroin**

**Metamphetamine**

Loads g/day
Temporal Trends– Ebro River Basin

Drug Use in the Ebro River Basin, **Spain** (2007-2008)  
(Postigo et al., *Environment International*, 2010)

Study area
7 wastewater treatment plants

Cocaine
Most used substance

<table>
<thead>
<tr>
<th>Substance</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocaine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amphetamine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecstasy*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methamphetamine*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ephedrine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heroin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannabis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

g/day/1000 inhabitants aging 15-64
European study – Temporal trends

Drug Use in Europe (Ort et al., Addiction, 2014)

Study area

2011: 19 cities
2012: 25 cities
2013: 43 cities
Temporal trends – Novel synthetic stimulants

Drug Use in Adelaide, Australia (Chen et al., Forensic Science International, 2013)
Monitoring of new synthetic recreational drugs

Profile of KETAMINE use in Milan in a six-year study

Ketamine is a dissociative anaesthetic drug...
...with documented increase in its use as a recreational drug.

Increased use in Milan from 2008 to 2013
4-5 weeks investigated per year
Monitoring of drinking habits
Milan (30 September - 03 November 2013)

Ethyl sulphate (EtS)

Lods g/day

0 500 1000 1500 2000 2500 3000 3500 4000

Wastewater - Based Epidemiology

This method can provide

- Evidence-based and real-time estimates of drug collective consumption

It can be used to

- Estimate local and national consumptions
- Estimate spatial differences
- Monitor consumption changes with time
- Estimate temporal differences

Thanks for your attention!