

Illicit drugs in the urban water cycle

Kevin V Thomas

Norwegian Institute for Water Research (NIVA)



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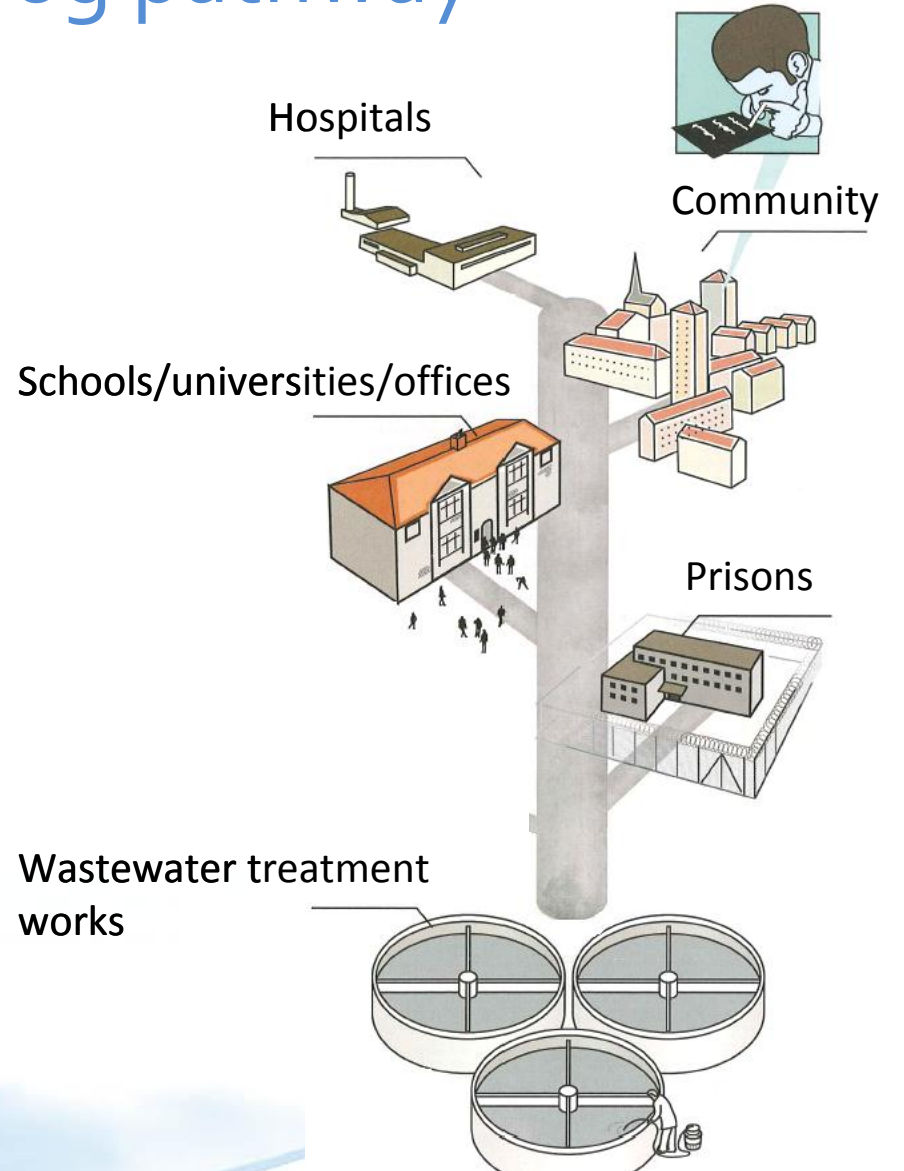
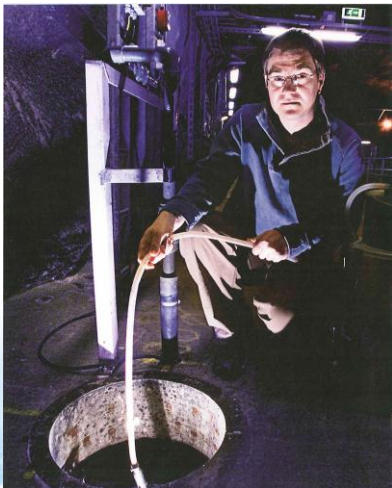
See other side. ¹⁸



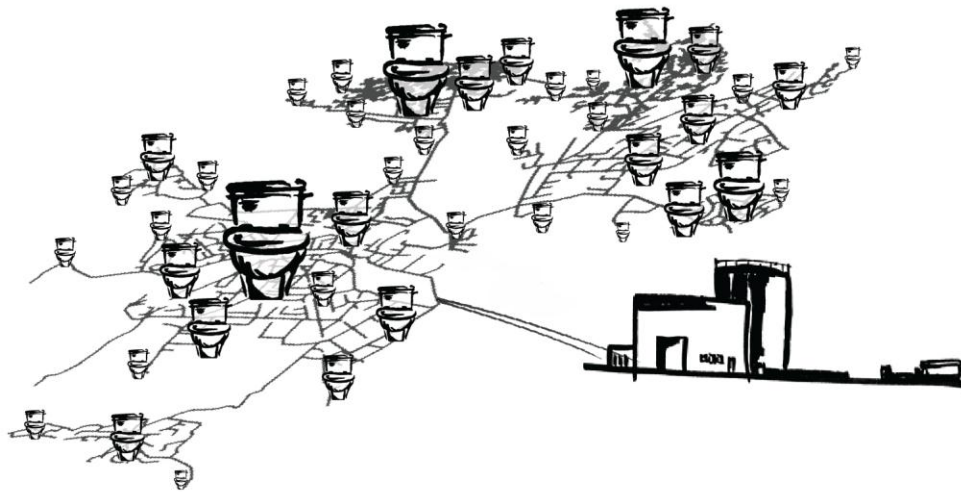




Illicit drug pathway



Estimating drug use through sewage analysis

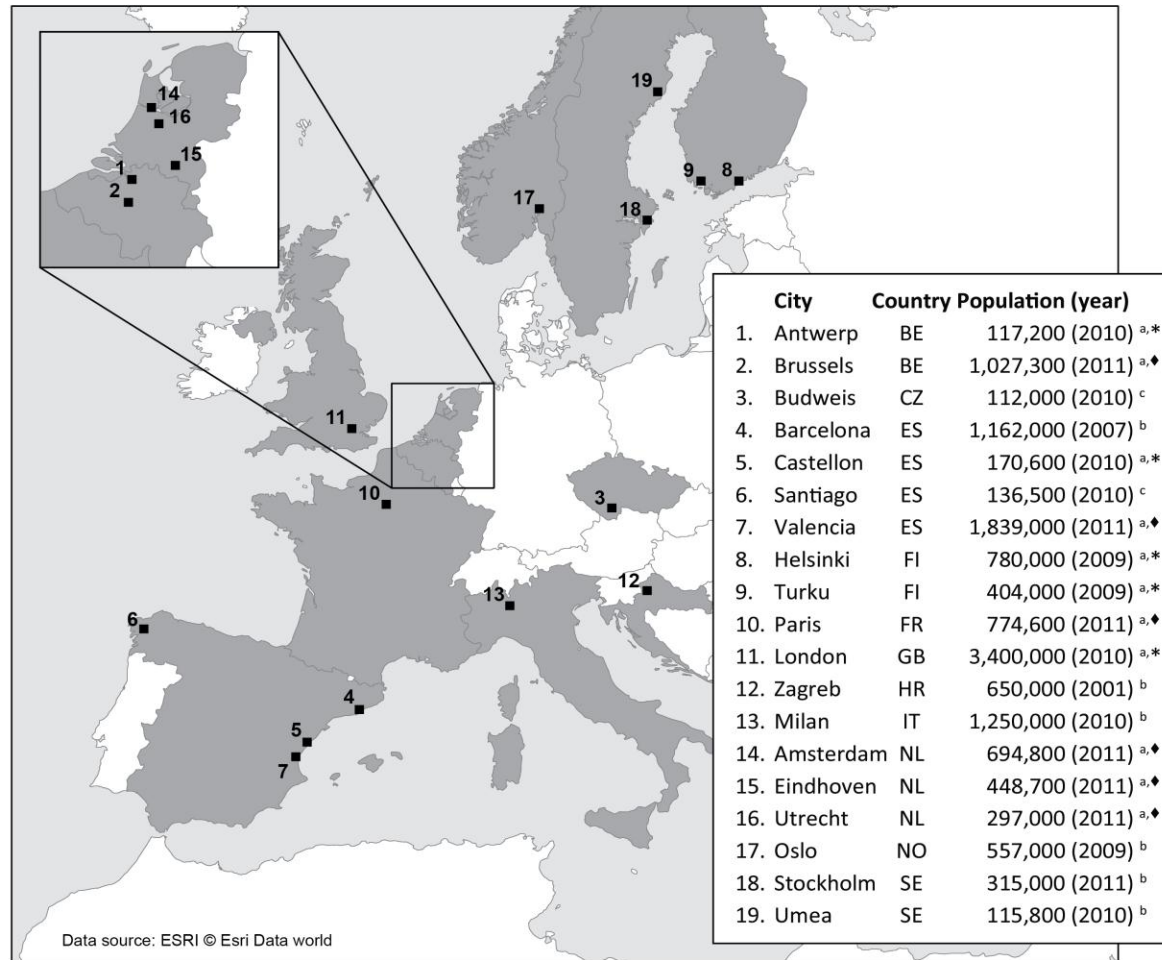


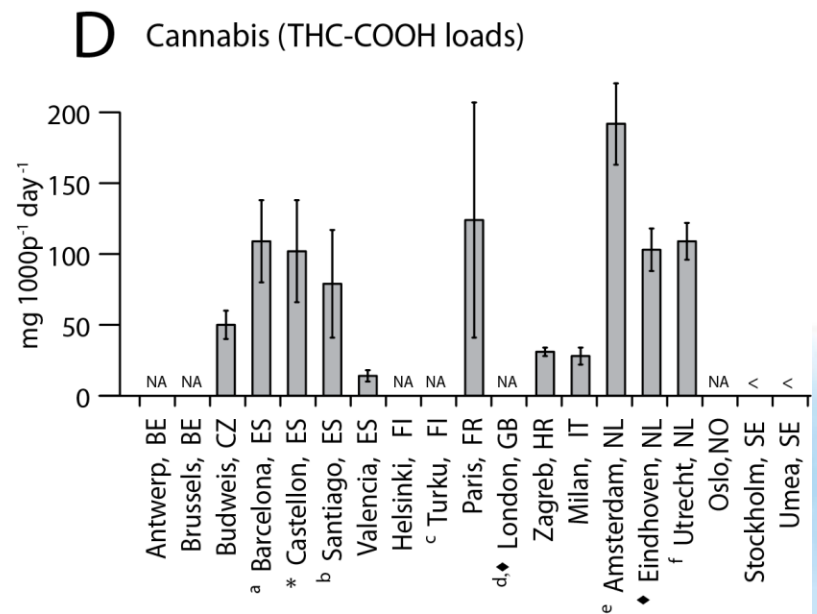
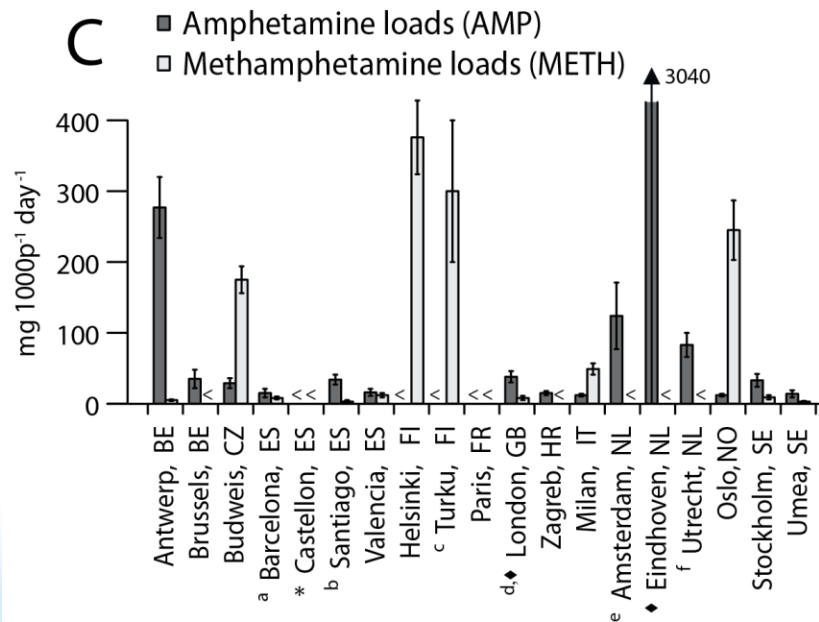
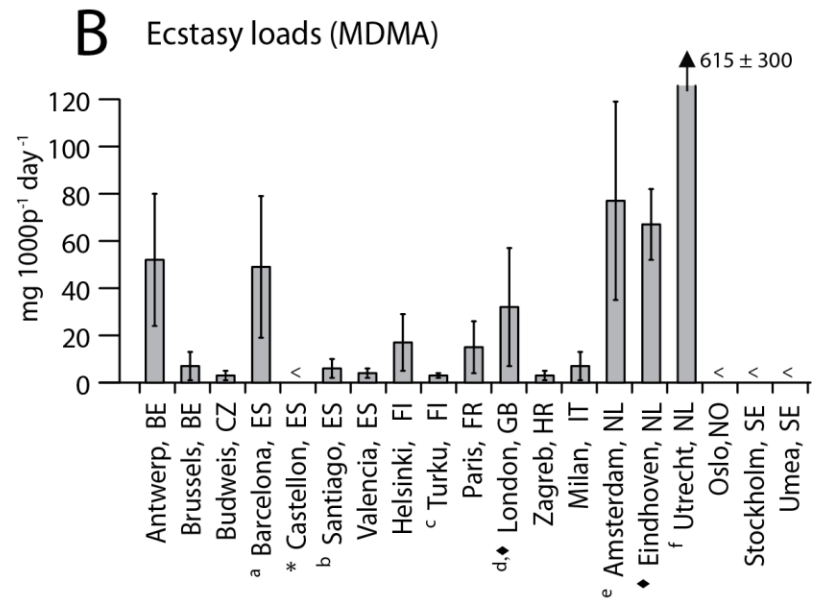
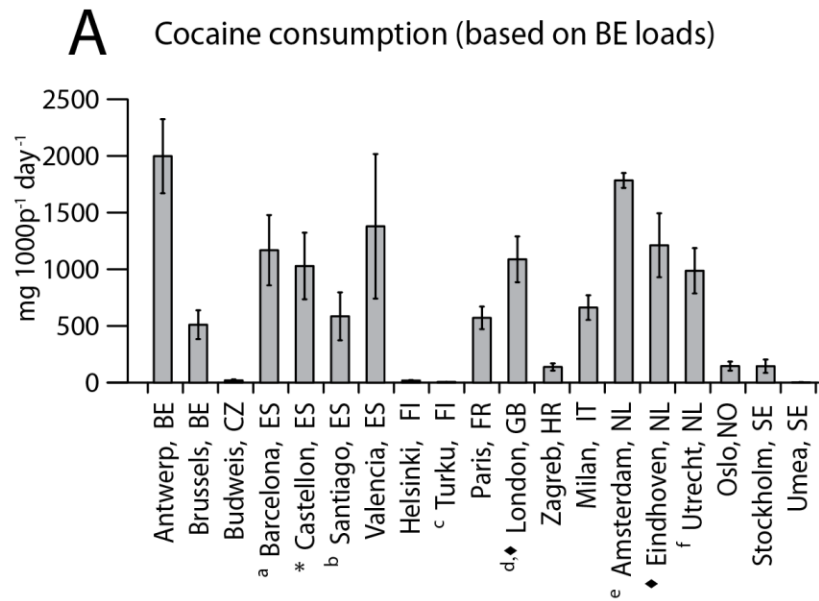
- Step 4. Correct for metabolism and normalise to number of people ⇒ **drug use**
- Step 3. Multiply concentration with total sewage volume ⇒ **daily load of compound in sewer**
- Step 2. Analyse sample for target compound ⇒ **average daily concentration**
- Step 1. Collect raw sewage at sewage treatment plant ⇒ **anonymous composite sample**

Illicit drugs of Interest



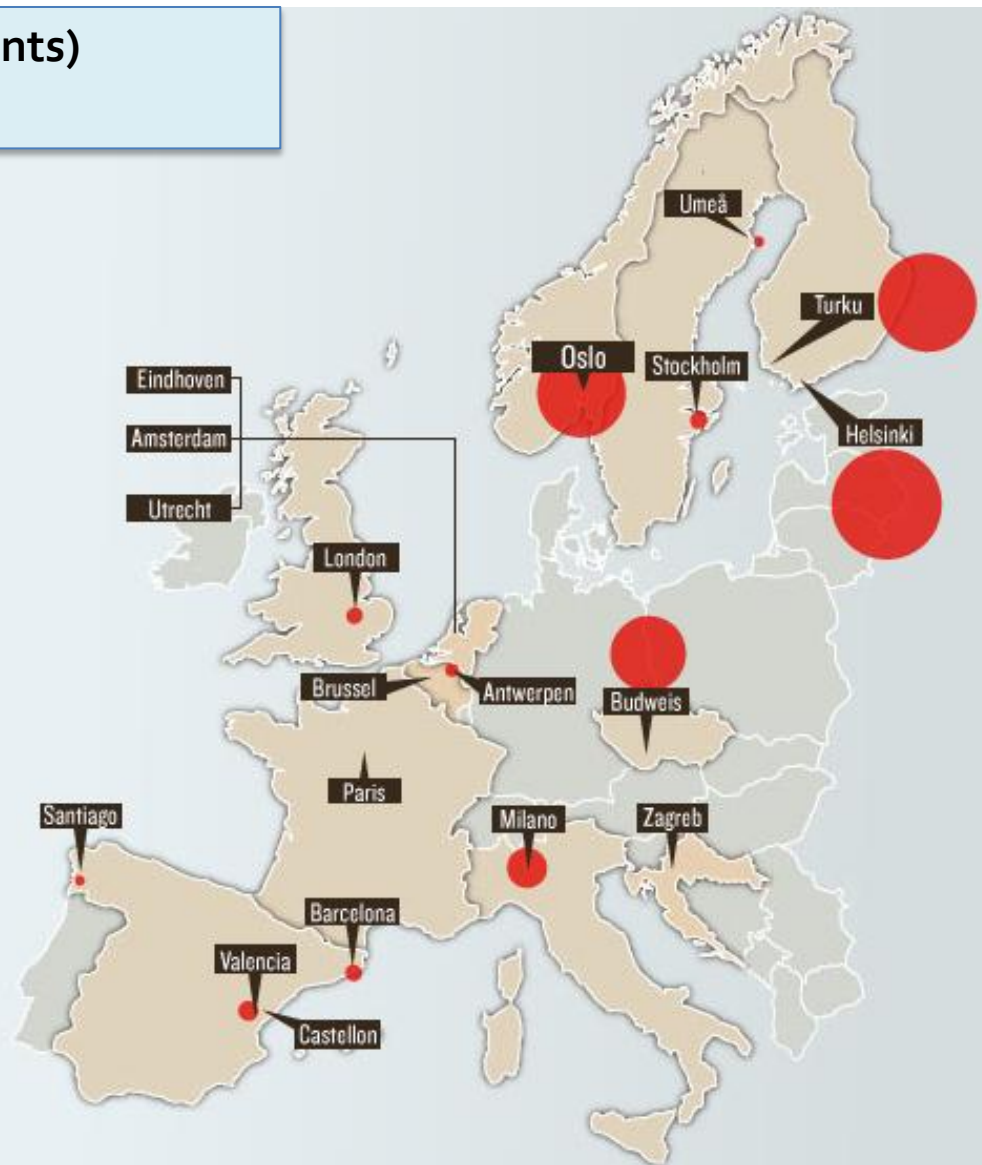
Europe wide monitoring: March 2011




















Influent load (mg/day/1000 inhabitants)

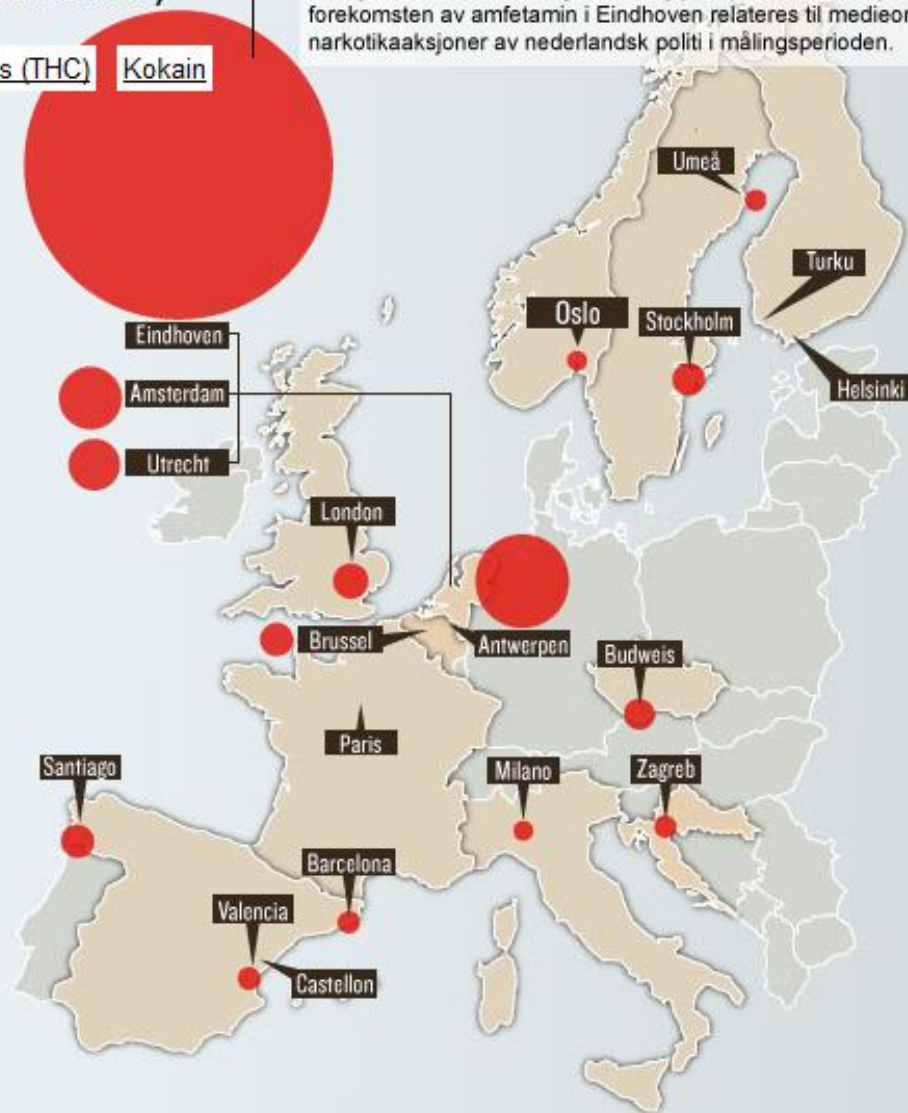
By	Metamfetamin
 Helsinki, Finland	376
 Turku, Finland	300
 Oslo, Norge	245
 Budweis, Tsjekkia	175
 Milan, Italia	49
 Valencia, Spania	12
 Stockholm, Sverige	9
 Barcelona, Spania	8
 London, Storbritannia	8
 Antwerpen, Belgia	5
 Santiago, Spania	3
 Umea, Sverige	3


















Narkotika målt i avløpsvann (mg pr. dag pr. 1000 mennesker)

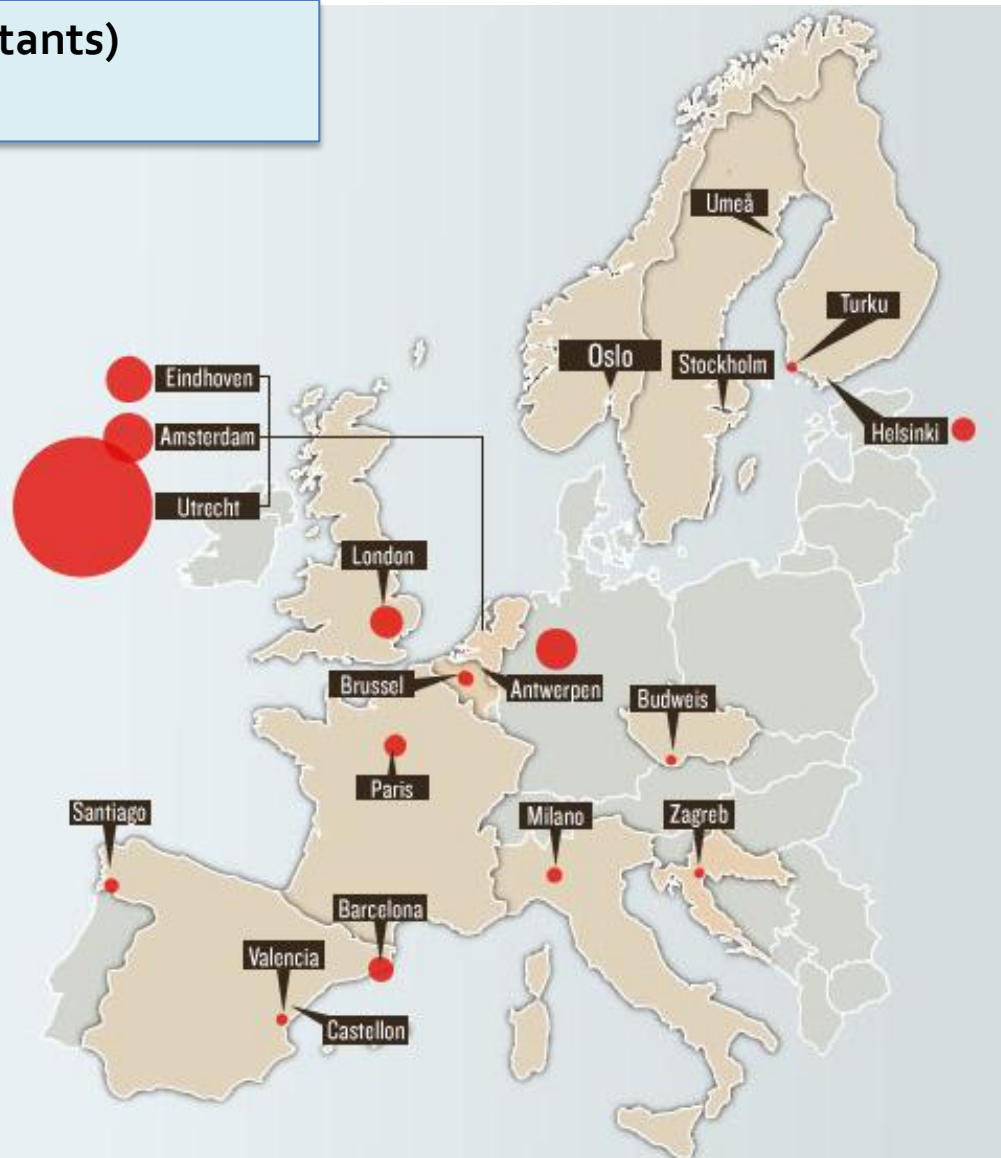
Metamfetamin Amfetamin Ecstasy (MDMA) Cannabis (THC) Kokain

By	Amfetamin
 Eindhoven, Nederland	3040
 Antwerpen, Belgia	277
 Amsterdam, Nederland	124
 Utrecht, Nederland	83
 London, Storbritannia	38
 Brussel, Belgia	35
 Santiago, Spania	34
 Stockholm, Sverige	33
 Budweis, Tsjekkia	29
 Valencia, Spania	16
 Barcelona, Spania	15
 Zagreb, Kroatia	15
 Umea, Sverige	14
 Milan, Italia	12
 Oslo, Norge	12



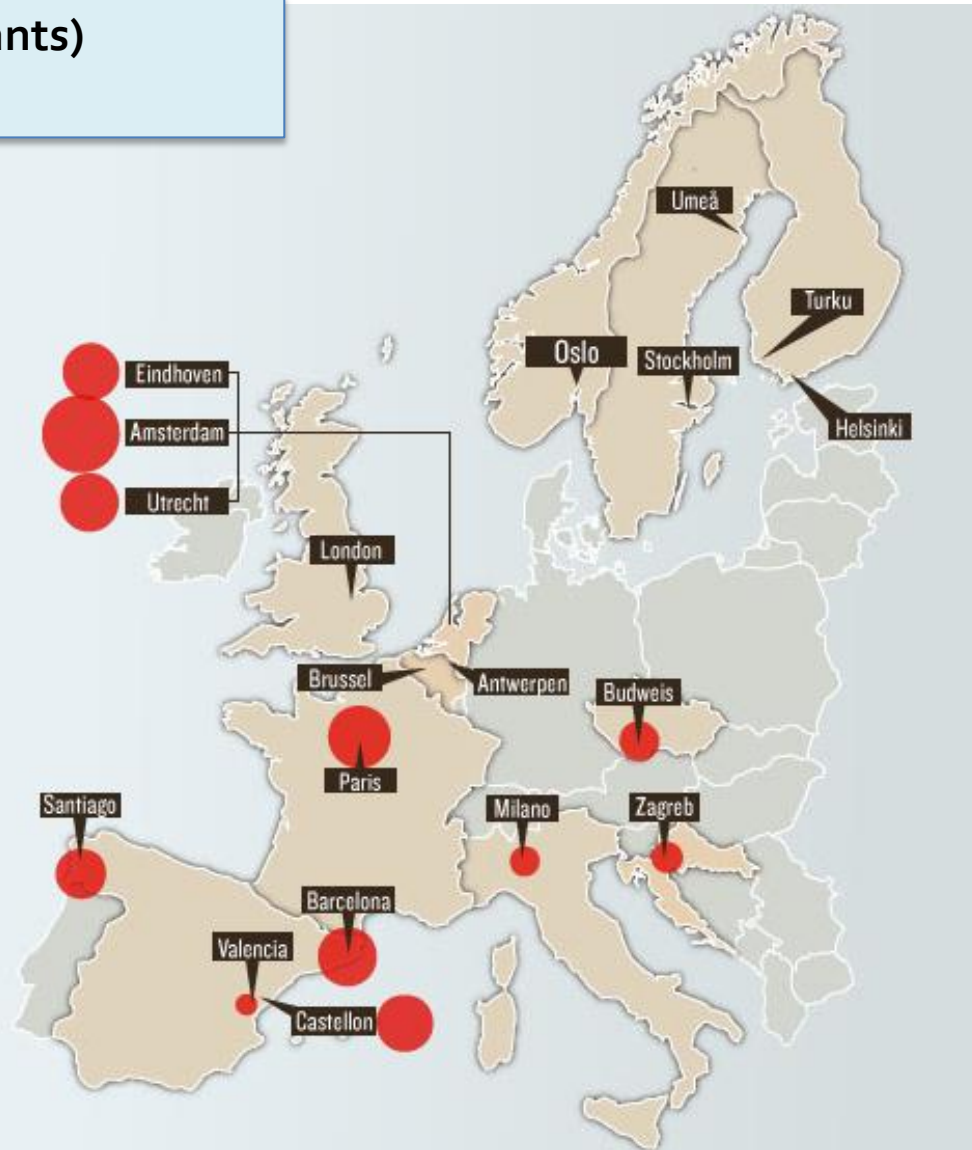
Influent load (mg/day/1000 inhabitants)

By	Ecstasy (MDMA)
 Utrecht, Nederland	615
 Amsterdam, Nederland	77
 Eindhoven, Nederland	67
 Antwerpen, Belgia	52
 London, Storbritannia	32
 Barcelona, Spania	19
 Helsinki, Finland	17
 Paris, Frankrike	15
 Brussel, Belgia	7
 Milano, Italia	7
 Santiago, Spania	6
 Valencia, Spania	4
 Turku, Finland	3
 Budweis, Tsjekkia	3
 Zagreb, Kroatia	3






















Influent load (mg/day/1000 inhabitants)

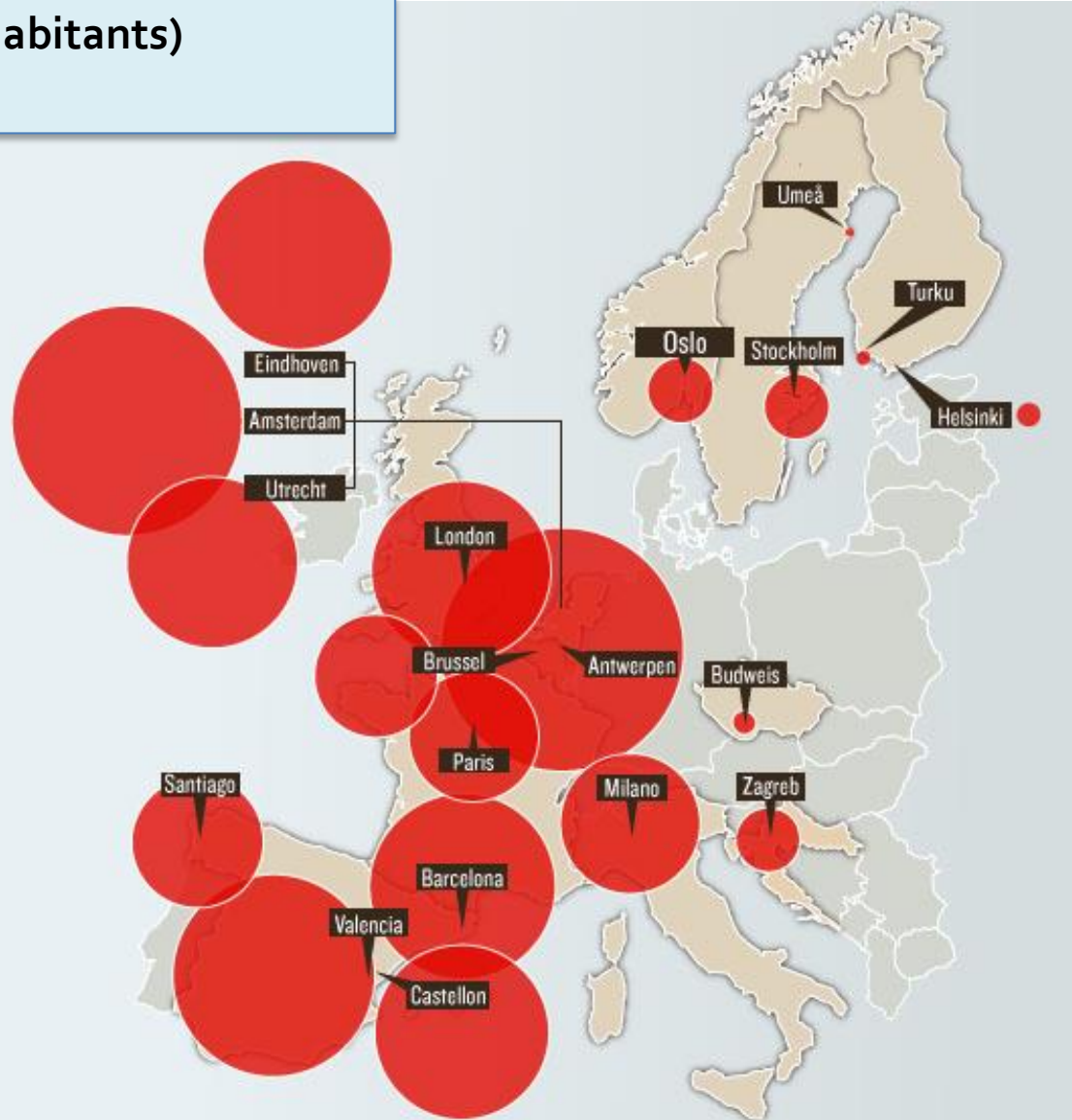
By	Cannabis (THC)
 Amsterdam, Nederland	192
 Paris, Frankrike	124
 Utrecht, Nederland	109
 Barcelona, Spania	109
 Eindhoven, Nederland	103
 Castellon, Spania	102
 Santiago, Spania	79
 Budweis, Tsjekkia	50
 Zagreb, Kroatia	31
 Milan, Italia	28
 Valencia, Spania	14



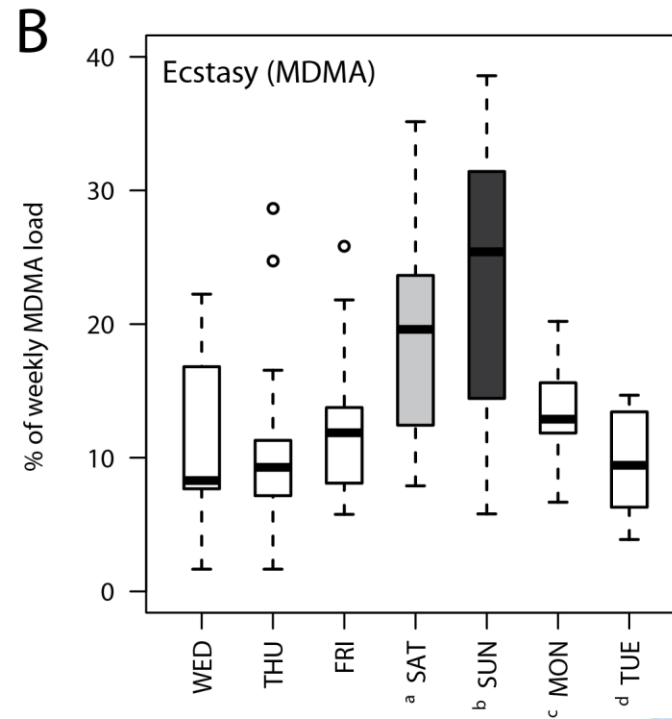
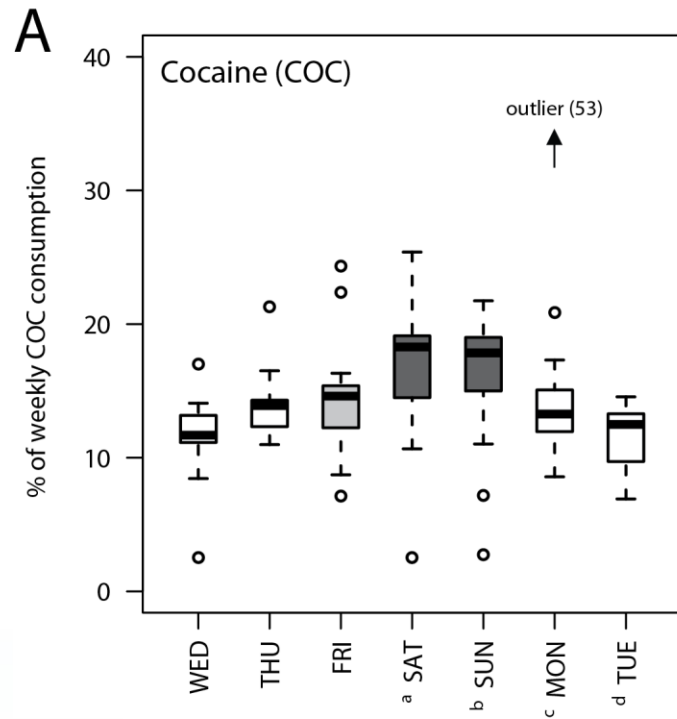
Cocaine use (mg/day/1000 inhabitants)

By Kokain

 Antwerpen, Belgia	1998
 Amsterdam, Nederland	1784
 Valencia, Spania	1379
 Eindhoven, Nederland	1212
 Barcelona, Spania	1168
 London, Storbritannia	1088
 Castellon, Spania	1029
 Utrecht, Nederland	987
 Milan, Italia	662
 Santiago, Spania	585
 Paris, Frankrike	571
 Brussel, Belgia	511
 Oslo, Norge	146
 Stockholm, Sverige	145
 Zagreb, Kroatia	138
 Budweis, Tsjekkia	19
 Helsinki, Finland	18
 Turku, Finland	6
 Umea, Sverige	2



Europe-wide weekend increase



Long-term monitoring

- Passive sampling approach
 - Time integrated concentrations
 - Simple, robust, low cost, unattended sampling





PATCH - Passive Sampler – the simple solution

Currently, passive sampling of water and air requires bulky deployment equipment which must be installed at the sampling site e.g., with mooring rigs in aquatic environments or at static air monitoring installations.

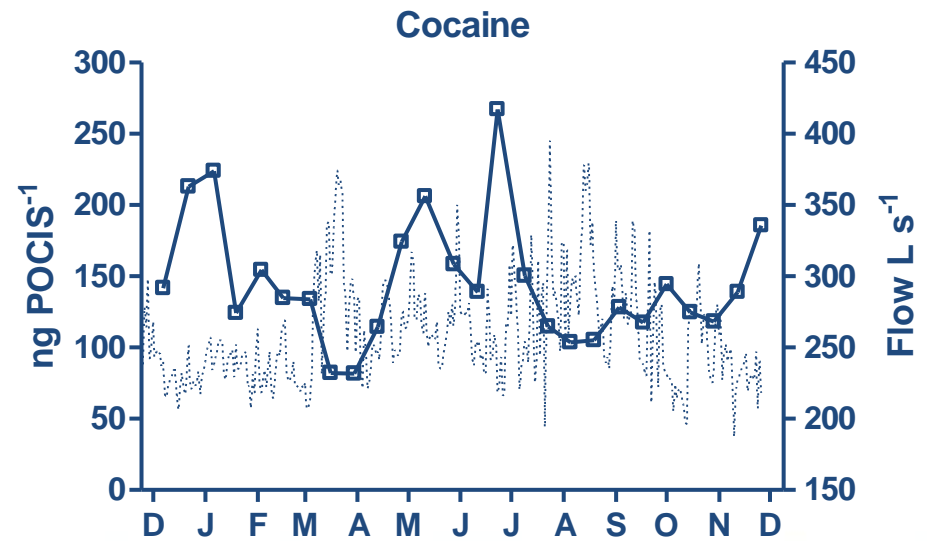
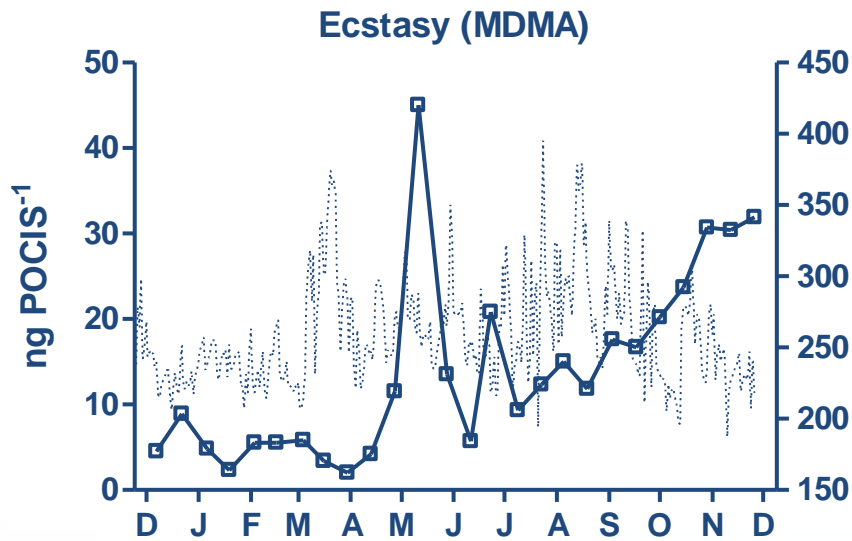
Both installation and retrieval of samplers from traditional equipment is time consuming and deployment is not possible in small channels and pipelines due to the inherent risk of clogging.

The new PATCH is a revolution when it comes to taking samples in a simple and effective way.



www.niva.no/patch

Results – year-long monitoring

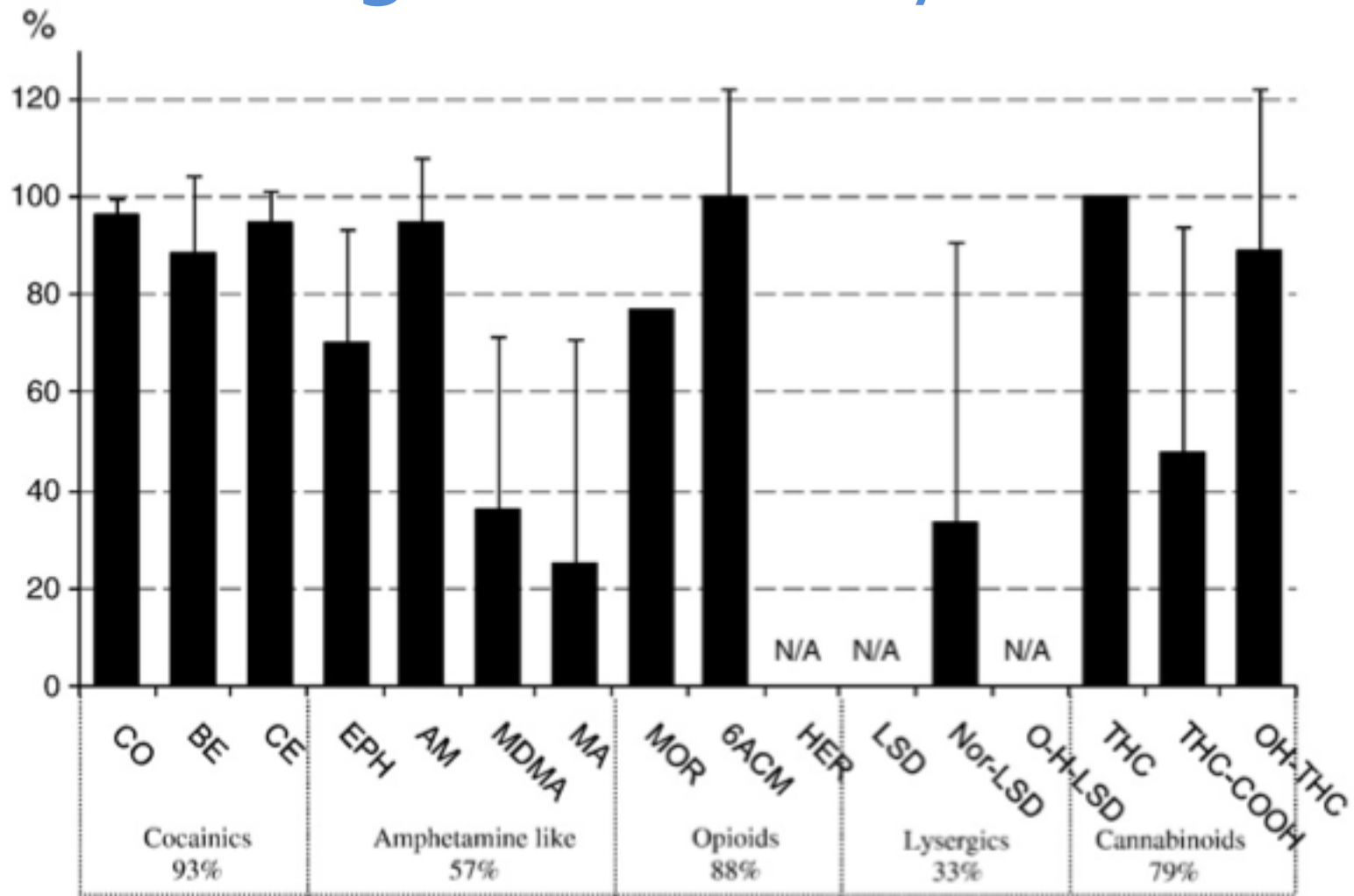


How effective is treatment?

STP effluents (median, ng l⁻¹)

	Spain		Italy	Switzerland	UK	USA	Germany	Ireland
	42 STPs NE Spain ^a	Barcelona, Valencia, Benicassin, Candia ^b	Milan ^c (one week)	Lugano ^c (one week)	Cilfynydd ^d	3 STPs ^e	12 STPs ^f	Dublin ^g
amphetamine	28	1.6	2.6	<LOQ	127	—	—	—
methamphetamine	6	2.3	2.3	<LOQ	—	2	—	—
MDMA	56	60	4.7	4.2	—	0.5	—	—
MDEA	12	—	<LOQ	<LOQ	—	—	—	—
MDA	22	—	1.4	<LOQ	—	—	—	—
cocaine	10	58	<LOQ	11.3	149	—	—	94
BE	90	135	0.57	88	1597	—	49	26.5
nor-BE	—	—	1.8	6.5	—	—	—	—
norcocaine	—	—	<LOQ	0.8	—	—	—	—
cocaethylene	—	2.9	<LOQ	<LOQ	—	—	—	—
ephedrine	—	150	—	—	—	—	—	—
ketamine	5	—	—	—	—	—	—	—
LSD	—	0.45	—	—	—	—	—	—
	5 STPs, NE Spain ^h							
morphine	10.4	20	1.5	59	—	—	40	226
6-acetylmorphine	<LOQ	2.7	<LOQ	<LOQ	—	—	—	—
morphine 3-β-glucuronide	—	—	<LOQ	<LOQ	—	—	—	—
heroin	<LOQ	<LOQ	—	—	—	—	—	—
codeine	35.1	—	<LOQ	144	—	—	85	—
EDDP	7.2	—	22.6	73	—	—	—	58
methadone	9.4	—	9.1	36	—	—	—	—
THC	<LOQ	6.5	—	—	—	—	—	—
THC-COOH	33.7	9.6	0.6	7	—	—	—	—
OH-THC	—	11.05	—	—	—	—	—	—

Average removal by STPs



Surface waters

	surface water (median, ng l ⁻¹)							
	Spain Llobregat river ^a	Italy four rivers ^b	lake water ^b	UK rivers Taff and Ely ^c	Thames ^b	Belgium three rivers ^d	Germany 11 rivers ^e	Ireland two rivers ^f
amphetamine	9	<LOQ	<LOQ	3.5	<LOQ	—	—	—
methamphetamine	1	1	<LOQ	—	<LOQ	—	—	—
MDMA	3	1.1	<LOQ	—	4	—	—	—
MDA	10	1.5	<LOQ	—	3	—	—	—
cocaine	10	1	<LOQ	2	5	13	—	29
BE	50	14	9.7	23	13	53	3	<LOQ
nor-BE	—	1.2	0.3	—	—	—	—	—
norcocaine	—	0.3	<LOQ	—	—	—	—	—
cocaethylene	—	0.1	<LOQ	—	—	—	—	—
ketamine	<LOD	—	—	—	—	—	—	—
LSD	<LOD	—	—	—	—	—	—	—
morphine	Llobregat river ^g 5.2	3.4	3.5	—	8	—	10	<LOQ
6-acetylmorphine	<LOQ	<LOQ	<LOQ	—	—	—	—	—
morphine 3-β-glucuronide	—	<LOQ	<LOQ	—	—	—	—	—
heroin	<LOQ	—	—	—	—	—	—	—
codeine	23	5	7	—	—	—	38	—
EDDP	12	3	5	—	—	—	—	<LOQ
methadone	5.4	2.1	2.5	—	—	—	—	—
THC	<LOQ	—	—	—	—	—	—	—
THC-COOH	24	0.7	<LOQ	—	1	—	—	—

Important considerations

- Level of drug use
- Population demographics
- Cultural practices
- Environment/climate
- Wastewater handling infrastructure
- Drinking water treatment
- Urbanization and population increases

Drugs found in New York tap water: Cause for alarm?

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By David W Freeman Topics News, Food and Drink



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Cocaine, Spices, Hormones Found in Drinking Water



Illicits in tap water

Non-controlled and illicit drugs in tap water from cities of other countries ($n = 26$). Summary of the rate of detection; mean, median and maximum levels as well as the 75th and 95th percentiles. All values are expressed in ng L^{-1} .

Name	No. >LOQ ^a	%Freq.	Mean				Median				Max.	75% percentile ^b	95% percentile ^b
			Global ^c	Europe	Japan	Lat.Am.	Global	Europe	Japan	Lat.Am.			
<i>Non-controlled</i>													
Caffeine	21	81	19	7.0	33	38	8.9	4.1	37	28	146	25	55
Nicotina	23	88	18	5.9	7.0	40	4.4	4.1	7.1	5.7	305	7.1	27
Cotinine	14	54	2.2	0.4	4.5	4.0	0.8	<LOQ	4.6	2.1	14	2.2	7.2
<i>Cocainics</i>													
Cocaine	12	46	0.3	0.1	<LOQ	0.6	<LOQ	<LOQ	<LOQ	0.1	2.9	0.2	1.2
Cocaethylene	3	11	-	<LOQ	-	<LOQ	<LOQ	<LOQ	-	<LOQ	0.4	<LOQ	0.3
Benzoylcegonine	9	35	1.8	0.2	-	4.5	<LOQ	<LOQ	<LOQ	0.9	15	0.8	10
<i>Opiates</i>													
Methadone	5	19	0.1	0.1	-	0.2	<LOQ	<LOQ	-	<LOQ	1.2	<LOQ	0.8
EDDP	15	58	0.3	0.4	0.1	0.4	0.2	0.1	<LOQ	0.3	3.3	0.3	1.5
Fentanyl	0	0	-	-	-	-	-	-	-	-	<LOQ	-	-
<i>Amphetamines</i>													
AMP	0	0	-	-	-	-	-	-	-	-	<LOQ	<LOQ	<LOQ
MDA	4	15	<LOQ	-	-	<LOQ	<LOQ	-	-	<LOQ	1.3	<LOQ	0.8
METH	1	4	<LOQ	-	-	<LOQ	<LOQ	-	-	<LOQ	0.6	<LOQ	<LOQ
MDMA (ecstasy)	4	15	<LOQ	-	-	<LOQ	<LOQ	-	-	<LOQ	0.4	<LOQ	0.3
MDEA	2	8	<LOQ	-	-	<LOQ	<LOQ	-	-	<LOQ	0.4	<LOQ	0.2

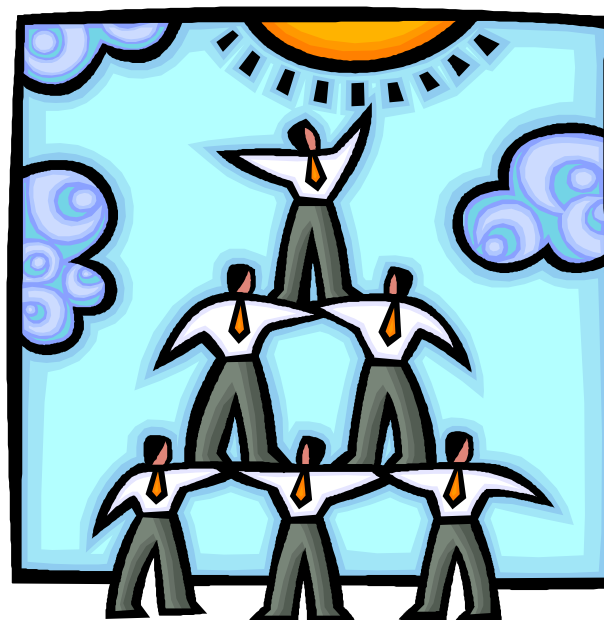
Compounds not identified in any sample: Opiates – morphine, morphine glucuronide, normorphine, codeine, norcodeine, heroin and 6-acetylmorphine. Cannabinoids – THC-COOH, THC and THC-OH. Miscellaneous – LSD, ketamine and PCP.

Summary

- Illicit drugs are part of the urban water cycle
- (High) loads released from all cities
- Sewage treatment seems effective
- Occurrence in surface waters
 - Higher where there is little treatment
- Reported occurrence in finished drinking water
- Perceived risk is probably low

Acknowledgements

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www.niva.no/drugmon

www.emcdda.europa.eu/wastewater-analysis

European collaborative group on illicit drugs in sewage

- 15 labs
- 30 cities (2012)
- 15 M people tested
- Intercalibration
- Workshops
- Publications
- Publicity

- kth@niva.no



Testing the waters: ESF conference

The screenshot shows a web browser window displaying the ESF website. The address bar shows the URL <http://www.esf.org/index.php?id=9600>. The page features the ESF logo and a navigation menu with options like Home, About ESF, Activities, Research Areas, Publications, Media Centre, Jobs, and Contact. The main content area is titled 'ESF Research Conferences' and highlights the 'ESF-LFUI Conference: Testing the waters: first international multidisciplinary conference on detecting illicit drugs in wastewater' held from 06 - 11 May 2013 in Oberurgl, Austria. It lists the chair and co-chair, along with a 'Programme' section. A 'Practical Information' box and a 'Partnership' section are also visible, mentioning the European Science Foundation (ESF) and the Leopold-Franzens-Universität Innsbruck (LFUI). The footer includes social media links and a language selector.