

Znanost
na cesti

In ZRC SAZU



Institut
"Jožef Stefan"
Ljubljana, Slovenija

ARRS
JAVNA AGENCIJA ZA OCHRANO OKOLJA
REPUBLIKE SLOVENIJE

Se tudi reke drogirajo?

prof. dr. Ester Heath, Institut „Jožef Stefan“
Matic Jerman

19. marec 2019 ob 19:00

Javna agencija
za raziskovalno dejavnost
Republike Slovenije

S A T E N A

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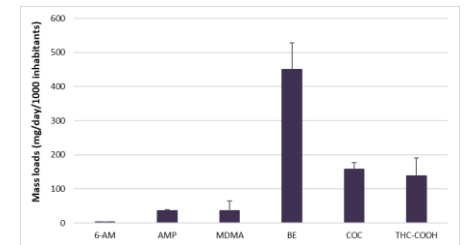
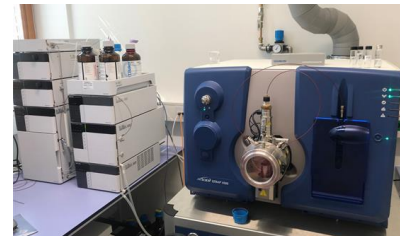
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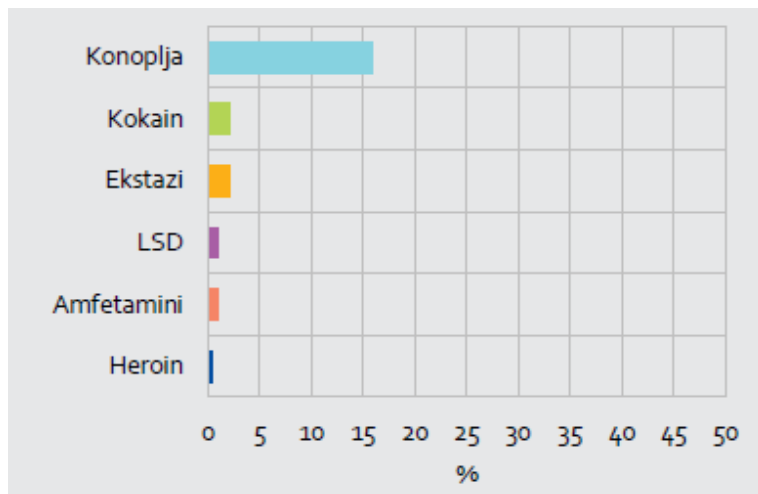
EPIDEMIOLOGIJA ODPADNIH VOD: komplementaren pristop za ocenjevanje uporabe drog v določenih populacijah

prof. dr. Ester Heath



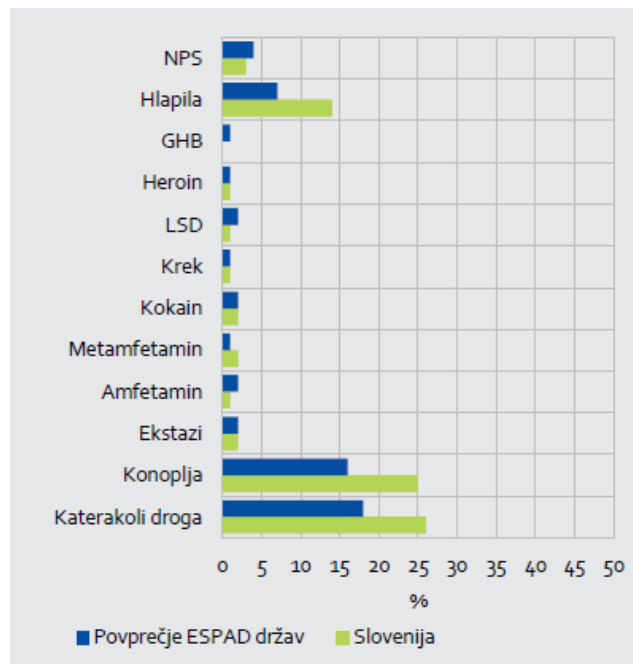
Kako razširjena je uporaba prepovedanih drog v Sloveniji?

Prebivalci Slovenije (15-64 let)



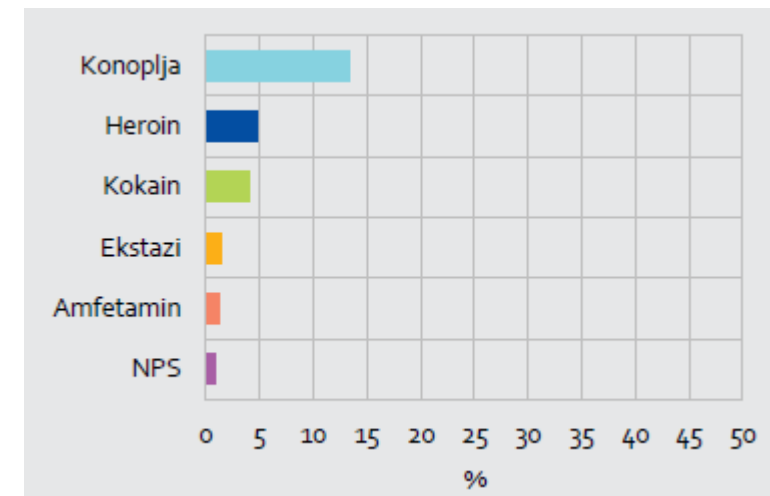
Vir: NIJZ, Raziskava o uporabi alkohola, tobaka in drugih drog med splošno populacijo Slovenije, 2011-2012

15-16 letniki – uporaba droge kadarkoli v življenju



Vir: ESPAD Report 2015

Osebe med prestajanjem zaporne kazni



Vir: NIJZ, Raziskava o uporabi alkohola, tobaka in drugih drog med splošno populacijo Slovenije, 2011-2012

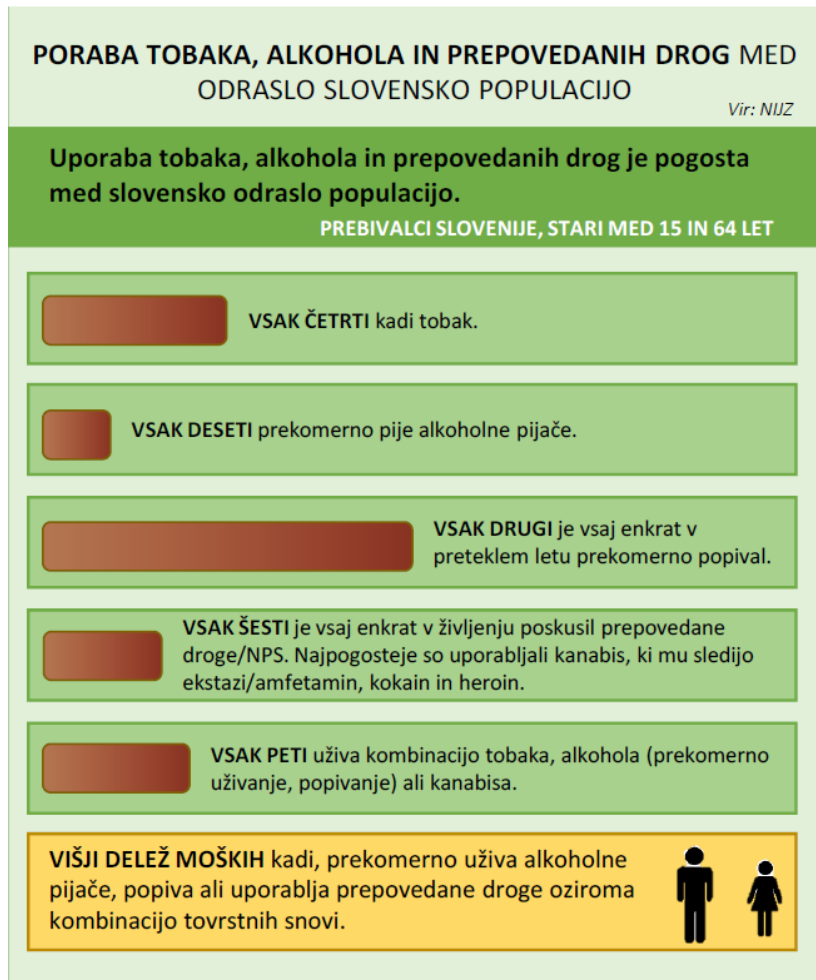
Uporaba – **nočno življenje** (Vir: Raziskavo o evalvaciji storitev testiranja drog, n=554 , DrogArt):

✓ Uporaba v **zadnjem mesecu** med anketiranci:

marihuana (83,4 %) > MDMA (54,2 %) > kokain (38,0 %) > amfetamini (31,8 %) > halucinogeni (11,9 %) > pomirjevala (8,9 %) > GHB/GBL (7,5 %) > 3-MMC (6,8 %) > metamfetamin (5,6 %) > ketamin (5,1 %) > heroin (2,4 %)

✓ Uporaba na **povprečnem partiju**:

marihuana (63,0 %) > MDMA (59,3 %) > amfetamini (32,9 %) > kokain (27,7 %) > 3-MMC (4,9 %) > GHB/GBL (4,3 %) > metamfetamin (3,6 %)



➤ Uporaba in zloraba prepovedanih in dovoljenih drog predstavlja veliko breme za družbo, saj vpliva na javno zdravje, stopnjo kriminala in gospodarstvo → **pomembno spremljati razširjenost uporabe dovoljenih in prepovedanih drog**

➤ **Natančni podatki o uporabi drog** je nujna za vzpostavitev učinkovitih programov preprečevanja in zdravljenja zasvojenosti

OBIČAJNI VIRI PODATKOV:

populacijske/prevalenčne raziskave (ankete),
podatki o zasegih drog,
študije družboslovnih ved (vedenjski dejavniki,
priprava politik za spremembe v družbi),
toksikološki podatki, bolnišnični zapisi....



nepopolni, nezanesljivi, pristranski/negotovi, lahko so etično sporni, nizka odzivnost, časovna zahtevnost

VS.

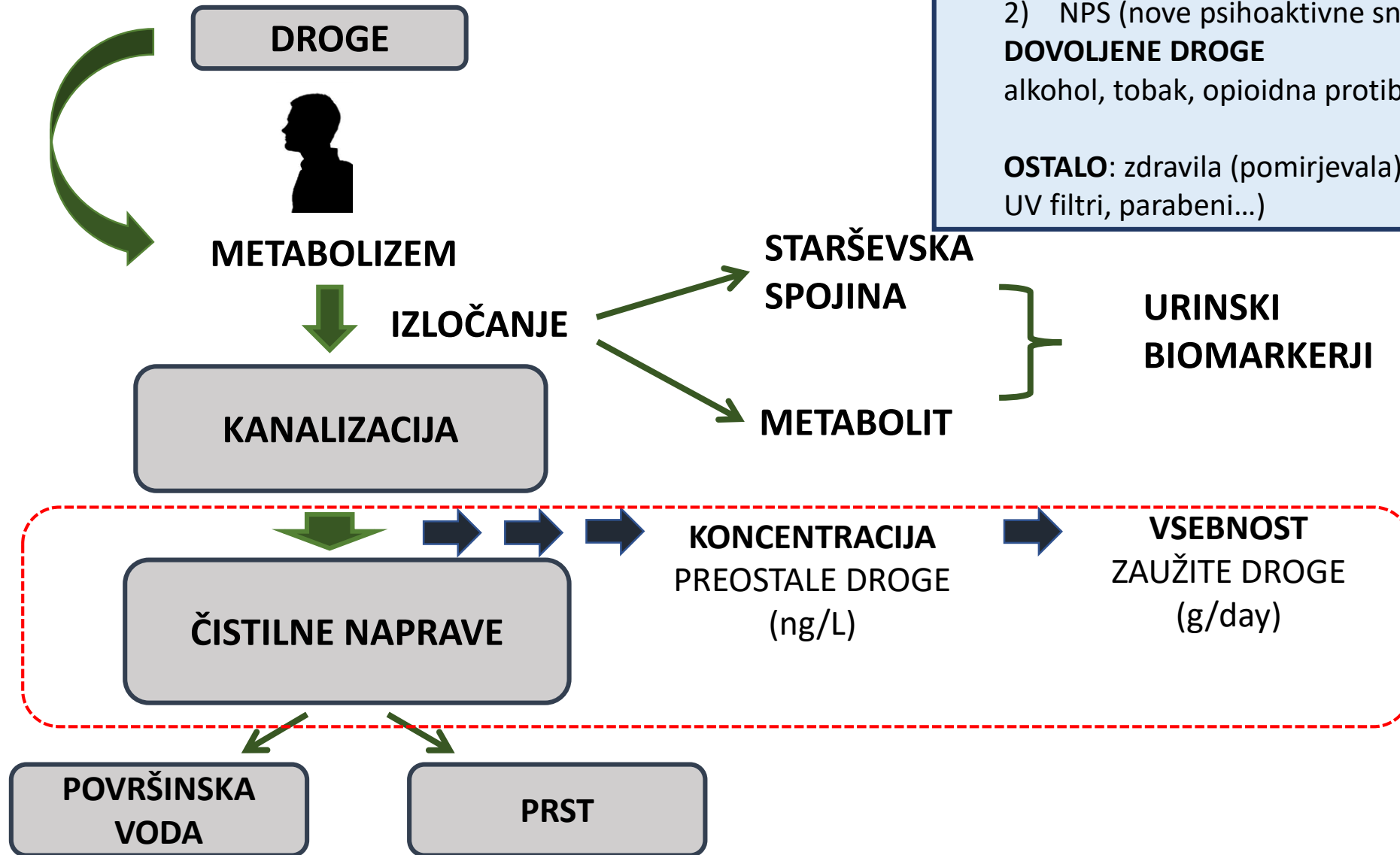
EPIDEMIOLOGIJA ODPADNIH VOD (WBE)

komplementaren pristop
za ocenjevanje uporabe drog v določenih
populacijah (niso potrebna etična dovoljenja,
ocena uporabe drog v realnem času....)



vse bolj razširjen postopek
(Daughton, 2001
Zuccato et al., 2005)

KAJ JE EPIDEMIOLOGIJA ODPADNIH VOD (WBE)?



PREPOVEDANE DROGE

1) Klasične vrste drog: kanabis, kokain, heroin, amfetamin, metamfetamin, ekstazi (MDMA)

2) NPS (nove psihoaktivne snovi)

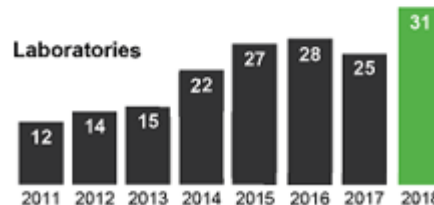
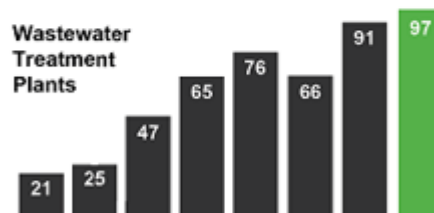
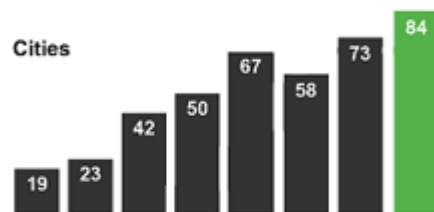
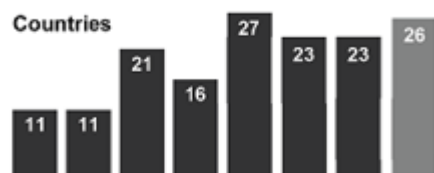
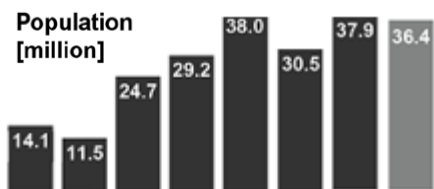
DOVOLJENE DROGE

alkohol, tobak, opioidna protibolečinska zdravila...

OSTALO: zdravila (pomirjevala), onesnažila (pesticidi, UV filtri, parabeni...)

EMCDDA in SCORE: Sewage Analysis CORe group Europe

Evropski center za
spremljanje drog in
zasvojenosti z
drogami
Vladna agencija



1. KOKAIN
2. AMFETAMIN
3. METAMFETAMIN
4. EKSTAZI (MDMA)

IJS: SCORE partner (2017), sodelovanje z IRB, UA,
I. Mario Negri, podpora EMCDDA

1 SLO ČN 2017 – Ljubljana

3 SLO ČN 2018

Ljubljana (360.000 PE)

Domžale-Kamnik (92.000 PE)

Maribor (136.356 PE)

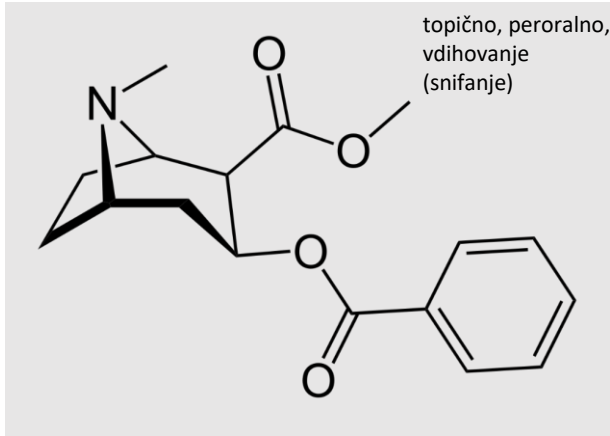


5 SLO ČN 2019

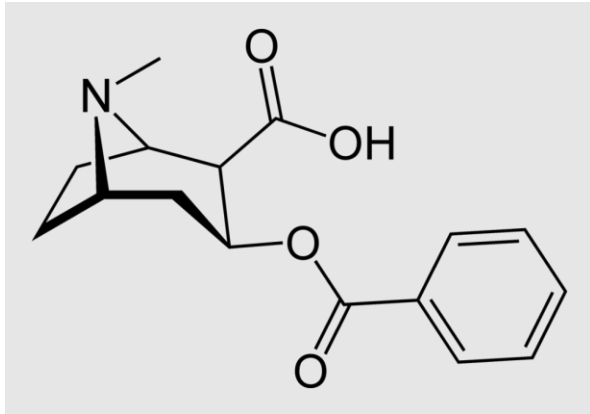
LETNA VZORČENJA: marec/april, 7 zaporednih dni,
VTOK, 24h kompozitni vzorci

Analiza: SCORE partnerji, predhodno interlab

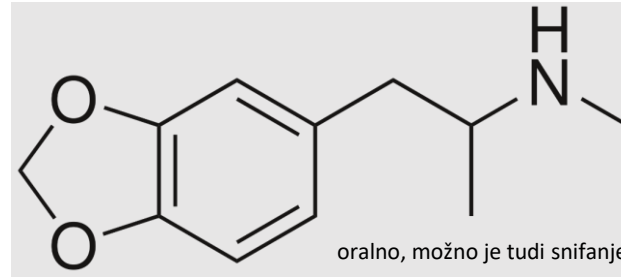




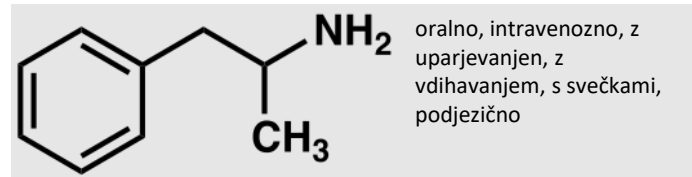
COC: **KOKAIN**



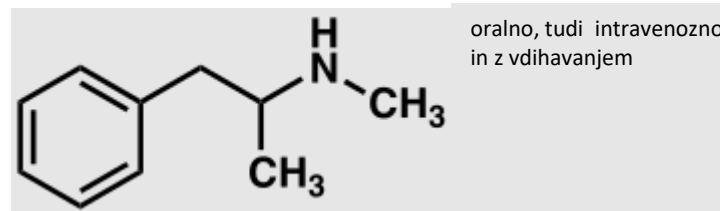
BE: metabolit COC



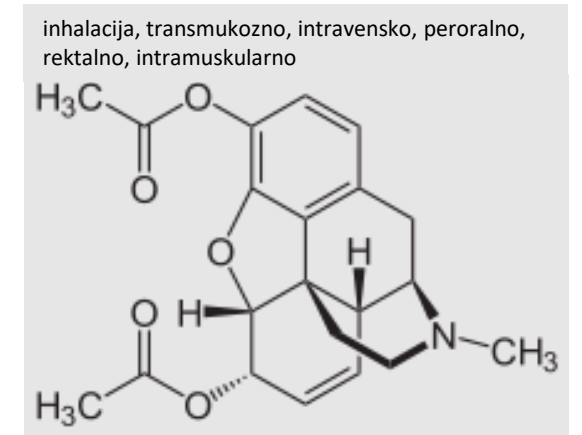
MDMA; tablete oz. **EKSTAZI**
(»x«, »e«, »bombon«, »cukr« itd.)
prah oz. kristali (»molly«, »madam«,
»adam« itd.)



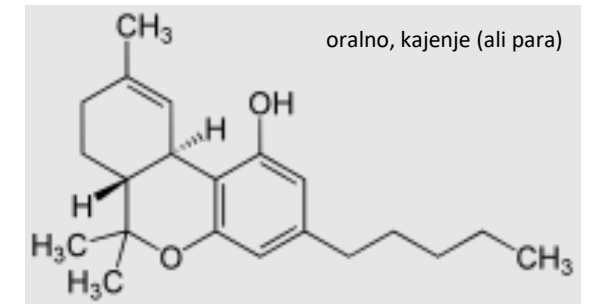
AMP: **AMFETAMIN** („speed“ sulfat AMP)



MAMP: **METAMFETAMIN**
(+caffeine: „ya ba“, „shaboo“)



HEROIN derivat morfina



THC: Tetrahydrokanabinol

Konoplja, Marihuana, Kanabis,
Trava

Zvitek marihuane

Špinel, metla, kanon, doint....

Hašiš (> THC)

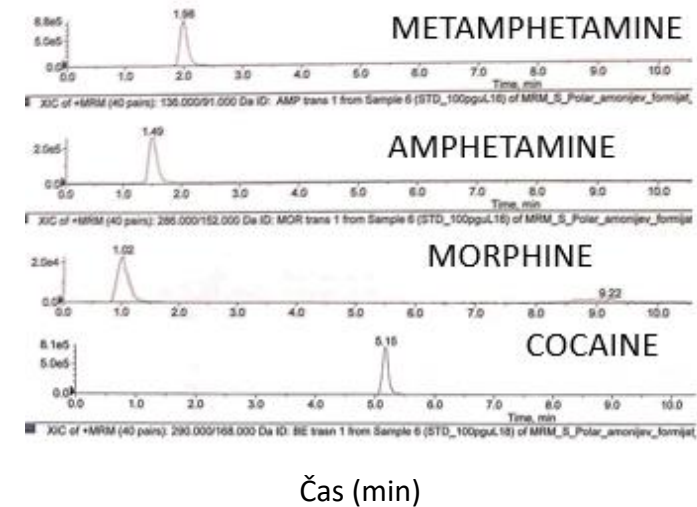
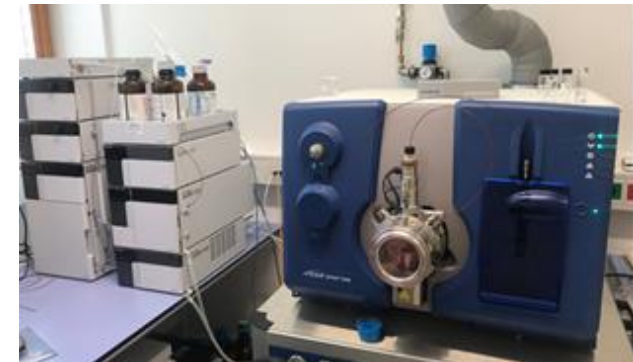
šit, čokolada, plastelin

Kako določamo sledove preiskovanih spojin (t.j. biomarkerjev izbranih drog) v odpadnih vodah?

4. Ločba in analiza

1. Biomarkerji prepovedanih drog

	DROGA	ANALIT (BIOMARKER)	OKRAJŠAVA
PREPOVEDANE DROGE	HEROIN	morfin	MOR
		6-acetilmorfin	6-AM
		morfin-3-β-D-glukuronid	M3G
	KOKAIN	benzoilekgonin	BE
		kokain	COC
	AMFETAMIN	amfetamin	AMP
	METAMFETAMIN	metamfetamin	MAMP
EKSTAZI (MDMA)	3,4-metilendioksimetamfetamin	MDMA	
KANABIS	karboksi – THC (tetrahydrocannabinol)	THC-COOH	
		hidroksi - THC	THC-OH



LC-MS/MS: kromatogram izbranih urinskih biomarkerjev drog (standardne raztopine)

2. Vzorčenje

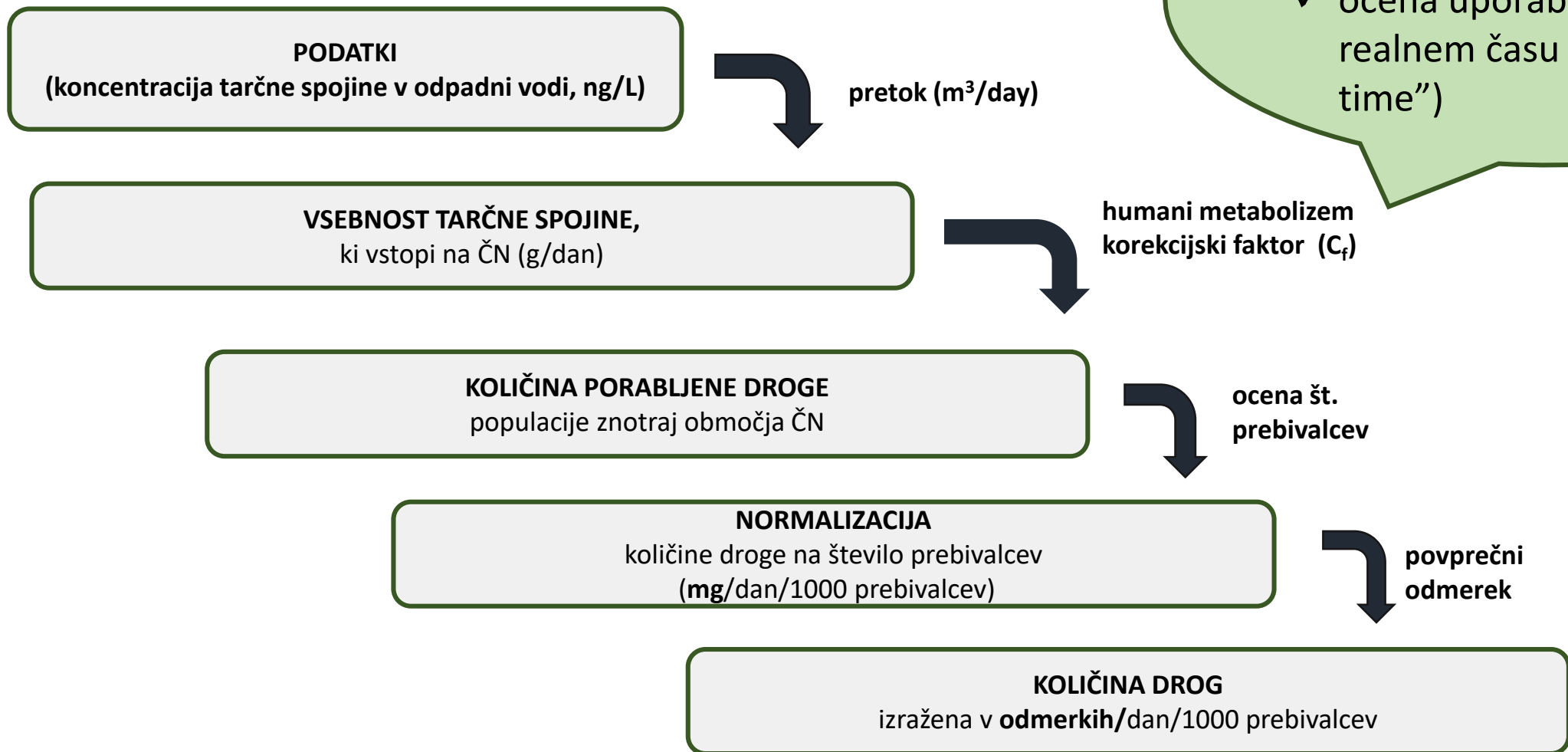


3. Ekstrakcija in koncentriranje



SPE (ekstrakcija na trdni fazi)

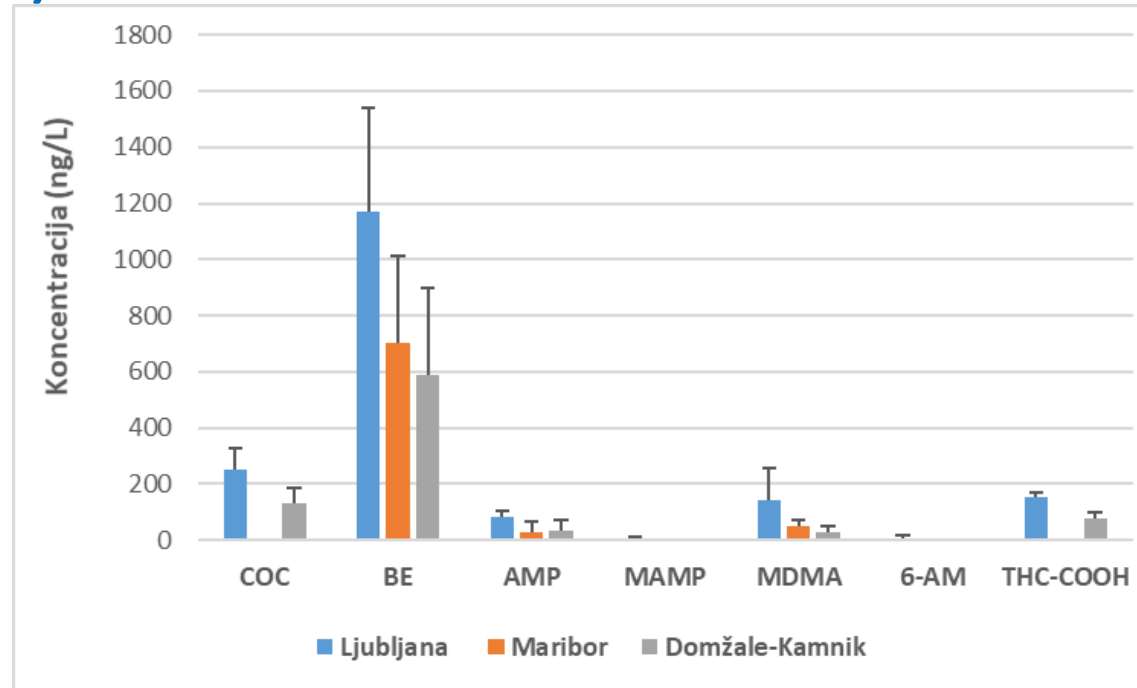
Kako obdelamo podatke?



Prednosti WBE:

- ✓ objektivnost
- ✓ ocena uporabe drog v realnem času (angl. "real-time")

REZULTATI: Koncentracije izbranih urinskih biomarkerjev v slovenskih odpadnih vodah (ng/L, 2018)



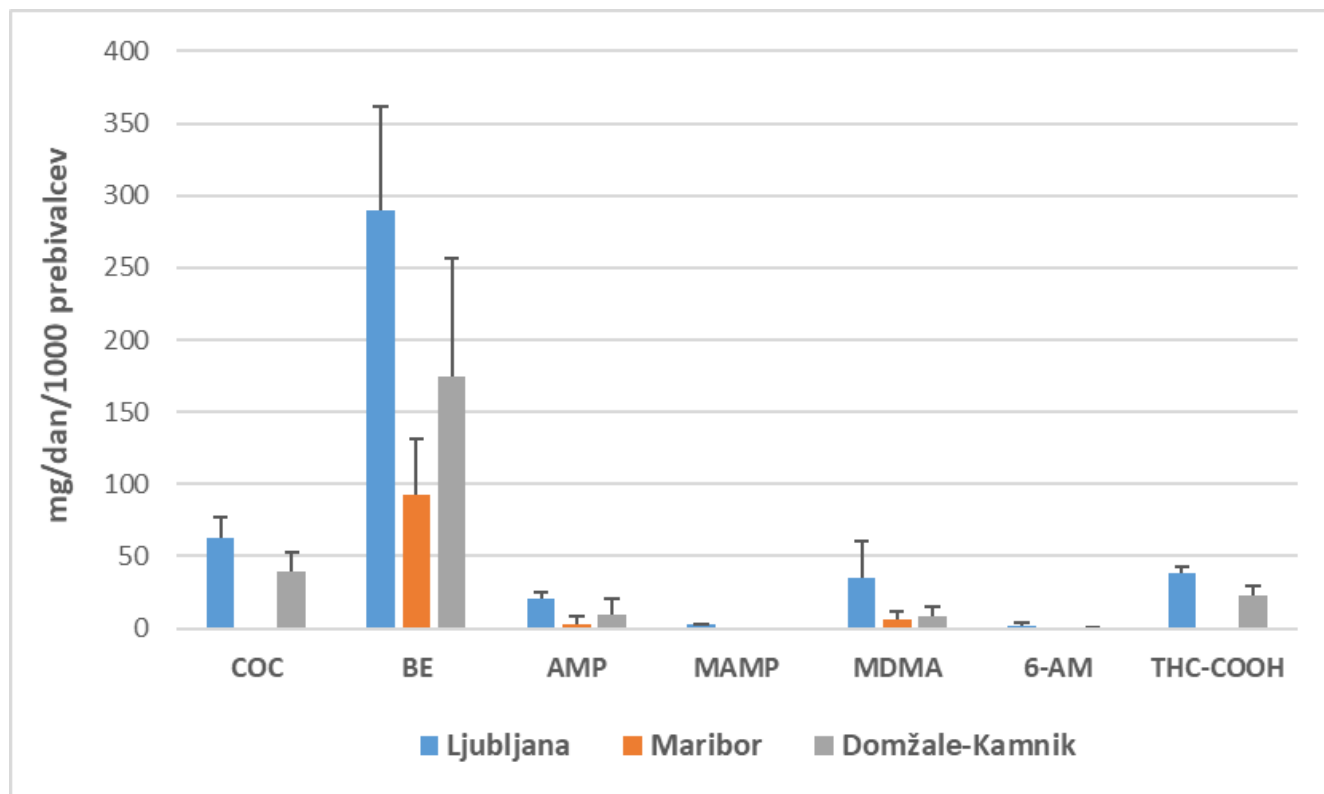
Povprečna koncentracija biomarkerjev ilegalnih drog (7 dni)

- ✓ **Kokain** (51-360 ng/L) in njegov glavni metabolit **BE** (benzoilekgonin, 215-1720ng/L) → izmerjena v najvišjih koncentracijah
- ✓ Prav tako visoke koncentracije **THC-COOH** (37-170 ng/L)
- ✓ Nižje koncentracije **drog amfetaminskega tipa** (AMP: 2-117 ng/L, MDMA: 6-322 ng/L)
- ✓ **MAMP** → detektiran v manj kot 30 % vzorcev (< 15 ng/L)
- ✓ **6-AM** (6-acetilmorfin) → večinoma pod mejo detekcije

Kako primerjamo različna mesta med seboj?

- ✓ **Obremenitev** (angl. **mass loads**) izračunana na podlagi *koncentracije* biomarkerjev in *dnevnih pretokov* odpadne vode
- ✓ Za primerjavo podatkov pridobljenih za različne ČN/mesta, se masna obremenitev normalizira glede na populacijo/PEs

→ **normalizirana obremenitev**

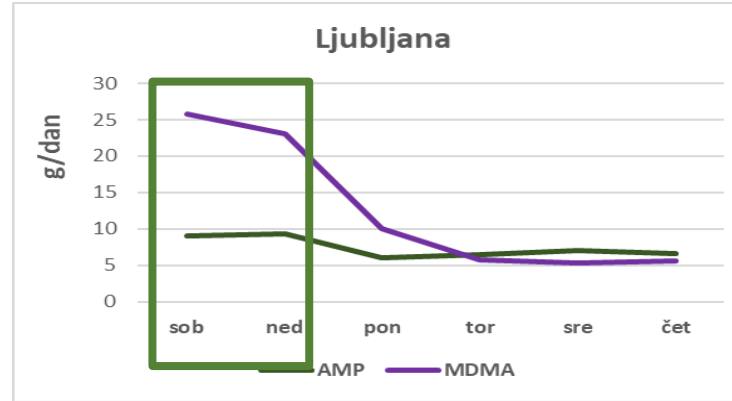
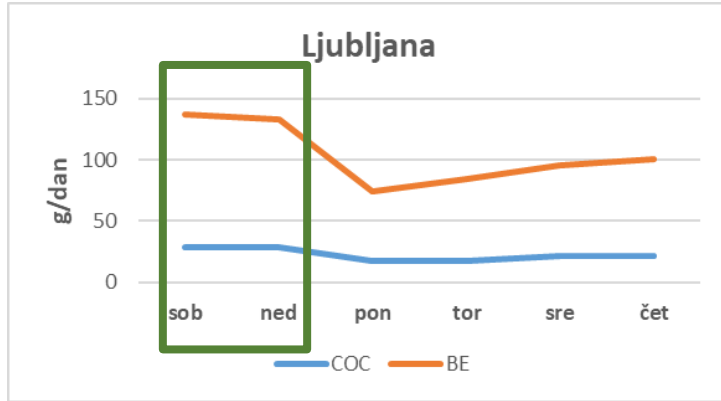


Normalizirana obremenitev urinarnih biomarkerjev prepovedanih drog

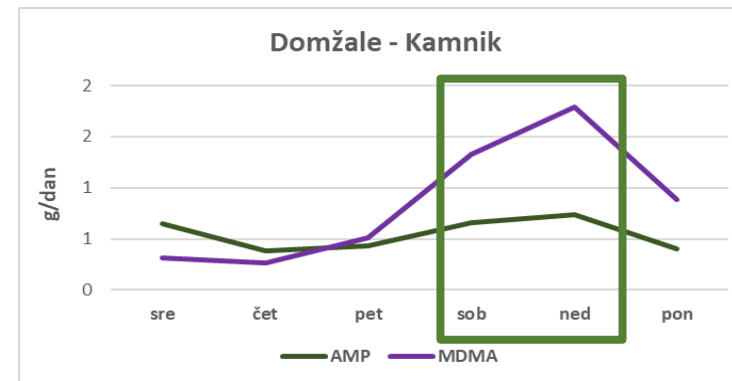
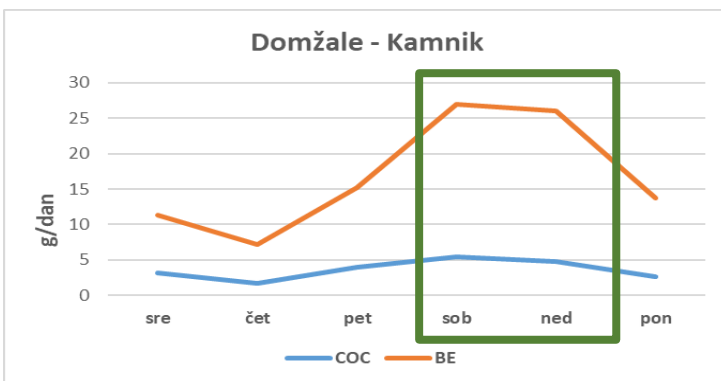
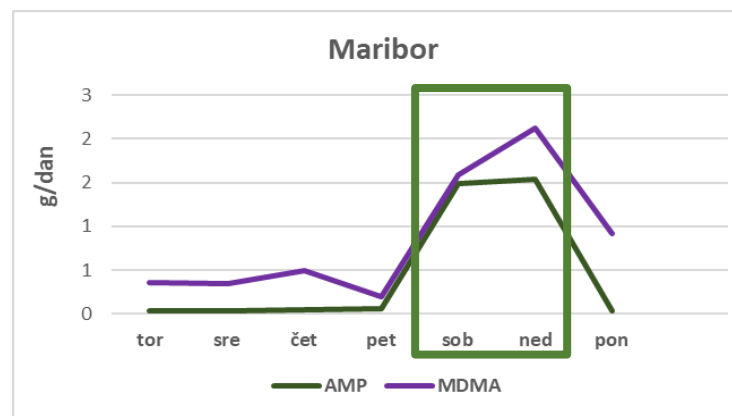
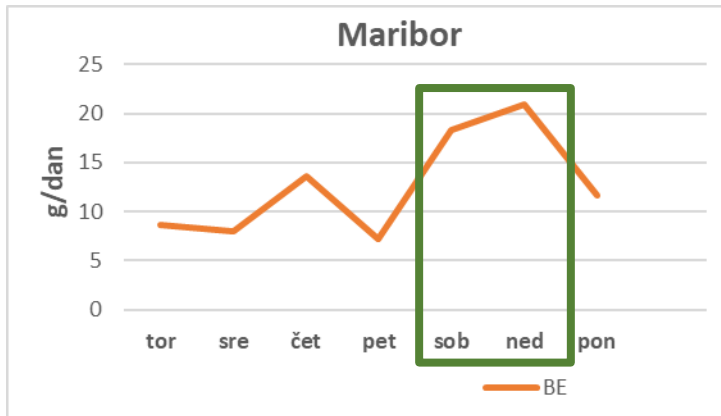
- ✓ **Kokain** (18-80 mg/dan/1000 prebivalcev) in njegov metabolit, **BE** (53-382 mg/dan/1000 prebivalcev) → določena najvišja obremenitev
- ✓ Prav tako visoka obremenitev z **THC-COOH** (13-44 mg/dan/1000 prebivalcev)
- ✓ Nižja masna obremenitev **drog amfetaminskega tipa** (AMP: <1 - 33 mg/dan/1000 prebivalcev, MDMA: 1.4 -72 mg/dan/1000 prebivalcev)
- ✓ **6-AM** detektiran le v enem vzorcu - Ljubljana (< 8 mg/dan/1000 prebivalcev)
- ✓ **MAMP** → nizka obremenitev (< 3mg/dan/1000 prebivalcev)

Kakšne so dnevne variacije obremenitev stimulativnih drog po ČN

LEVO: COC, BE



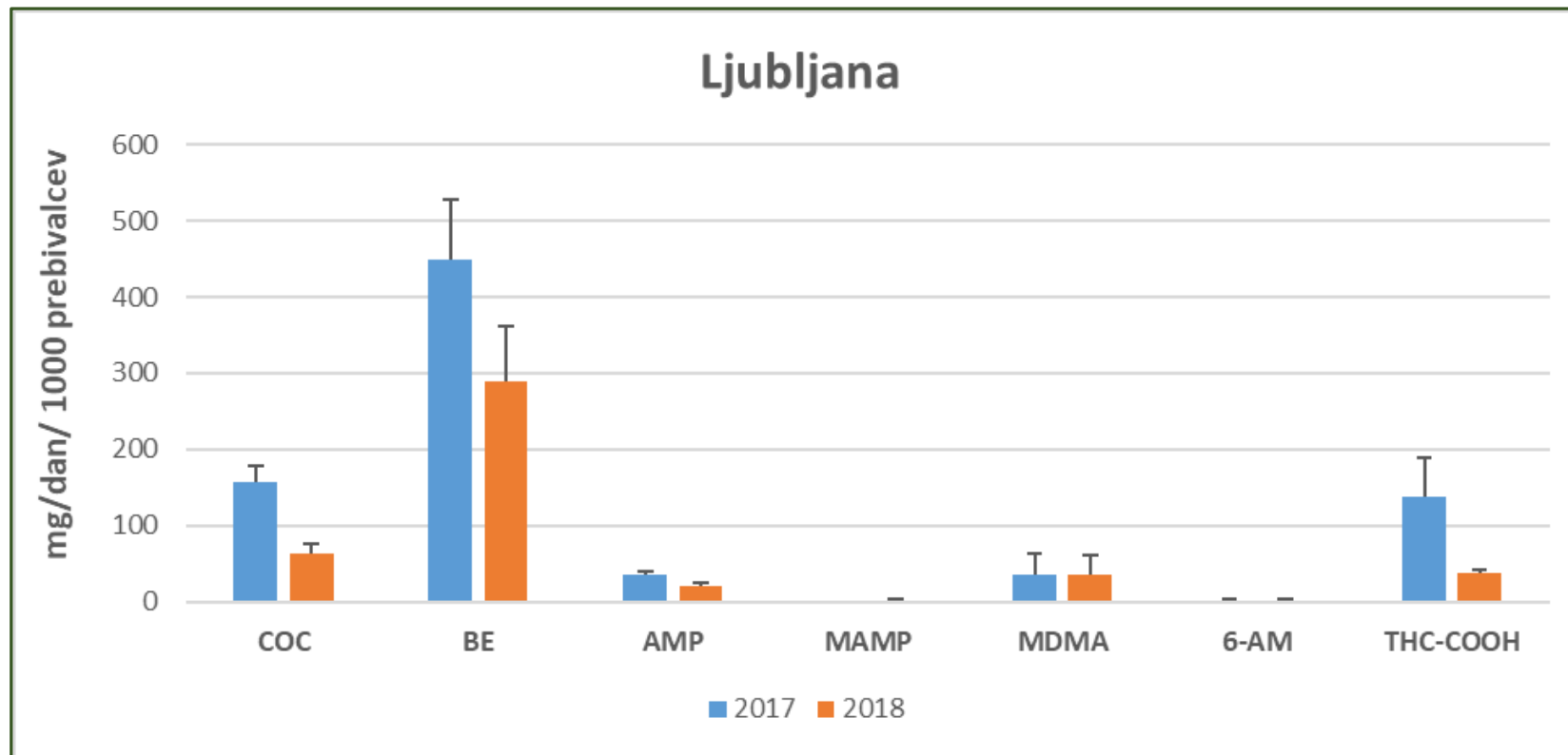
DESNO: AMP, MDMA



➡ Vikend - povečana uporaba stimulativnih drog (COC, AMP, MDMA) (THC ni stimulativna droga)

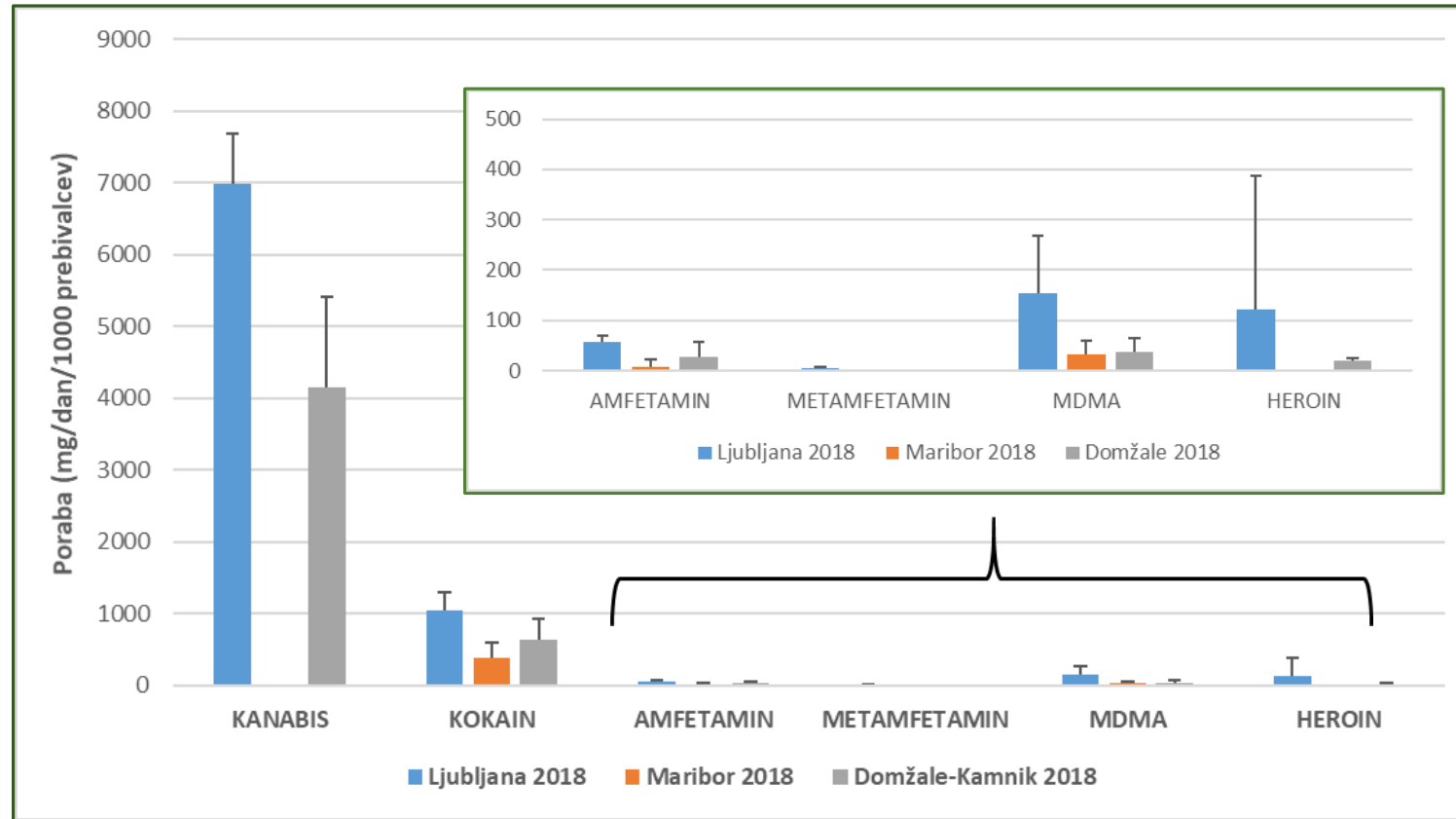
Dnevne variacije obremenitev stimulativnih drog

Normalizirana obremenitev – Ljubljana 2017 vs. 2018 (biomarkerji)



Primerjava normaliziranih obremenitev izbranih biomarkerjev za leti
2017 in 2018

Uporaba prepovedanih drog (mg/dan/1000 prebivalcev)



DROGA	Biomarkerji za oceno uporabe	Konverzijski faktor
Heroin	6-AM	86.9 ^a
Kokain	BE	3.6 ^b
Amfetamin	AMP	2.8 ^c
Metamfetamin	MAMP	2.44 ^c
MDMA	MDMA	4.4 ^c
THC (Kanabis)	THC-COOH	182 ^c

Ocena uporabe prepovedanih drog izražena kot mg/dan/1000 prebivalcev

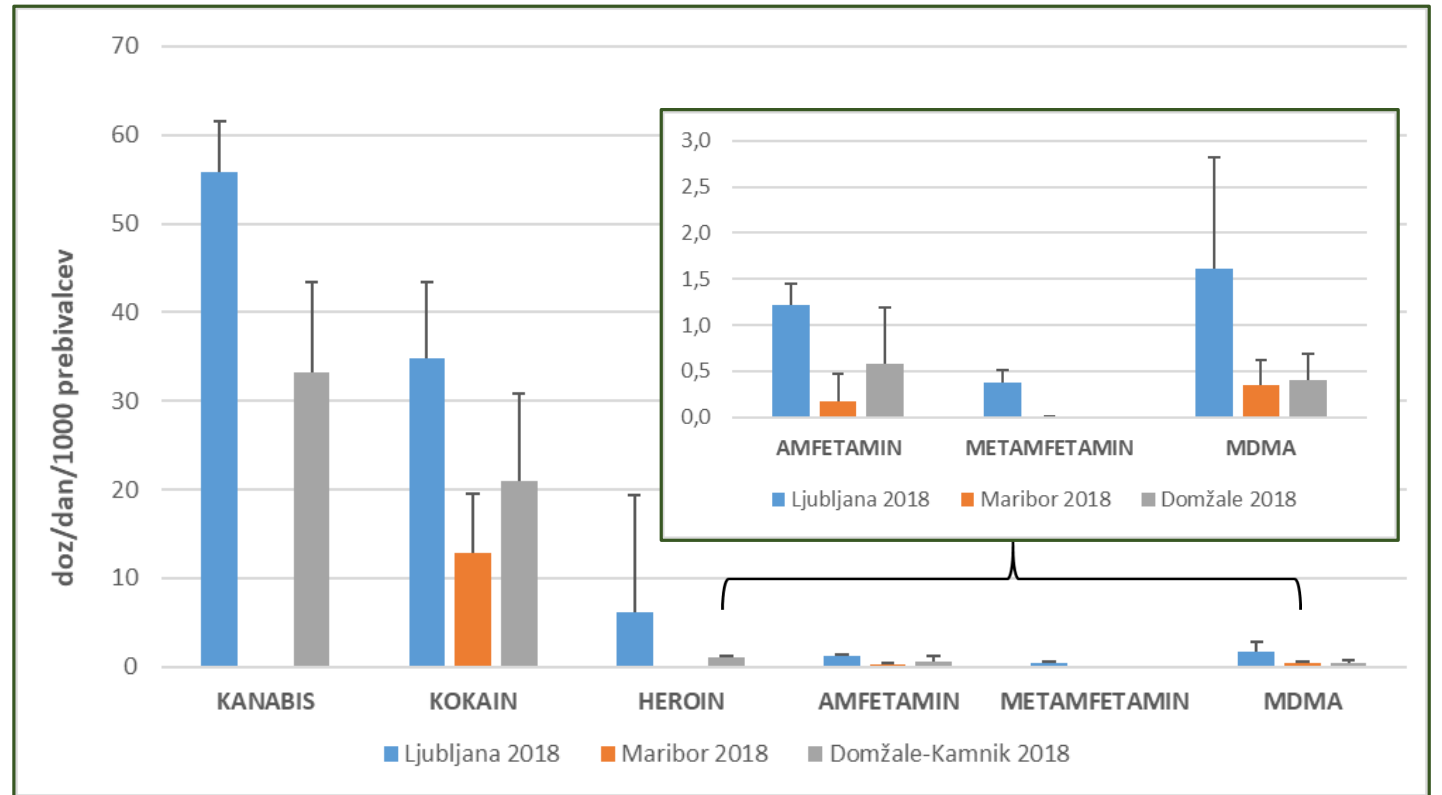
^avan Nuijs et al., 2011; ^bCastiglioni 2013; ^cGracia-Lor et al. 2016

Uporaba prepovedanih drog (odmerek/dan/1000 prebivalcev)

DROGA	Biomarkerji za oceno uporabe	Povprečni odmerek (mg)
Heroin	6-AM	20 ^a
Kokain	BE	30 ^a
Amfetamin	AMP	47.5 ^a
Metamfetamin	MAMP	15 ^a
MDMA	MDMA	95 ^a
THC (Kanabis)	THC-COOH	125 ^b

^aDrogArt;

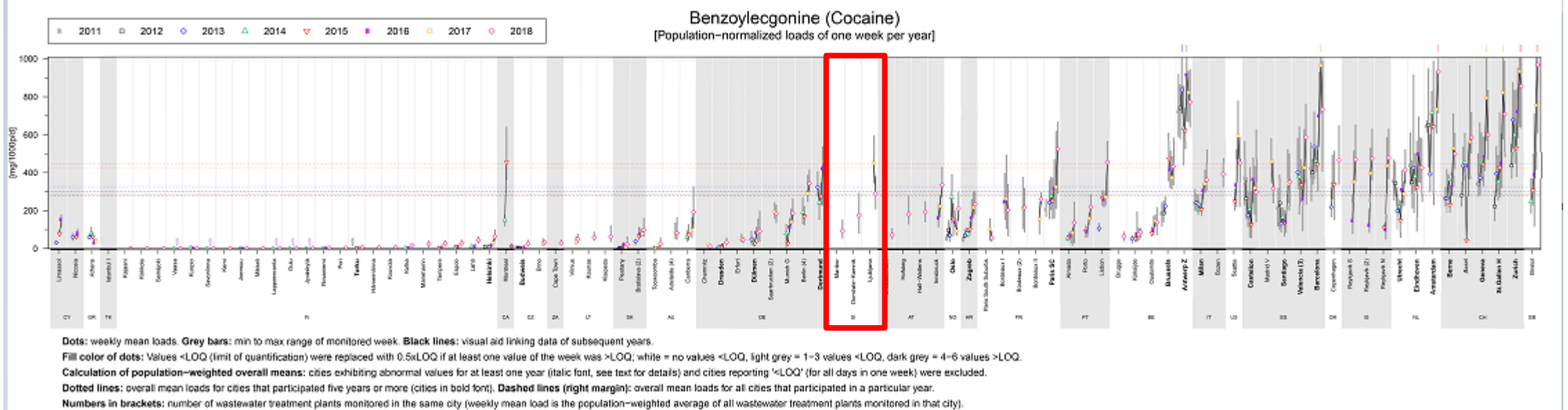
^bZuccato et al., 2008



Ocena uporabe prepovedanih drog izražena kot odmerek/dan/1000 prebivalcev

BENZOILEKGONIN (BE)

Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta

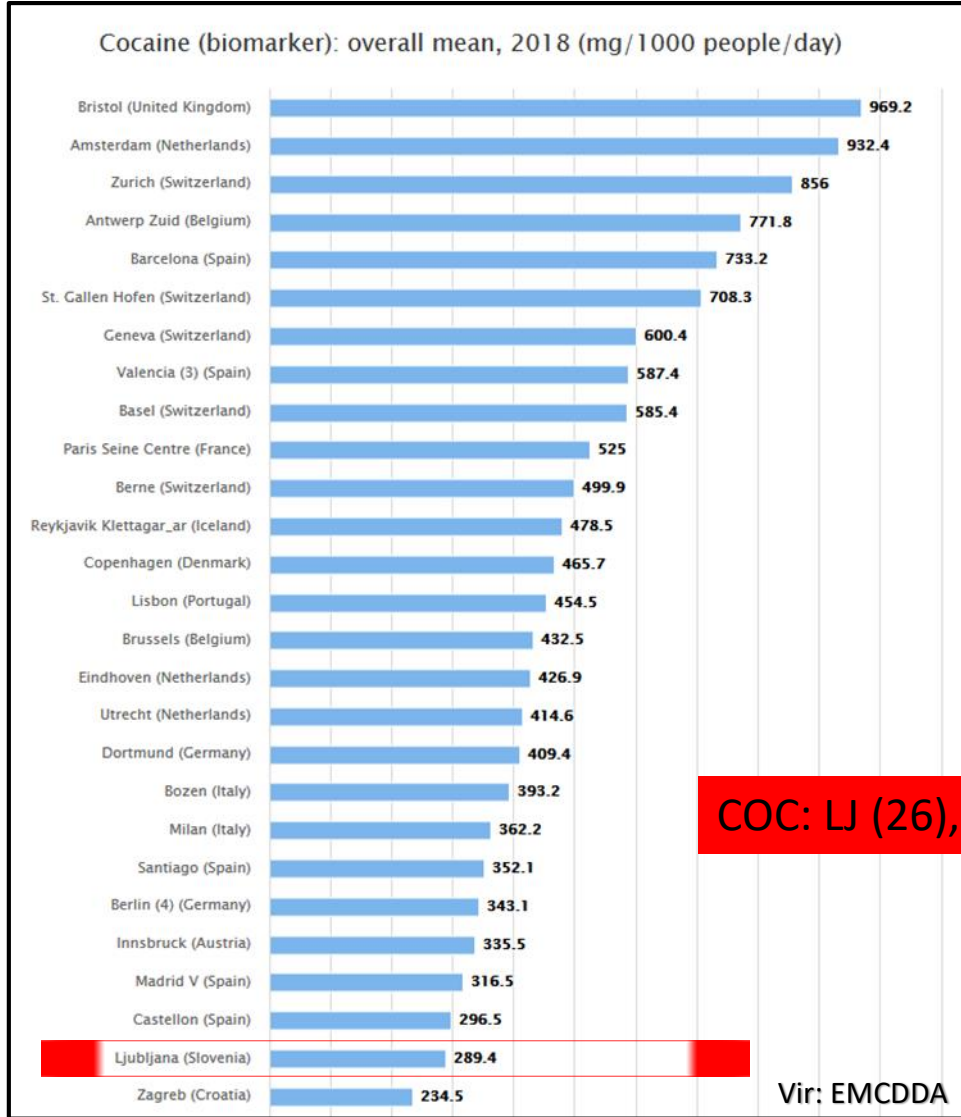


Vir: SCORE group

- ✓ Slovenija je po uporabi **COC** v sredini razpona sodelujočih držav v letu **2018**
- ✓ Normalizirana obremenitev → **pod celokupnim povprečjem** mest, ki v projektu sodelujejo 5 ali več let

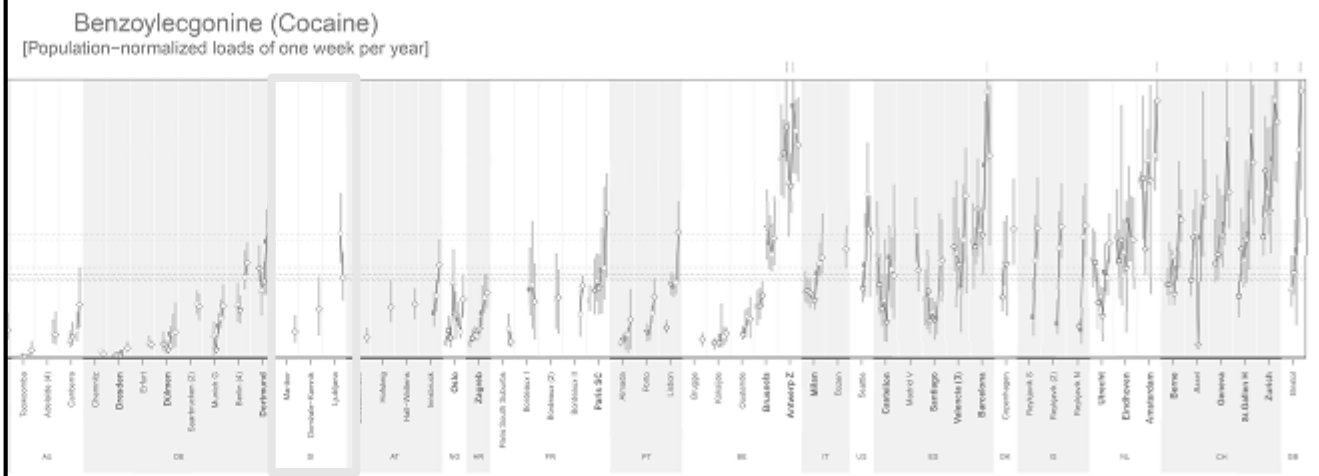
BENZOILEKGONINE (BE)

Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta (2018)



Vir: EMCDDA

COC: LJ (26), DK(34), MB (38)

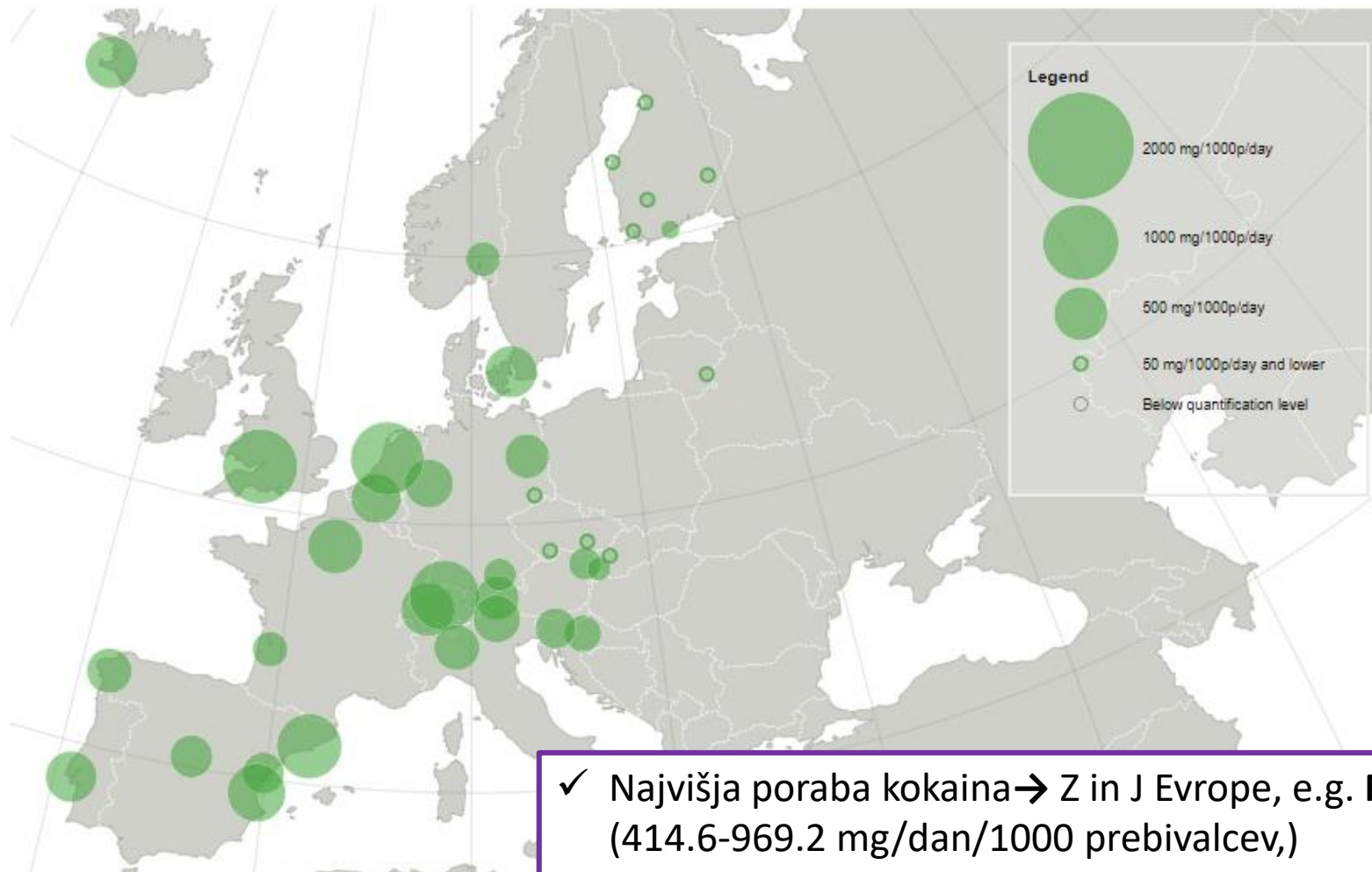


White = no values <LOQ, light grey = 1-3 values <LOQ, dark grey = 4-6 values >LOQ.
Details and cities reporting '<LOQ' (for all days in one week) were excluded.
Overall mean loads for all cities that participated in a particular year.
Lighted average of all wastewater treatment plants monitored in that city.

Vir: SCORE group

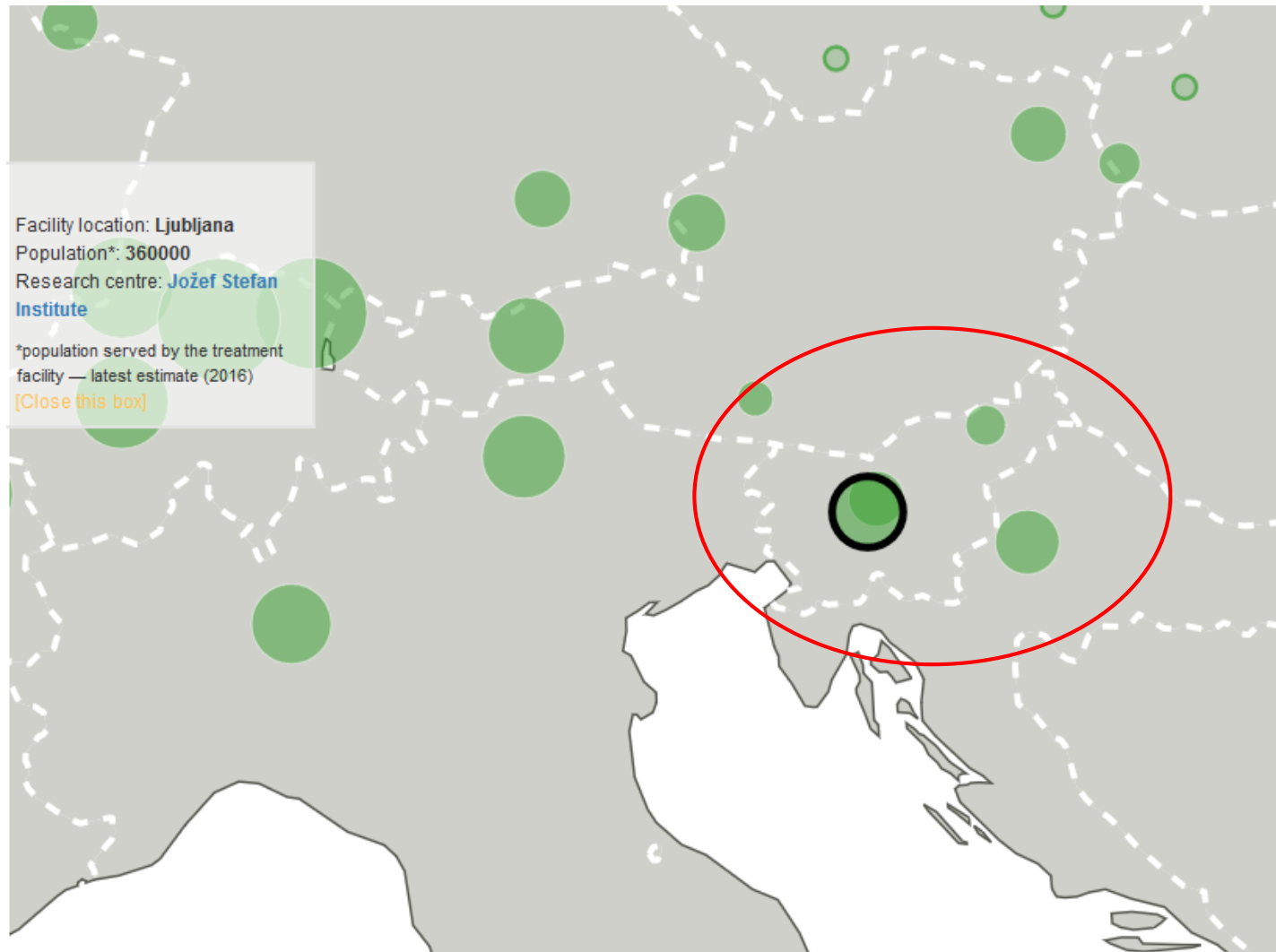
lini razpona sodelujočih držav v letu 2018
→ pod celokupnim povprečjem mest, ki v kampaniji

BENZOILEKGONINE - normalizirana obremenitev (2018)



- ✓ Najvišja poraba kokaina → Z in J Evrope, e.g. **NL, CH, UK, ES in BE** (414.6-969.2 mg/dan/1000 prebivalcev),
- ✓ Nižje vrednosti za BE za **Ljubljano** (289.4 mg/dan/1000 prebivalcev), še nižje za **Domžale-Kamnik** (174.8 mg/dan/1000 prebivalcev) in **Maribor** (92.6 mg/day/1000 prebivalcev)

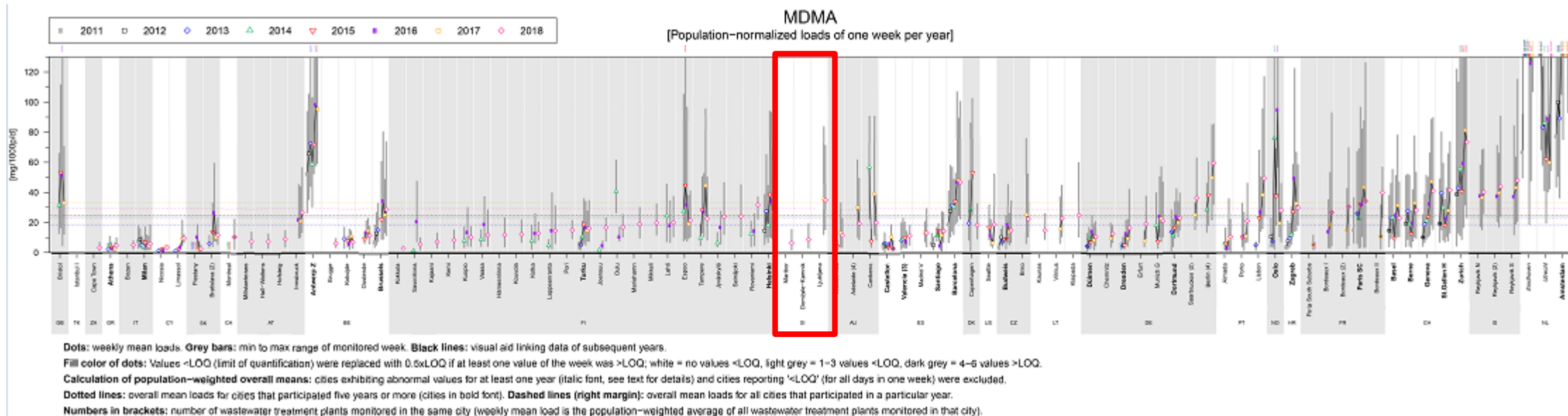
BENZOILEKGONIN - normalizirana obremenitev (2018)



Vir: <http://www.emcdda.europa.eu/topics/pods/waste-water-analysis>

MDMA

Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta (2018)

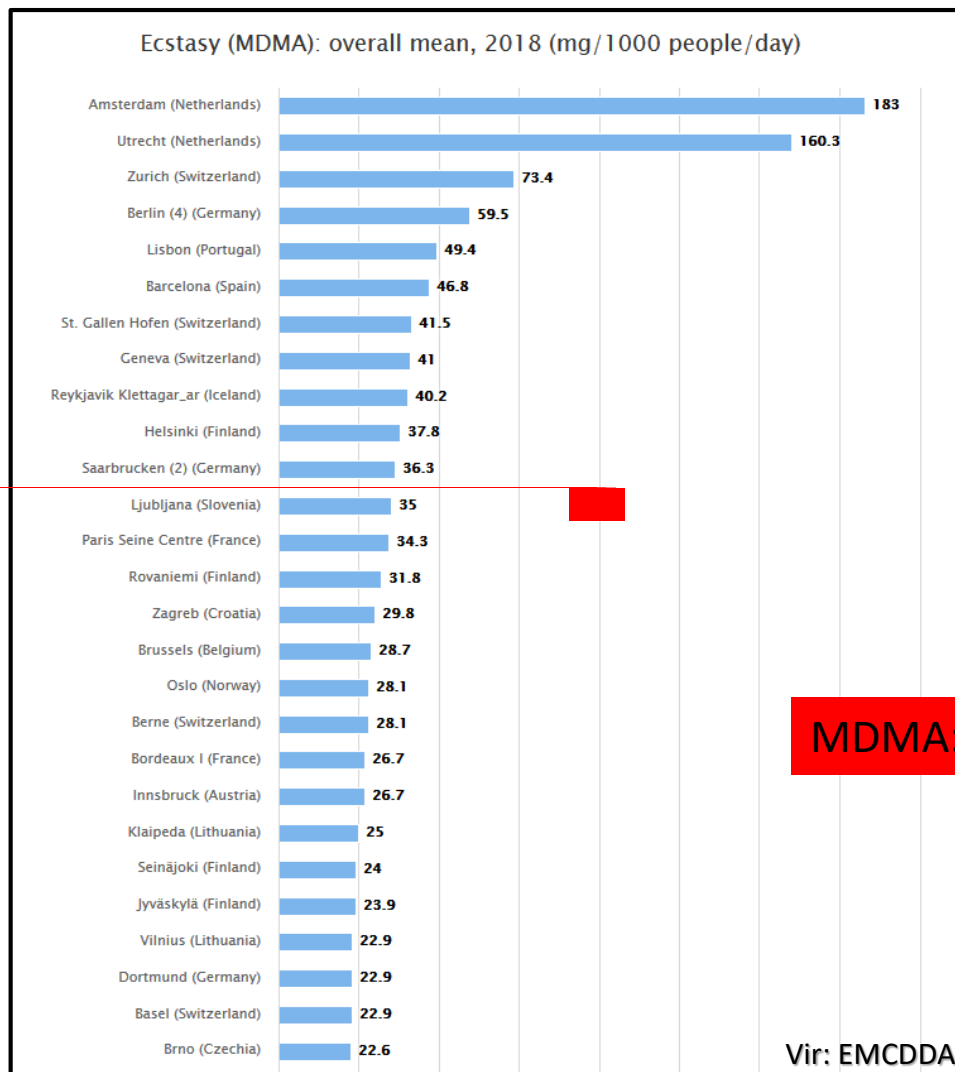


Vir: SCORE group

- ✓ Slovenija je po uporabi **MDMA** v sredini razpona sodelujočih držav v letu **2018**
- ✓ Normalizirana obremenitev → **pod celokupnim povprečjem** mest, ki v projektu sodelujejo 5 ali več let → izjema: masna obremenitev za **Ljubljano**

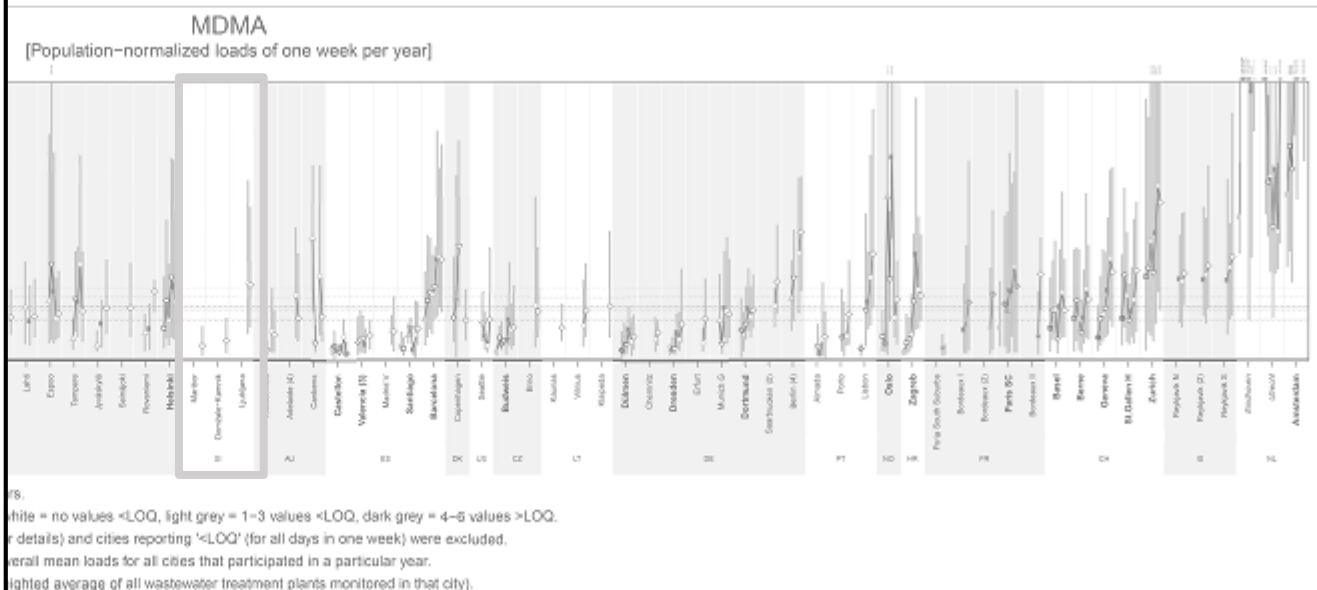
MDMA

Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta (2018)



Vir: EMCDDA

MDMA: LJ (12), DK (59), MB (65)



ona sodelujočih držav v letu 2018
okupnim povprečjem mest, ki v kampanji
masna obremenitev za Ljubljano

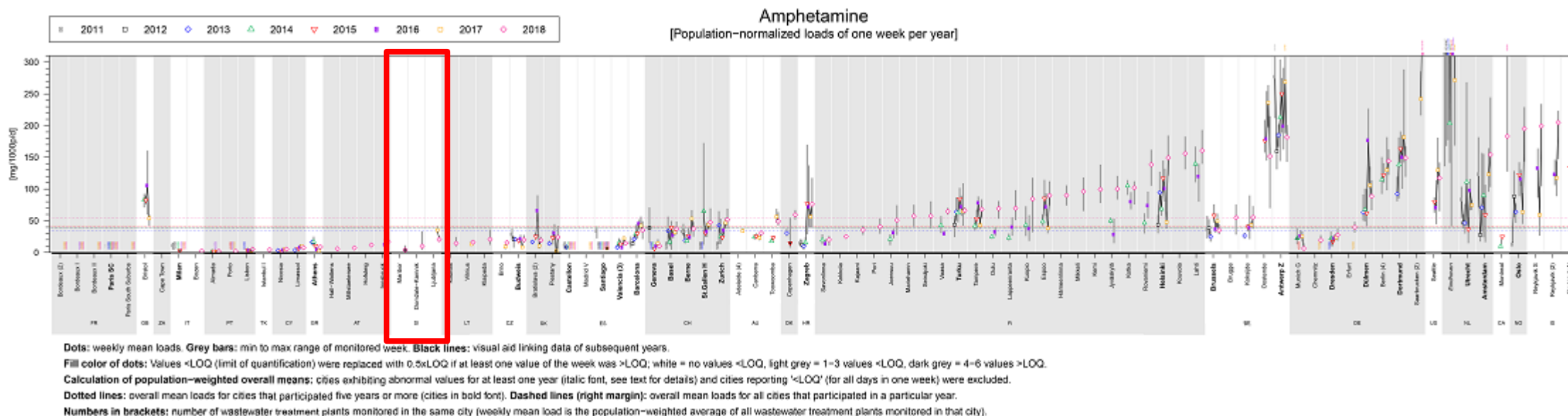
MDMA - normalizirana masna obremenitev (2018)



- ✓ Najvišje obremenitve v **DE, NL in CH**
- ✓ **Ljubljana:** 35 mg/dan/1000 prebivalcev
- ✓ **Domžale-Kamnik in Maribor:** nižje obremenitve: 6.3 - 8.6 mg/dan/1000 prebivalcev)

AMFETAMIN

Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta (2018)

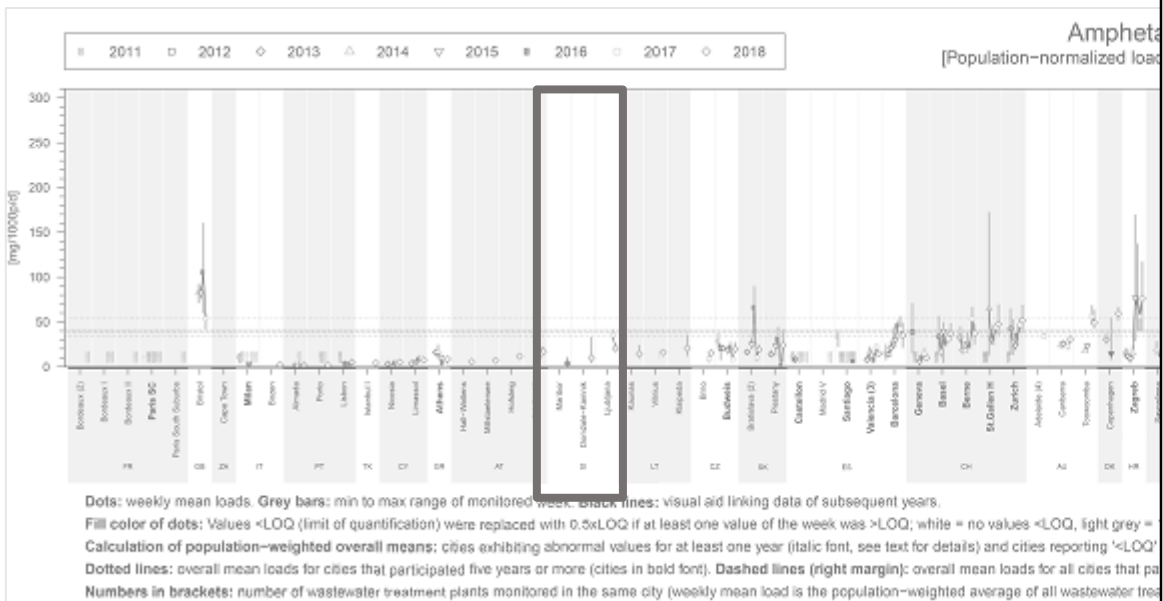


Vir: SCORE group

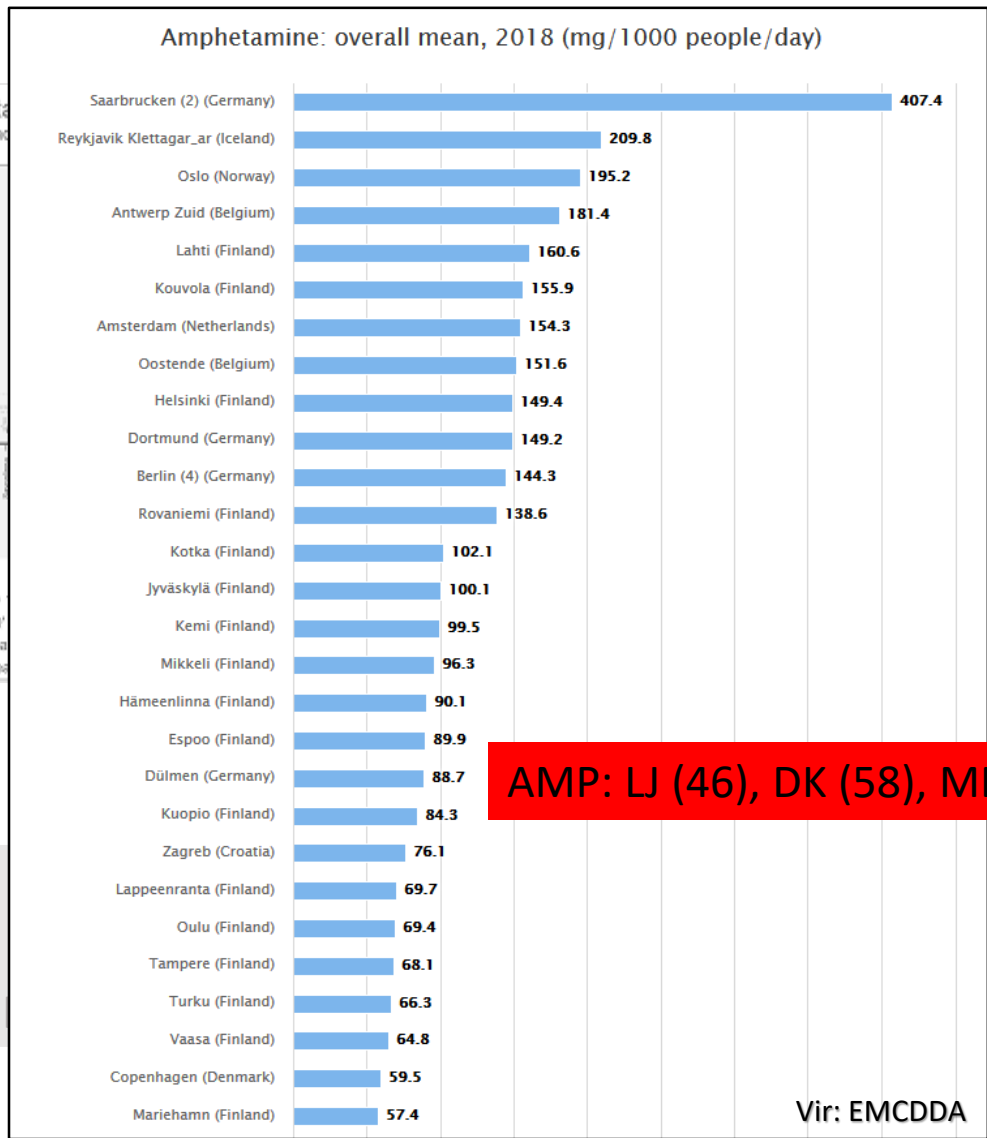
- ✓ Slovenija je po uporabi **AMP** v spodnjem delu razpona sodelujočih držav v letu **2018**
- ✓ Normalizirana masna obremenitev → **pod celokupnim povprečjem** mest, ki v projektu sodelujejo 5 ali več let

AMFETAMIN

Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta (2018)



Dots: weekly mean loads. Grey bars: min to max range of monitored week. Black lines: visual aid linking data of subsequent years.
 Fill color of dots: Values <LOQ (limit of quantification) were replaced with 0.5xLOQ if at least one value of the week was >LOQ; white = no values <LOQ, light grey = <LOQ.
 Calculation of population-weighted overall means: cities exhibiting abnormal values for at least one year (italic font, see text for details) and cities reporting <LOQ' (light grey).
 Dotted lines: overall mean loads for cities that participated five years or more (cities in bold font). Dashed lines (right margin): overall mean loads for all cities that participated five years or more.
 Numbers in brackets: number of wastewater treatment plants monitored in the same city (weekly mean load is the population-weighted average of all wastewater treatment plants).

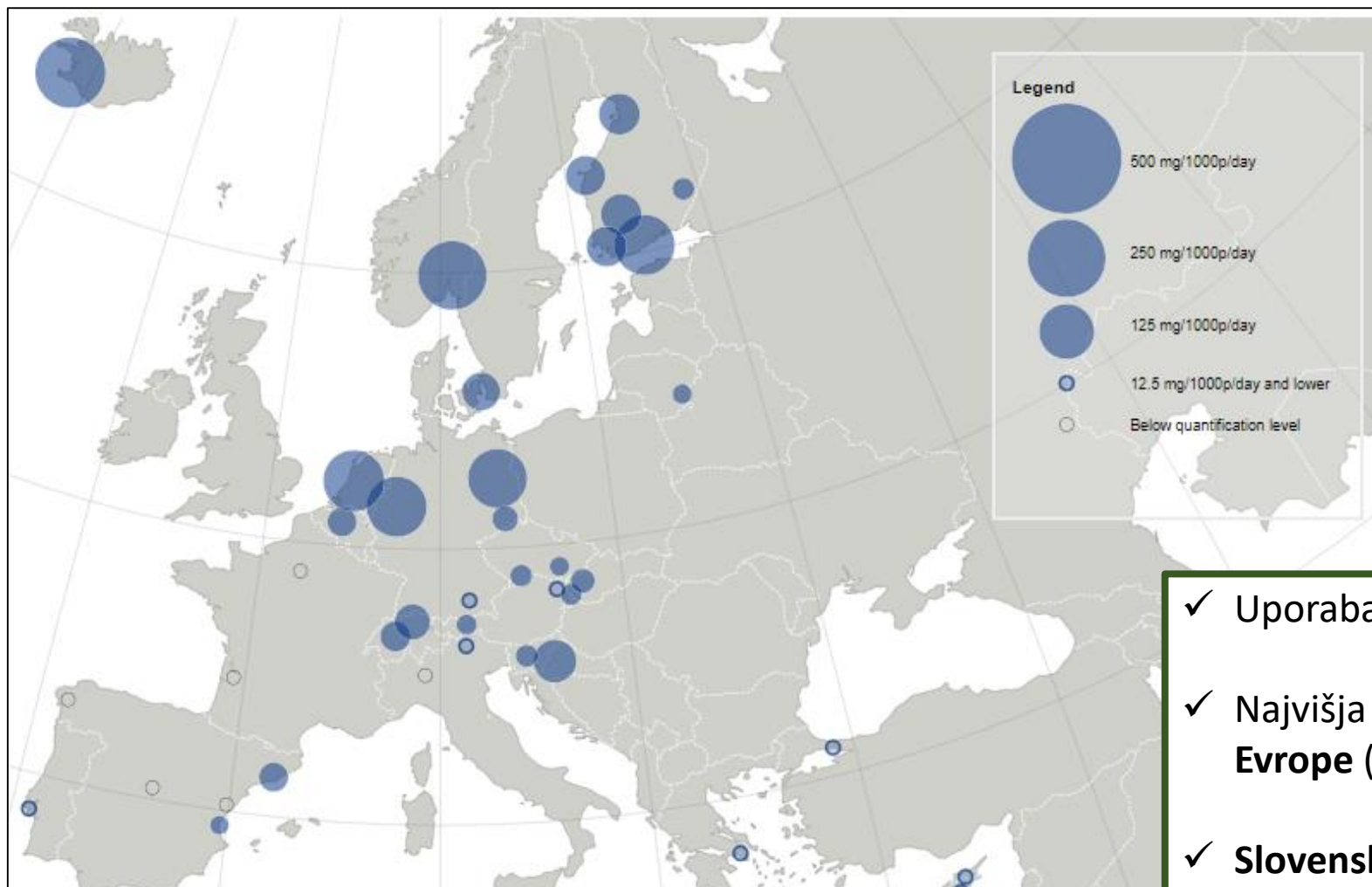


- ✓ Slovenija je po uporabi AMP v spodnjem delu razpona
- ✓ Normalizirana masna obremenitev → pod celokupnim

č let

Vir: EMCDDA

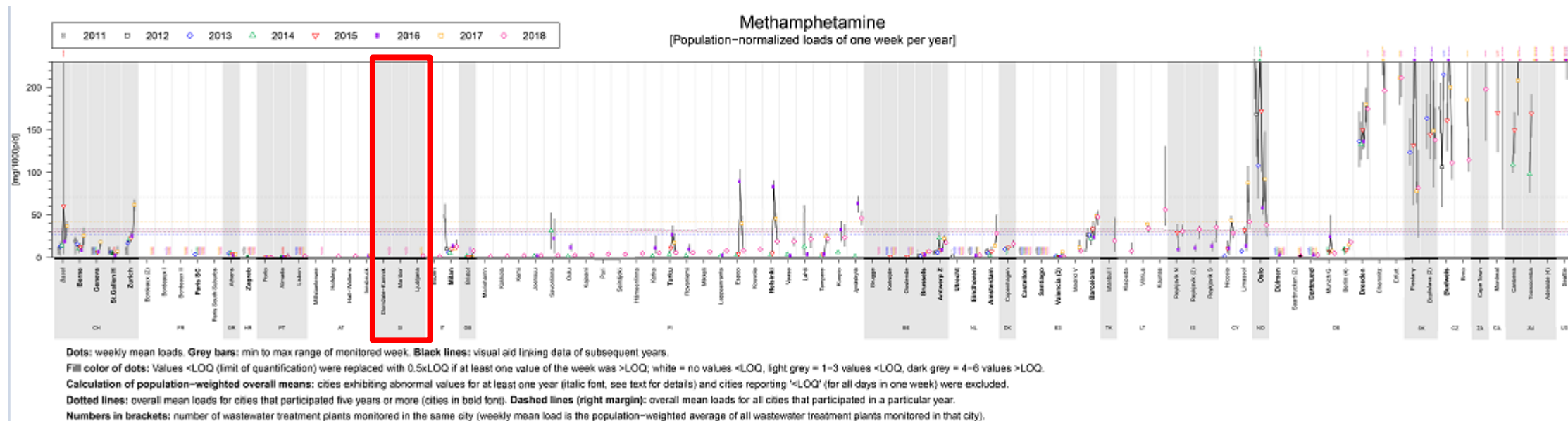
AMFETAMIN - normalizirana masna obremenitev (2018)



- ✓ Uporaba niha med lokacijami
- ✓ Najvišja obremenitev v mestih **S in V Evrope** (J manj)
- ✓ **Slovenska mesta** relativno nizka obremenitev (3.9-20 mg/dan/1000 prebivalcev)

METAMFETAMIN

Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta (2018)

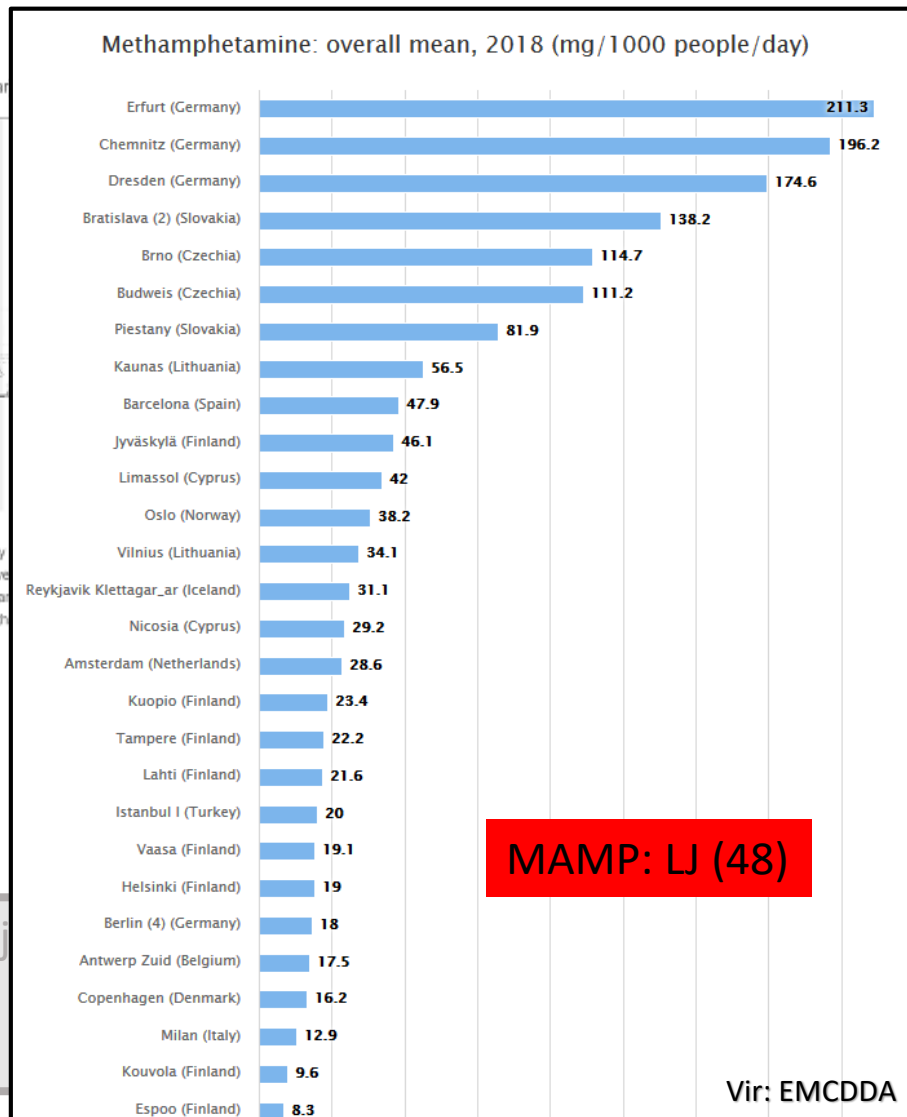
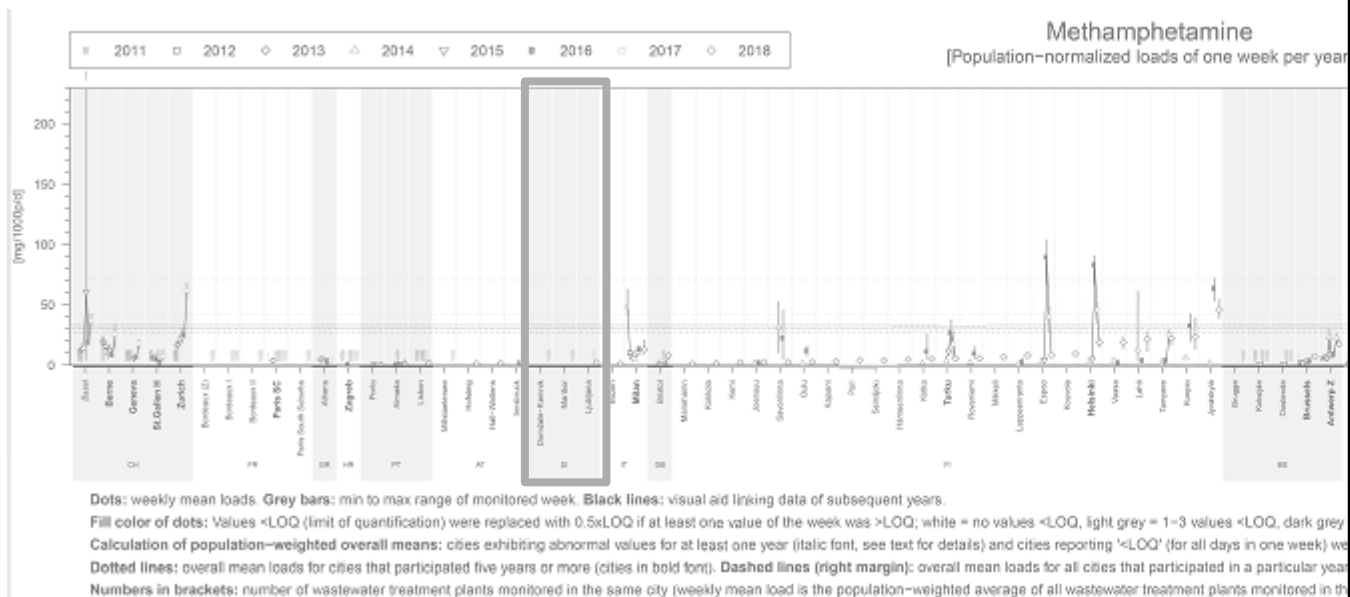


Vir: SCORE group

- ✓ Slovenija je po uporabi **MAMP** v spodnjem delu razpona sodelujočih držav v letu **2018**
- ✓ **MAMP** → znan le v **Ljubljani**

METAMFETAMIN

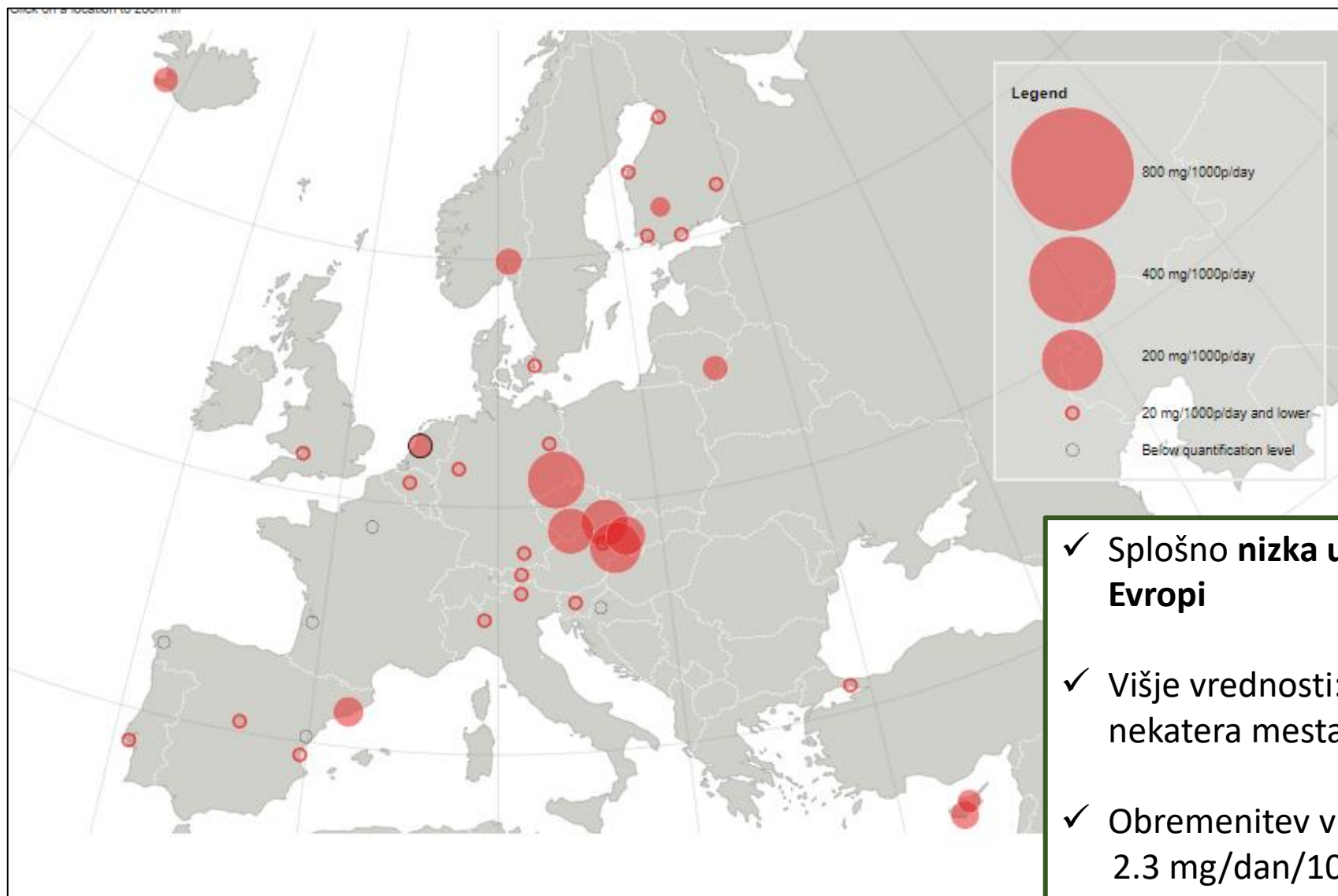
Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta (2018)



- ✓ Slovenija je po uporabi MAMP v spodnjem delu razpona sodelujočih mest
- ✓ MAMP → zaznan le v Ljubljani

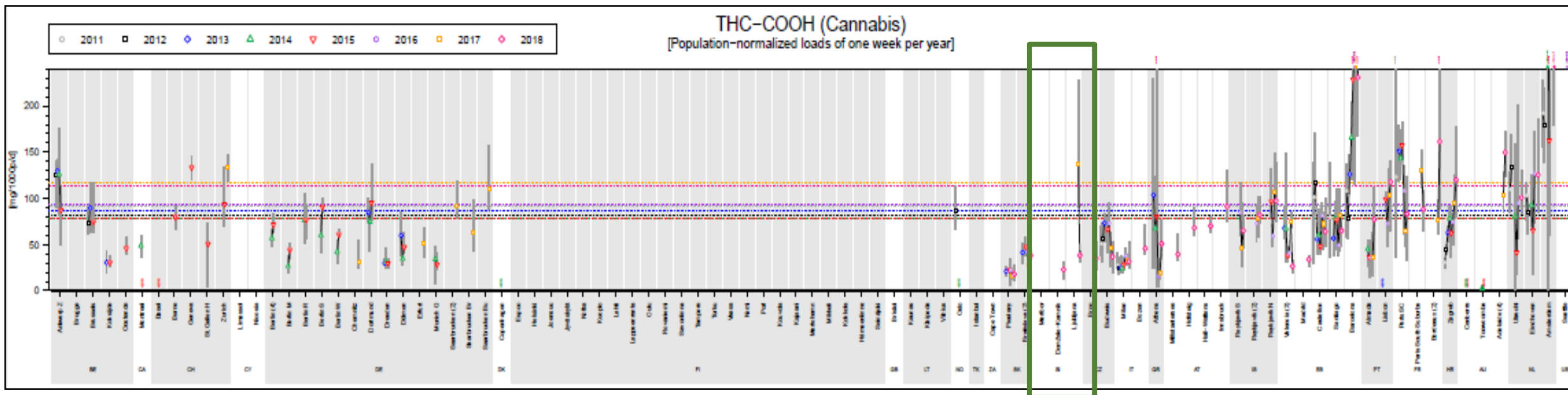
Vir: EMCDDA

METAMFETAMIN - normalizirana masna obremenitev (2018)



THC-COOH

Normalizirana obremenitev z izbranimi analiti za sodelujoča mesta



Vir: SCORE group

- ✓ Slovenija je po uporabi **kanabisa** v sredini razpona sodelujočih držav v letu **2018**
- ✓ Normalizirana masna obremenitev → **pod celokupnim povprečjem** mest, ki v projektu sodelujejo 5 ali več let
- ✓ **THC-COOH** → ni bil določen v **Mariboru**

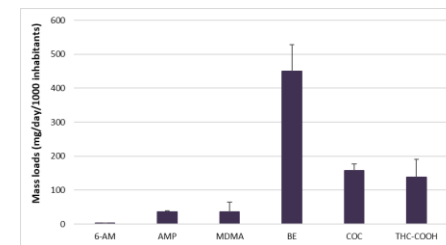
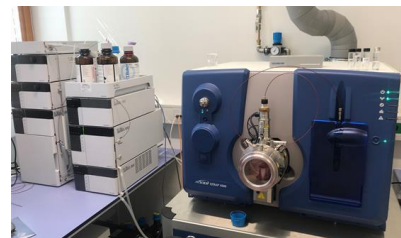
Evropski center za
spremljanje drog in
zasvojenosti z
drogami
Vladna agencija



Spletna stran **EMCDDA** (European Monitoring Center for Drugs and Drug Addiction)

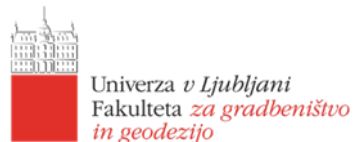
<http://www.emcdda.europa.eu/topics/pods/waste-water-analysis>

PREPOVEDANE DROGE, ALKOHOL IN TOBAK: EPIDEMIOLOGIJA ODPADNIH VOD, USPEŠNOST ČIŠČENJA IN RANLJIVOST VODNEGA SISTEMA (L1-9191)



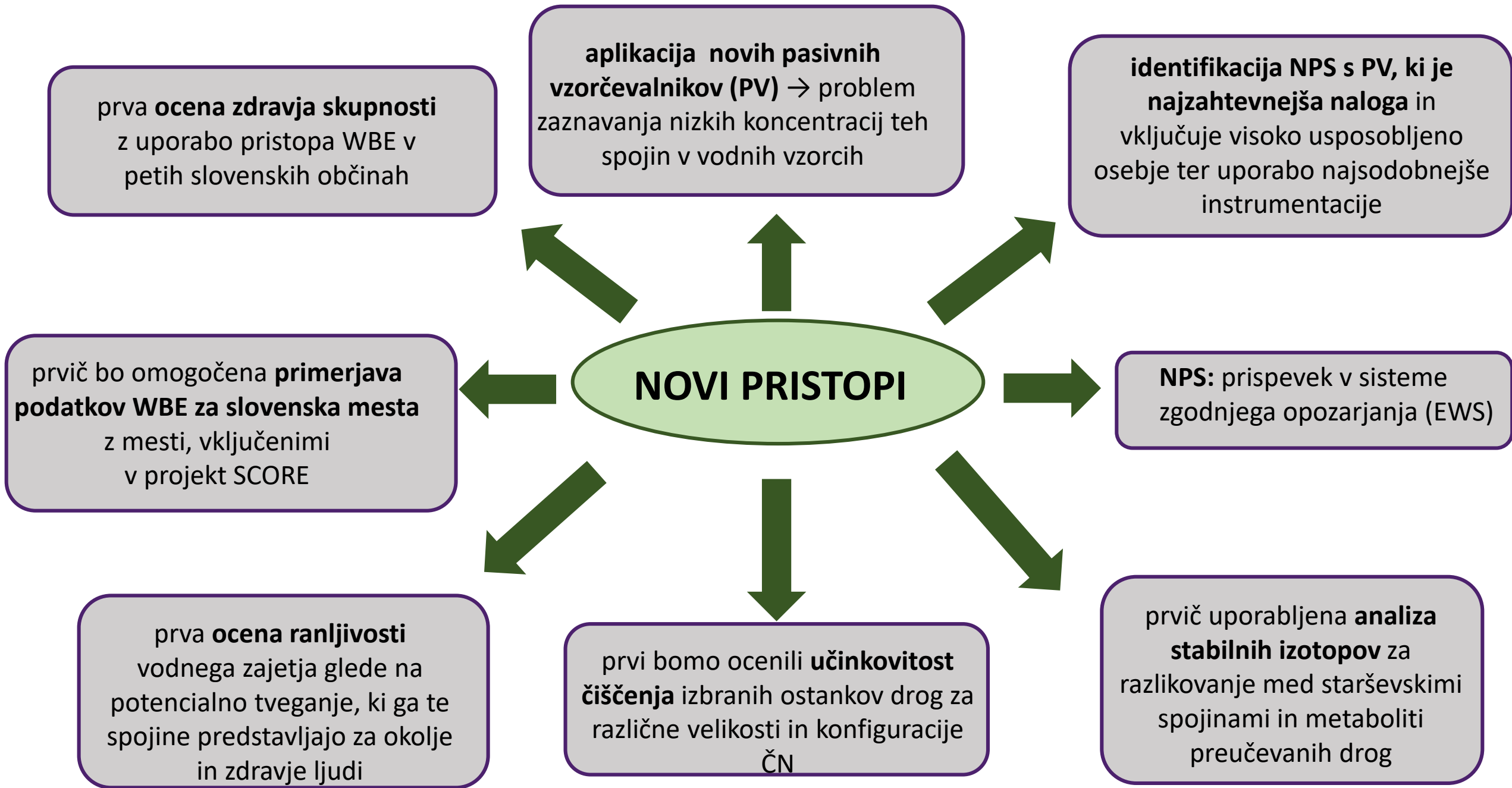
Skupina za organsko analizo, Odsek za znanosti o okolju

RAZISKOVALNI PARTNERJI



PODPORNIKI





High levels of cocaine found in the Thames by monitoring station near Houses of Parliament are making eels hyperactive

- Cocaine ingested and urinated into London's water system rising, research says
- Downpours that overwhelm waste plants carry cocaine into the River Thames
- Low levels of cocaine found in the Thames affecting wildlife including eels
- Research from monitoring plant near Houses of Commons reveals worrying rise

By [ROD ARDEHALI FOR MAILONLINE](#)

PUBLISHED: 19:47 GMT, 20 January 2019 | **UPDATED:** 20:09 GMT, 20 January 2019

<https://www.dailymail.co.uk/news/article-6613169/High-levels-cocaine-Thames-making-eels-hyperactive.html>

<https://www.kurir.rs/planeta/3192741/u-londonu-se-toliko-drogiraju-da-su-zatrovali-ribe-u-temzi-naucnici-objavili-sokantne-rezultate-a-evo-gde-su-najvise-istrazivali>



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Londoners are taking so much cocaine that the class A drug can be found in the River Thames - and it's making the eels hyperactive. Cocaine from users' urine has been detected in increasing quantities research from the Thames monitoring station near the Houses of Parliament has shown (file image)



Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

journal homepage: www.elsevier.com/locate/ecoenv



Changes in the gills of the European eel (*Anguilla anguilla*) after chronic exposure to environmental cocaine concentration

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Gills alterations
Histomorphometric parameters
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Illicit drugs

ABSTRACT

The recent discovery of illicit drugs in the aquatic environment has raised concerns about the possible effects on the aquatic fauna, because of the pharmacological activity of these substances. Cocaine is an illicit drug widespread in surface waters since it is the third most widely used drug in North America, Western and Central Europe, and the second in Latin America and the Caribbean. The aim of this study was to evaluate the influence of environmental concentrations of cocaine on the gills of the European eel (*Anguilla anguilla*). The gills of male silver eels exposed to 20 ng L⁻¹ of cocaine for fifty days were compared to control, vehicle control and post-exposure recovery ten days groups. The following parameters were evaluated: the thickness of the interlamellar epithelium (TIE), the length of the secondary lamellae (LSL) and the fraction of the interlamellar epithelium and the secondary lamellae occupied by the mucous cells (MC(IE-SL)FA) 3) the plasma cortisol and prolactin levels. After cocaine exposure, the gill epithelium appeared hyperplastic. The following changes were observed: proliferation in the interlamellar epithelium; partial and total fusion of the secondary lamellae, that appeared shortened and dilated; epithelial lifting and aneurism in the secondary lamellae. Moreover, in cocaine exposed eels, an increase in TIE and MC(IE-SL)FA and a decrease in LSL were observed. These changes were still present ten days after the interruption of cocaine exposure. Plasma levels of both cortisol and prolactin increased after cocaine exposure; ten days after the interruption of cocaine exposure, the plasma cortisol levels were still higher, whereas the plasma prolactin levels were lower, than control values. Our results show that even a chronic exposure to low environmental cocaine concentrations severely harms the eel gills, suggesting damages to their functions, and potentially affecting the survival of this species.



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv



Evaluation of combined sewer overflow impacts on short-term pharmaceutical and illicit drug occurrence in a heavily urbanised tidal river catchment (London, UK)

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HIGHLIGHTS

- Combined sewer overflows (CSOs) affected drug concentrations in river water
- 27 drugs determined hourly, daily and over four dry and wet months in 2014
- Cocaine, benzoylcegonine and caffeine were the best CSO drug markers.
- Ammonium and dissolved oxygen correlated with elevated drug concentrations
- CSOs detected in the river within 24 h and lasted for 24–48 h depending on rainfall

GRAPHICAL ABSTRACT



Znanost
na cesti

In ZRC SAZU



Credit: CERN

Pospeševalniki danes, jutri...in nikoli več?

prof. dr. Marko Mikuž, Institut „Jožef Stefan“ in Fakulteta za matematiko in fiziko UL
Igor E. Bergant, TV Slovenija

9. april 2019

