DroMedAric Project

(German acronym for ***Dru***gs, ***Med***icaments, ***A***lcohol and tobacco ***R***esidues: Wastewater-based ep***i***demi***o***logy in Switzerland)

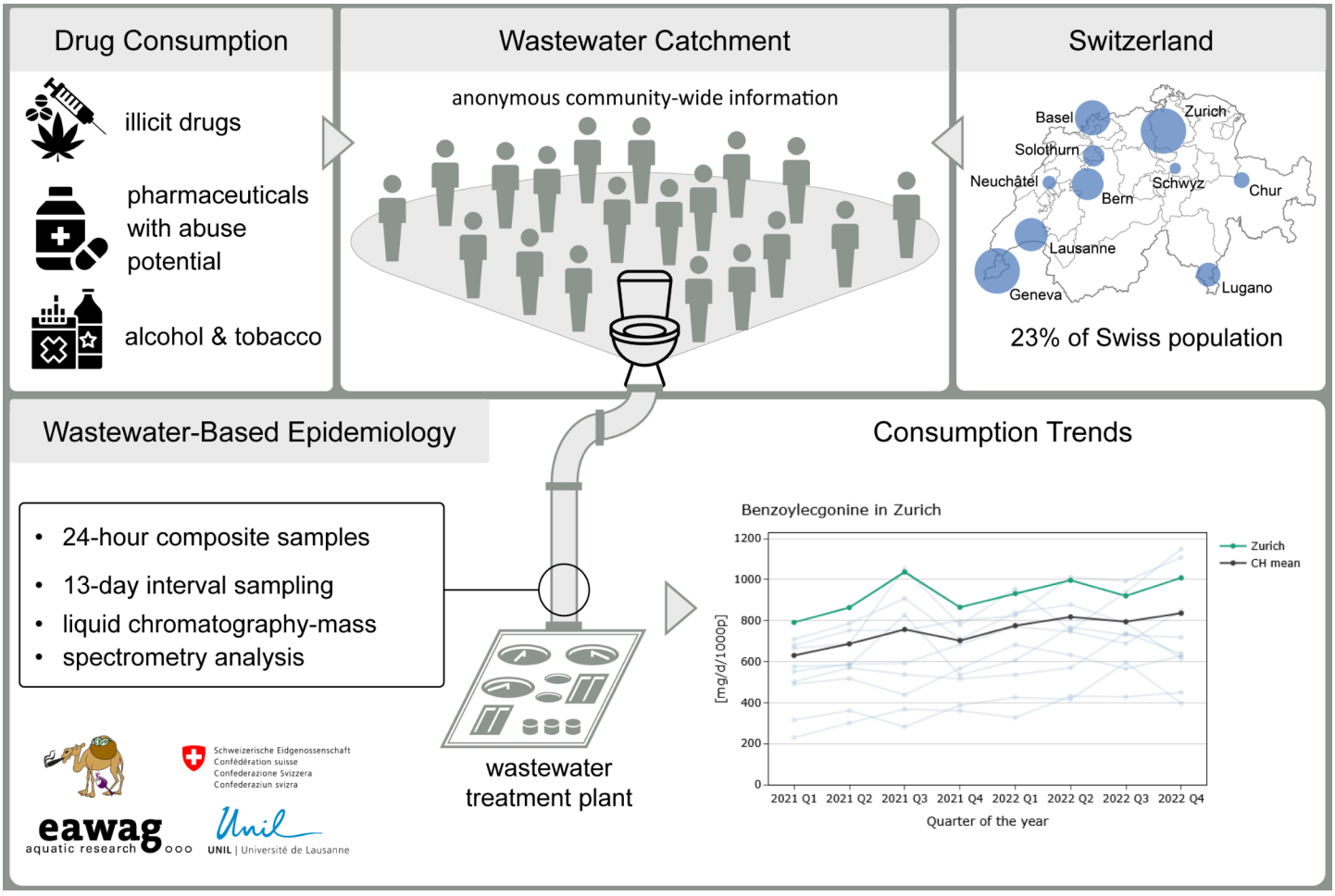
More details

Below is a brief summary of the project. For detailed information, please refer to the methodological report on the Eawag project website.

Overview

In this project we analyze substances of abuse and their metabolites in wastewater as independent indicators for community-wide consumption. Various markers are monitored:

- ***Drugs***: cocaine (benzoylecgonine), crack (AEME), amphetamine, methamphetamine, ecstasy (MDMA) and cannabis (THC-COOH).
- ***Opioids***: cough suppressants (codeine, dextromethorphan), heroin (morphine), methadone, oxycodone and tramadol.
- ***Other medications***: antidepressants (Citalopram, Trazodone and Venlafaxine), stimulants (Ritalin), sedatives (Oxazepam), anesthetics (Ketamine), antibiotics (Sulfamethoxazole and Trimethoprim), anticonvulsants (Carbamazepine).
- ***Alcohol***, ***tobacco*** and ***nicotine***



Methodology

Composite samples from ten Swiss wastewater treatment plants are collected in a thirteen-day interval over a period of four years (2021-2024). Together, the participating plants treat sewage of almost 2 million people which corresponds to approximately 23% of the Swiss population. Some of the treatment plants have already participated in the SCORE (Sewage Analysis CORe group Europe)/ EMCDDA (European Monitoring Centre for Drugs and Drug Addiction) wastewater-based monitoring program for illicit drugs in previous years. The collected wastewater samples are analyzed by liquid chromatography-tandem mass spectrometry which allows quantitative measurement of target analytes and qualitative screening for suspect chemicals. In the project, wastewater markers for illicit drugs, pharmaceuticals with abuse potential, alcohol and tobacco are quantified. The monitoring of these markers in wastewater allows estimation of temporal trends and spatial differences in consumption.

Contributors

Stephan Baumgartner, Livia Andrani, Michelle Salvisberg, Christoph Ort, Heinz Singer, Pierre Esseiva , Olivier Delémont

Funding

Swiss Federal Office for Public Health, Eawag, and UNIL.

Select Compound Group: drugs

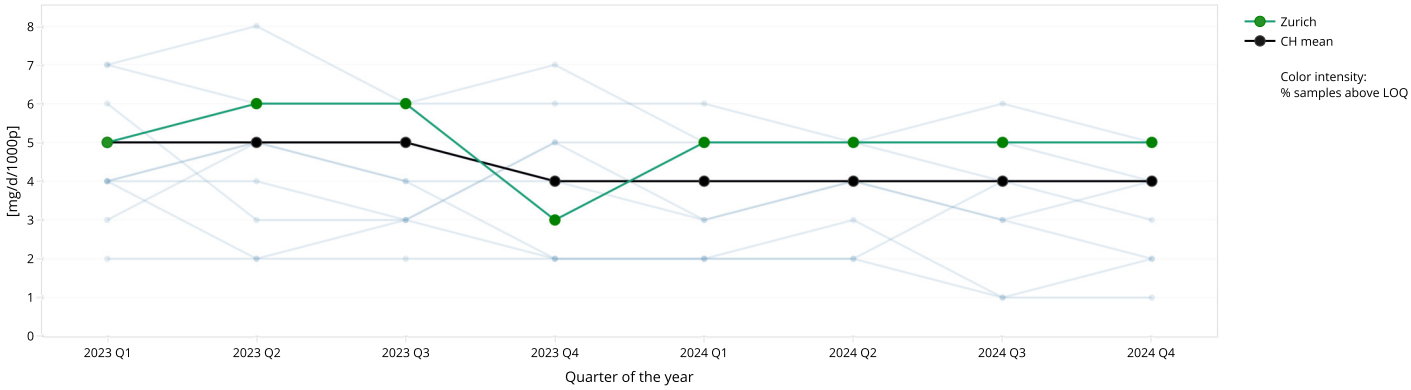
Select Region: Zurich

Select Visualization: Line – per quarter

Seven illicit drug markers were quantified in wastewater as indicators of consumption, including substances related to **cocaine** (benzoylecgonine), **crack** (AEME), amphetamine, methamphetamine, **ecstasy** (MDMA), and **cannabis** (THC-COOH). The selection of analytes is based on their epidemiological relevance and their quantifiability in wastewater.
For a guided example on how to read the wastewater data, please refer to user guide.

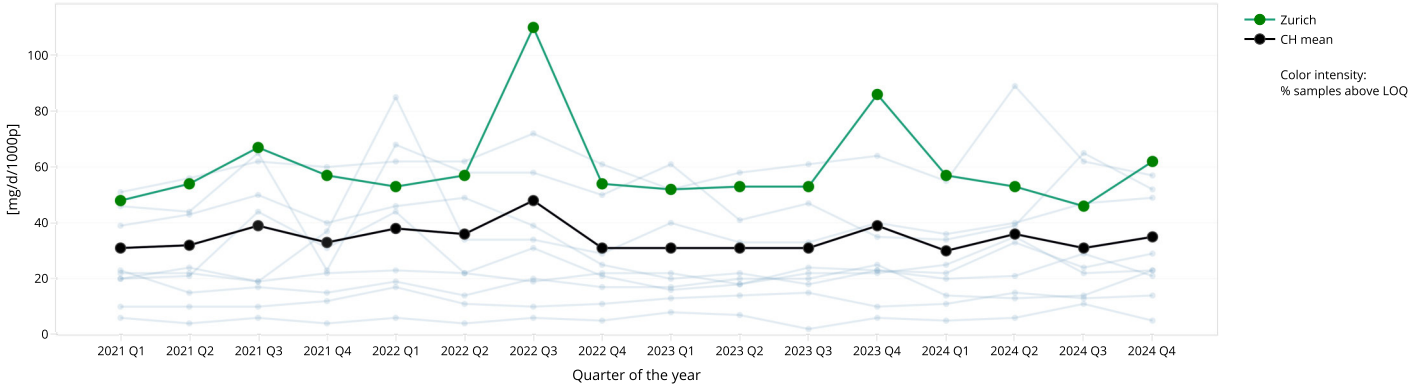
AEME

Metabolite of **crack / freebase** ** ⚠ The analysis is in its initial stages. Exercise caution in interpreting the limited data. Additional data will be provided in due course.



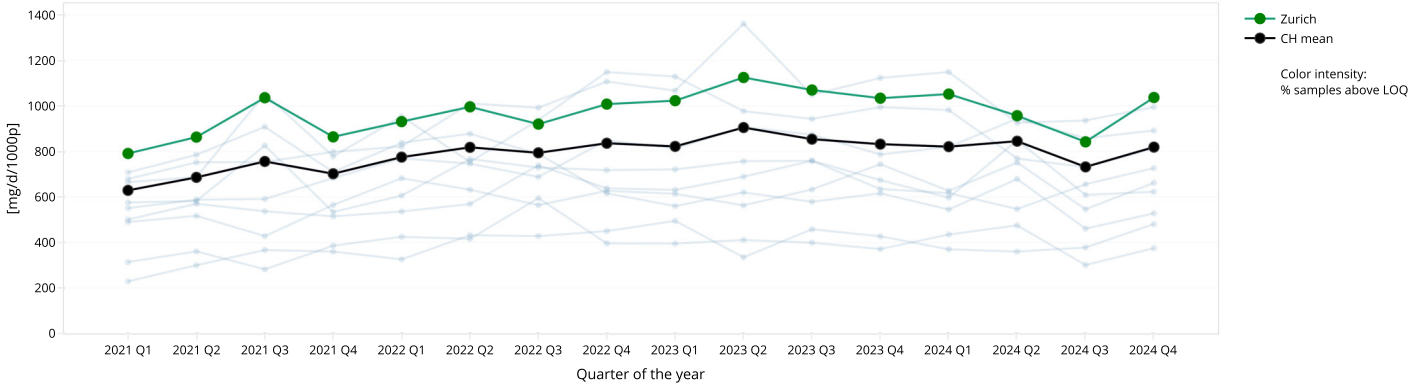
Amphetamine

Quantified as parent compound



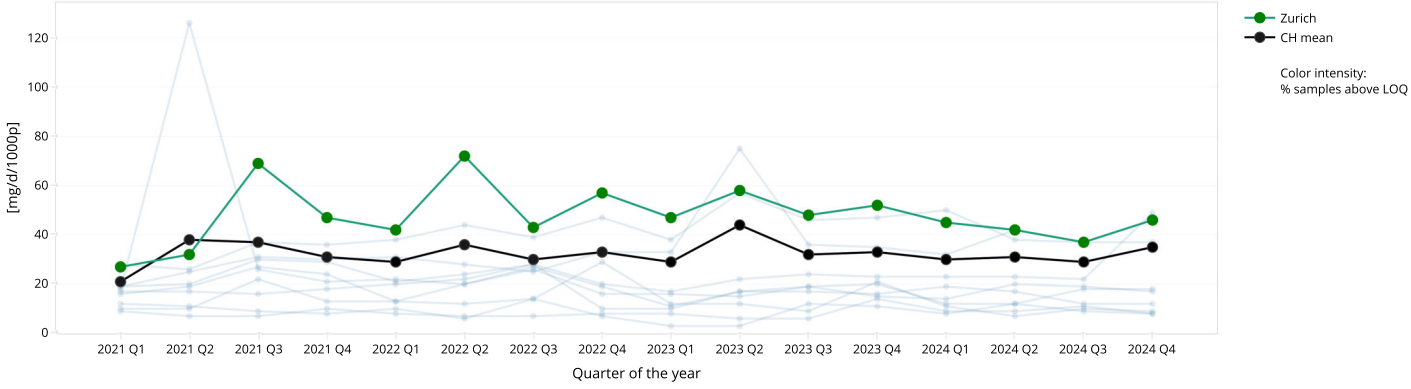
Benzoylecgonine

Main urine metabolite of **cocaine**



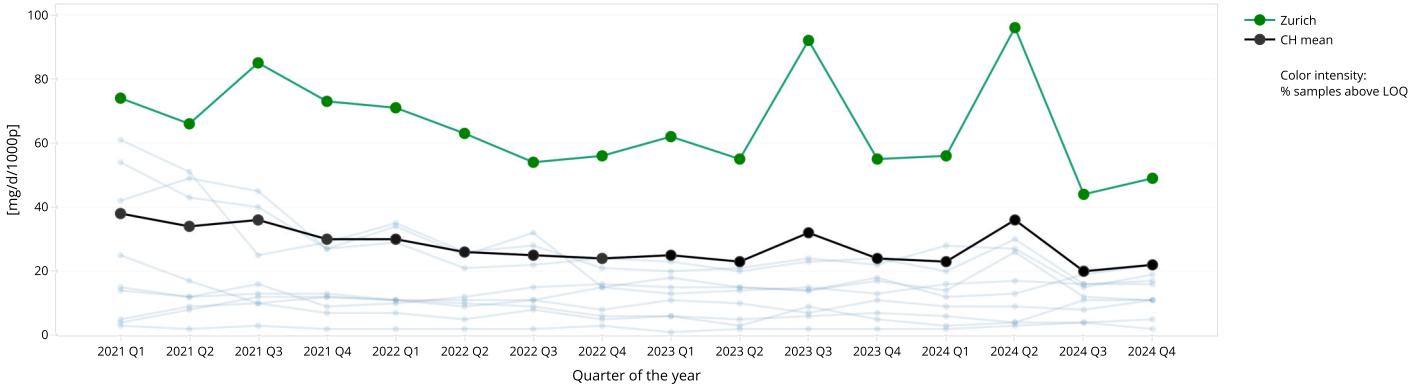
MDMA

Quantified as parent compound



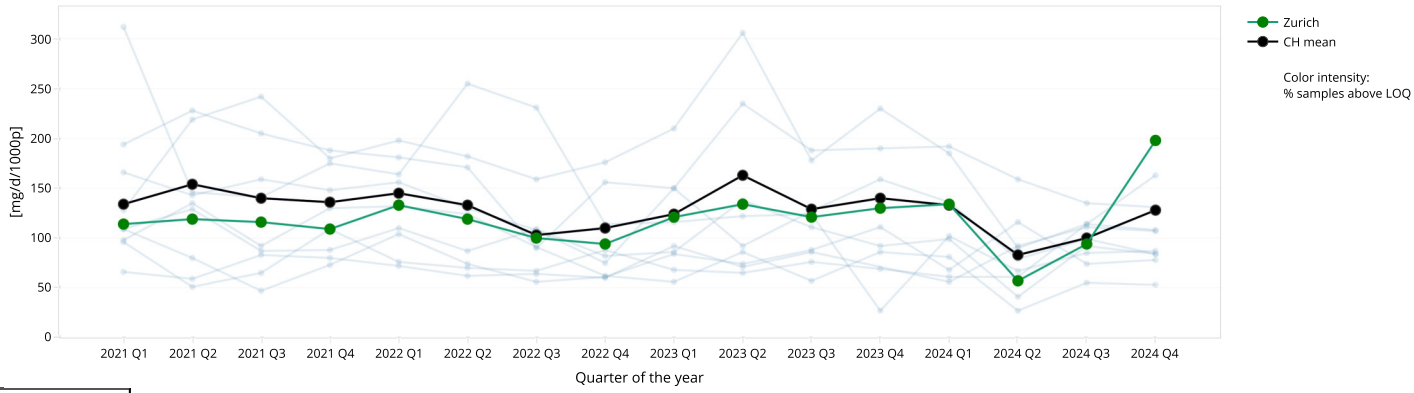
Methamphetamine

Quantified as parent compound. **Color intensity of markers reflects the percentage of samples above the limit of quantification.



THC-COOH

Main urine metabolite of THC (**cannabis**)



Download CSV

Select Compound Group: drugs

Select Region: Zurich

Select Visualization: Bar – per year

Seven illicit drug markers were quantified in wastewater as indicators of consumption, including substances related to **cocaine** (benzoylecgonine), **crack** (AEME), amphetamine, methamphetamine, **ecstasy** (MDMA), and **cannabis** (THC-COOH). The selection of analytes is based on their epidemiological relevance and their quantifiability in wastewater.
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AEME

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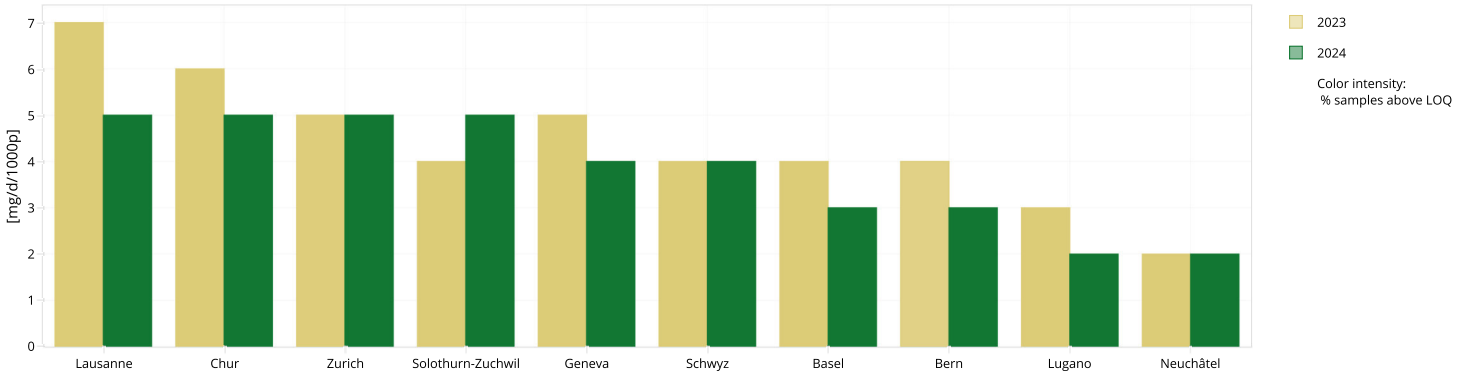
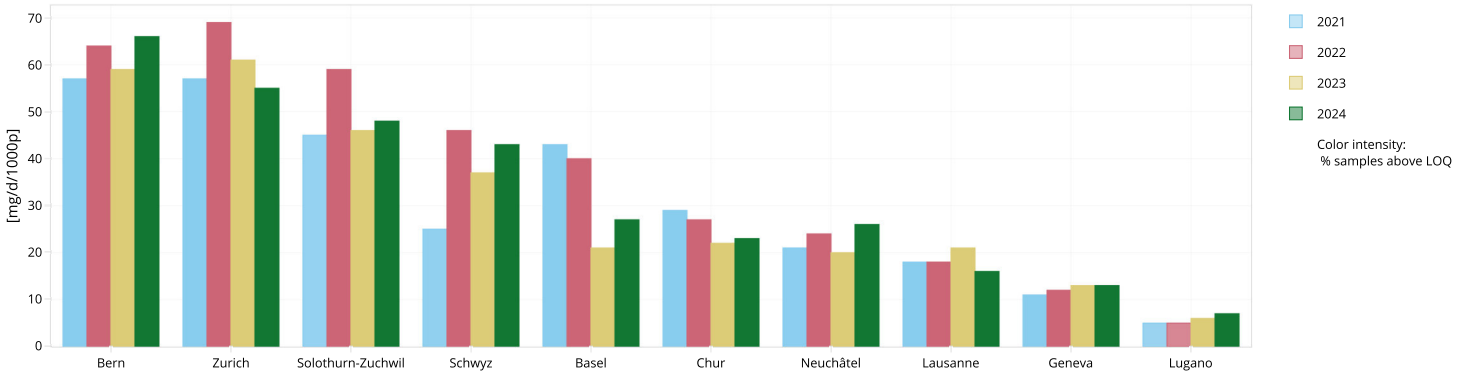


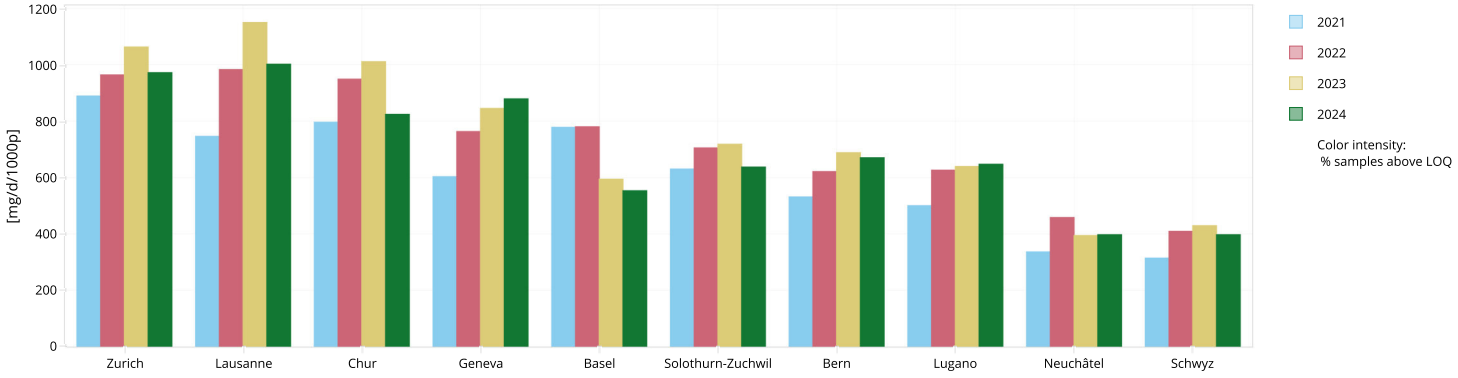
Amphetamine

Quantified as parent compound



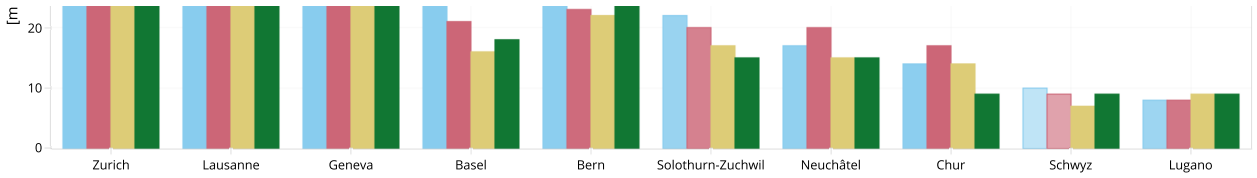
Benzoylecgonine

Main urine metabolite of **cocaine**



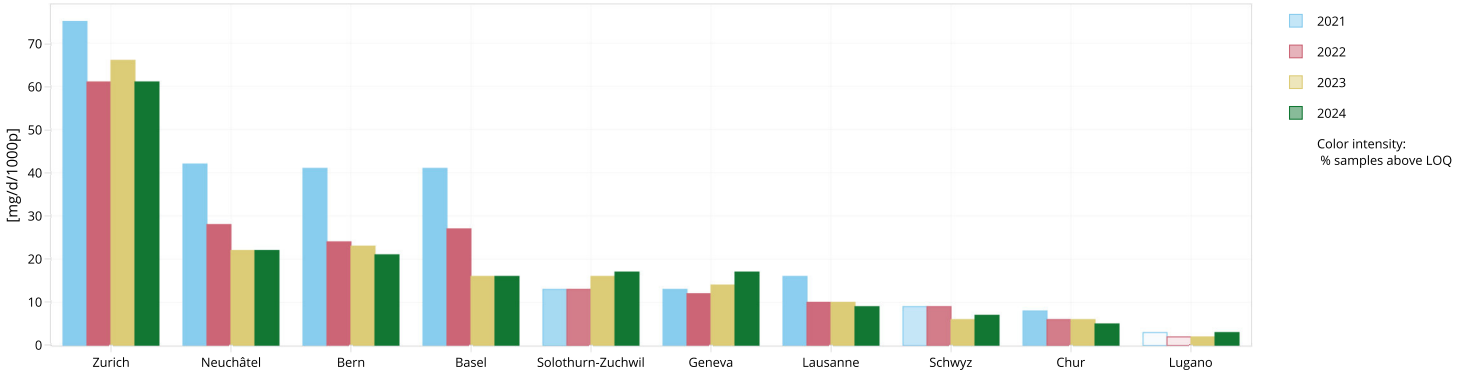
MDMA

Quantified as parent compound



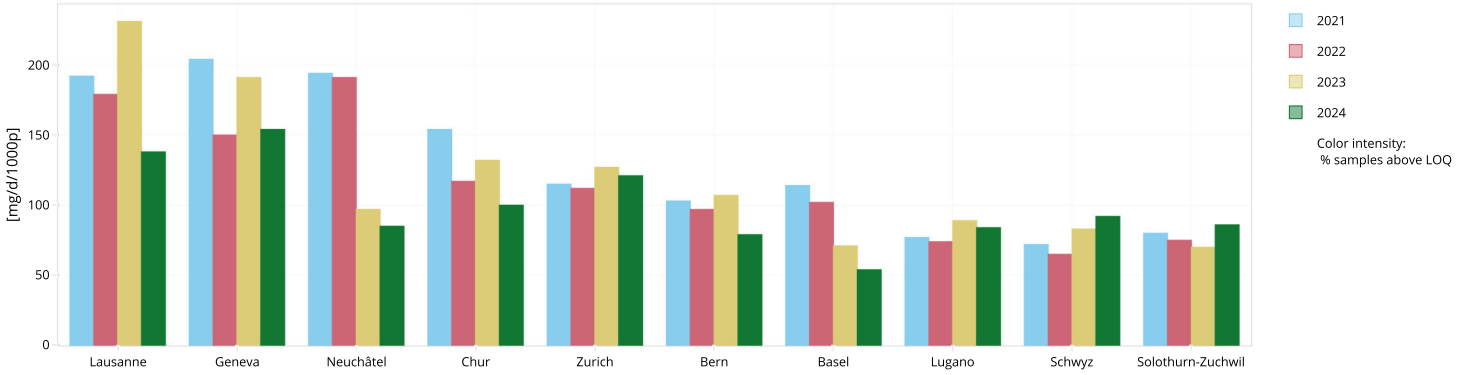
Methamphetamine

Quantified as parent compound. **Color intensity of markers reflects the percentage of samples above the limit of quantification.



THC-COOH

Main urine metabolite of THC (**cannabis**)



Download CSV

Select Compound Group: opioids

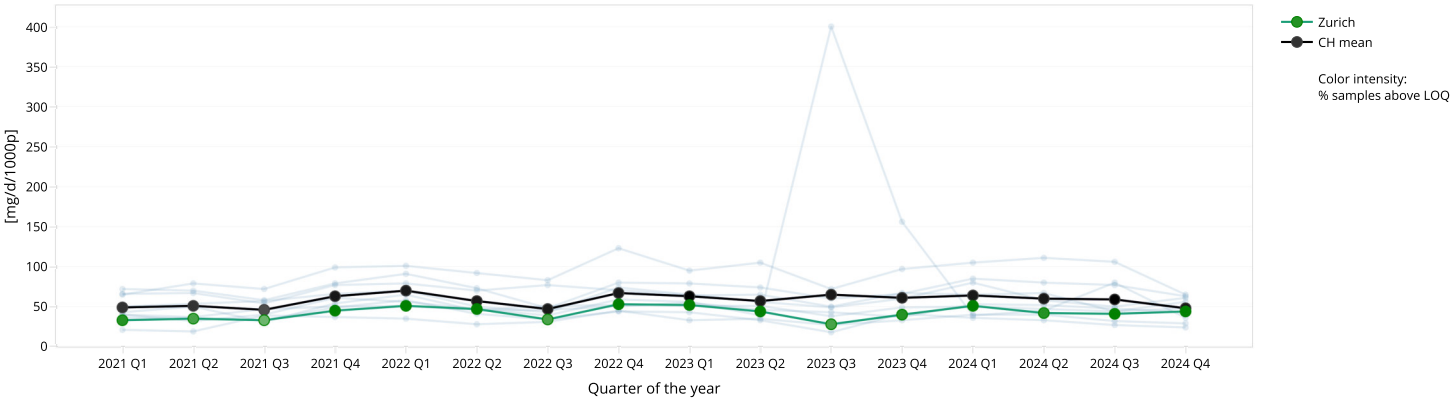
Select Region: Zurich

Select Visualization: Line – per quarter

Seven opioid markers are analyzed in connection with **cough suppressants** (Codeine, Dextromethorphan), **heroin** (Morphine), Methadone, Oxycodone, and Tramadol. Only opioids that can be detected in wastewater in a stable manner are presented. **Fentanyl** is also measured but wastewater amounts are usually below the limit of quantification (LOQ).
For a guided example on how to read the wastewater data, please refer to user guide.

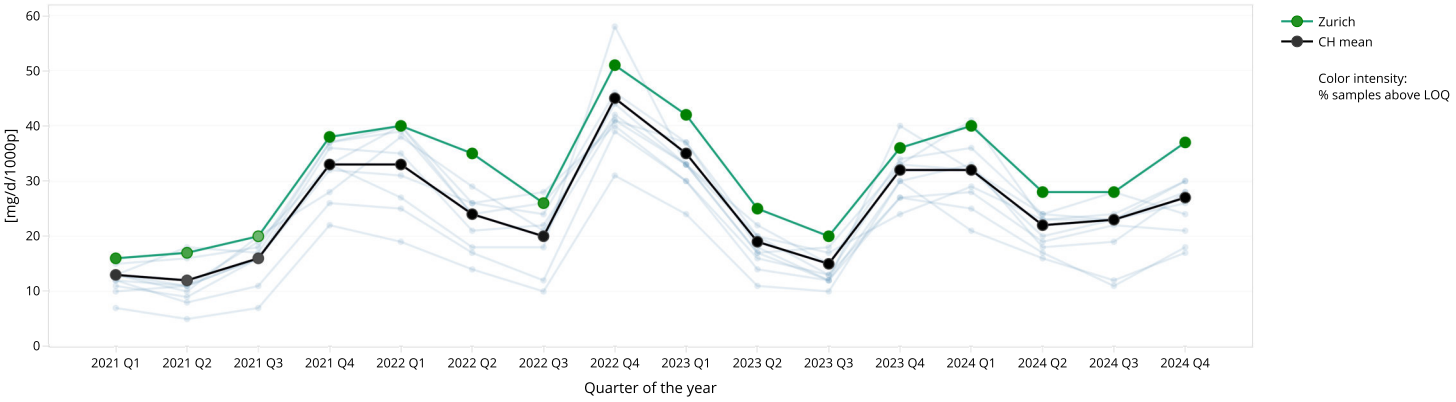
Codeine

Quantified as parent compound



Dextrorphan

Main urine metabolite of **dextromethorphan**

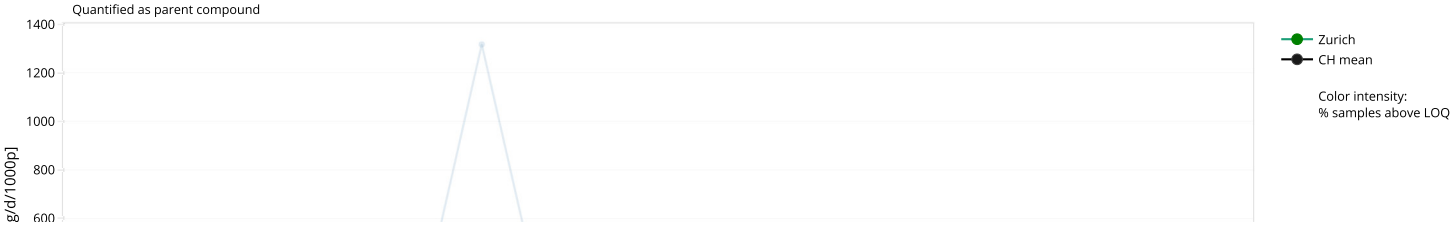


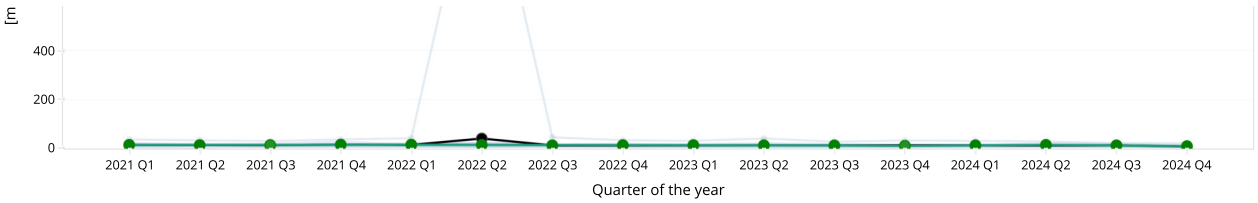
Fentanyl

Quantified as parent compound. ** ⚠ Concentrations are below the limit of quantification values.

Methadon

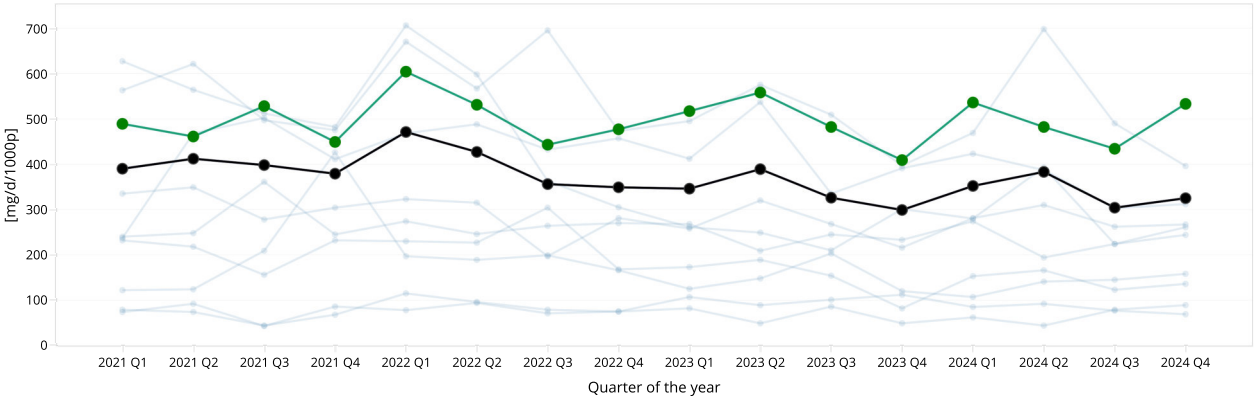
Quantified as parent compound





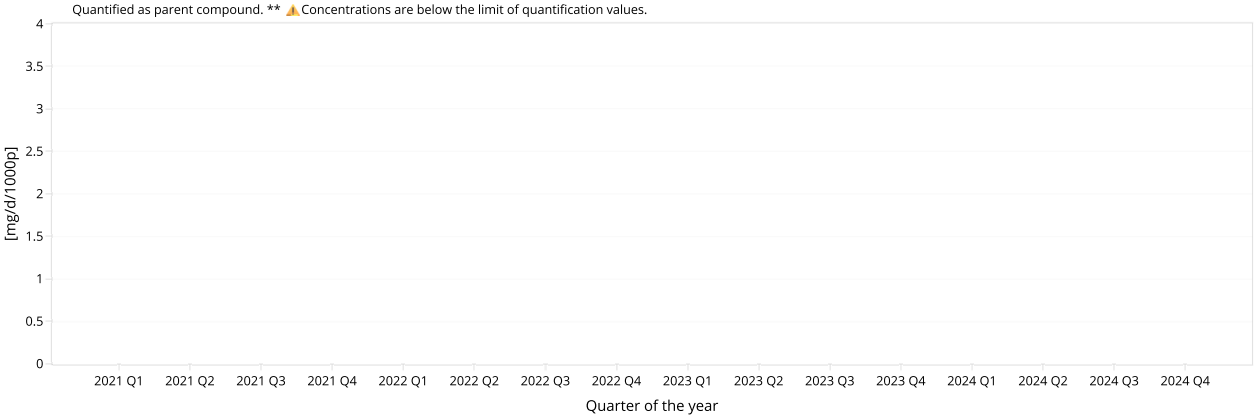
Morphine

Quantified as parent compound. Also metabolit of **heroine**



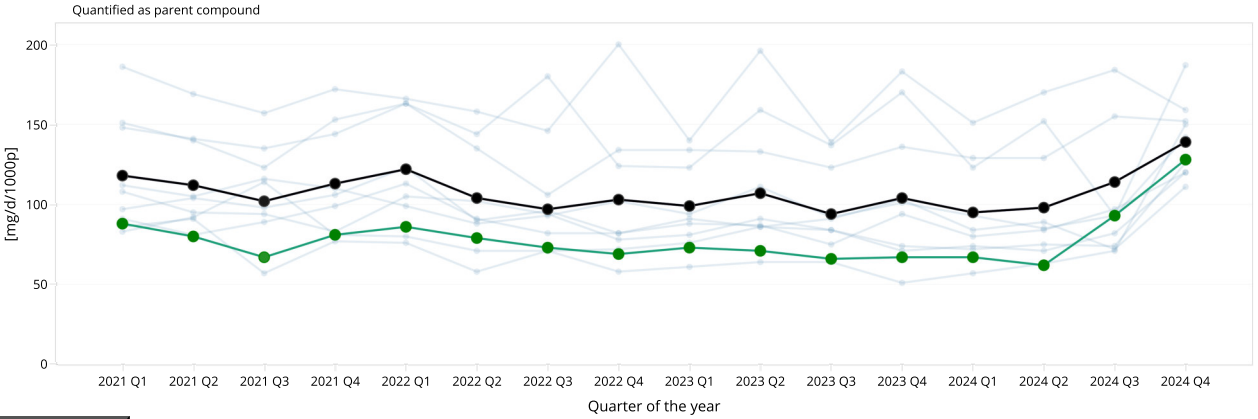
Oxycodone

Quantified as parent compound. ** ⚠ Concentrations are below the limit of quantification values.



Tramadol

Quantified as parent compound



Download CSV

Select Compound Group: opioids

Select Region: Zurich

Select Visualization: Bar – per year

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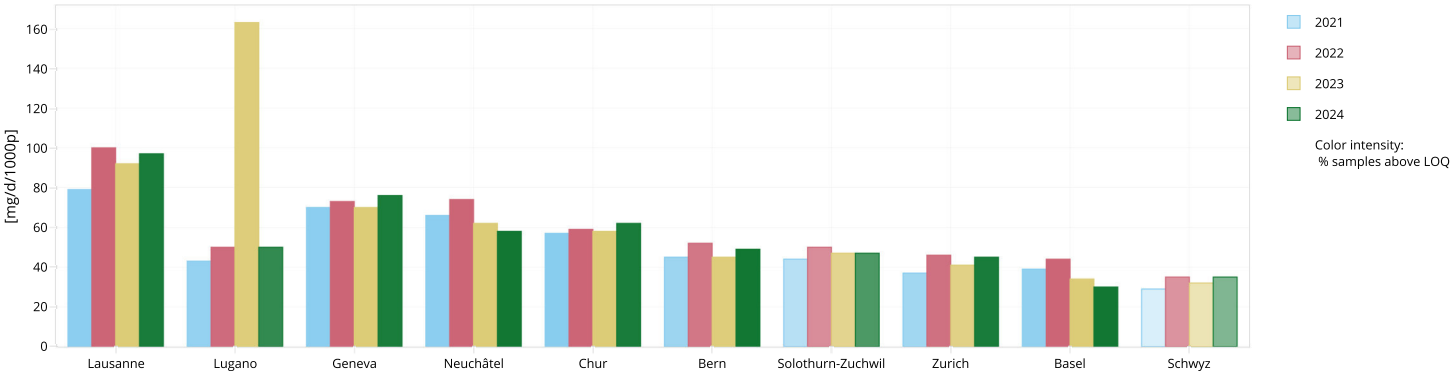
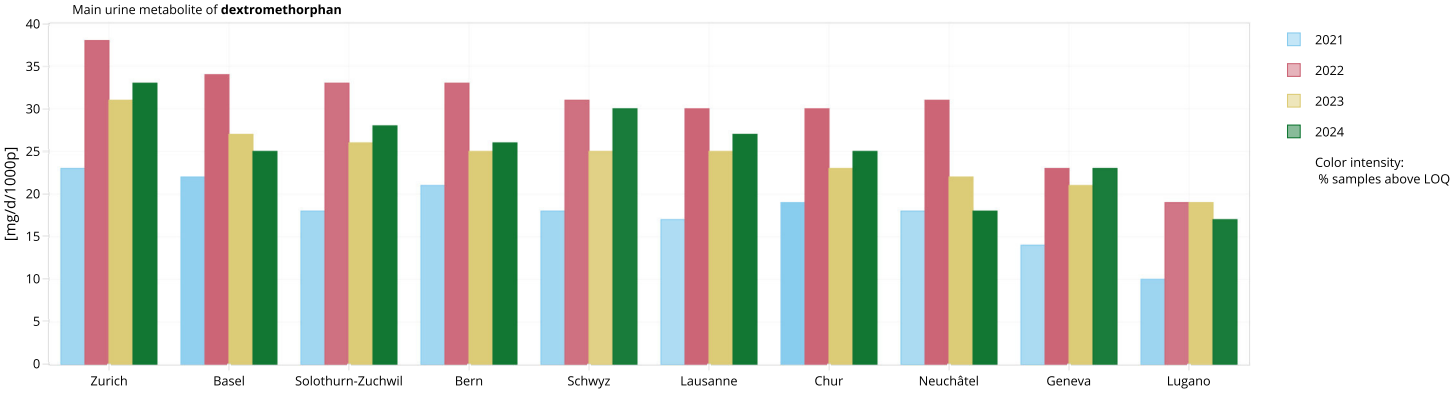
Codeine

Quantified as parent compound



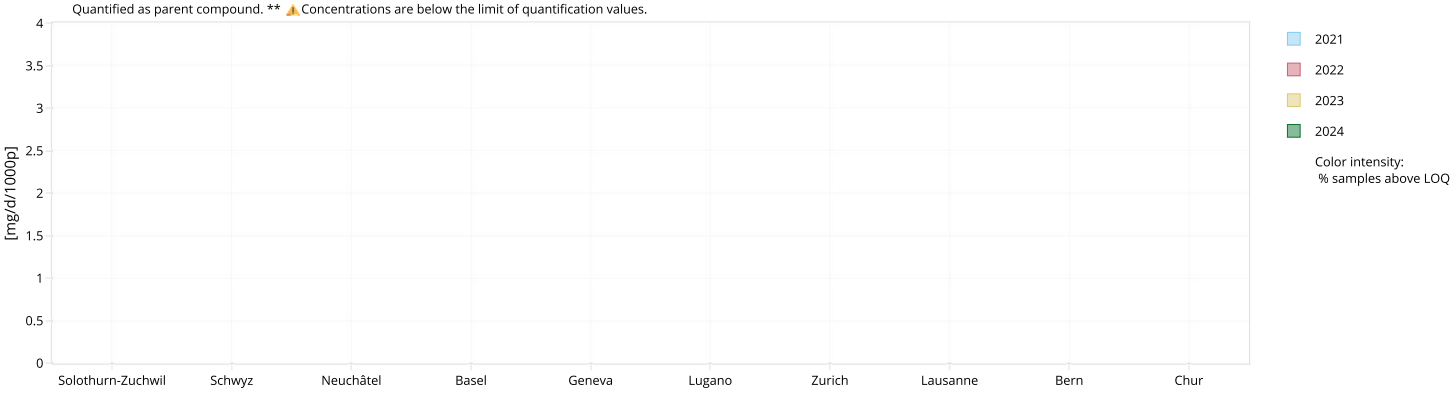
Dextrorphan

Main urine metabolite of **dextromethorphan**



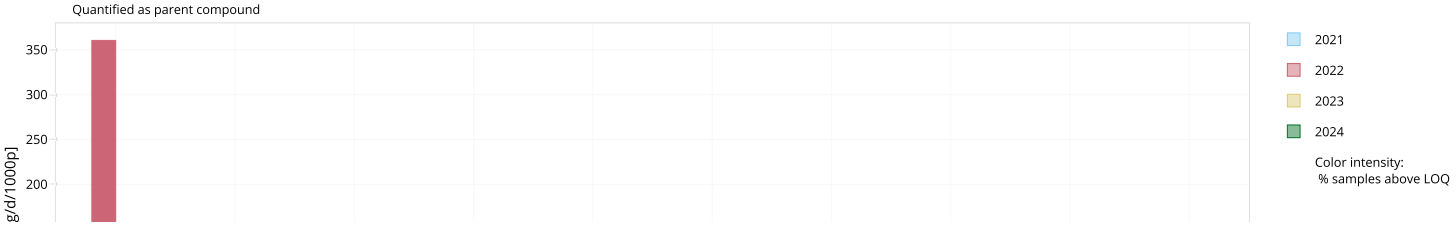
Fentanyl

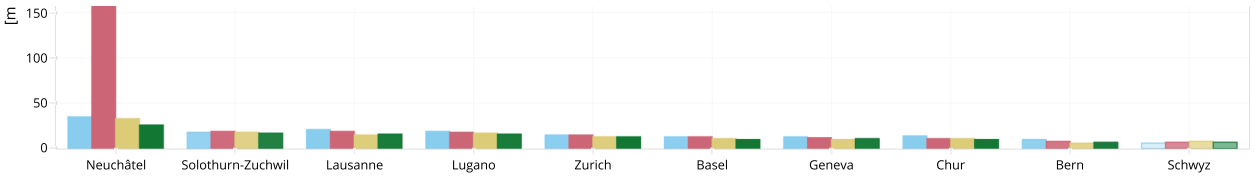
Quantified as parent compound. ** ⚠ Concentrations are below the limit of quantification values.



Methadon

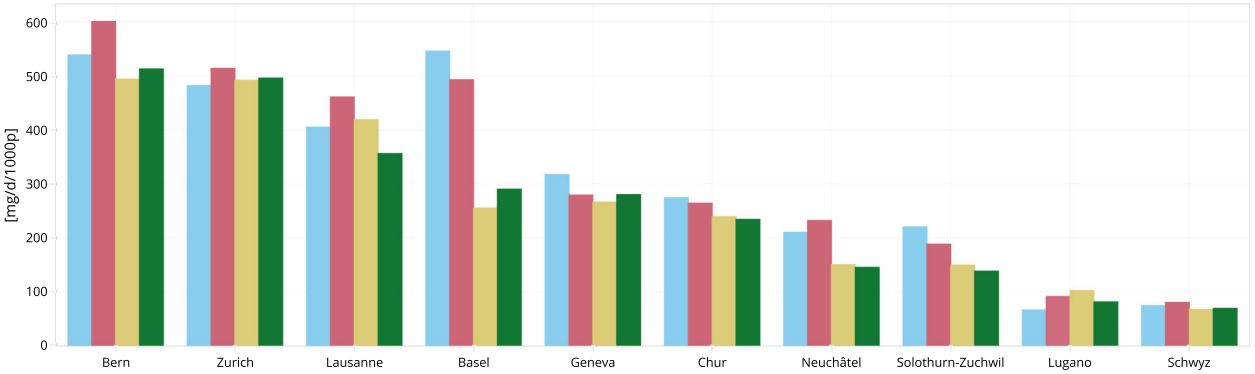
Quantified as parent compound





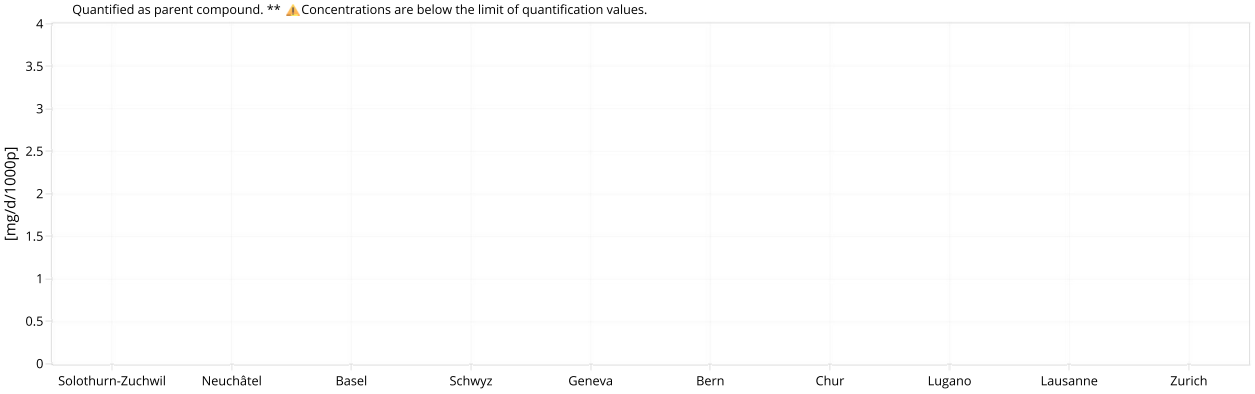
Morphine

Quantified as parent compound. Also metabolit of **heroine**



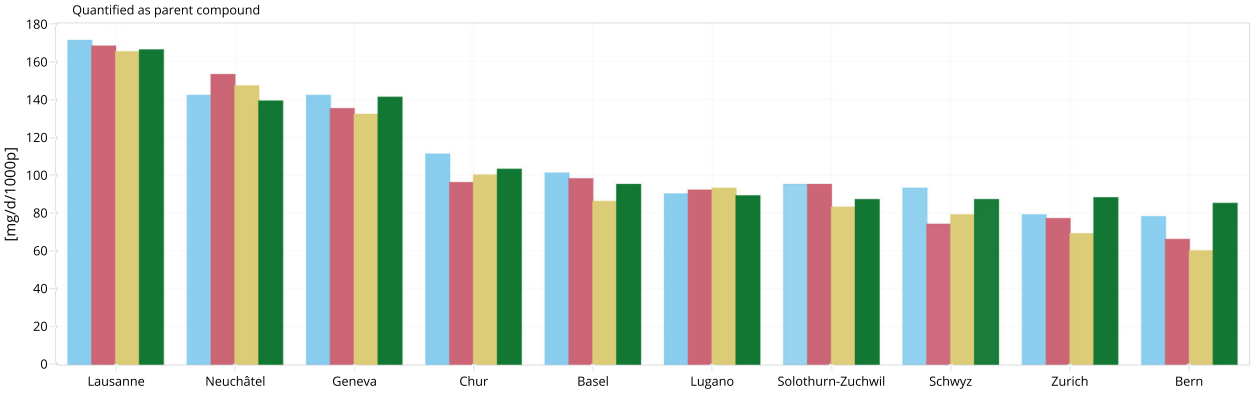
Oxycodone

Quantified as parent compound. ** ⚠ Concentrations are below the limit of quantification values.



Tramadol

Quantified as parent compound



Download CSV

Select Compound Group: antidepressants

Select Region: Zurich

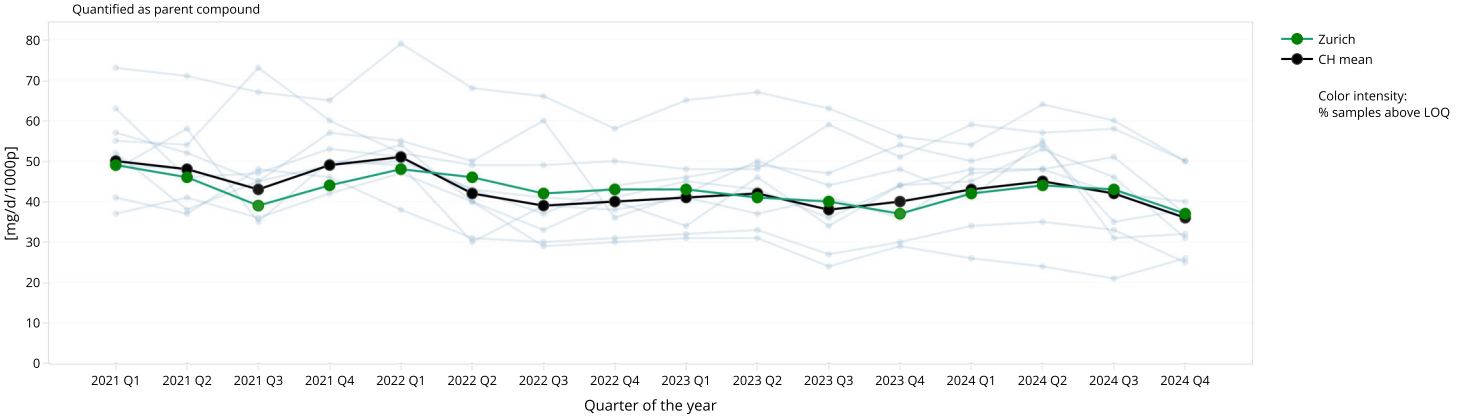
Select Visualization: Line – per quarter

Three antidepressant markers Citalopram, Trazodone, and Venlafaxine are measured.This reflects only a small selection of antidepressant pharmaceuticals and does not cover the entire spectrum; this consideration should be taken into account during interpretation.

For a guided example on how to read the wastewater data, please refer to user guide.

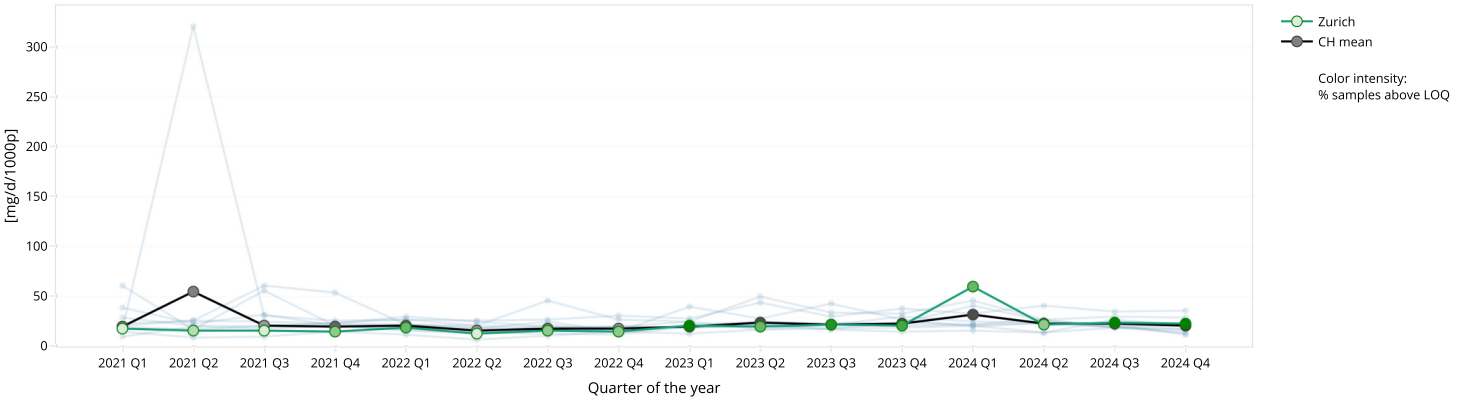
Citalopram

Quantified as parent compound



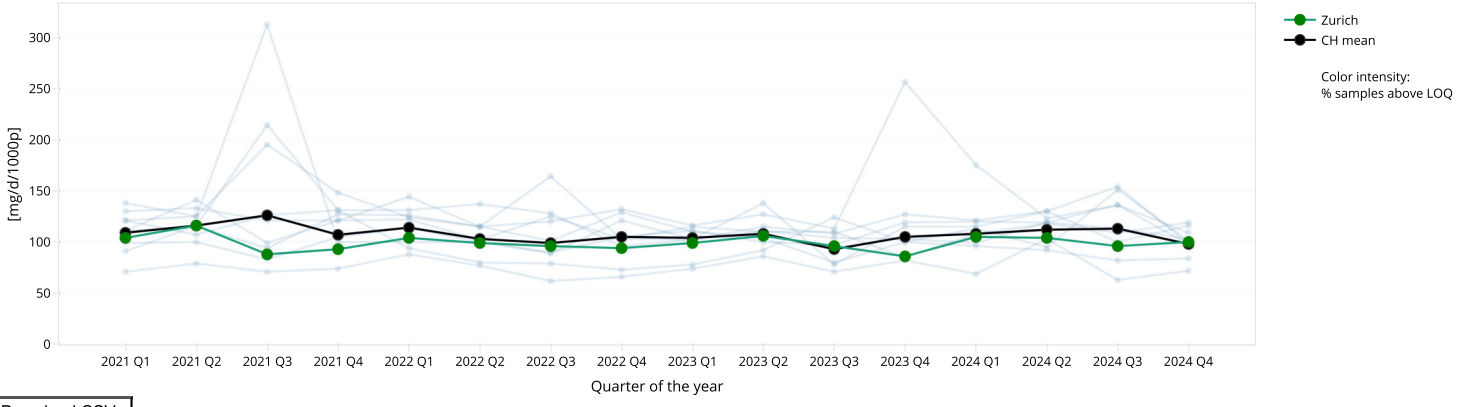
Trazodone

Quantified as parent compound. **Color intensity of markers reflectsthe percentage of samples above the limit of quantification.



Venlafaxine

Quantified as parent compound



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Select Compound Group: antidepressants

Select Region: Zurich

Select Visualization: Bar – per year

Three antidepressant markers Citalopram, Trazodone, and Venlafaxine are measured.This reflects only a small selection of antidepressant pharmaceuticals and does not cover the entire spectrum; this consideration should be taken into account during interpretation.

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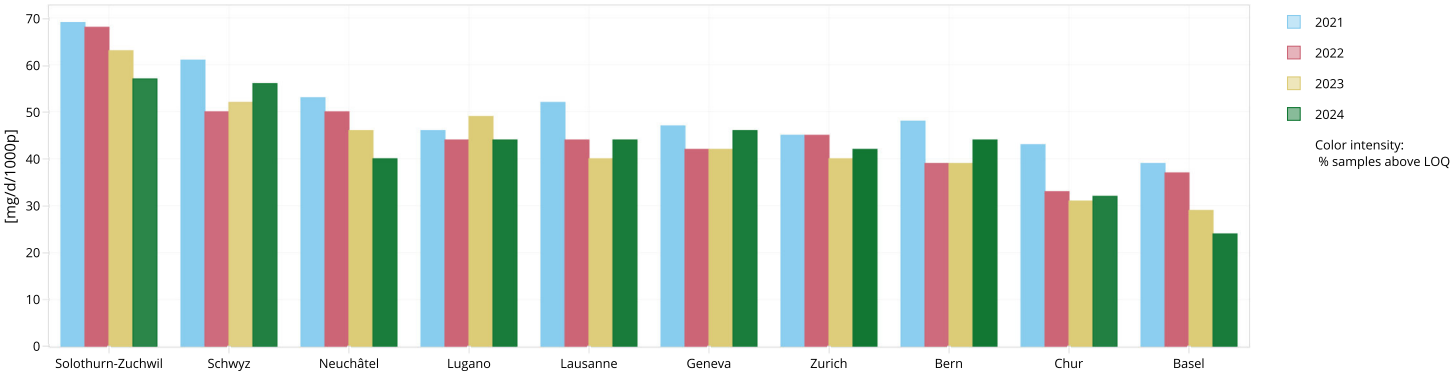
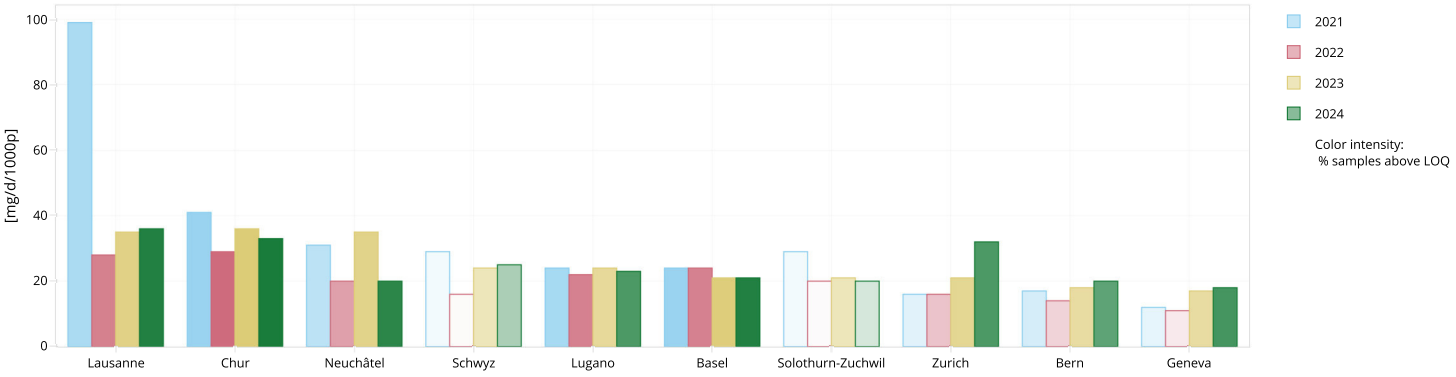
Citalopram

Quantified as parent compound



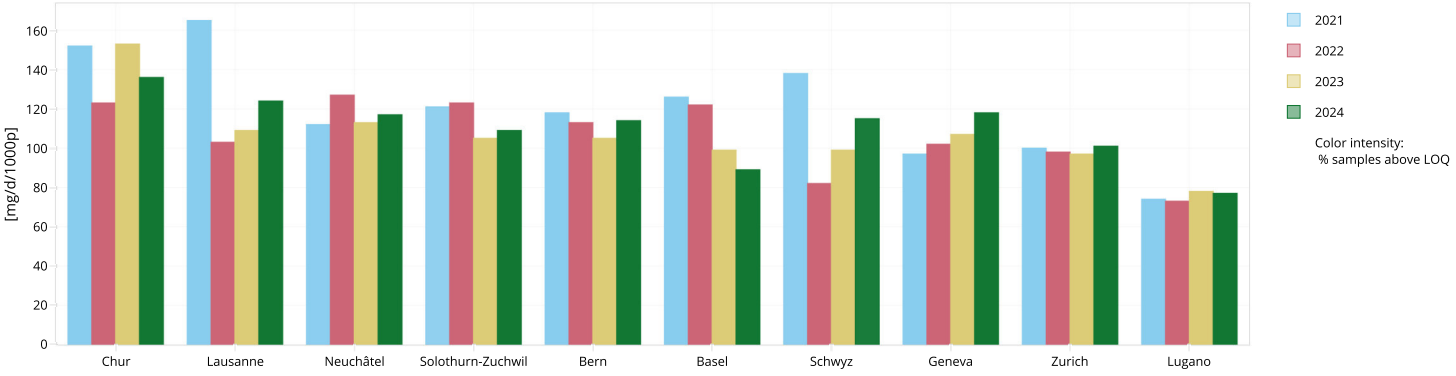
Trazodone

Quantified as parent compound. **Color intensity of markers reflectsthe percentage of samples above the limit of quantification.



Venlafaxine

Quantified as parent compound



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Select Compound Group: additional medications

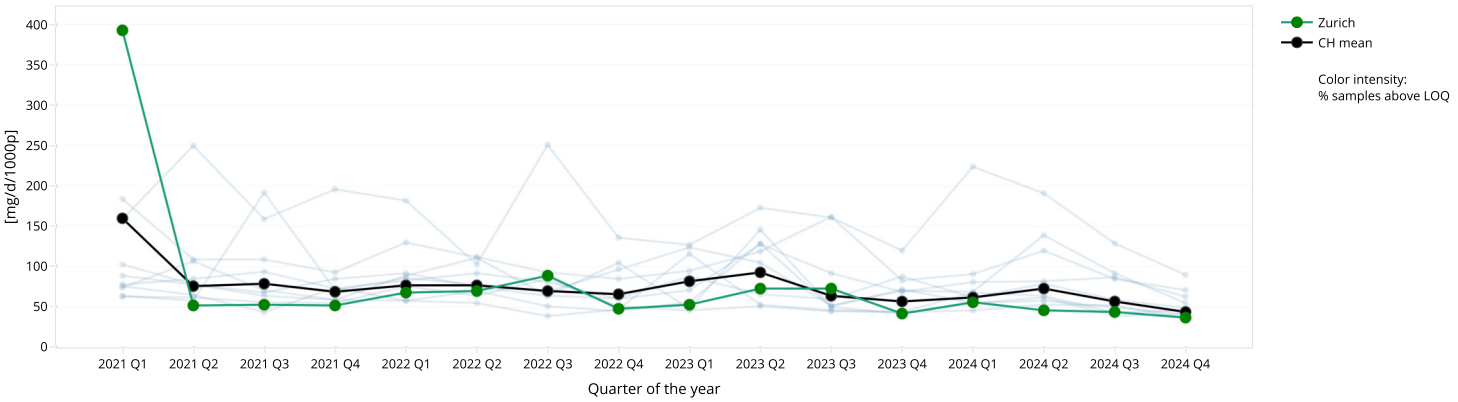
Select Region: Zurich

Select Visualization: Line – per quarter

Six additional drug markers have been analyzed in connection with **stimulants (**Ritaline**)**, **sedatives (**Oxazepam**)**, **anesthetics (**Ketamin**)**, **antibiotics (**Sulfamethoxazole** and** Trimethoprim**)**, and **anticonvulsants (**Carbamazepine**)**. The selection was based on frequently prescribed medications in Switzerland or those with a risk of abuse. They must also be detectable in wastewater in a stable manner.
For a guided example on how to read the wastewater data, please refer to user guide.

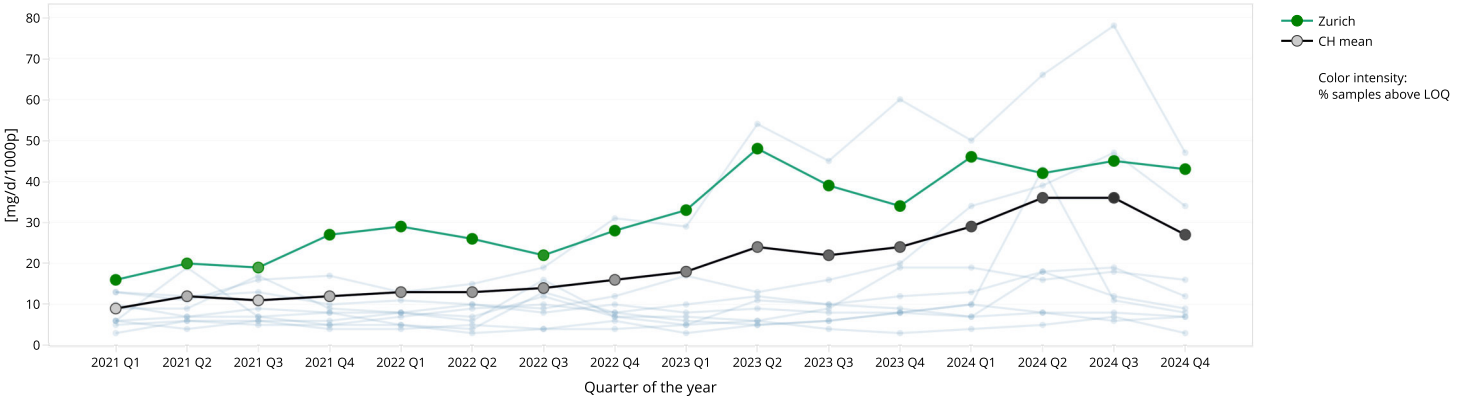
Carbamazepin

Anticonvulsant. Quantified as parent compound



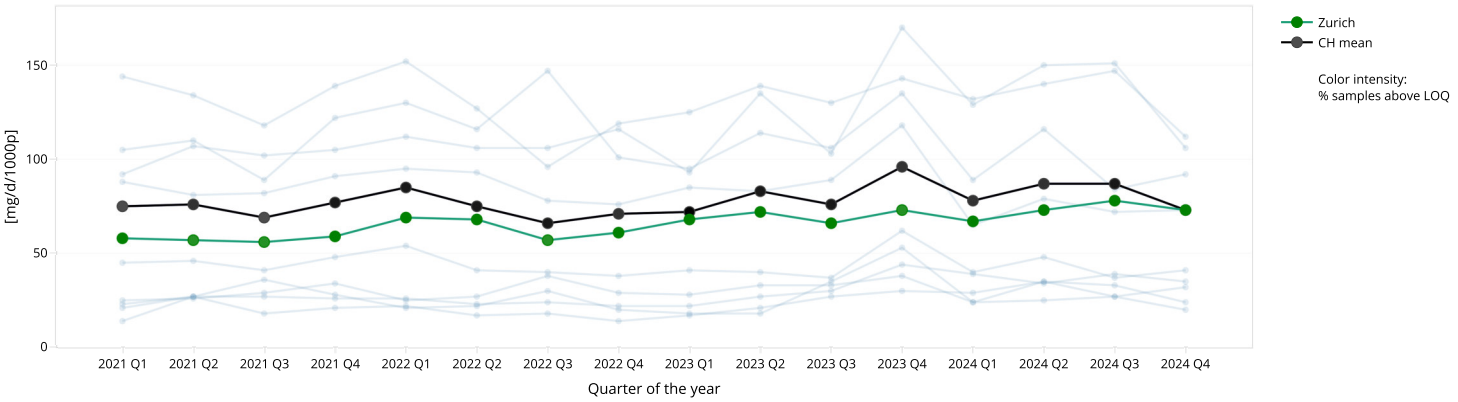
Ketamin

Anesthetic. Quantified as parent compound. **Color intensity of markers reflectsthe percentage of samples above the limit of quantification.



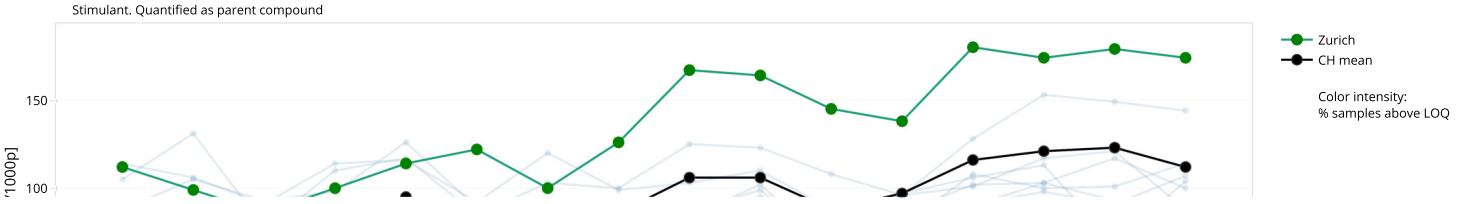
Oxazepam

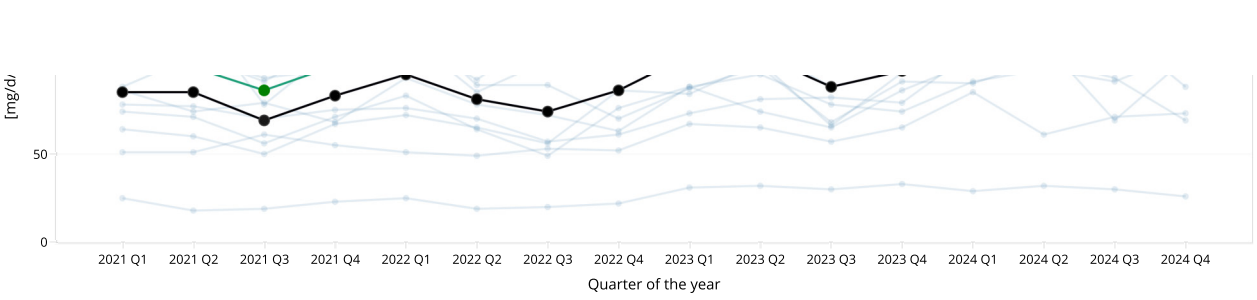
Sedative. Quantified as parent compound



Ritalinic acid

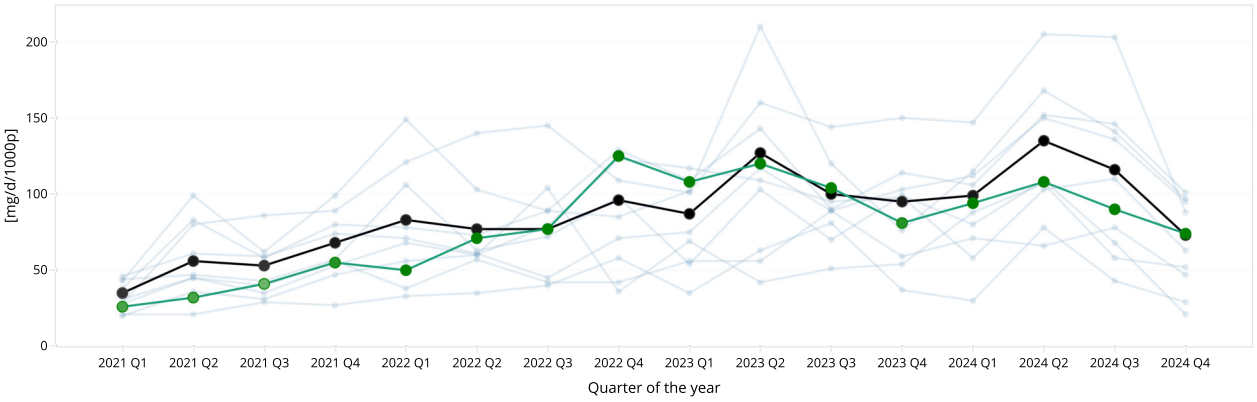
Stimulant. Quantified as parent compound





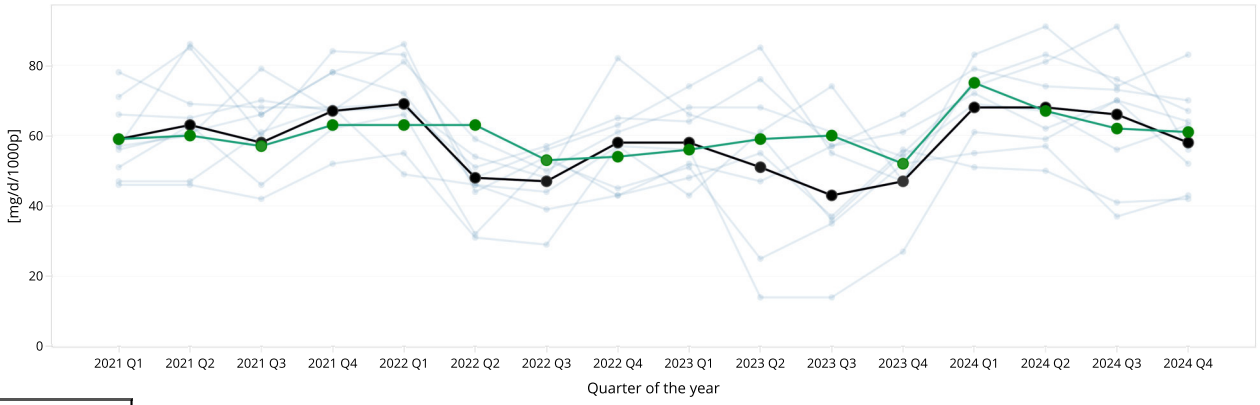
Sulfamethoxazole

Antibiotic. Quantified as parent compound



Trimethoprim

Antibiotic. Quantified as parent compound



Download CSV

Select Compound Group: additional medications

Select Region: Zurich

Select Visualization: Bar – per year

Six additional drug markers have been analyzed in connection with **stimulants (Ritaline)**, **sedatives (Oxazepam)**, **anesthetics (Ketamin)**, **antibiotics (Sulfamethoxazole and Trimethoprim)**, and **anticonvulsants (Carbamazepine)**. The selection was based on frequently prescribed medications in Switzerland or those with a risk of abuse. They must also be detectable in wastewater in a stable manner.
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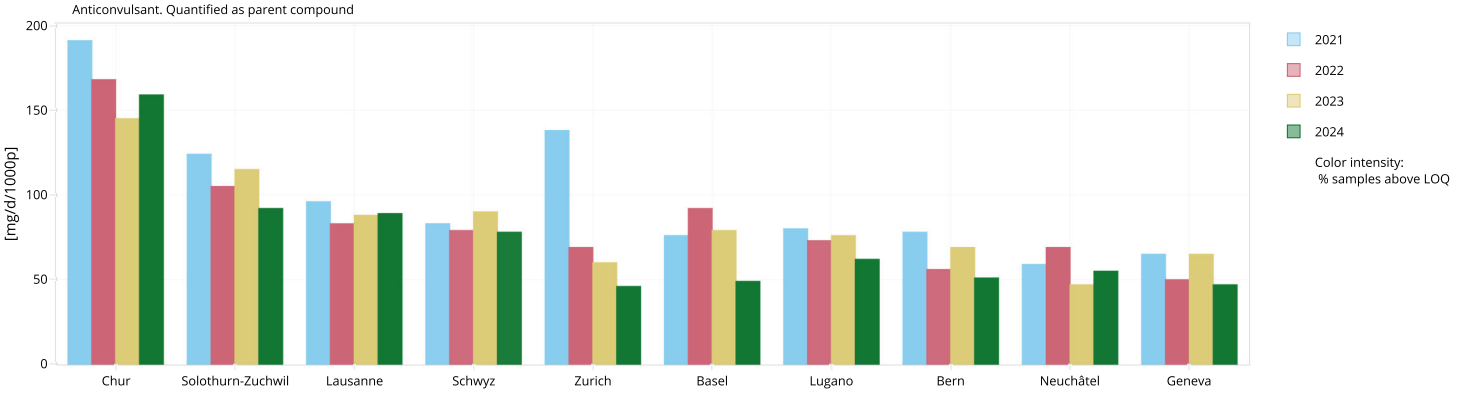
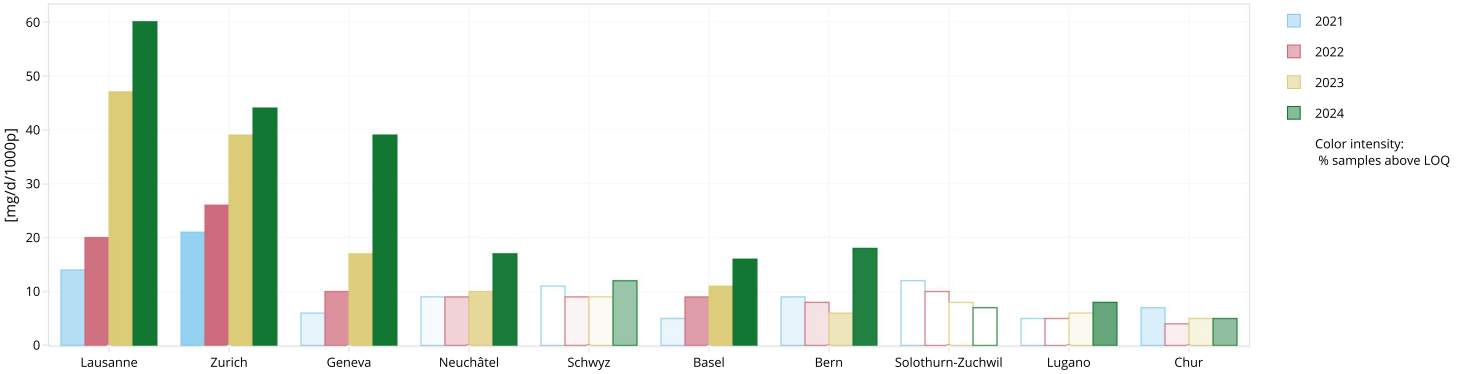
Carbamazepin

Anticonvulsant. Quantified as parent compound



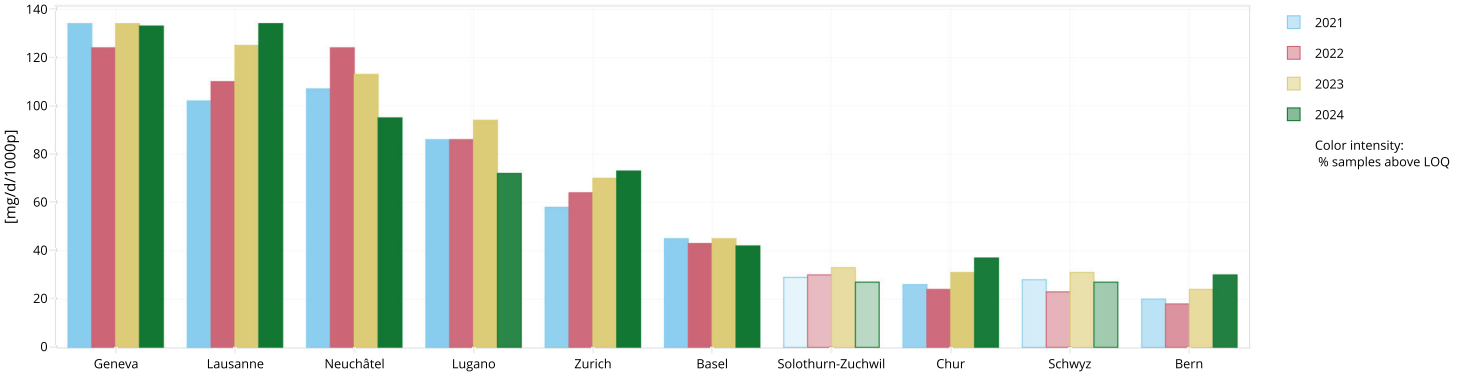
Ketamin

Anesthetic. Quantified as parent compound. **Color intensity of markers reflectsthe percentage of samples above the limit of quantification.



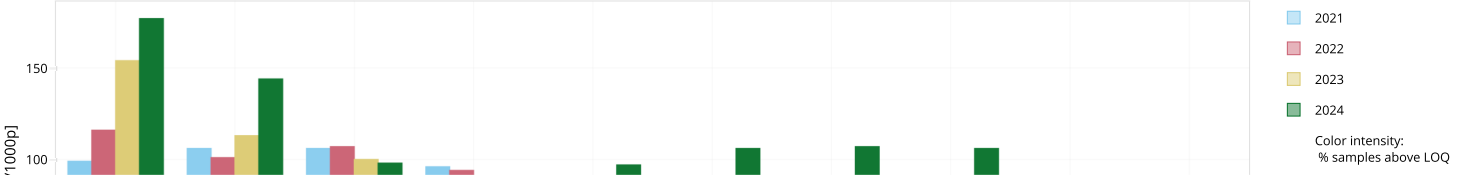
Oxazepam

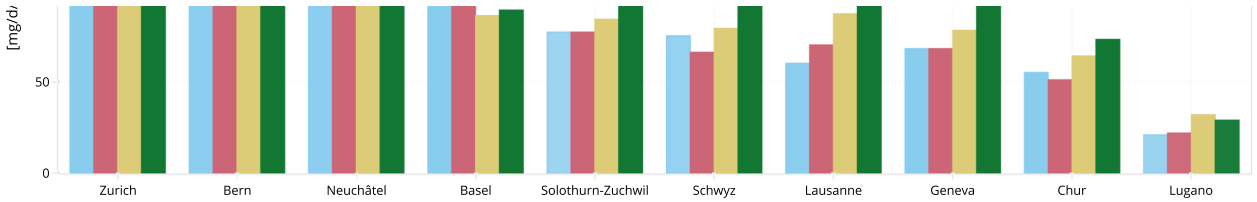
Sedative. Quantified as parent compound



Ritalinic acid

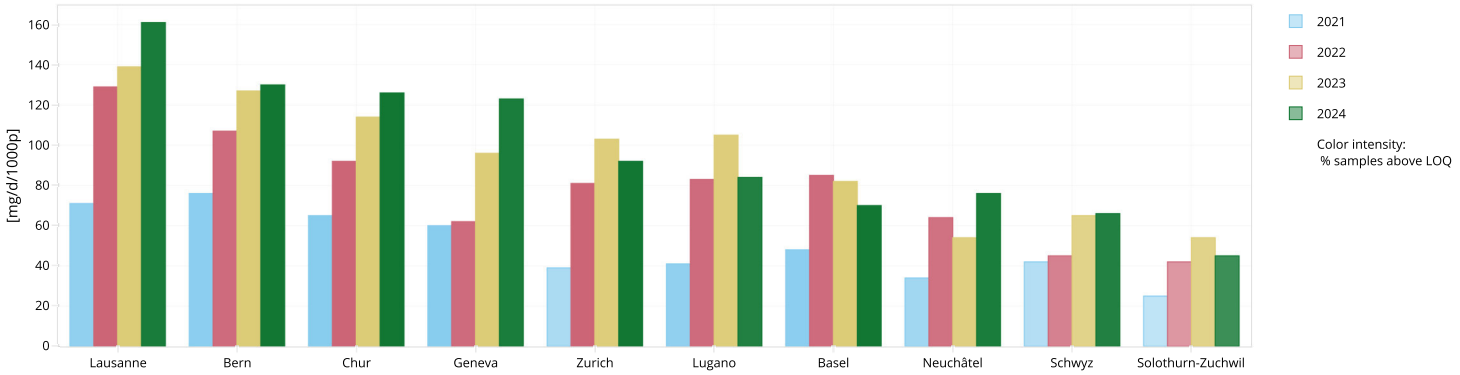
Stimulant. Quantified as parent compound





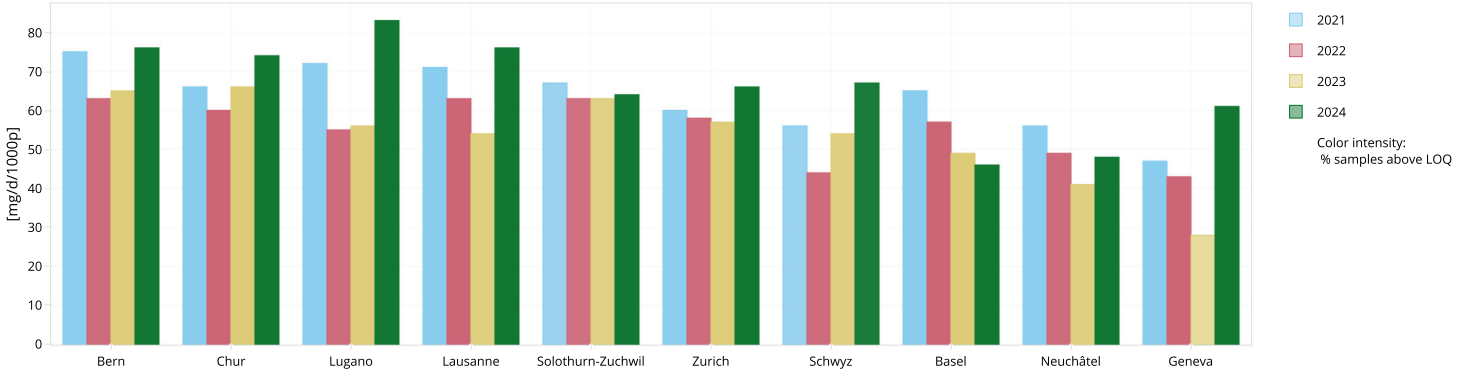
Sulfamethoxazole

Antibiotic. Quantified as parent compound



Trimethoprim

Antibiotic. Quantified as parent compound



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Select Compound Group: tobacco & alcohol

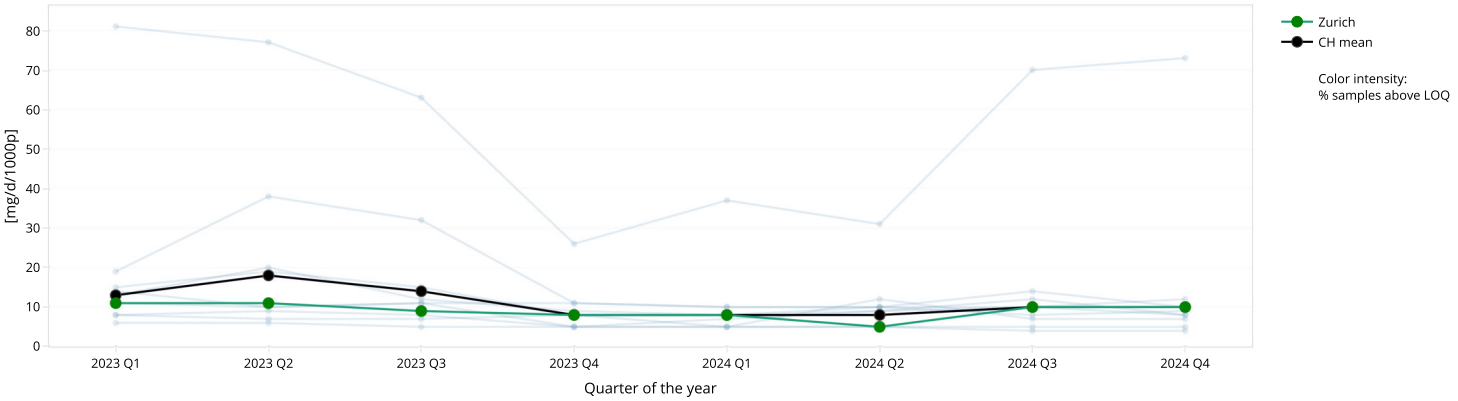
Select Region: Zurich

Select Visualization: Line – per quarter

We analyze two key metabolites of tobacco in wastewater: **Cotinine**, a metabolite product of **nicotine**, and **Anabasine**, a specific alkaloid marker for **tobacco** use.
Additionally, we monitor **Ethylsulfate**, a metabolite of ethanol, to indicate **alcohol** consumption.
However, for these markers of tobacco and alcohol, less reference data from additional studies is available. As a result, the factors that may influence excretion at the population level are not yet fully understood. Therefore, these results should be interpreted with caution until more data is collected and comparisons with other indicators are made.
For a guided example on how to read the wastewater data, please refer to user guide.

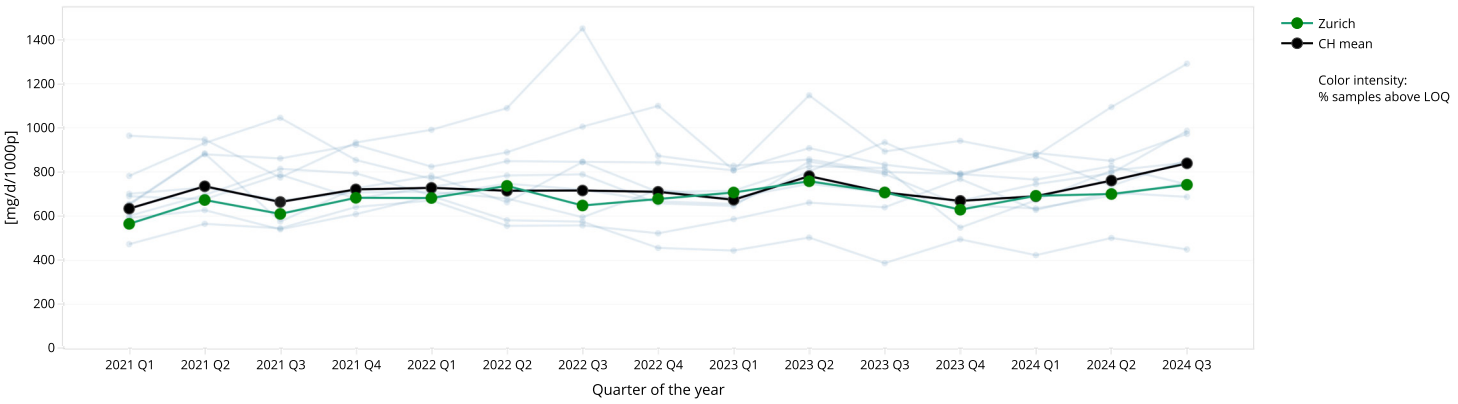
Anabasine

Urine alkaloid marker of **tobacco**



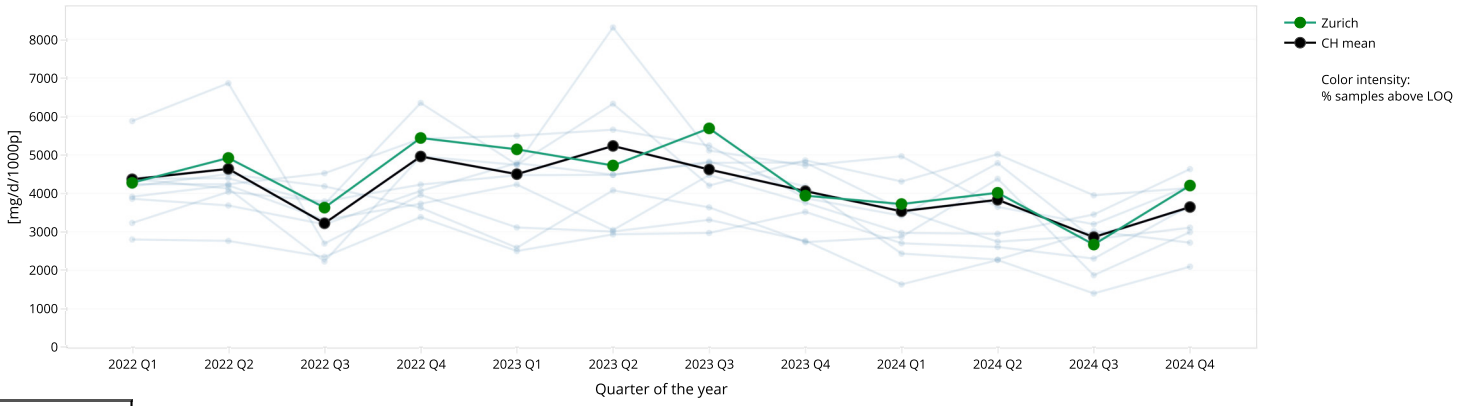
Cotinine

Main urine metabolie of **nicotine**



Ethylsulfate

Urine metabolite of alcohol **(ethanol)**



Download CSV

Select Compound Group: tobacco & alcohol

Select Region: Zurich

Select Visualization: Bar – per year

We analyze two key metabolites of tobacco in wastewater: **Cotinine**, a metabolite product of **nicotine**, and **Anabasine**, a specific alkaloid marker for **tobacco** use.
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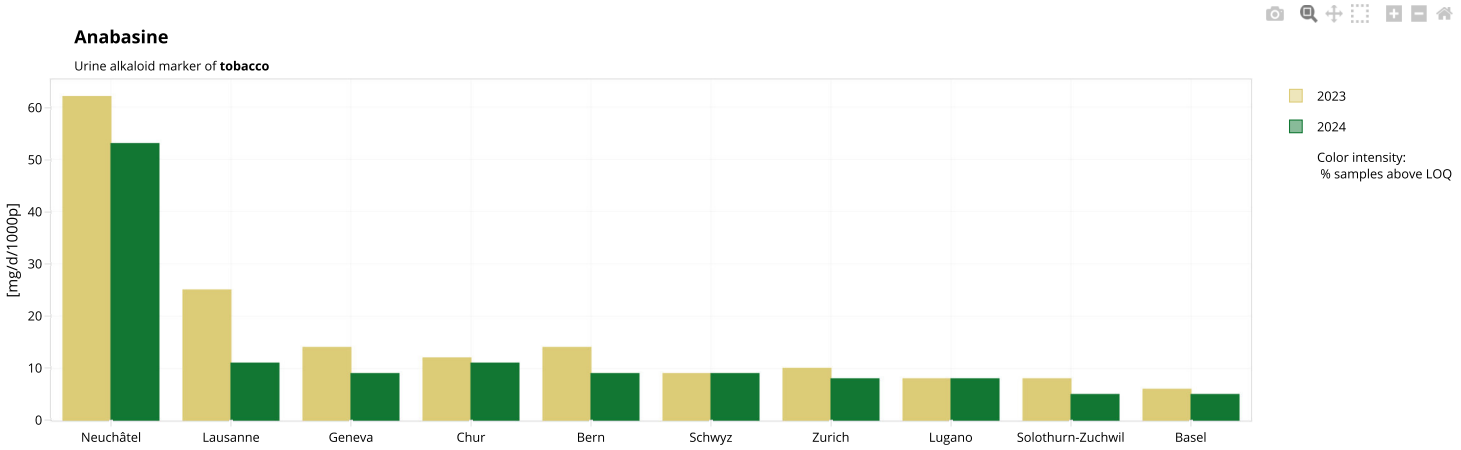

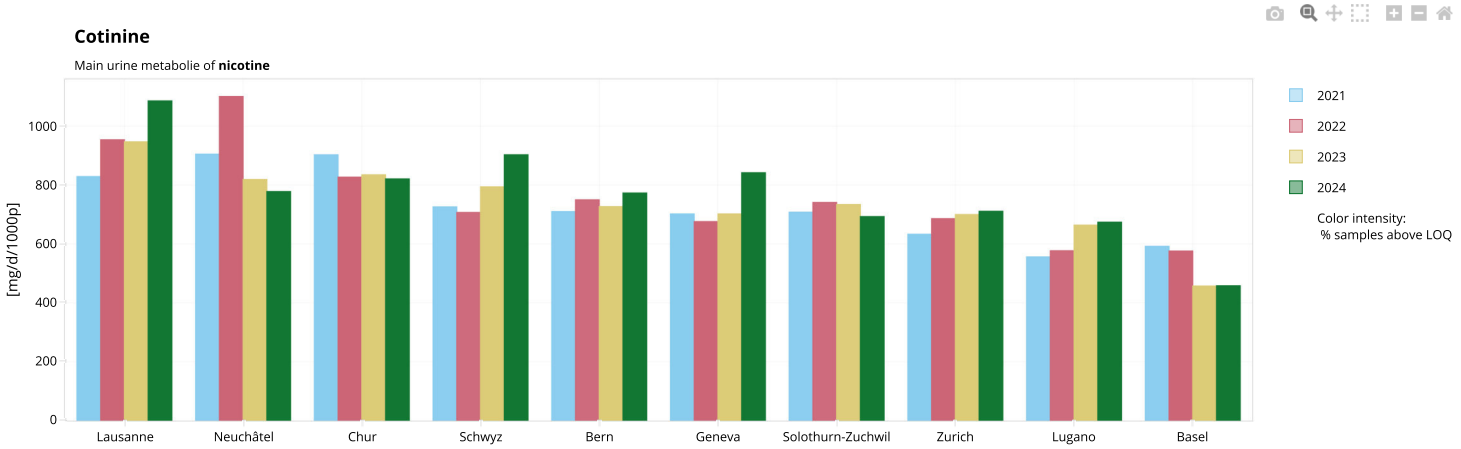

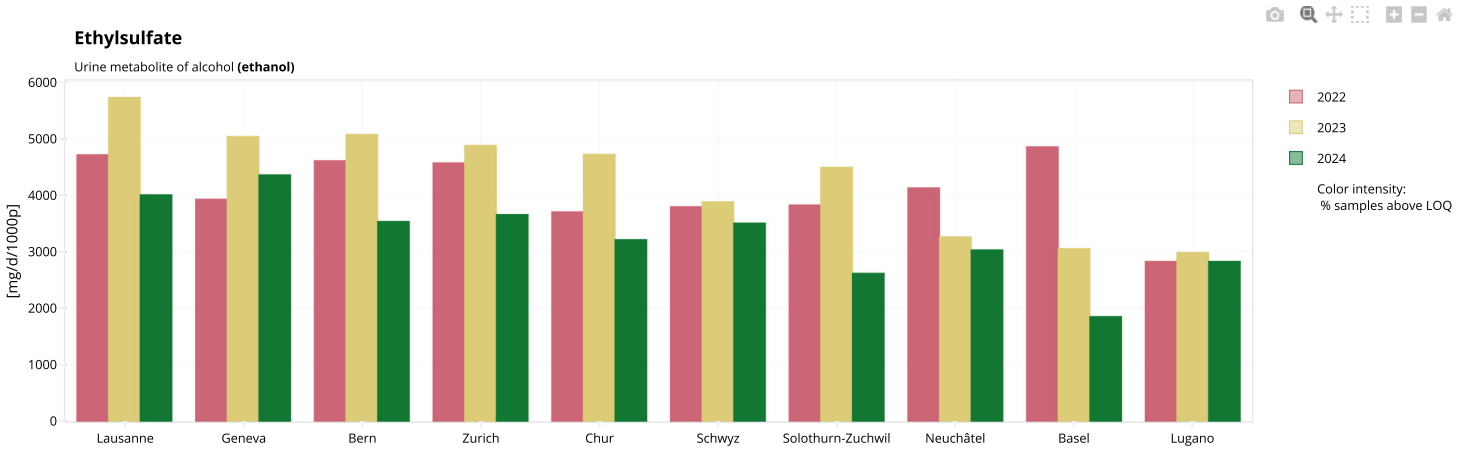

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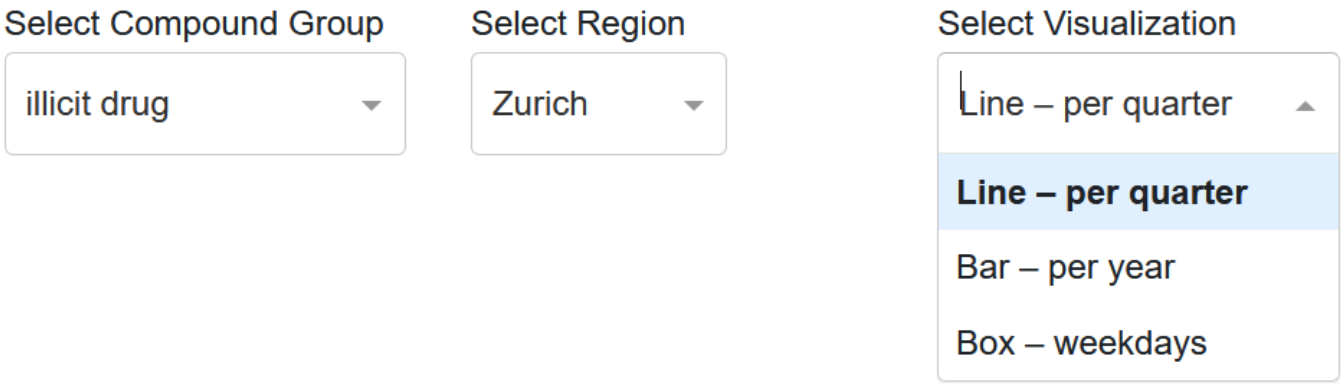
DroMedAria

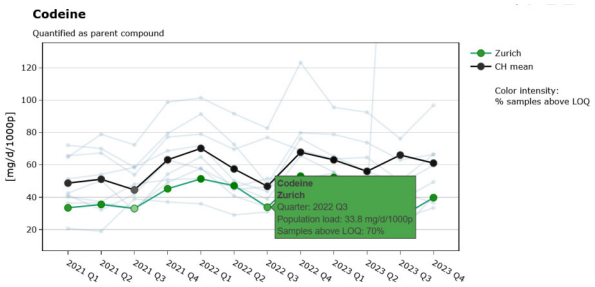
Dashboard User Guide

The wastewater data, gathered every 13 days from ten treatment plants across Switzerland, facilitates the exploration of diverse questions regarding substance consumption.
The results are given in mg/d/1000p. It means the milligrams of analyte / day / 1000 persons. The weighting is based on the official population of the municipalities connected to the wastewater treatment plants concerned.

To assist in this, several visualization options, detailed below, are available for selection.

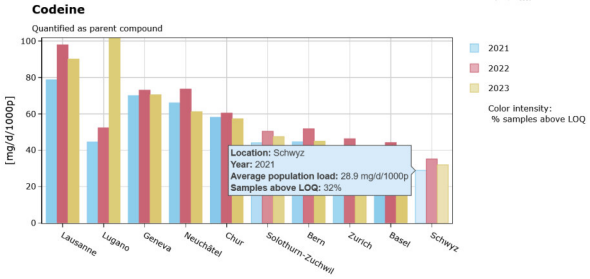


1. Line - per quarter visualization



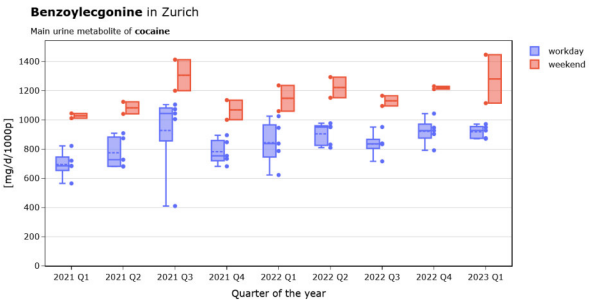
Purpose: To observe spatiotemporal trends in substance consumption, averaged quarterly.
Details: Lines corresponding to regional areas are shaded to emphasize the overall view. Choose a specific location to highlight its data. This can be compared with the "CH mean," which represents the population-weighted average of all ten locations. ***Special Note***: For some substances, like Codeine (example above), not all samples may reach concentrations above the Limit of Quantification (LOQ) due to factors such as low consumption or "diluted" wastewater. In such instances, the resulting loads are calculated based on sample concentrations estimated as ½*LOQ. The marker color intensity shows the percentage of samples above the LOQ in each quarter. Interpret comparisons of absolute loads over time and between locations with caution if only a few samples exceed the LOQ.

2. Bar - per year visualization



Purpose: To visualize spatial differences in consumption across locations.
Details: This visualization shows the annual mean values of each substance per location. The intensity of the bar's color indicates the percentage of samples above the LOQ, as can be seen in the example above for codeine.

3. Box - weekdays visualization



Purpose: To explore differences in consumption patterns between weekdays and weekends.
Details: Samples from each quarter are grouped according to whether they were collected on workdays or weekends, providing insights into consumption patterns of substances like Benzoylecgonine, the main urine metabolite of cocaine (example above).

Support: Should you have any questions during your exploration of the data, please refer to the FAQ section or contact us for more detailed information.

Proceed to the dashboard and begin exploring the data by clicking here.

FAQs

Are the wastewater loads representative of consumption?

Yes, the wastewater loads are indicative of consumption. However, consumed substances are transformed and excreted by the human body; therefore, we analyze the transformation products (e.g. THC as THC-COOH) for some substances and others, which are less altered, as the original substance. The absolute loads (mg/day/1000 people) are thus an indicator of relative consumption and allow comparisons over time and between locations. However, these cannot be directly compared with consumption or sales figures without including the substance-specific excretion factor.

Are the wastewater loads affected by rain, catchment population size, or the type of treatment plant?

The wastewater is collected at the influent of the treatment plant; therefore, the treatment processes do not affect our samples. Sampling is proportional to the volume of wastewater over a 24-hour period and is therefore adjusted for variations in wastewater flow, such as from rain (-except during heavy rain events that cause discharges of untreated wastewater). The wastewater loads are further normalized by the census population in the catchment area, making them comparable across locations.

Why are there extreme values?

Extreme values can arise from the disposal of medications affecting primary substances, or unusual events that lead to a significantly increased population and therefore higher loads in the catchment area for both primary substances and metabolites. Additionally, extreme rainfall events can cause discharges of untreated wastewater, leading to underestimated loads.

LOQ : How to interpret % samples above LOQ

LOQ or limit of quantification is the quantity of substances above which the results can be considered reliable. For some substances, like Fentanyl, not all samples may reach concentrations above the Limit of Quantification (LOQ) due to factors such as low consumption, or "diluted" wastewater. In such instances, the resulting loads are calculated based on sample concentrations estimated as ½*LOQ. Such loads serve as upper thresholds, with actual loads estimated below this value. The marker color intensity of the graphic shows the percentage of samples above the LOQ in each quarter. Interpret comparisons of absolute loads over time and between locations with caution if only a few samples exceed the LOQ.

Increase of 50% of the quantified substances: Does this mean that consumption has increased by 50% ?

Presence in water has increased by 50%. However, the causes may be an increase in the number of people consuming the substance, or a higher volume per person, or also a different concentration of the

substance (e.g. a higher purity of cocaine).

Impact of tourism or commuters

The treatment plants in each zone cover a large number of surrounding communes. The results are calculated on the basis of the population of each of these communes. The presence of tourists or commuters is not taken into account.

How were the substances selected?

The selection of analytes is based on their epidemiological relevance, on frequently prescribed medications or risk of abuse. They must also be detectable in wastewater in a stable manner.

How accurate are the values estimated from wastewater?

Based on international literature and our own experience in the Swiss context, we estimate the overall uncertainty for an individual daily value to be 20-50%. This is a conservative estimate including uncertainty due to chemical analyses, flow measurements and residential population to estimate population normalized loads measured from a wastewater sample. Quarterly and annual means are subject to less uncertainty due to averaging of individual values. Since some uncertainty are unknown but mostly constant over time, the assessment of temporal trends within one location is less affected by this overall uncertainty.