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Spatial and temporal trends in alcohol consumption in Belgian cities: a wastewater-based approach

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Abstract

Background

In recent years, scientific evidence has emerged that wastewater-based epidemiology can deliver complementary information concerning the use of different substances of abuse. In this study, the potential of wastewater-based epidemiology in monitoring spatial and temporal trends in alcohol consumption in different populations in Belgium has been examined.

Methods

Concentrations of ethyl sulphate, a minor phase II metabolite of ethanol, in 163 influent wastewater samples from eight wastewater treatment plants in Belgium in the period 2013-2015 were measured with liquid chromatography coupled to tandem mass spectrometry and used to estimate alcohol consumption.

Results

The highest levels of alcohol consumption were detected in the metropoles Antwerp and Brussels compared to smaller villages. Annual variations were detected, with a higher alcohol consumption measured in 2013 compared with 2014. The weekly pattern showed a clear week and weekend difference in alcohol use, with intermediate levels on Monday and Friday. The results were extrapolated and a volume of 5.6 L pure alcohol per year per inhabitant aged 15+ has been estimated in Belgium. The comparison with available information on drinking habits of the Belgian population further demonstrated the usefulness of the wastewater-based epidemiology approach.

Conclusions

This largest wastewater-based epidemiology study to monitor alcohol consumption up to now demonstrates that objective and quick information on spatio-temporal trends in alcohol consumption on a local and (inter)national scale can be obtained.

Keywords

Ethyl sulphate, influent wastewater, sewage-based epidemiology, alcohol consumption, spatio-temporal trends

1.0 Introduction

Alcohol (ethanol, CH_3CH_2OH) abuse is the most common form of substance abuse and has a high impact on societies with a higher incidence of traffic accidents and criminality, economic damage and health treatment costs (WHO, 2014). Actually, abuse of alcoholic beverages and in particular binge drinking occurs so often that it has become a sociological phenomenon all over the world (Courtney & Polich, 2009). Therefore, a concern about concomitant health problems is manifesting in different countries which is demonstrated by the fact that four percent of all deaths on a global scale are caused by the (ab)use of alcoholic beverages (WHO, 2014). Because of this serious impact on human health in general, it is important to gather information on the average alcohol use in a population which can assist authorities to take measures to diminish the morbidity and mortality due to alcohol usage. The findings of the World Health Organization (WHO) suggest a worldwide annual intake of 6.2 L pure ethanol per capita aged 15+ in 2010, which implies the consumption of a daily dose of 1.4 standard consumptions per capita aged 15+ (NIAAA, 2010; WHO, 2014). For Belgium, the WHO suggests an annual consumption of 11 L pure ethanol per capita aged 15+ in 2010, which corresponds to 2.4 standard consumptions per day (WHO, 2014). This value is considerably higher than the finding of 1.5 standard consumption per day per capita aged 15+, reported by the Belgian Scientific Institute of Public Health in 2013 (WIV-ISP, 2013).

In order to better evaluate these discrepancies and to have up-to-date and timely numbers on alcohol consumption, there is a need for quick, objective and complementary approaches to estimate the amount of consumed alcohol within communities. Currently, alcohol consumption is measured mostly based on individual surveys or sales statistics, but these approaches are not always reliable (NIAAA, 2003). Sales numbers are often inaccurate because they are only an indirect measure of alcohol consumption and they do not take international purchases and wastage or stock-pilling into account. Interview and questionnaire-based information on a large population scale suffer from bias since these methods rely on the self-report of the users themselves (NIAAA, 2003; Smith et al., 1990).

Recently, scientific evidence has emerged that the analysis of wastewater for the presence of urinary biomarkers of different substances can deliver objective and complementary information on the use of these compounds within communities (Daughton, 2001). The approach, called wastewater-based epidemiology (WBE), has already proven its applicability in evaluating spatial and temporal trends in illicit drug consumption on a regional, national and international scale (Castiglioni et al., 2014; Ort & van Nuijs et al., 2014). The proven potential of the WBE approach opens possibilities for applying it to monitor the use of other substances such as alcohol (Thomas & Reid, 2011).

Alcohol is mainly metabolized through oxidation which involves alcohol dehydrogenase and aldehyde dehydrogenase to form acetaldehyde and acetic acid. However, a small fraction of alcohol undergoes Phase-II metabolism to form ethyl sulphate (EtS) and ethyl glucuronide (EtG) in which sulphotransferase and UDP-glucuronosyltransferase enzymes play a key role (Kurogi et al., 2012; Schwab & Skopp, 2014; Walsham & Sherwood, 2014). EtS and EtG are commonly used in clinical and forensic toxicology to monitor individual alcohol consumption via the analysis of hair, urine and blood (Crunelle et al., 2014; Walsham & Sherwood, 2012; Walsham & Sherwood, 2014). Based on this scientific evidence, both EtS and EtG form potential biomarkers that could be targeted in influent wastewater samples to determine the amount of alcohol used by a certain population. Previous studies have already proven the stability of EtS in this matrix and used it successfully on samples that originated from Italian, Spanish and Norwegian populations (Mastroianni et al., 2014; Reid et al., 2011; Rodriguez-Alvarez et al., 2014; Rodriguez-Alvarez et al., 2015). Unlike EtS, EtG was not suitable as an alcohol biomarker in wastewater due to its marked instability in wastewater (Reid et al., 2011).

The present study reports on the application of WBE to evaluate spatial and temporal trends in alcohol consumption in eight different communities in Belgium through the analysis of EtS in wastewater samples and to compare our findings with other figures obtained through the classical approaches. The rationale of the WBE approach can be found in Figure 1.

2.0 Materials and methods

2.1. Reagents and materials

LC-grade methanol (MeOH), acetonitrile (ACN), and acetic acid (CH_3COOH) were purchased from Merck (Darmstadt, Germany). Ultrapure water was obtained by purifying demineralized water in an Elga LabWater Purelab Flex system (Veolia Water Solutions & Technologies Belgium, Tienen, Belgium). Analytical standards of EtS and EtS-D_5 were acquired from Athena Enzyme Systems (Baltimore MD, USA) in neat powder. Dilutions of the reference standards were prepared in MeOH. Safe-Lock tubes (1.5 mL and 2 mL) were obtained from Eppendorf (Rotselaar, Belgium) and centrifugal filters with a nylon membrane with pore size 0.2 µm were purchased from VWR (Leuven, Belgium).

2.2. Sampling

Influent wastewater samples were collected from eight Belgian wastewater treatment plants (WWTPs) covering approximately 1.6 million inhabitants: Antwerpen-Zuid, Deurne, Ninove, Geraardsbergen, Lier, Oostende, Brussel-Noord and Wulpen. To obtain samples that were representative for an entire day, 24-h composite samples were collected using time- or volume-proportional techniques (Ort et al., 2010). For each WWTP, at least seven consecutive daily samples were collected over a period of three years (2013-2015); in total 163 samples were collected (see Table 1). Samples were immediately frozen after collection and stored at -20 °C until analysis.

2.3. Analysis

2.3.1. Sample preparation

Prior to the analysis, samples were thawed at room temperature and afterwards vigorously shaken. One mL of influent wastewater was transferred to a 2 mL Eppendorf tube which was centrifuged at 8000 rpm for 5 min. Thereafter, 190 µL supernatant was transferred to a 1.5 mL Eppendorf tube and 10 µL of the internal standard EtS-D_5 at a concentration of 1 ng/µL was added. The sample was vortexed for 1 min, subsequently brought to a centrifugal filter (0.2 µm) and centrifuged for 5 min at 8000 rpm. The resulting filtrate was transferred to a vial for determination with liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS).

2.3.2. Liquid chromatography-tandem mass spectrometry

The LC system consisted of an Agilent 1290 series binary pump and an autosampler module. Separation was achieved with an Atlantis T3 column (150 mm x 2.1 mm, 3 µm) maintained at 30 °C and a mobile phase composed of (A) Ultrapure water with 0.1% CH_3COOH and (B) ACN using a gradient as follows: 0-10 min: 2%-15% B; 10-11 min: 15%-95% B; 11-12 min: 95% B; 12-13 min: 95%-2% B; 13-20 min: 2% B for column equilibration. The flow rate was 0.18 mL/min and the injection volume was set at 4 µL. EtS and EtS-D_5 eluted at 4.80 and 4.75 min, respectively.

The MS system was an Agilent 6460 triple quadrupole mass spectrometer equipped with an electrospray interface operating in negative ionisation mode and the following settings: gas temperature 250 °C, gas flow 12 L/min, nebulizer pressure 35 psi, sheath gas heater 325 °C, sheath gas flow 11 L/min, capillary voltage 2750 V, and nozzle voltage 750 V. Quantitative analyses was performed in multiple reaction monitoring (MRM) mode and the two most abundant fragmentation products (selected as quantifier and qualifier) were recorded. Optimized MS parameters for both analyte and internal standard are shown in Table 2. The LC flow was diverted to the waste in the first two minutes after injection and from 10 to 20 min, to avoid excessive contamination of the mass spectrometer.

A curve containing seven calibration points was constructed with increasing concentrations of EtS (range: 1.5 to 100 µg/L) and a fixed amount of EtS-D_5 (50 µg/L). The calibration was considered as satisfactory when a coefficient of determination (R^2) >0.99 was obtained and when the back-calculated concentrations of the calibrators had an accuracy within 85-115% (EMA, 2011). The precision of the method could be determined based on these calibrators and was <10% relative standard deviation. The limit of quantification of the method was 1.5 µg/L and was determined as the lowest point of the calibration curve with an accuracy of the back-calculated concentration between 80% and 120% and a precision <20% relative standard deviation (EMA, 2011).

2.4. Calculations and statistical analysis

Firstly, the measured concentrations (in µg/L) were multiplied with a factor of 1.05 to correct for the dilution occurring during sample preparation. Corrected concentrations were then multiplied with the wastewater flow rate (L/day) recorded at the WWTPs to obtain mass loads of EtS (in g/day). To compare EtS loads for cities and villages of different population size, mass loads were divided by the number of inhabitants served by each WWTP. In order to obtain realistic figures and to compare results with existing data, only inhabitants aged 15+ were taken into account (FOD Economy, 2015). This calculation resulted in the daily per capita load of EtS, expressed in g/day/1000 inhabitants aged 15+.

Secondly, back-calculations were made to transform to obtained population-normalized mass loads of EtS into a consumed amount of alcohol (Figure 1, see Table S1 for the all raw data). Therefore, the excretion rate (0.012%) and the molar mass ratio of EtS and alcohol (0.369) were considered, resulting in a correction factor of 3047 (Hoiseth et al., 2008; Rodriguez-Alvarez et al., 2015). Note that when the volume of pure alcohol is desired, the density (ρ=789 g/L) needs to be included. In order to report an amount of consumed alcohol doses per day per capita aged 15+, the value for a standard dose of alcohol needs to be known (9.86 g pure alcohol) (NIAAA, 2010).

Statistical analysis was performed with IBM SPSS Statistics 22 software (IBM, Armonk, USA). A One-Sample Kolmogorov-Smirnov normality test was applied to determine if parametric or non-parametric tests should be used. To investigate if there were any daily differences in alcohol consumption, paired samples T-test or Wilcoxon signed pair rank test were used depending on the normal distribution. Variations between years and locations were evaluated by using the parametric One-Way Anova test, followed by a Bonferroni post-hoc test after validating the normality of these data. The limit for significance in all cases was set at $p<0.05$.

3.0 Results and discussion

3.1. Spatial analysis

To evaluate spatial variations in alcohol consumption, the calculated use (in standard consumptions per day per capita 15+) in each of the seven locations that were targeted in 2015 was averaged and compared (Figure 2).

Two WWTPs that receive wastewater from the city of Antwerp were included in the present study: WWTP Antwerpen-Zuid covers the centre of Antwerp, whereas WWTP Deurne covers the eastern districts of this city. This is reflected in the statistically significant differences observed in the measured alcohol consumption between the two WWTPs. The alcohol consumption in the area of WWTP Deurne was considerably lower than the use in the area covered by WWTP Antwerpen-Zuid ($p=0.002$, One-Way Anova). This observation can be related to the higher density of recreational accommodations (discotheques, pubs, etc.) in the centre of Antwerp compared to the suburbs of the city. Consequently, this can be linked with higher alcohol consumption in the centre of Antwerp.

Statistical analysis revealed that alcohol consumption in the regions covered by WWTP Antwerpen-Zuid and WWTP Brussel-Noord is different from its use in the other regions (Figure 2). These results suggest that the use of alcohol in more urbanised cities, such as Brussels and Antwerp is higher than those from smaller villages and cities, such as Ninove, Geraardsbergen, Oostende and Wulpen. The alcohol consumption measured in the neighbouring villages of Ninove and Geraardsbergen was very similar, which can be linked with the matching socio-demographic character of both villages. WWTPs

Oostende and Wulpen both receive wastewater from several seaside villages. Although the difference between Oostende en Wulpen was not statistically significant, it seems that the alcohol use in the catchment area of WWTP Oostende is somewhat higher than in WWTP Wulpen. Probably this can be related to the different tourist influxes and activities between these two recreational locations. This study is the first to report on the applicability of WBE to detect spatial differences in alcohol consumption by comparing results of seven cities with different demographics within one country.

3.2. Temporal analysis

3.2.1. Daily variations

When evaluating daily variations in alcohol consumption based on wastewater analysis, one needs to consider two important issues: 1) 24 h-composite sampling is applied to obtain representative samples and 2) EtS is excreted from the body via urine with peak concentrations after 2-4 h and with more than 90% of the total EtS excreted within 12 h after alcohol consumption (Helander et al., 2008; Wurst et al., 2011).

The 24-h samples are pooled samples consisting of discrete subsamples collected after a fixed interval (time or volume) (Ort et al., 2010). Consequently, in addition to the abovementioned information regarding the excretion pattern of EtS, a 24-h composite sample from e.g. Sunday contains EtS that is mostly originating from alcohol consumption on Saturday (evening) and Sunday.

Clear variations in alcohol consumption were observed during the week with a recurrent trend. The consumption patterns typically describe the highest use over the weekend period. Previous studies based on wastewater analysis have already shown a significantly increased consumption of alcohol during the weekend in Italy, Norway and Spain (Mastroianni et al., 2014; Reid et al., 2011; Rodriguez-Alvarez et al., 2014; Rodriguez-Alvarez et al., 2015). However this study included multiple locations within Belgium and these were monitored over multiple years. In this way, a more profound and reliable statistical evaluation of the daily variation in alcohol consumption could be performed (Figure 3). Consumption from Tuesday to Thursday was lower than the consumption on Saturday and Sunday ($p<0.001$, Paired Samples T-test) which can be explained by more recreational use of alcohol during the weekend. Interestingly, we observed that the alcohol consumption calculated for Friday and Monday was higher than the consumption on Tuesday to Thursday ($p<0.001$, Paired Samples T-test) was lower than the consumption on Saturday and Sunday ($p<0.001$, Paired Samples T-test). This probably can be linked with the fact that the samples from Friday and Monday capture parts of the typical weekend alcohol consumption.

3.2.2. Annual variations

Another interesting feature of the WBE approach is the possibility to compare alcohol consumption over the years. To this end, the results of the three WWTPs (Antwerpen-Zuid, Deurne and Ninove) sampled in all three years (2013-2015) were used for further statistical analysis (Figure 4). The alcohol consumption in 2013 was significantly higher than in 2014, however there was no significant difference between 2013 and 2015 or between 2014 and 2015.

A similar pattern in alcohol use was observed in WWTP Antwerpen-Zuid and Deurne between the three years with a clearly higher alcohol consumption in 2013 compared with 2014 and 2015. Alcohol consumption in 2014 was lower than in 2015 for both two locations. In the catchment area in WWTP Ninove, however, a different pattern was observed. The highest alcohol use was found in 2013, which is similar to the findings from the two WWTP areas in Antwerp, but the alcohol consumption in 2014 in WWTP Ninove was higher than in 2015. These results highlight the usefulness of the WBE approach: temporal variations on a local scale can be monitored on a short-term and long-term resolution.

3.3. Extrapolation to a national level and comparison with other studies

The full data set included 163 days of sampling spread over three years and covered approximately 1.6 million inhabitants from large cities and smaller villages, which corresponds to 12% of the Belgian population. These features made appropriate an extrapolation of the results to an annual amount of consumed ethanol for the whole of Belgium (11.2 million inhabitants) for the period 2013-2015. The extrapolation resulted in a use of 1.2 ± 0.5 standard consumptions per day per capita aged 15+, corresponding to a yearly consumption of 5.6 ± 2.0 L pure ethanol per capita aged 15+ in Belgium. This value is lower than the values reported by the WHO (2010) and the Belgian Scientific Institute for Public Health (2013), with respectively 2.4 and 1.4 standard consumptions per day per inhabitant (15+ population) (WHO, 2014; WIV-ISP, 2013). However, considering the uncertainties related to all three estimations (see 3.4.), the estimation of alcohol consumption based on the WBE approach results in a logical and realistic figure.

A similar WBE approach was applied by Reid et al. (2011) on the population of Oslo, Norway, by Rodríguez-Álvarez et al. (2014) on the population of a city in Galicia, Spain (exact location is unknown due to reasons of confidentially), and by Mastroianni et al. (2014) on the population of Barcelona, Spain. These values yielded respectively 6.8, 5.9 and 8.0 L/year/inhabitant. The values found in these studies ranged within a similar magnitude as the values found in our study. It is important to point out that these previous studies only included a single urbanised location in their analysis, unlike the present study which also took into account smaller villages, such as Geraardsbergen and Ninove, which reflects better the general population within a country. Because various locations were integrated in this research, the tested population was also larger than the populations examined in the above-mentioned studies. The presented results are originating from the largest sampling campaign up to now in the frame of WBE to detect alcohol consumption, which increases the statistical validity of the observed results. .

3.4. Uncertainties of the methods

The WBE approach to assess alcohol consumption in populations has evidently some uncertainties (Castiglioni et al., 2013). A first factor is the applied sampling frequency and sampling mode. Since pulses or losses of compounds of interest may exist within this method of wastewater sampling, it must be performed with a high frequency to take these changes into consideration (Ort et al., 2010). The sampling mode for the locations included in this study was already evaluated in the frame of a Europe-wide WBE study to monitor illicit drug consumption and it was concluded that the applied discrete levels of the sampling mode were considered to be small enough to minimize errors related to sampling (Castiglioni et al., 2013). Considering that the prevalence of alcohol consumption is much higher than the illicit drug use prevalence, it is valid to assume that the applied sampling schemes are appropriate to apply WBE to evaluate alcohol consumption (Castiglioni et al., 2013; Ort et al., 2010). Another uncertainty arising in the WBE approach is the possibility of (bio)transformation of the compounds during the in-sewer transport from the place of excretion to the WWTP. However, in the case of EtS analysis, this is minimalised since Reid et al. (2011) have already proven the stability of EtS in wastewater and its exclusive formation through metabolism. The estimation of the use of alcohol from measured concentrations of EtS and its pharmacokinetic information (absorption, distribution, metabolism and excretion) creates additional uncertainties to the approach. The small amounts (0.012%) of EtS formed from alcohol result in the necessity of a large correction factor with a relatively high uncertainty to be used in the back-calculations. In this light, it is important to mention that only one study has been published which reports on the excretion percentage of EtS after alcohol intake (Hoiseth et al., 2008). This highlights the absolute need for future pharmacokinetic studies on the excretion of alcohol as EtS to confirm or update the value of 0.012%. Another critical factor is the normalization of the data for the population number that is contributing to a wastewater sample. At the moment, a fixed number of people are used while some variations in population amounts could occur due to commuting, tourist activities,… Finally, the use of equipment, like LC-MS/MS or flow rate measurement systems are linked with a certain degree of uncertainty. For all these reasons, further investigations are needed to validate this approach. Nevertheless, WBE offers a quick and objective methodology to monitor spatio-temporal trends in alcohol consumption and could deliver information that is complementary to the classical methods used by the WHO and the Belgian Scientific Institute for Public Health.

4.0 Conclusions

This study is the largest study to date to demonstrate the applicability of WBE in monitoring spatio-temporal trends in alcohol consumption on a local and national scale, by measuring an alcohol metabolite (EtS) in 163 daily influent wastewater samples from eight locations in Belgium spread over three years. Higher alcohol consumption was evidenced in the metropoles Antwerp and Brussels, compared to smaller cities such as Ninove, Geraardsbergen, Oostende and Wulpen. Clear daily variations in alcohol consumption could be observed with lower alcohol use from Tuesday to Thursday compared to Saturday-Sunday. Interestingly, use on Monday and Friday was higher than the use on Tuesday-Thursday but lower than the use on Saturday-Sunday. On an annual level, 2013 has been shown different from 2014, but no differences were found between 2013 and 2015 or between 2014 and 2015. Finally, alcohol consumption was extrapolated to a national level which resulted in a daily use of 1.2 standard consumptions per capita aged 15+. This value is in agreement with findings on alcohol use in Belgium by the Belgian Scientific Institute of Public Health, but is lower than the value found by the WHO. Future monitoring campaigns based on WBE could provide timely, valuable and reliable information on the amount of alcohol used by the general population simultaneously on a spatial and temporal resolution.

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Nothing declared

Conflict of Interest

No conflict declared

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Supplementary material

Supplementary material for this work is available.

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Table 1. Summary of the sampling locations and periods. WWTP = wastewater treatment plant

WWTP	Main area served by WWTP	Population served (census data)	Sampling mode	Sampling dates
Antwerpen-Zuid	Antwerp (centre)	130,218	Time-proportional	06/03/2013-12/03/2013 09/04/2014-15/04/2014 18/03/2015-26/03/2015
Brussel-Noord	Brussels	953,987	Volume-proportional	18/03/2015-25/03/2015
Deurne	Antwerp (suburbs)	213,876	Time-proportional	06/03/2013-12/03/2013 09/04/2014-15/04/2014 18/03/2015-25/03/2015
Geraardsbergen	Geraardsbergen	29,047	Time-proportional	19/03/2014-25/03/2014 11/03/2015-18/03/2015
Lier	Lier	31,539	Time-proportional	1/09/2014-14/09/2014 29/09/2014-13/10/2014 28/10/2014-10/11/2014 25/11/2014-11/12/2014
Ninove	Ninove	36,179	Time-proportional	06/03/2013-12/03/2013 19/03/2014-25/03/2014 11/03/2015-17/03/2015
Oostende	Oostende	160,000	Time-proportional	23/04/2015-30/04/2015
Wulpen	Koksijde	78,441	Time-proportional	11/03/2015-18/03/2015*

* Sampling on 12/03/2015 encountered technical problems and sample was thus not available

Table 2. MS/MS acquisition parameters. EtS = ethyl sulphate ; Q = quantifier ; q = qualifier

	Precursor ion	Product ion	Dwell time (msec)	Fragmentor voltage (V)	Collision Energy (eV)	Cell Accelerator voltage (V)
EtS-D_5	130.0	97.9 (Q)	50	90	14	4
EtS-D_5	130.0	80.0 (q)	50	90	38	4
EtS	125.0	96.9 (Q)	50	84	14	4
EtS	125.0	80.0 (q)	50	84	38	4

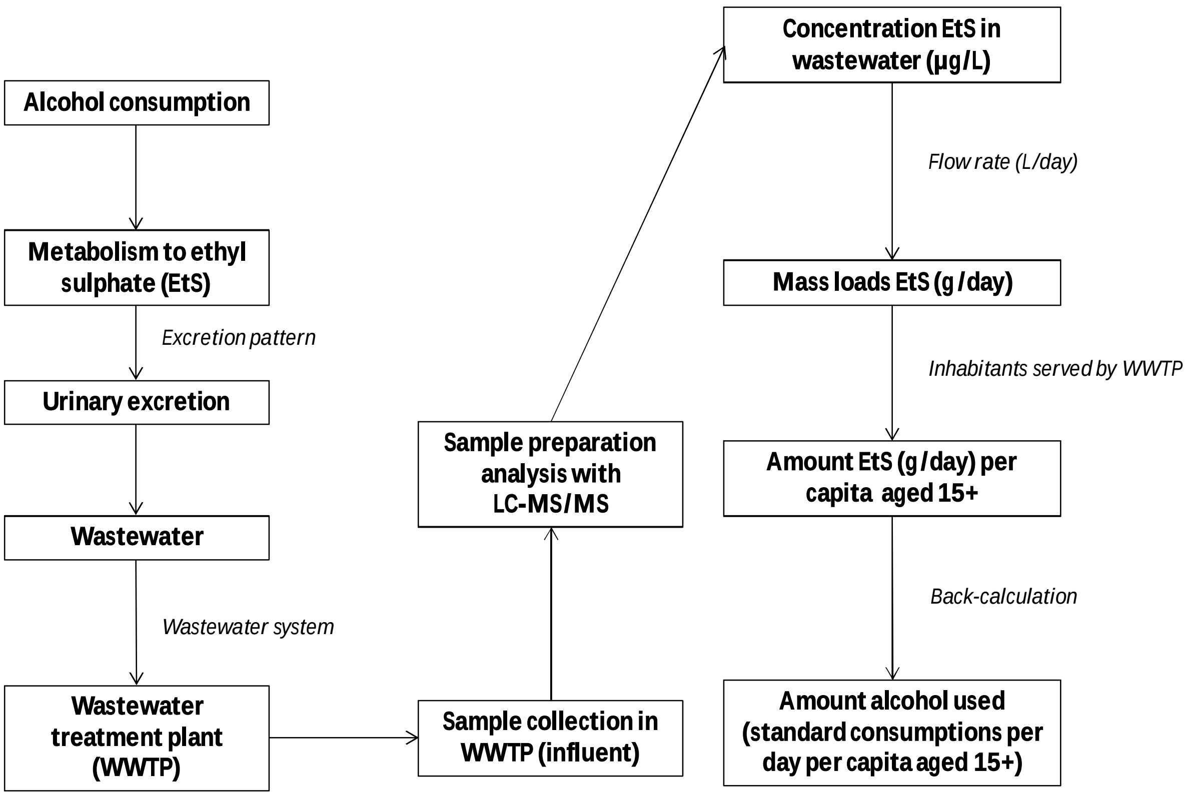
Figure captions

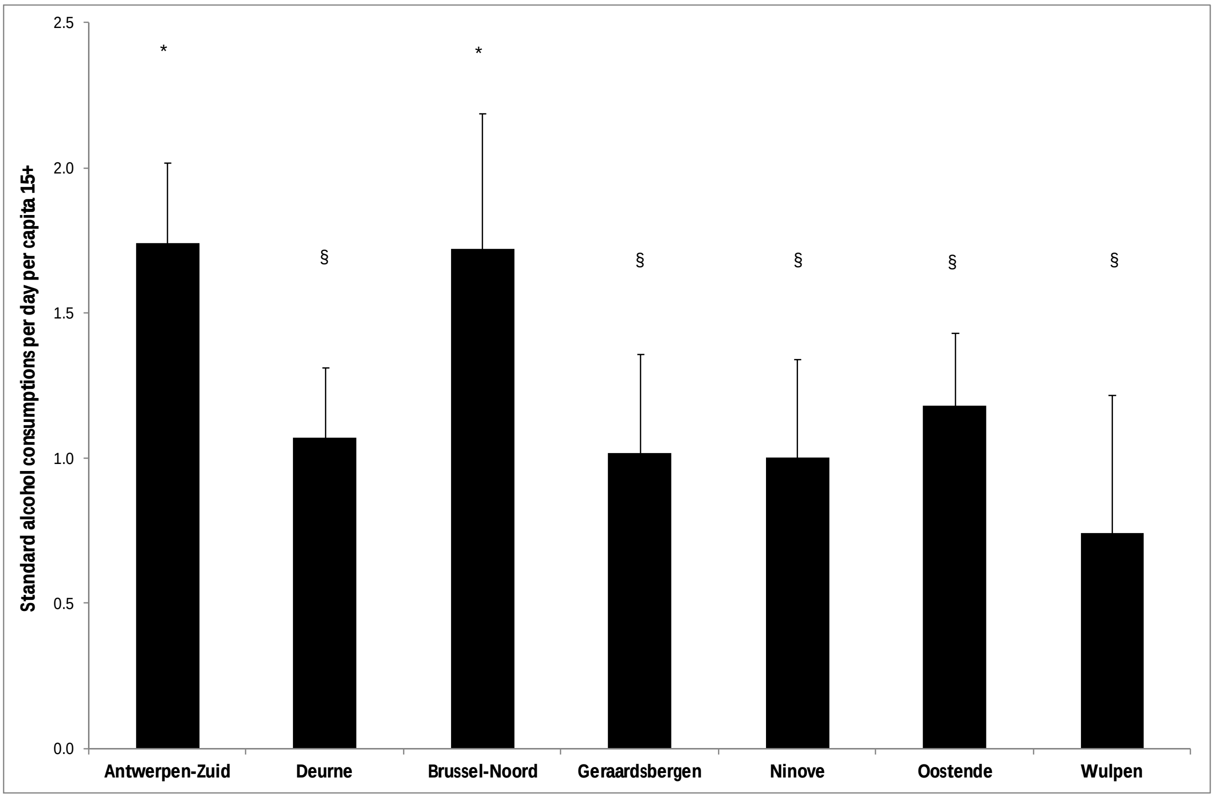
Figure 1. Wastewater-based epidemiology approach to assess the use of alcohol in communities

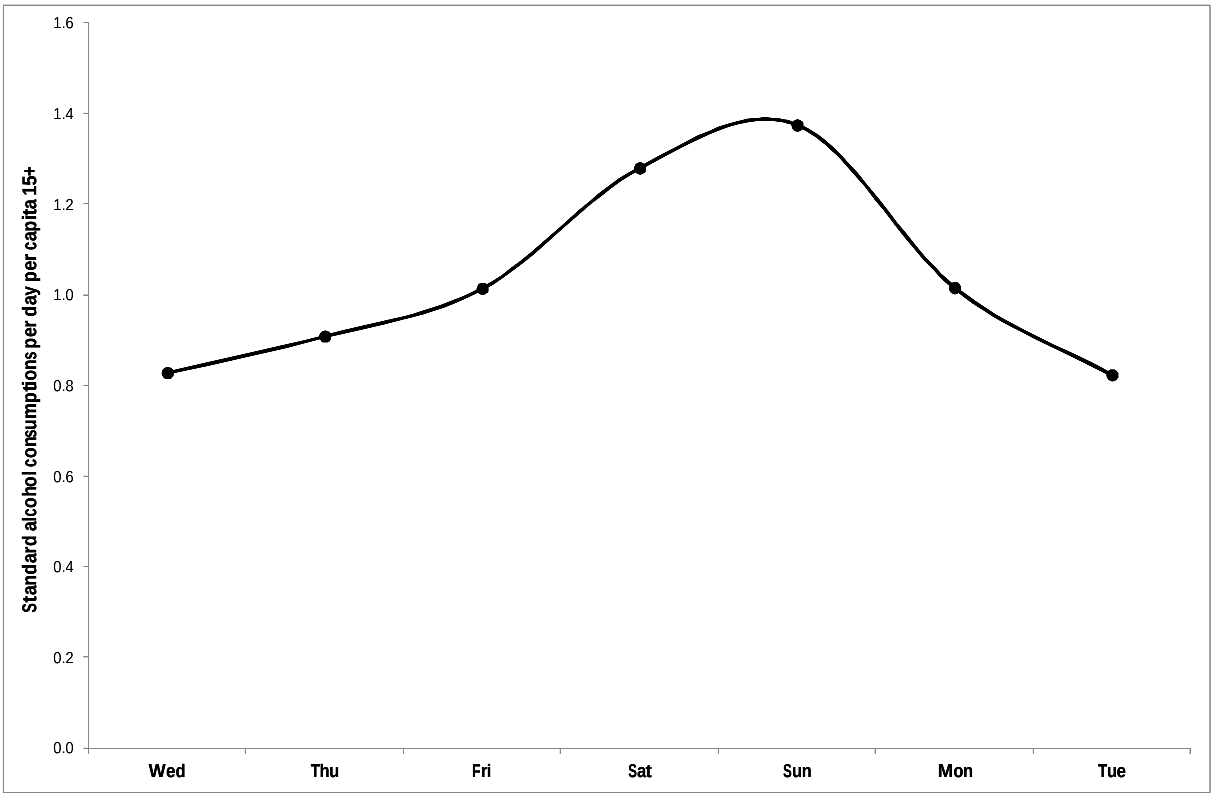
Figure 2. Spatial variations in alcohol consumption for seven locations in Belgium. The symbols (*; §) represent no statistical difference.

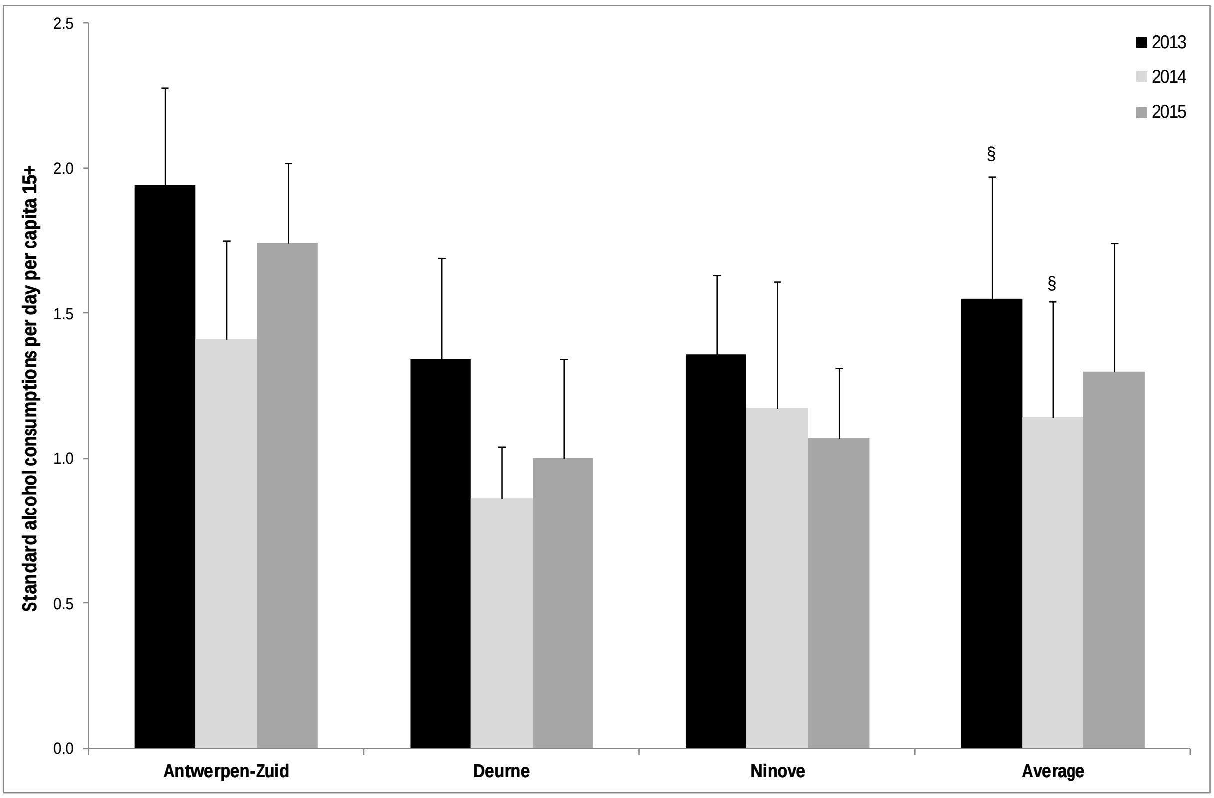
Figure 3. Weekly pattern in alcohol consumption. The graph represents per day of the week the average value of all investigated locations in all investigated years. The error bars represent the variation between the different locations.

Figure 4. Annual variation in ethanol consumption for three locations in Belgium and their average. The symbol (§) in the average represent statistically significant difference.


Alcohol consumption
Metabolism to ethyl sulphate (EtS)
Excretion pattern
Urinary excretion
Wastewater
Wastewater system
Wastewater treatment plant (WWTP)
Sample collection in WWTP (influent)
Sample preparation analysis with LC-MS/MS
Concentration EtS in wastewater (µg/L)
Flow rate (L/day)
Mass loads EtS (g/day)
Inhabitants served by WWTP
Amount EtS (g/day) per capita aged 15+
Back-calculation
Amount alcohol used (standard consumptions per day per capita aged 15+)


Standard alcohol consumptions per day per capita 15+
2.5
2.0
1.5
1.0
0.5
0.0
*
*
§
§
§
§
§
Antwerpen-Zuid
Deurne
Brussel-Noord
Geraardsbergen
Ninove
Oostende
Wulpen


Standard alcohol consumptions per day per capita 15+
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Wed
Thu
Fri
Sat
Sun
Mon
Tue


Standard alcohol consumptions per day per capita 15+
2.5
2.0
1.5
1.0
0.5
0.0
2013
2014
2015
§
§
Antwerpen-Zuid
Deurne
Ninove
Average