Wastewater Analysis for Illicit Drugs Monthly Report December 2017

20 December 2017

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CLIENT REPORT No: FW17077
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ACKNOWLEDGEMENTS

The authors wish to acknowledge the scientific expertise provided to the project from across the Forensic and Environmental Science business groups at ESR. We also are very grateful to samplers in Whangarei, Auckland and Christchurch for the collection of wastewater samples.

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DISCLAIMER

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. EXECUTIVE SUMMARY

The Drugs in Wastewater project is funded by the New Zealand Police, under the Proceeds of Crime funding, and is conducted by the Institute of Environmental Science and Research (ESR) Ltd.

Monthly sampling for Christchurch and Rosedale in Auckland began in December 2016, while monthly sampling for Whangarei began in August 2017. This report presents the results of analysis of wastewater samples for the month of December 2017 taken from Christchurch, Rosedale in Auckland, and Whangarei.

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 6th December to Tuesday 12th December 2017. In total, seven samples from Christchurch, seven samples from Auckland (Rosedale), and six samples from Whangarei were collected in December. All 20 samples were extracted by solid phase extraction (SPE) and analysed by liquid chromatography tandem mass spectrometry (LC-MS/MS) at ESR, Christchurch Science Centre.

Back calculations were undertaken based on the concentrations of the drug and/or it's metabolites in wastewater to estimate the amount of each drug used per thousand people. The back calculations do not take into account degradation, sorption and stability of drugs/metabolites in the wastewater system, leakage from pipes, or a number of other factors that may affect the drug estimates.

Methamphetamine, MDMA/ecstasy and cocaine were detected in wastewater from all cities except Whangarei, where no MDMA/ecstacy was detected this month. α-PVP and heroin were not detected in any of the wastewater samples. The drug use in mg/week/1000 people, during the week sampled in December is shown in Table 1.

Table 1 Weekly drug use (mg/week/1000 people) for Christchurch, Auckland (Rosedale) and Whangarei

	Weekly Drug Use (mg/week/1000 people)		
Drug	**Christchurch**	**Auckland (Rosedale)**	**Whangarei [1]**
Methamphetamine	1860	2631	4725
Cocaine	128	365	22
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2203	1169	170

The total load or amount of drug used in the population in Christchurch, Auckland (Rosedale) and Whangarei during the week sampled in December (g/week) is shown in Table 2. The data is the summation of the drug load for each of the seven days sampled, to give grams per week.

[1] Only six out of seven samples analysed for Whangarei, no sample provided for day four

Table 2 Total weekly drug load (grams per week) for Christchurch, Auckland (Rosedale) and Whangarei

	Weekly Total Drug Load (g/week)		
Drug	**Christchurch**	**Auckland (Rosedale)**	**Whangarei [2]**
Methamphetamine	675	631	222
Cocaine	47	88	1
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	799	281	8

Caution should be exercised before making comparisons of the results from this monthly report, with studies undertaken elsewhere without a thorough consideration of experimental differences, and back calculation assumptions and methodology. This type of comparison will be included in the full report at the conclusion of 12 months of sampling. We would also caution over interpreting results in this report based on a single week's data. For example while usage of cocaine and MDMA would appear higher on weekends, and methamphetamine usage more evenly spread across the week, a large amount of sampling data is required before statistically supported conclusions can be made.

[2] Only six out of seven samples analysed for Whangarei, no sample provided for day four

2. METHODOLOGICAL APPROACH

Wastewater-based epidemiology is the study of wastewater for factors related to health in the population. In this instance, the project studies drugs and metabolites as an indication of drug use in the community.

2.1 WASTEWATER-BASED EPIDEMIOLOGY APPROACH

The estimation of the drug usage based on analysis of sewage is dependent on the interaction of a number of factors:

1. Drug consumption behaviour by the population
2. Metabolism or the chemical transformation of a drug in the body
3. Urinary excretion of the drug (if any remains unmetabolised) and metabolite(s)
4. Conditions and transit times through the wastewater system
5. The method of sample collection
6. Sample extraction by solid phase extraction (SPE) and analysed by liquid chromatography tandem mass spectrometry (LC-MS/MS) in laboratory
7. Determination of the concentration of drugs and metabolites in wastewater
8. Back calculation approach taken.

Adapted from van Nuijs *et al.* (2011).

2.2 DRUGS AND METABOLITES

When a drug is used (injected, orally, smoked, etc.) it enters the body and under goes chemical transformations to produce a metabolite or several metabolites. In December 2017 the project studied five drugs and their associated metabolites suitable for use in the project. These are shown in Table 3 below.

Table 3: Drugs and metabolites studied in December 2017

Drug	Metabolite(s)
Methamphetamine	4-hydroxy-N-methylamphetamine
Cocaine	Benzoylecgonine Ecgonine methyl ester
α-PVP	Scientific literature has not identified any suitable metabolites
Heroin	6-acetylmorphine (6-MAM) Morphine
MDMA/ecstasy (3,4-methylenedioxymethamphetamine)	4-hydroxy-3-methoxymethamphetamine (HMMA)

2.3 SAMPLING AND ANALYSIS

Monthly sampling for Christchurch and Rosedale in Auckland began in December 2016, while monthly sampling for Whangarei began in August 2017.

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 6th December to Tuesday 12th December 2017.

There were problems with the autosampler at the Whangarei site for the fourth day of sampling in December. On day four, no wastewater was collected. The remaining six days were sampled successfully. It should be noted that combined weekly calculations (such as in tables 1 and 2) are therefore only a sum of the six days collected in Whangarei, and as such are likely lower than the true weekly figures. No attempt was made to adjust for the contribution from the missing day because there is not enough data to support an assumption that using an average result in place of the missing data would be justified.

The samples from Auckland (Rosedale) were delayed in their transport to ESR and took longer than normal to be delivered to ESR. While the samples were at room temperature on arrival, they were otherwise in good condition and had been acidified to help preserve the drugs and metabolites. The method used in the analysis of drugs in wastewater for this work requires samples to be chilled during transport and acidified. A brief investigation of stabilitiy in 2016 before the monitoring programme started suggested that the drugs and metabolites should be stable for a few days at room temperature. While we believe the samples have not been severely compromised, it is not ideal that these samples were at elevated temperatures compared to normal and their extraction in the laboratory was delayed. The results for Auckland (Rosedale) should be interpreted with caution.

The Auckland (Rosedale) samples represent a population estimate of 240,000 people, Christchurch samples represent a population estimate of approximately 360,000 people, and Whangarei samples represent a population estimate of approximately 47,000 people.

All 20 samples were extracted by solid phase extraction (SPE) and analysed by liquid chromatography tandem mass spectrometry (LC-MS/MS) at ESR, Christchurch Science Centre.

The method employed by ESR is based on Baker and Kasprzyk-Hordern (2011).

2.4 BACK-CALCULATIONS

Back calculations were undertaken based on the concentrations of the drug and/or it's metabolites in wastewater to estimate the amount of each drug used per thousand people.

Parameters included in the back calculations are population size (provided by the wastewater treatment plant staff), drug/metabolite excretion rate (from published scientific literature), and wastewater system flow rate (measured by the wastewater treatment plant). Excretion factors were taken from Baker *et al.* (2014); Tscharke *et al.* (2016); van Nuijs *et al.* (2011).

$$Drug\ use = \frac{Concentration\ \times Flow\ rate \times Excretion\ factor}{Population\ adjustment}$$

There are many other aspects of the system that may affect the accuracy of the calculation. The back calculations do not take into account degradation, sorption and stability of drugs/metabolites in the wastewater system, and leakage from pipes. Losses of drugs and

metabolites in the laboratory have been adjusted via co-extraction of a deuterated analogue. It should also be noted that excretion rates are based on only a small number of overseas studies which tend to have small and sometimes biased sample groups.

Where the concentrations of a drug or metabolite were present in the wastewater sample at a discernible level, but the quantity was too small to be accurately measured, these have been reported as being present at Trace levels. In these situations, we have used the method limit of detection in back calculations.

In this monthly report the back calculations for cocaine are based on levels of metabolite benzoylecgonine, while back calculations for methamphetamine and MDMA/ecstasy are based on the parent drug. Morphine is a metabolite of heroin, but is also prescribed legitimately and is widely used in the New Zealand population. In the absence of the detection of heroin, back calculations have not been conducted in this report on morphine due to the ambiguity of its origin.

3. RESULTS

3.1 DAILY DRUG USE

In Figure 1 to Figure 3, the amount of drug used in the population (mg/day/1000 people) is shown for Christchurch, Auckland (Rosedale) and Whangarei. The data is derived from back-calculations using wastewater system flow rate, population data and drug/metabolite excretion rate data.

The load of drugs in the wastewater system each day has been normalised to per 1000 people in order to compare drug usage between Christchurch, Auckland (Rosedale) and Whangarei.

α-PVP and heroin were not detected in the wastewater samples across all days of the week for Christchurch, Auckland (Rosedale) and Whangarei, therefore they are not represented in a graph below. Note that for the fourth day in Whangarei no sample was provided to ESR, so there is no bar for Saturday in the graphs below.

Figure 1 Methamphetamine use normalised to per 1000 people

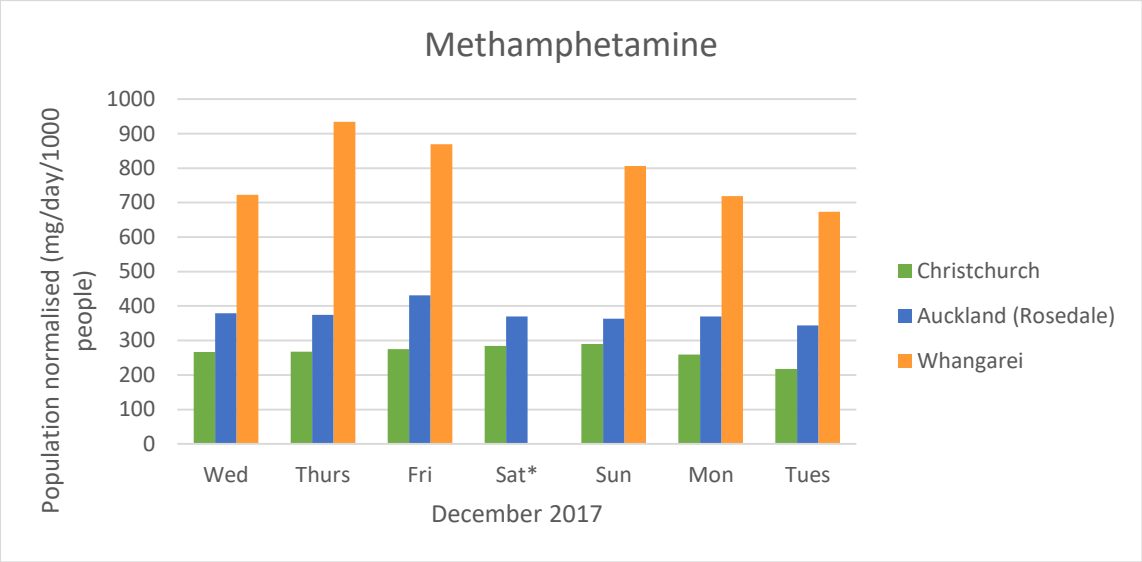


Figure 2 Cocaine use normalised to per 1000 people

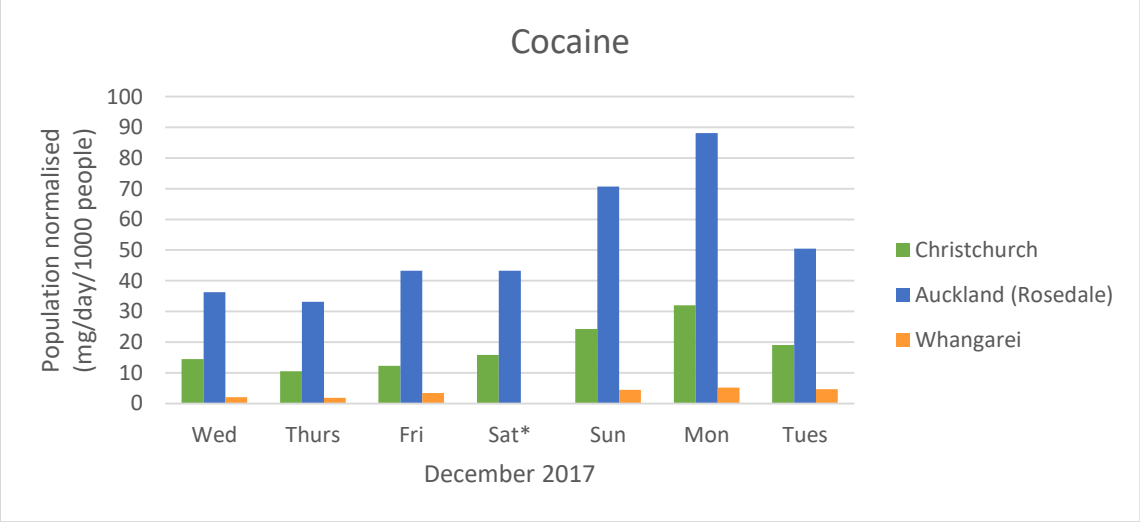
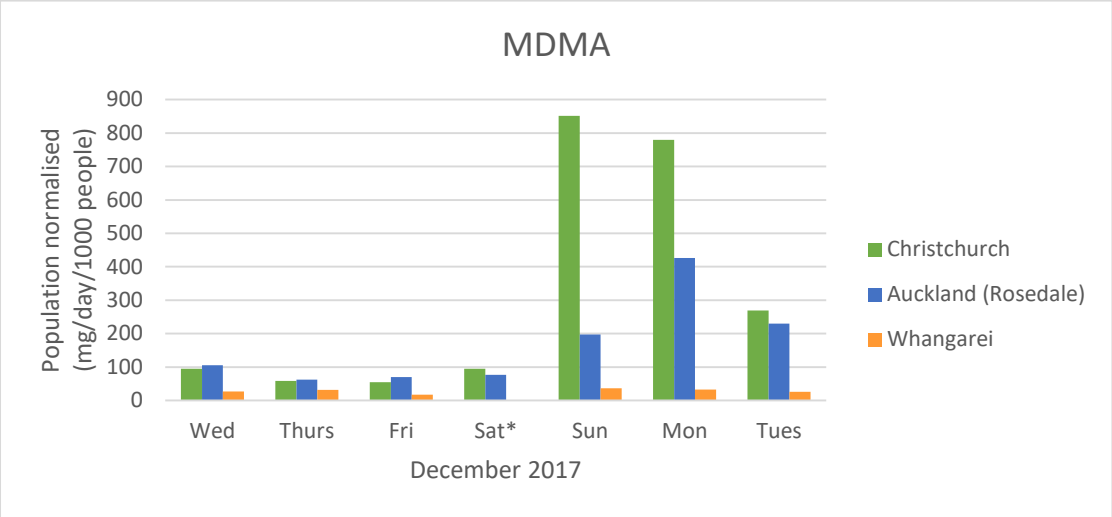


Figure 3 MDMA use normalised to per 1000 people



*Saturday sample not taken in Whangarei

3.2 WEEKLY DRUG USE

The drug use in the population during the week sampled in December is shown in Table 1. The data is the summation of the drug use for each of the seven days sampled to give mg/week/1000 people.

Only six days were sampled in Whangarei in December. The sum of these six days are reported in the table and graphs below, however this will under-represent the total drug use for the week, and make comparisons between other months and sites difficult.

Table 1 Weekly drug use (mg/week/1000 people) for Christchurch, Auckland (Rosedale) and Whangarei

	Weekly Drug Use (mg/week/1000 people)		
Drug	**Christchurch**	**Auckland (Rosedale)**	**Whangarei [3]**
Methamphetamine	1860	2631	4725
Cocaine	128	365	22
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2203	1169	170

As sampling continues, the graphs in Figure 4 to Figure 6 will be updated to monitor trends throughout the year. α-PVP and heroin were not detected in the wastewater samples across all days of the week for Christchurch, Auckland (Rosedale) and Whangarei, therefore they are not represented by a graph.

[3] Only six out of seven samples analysed for Whangarei, no sample provided for day four

Figure 4 Methamphetamine use for the weeks sampled in December 2016 to December 2017

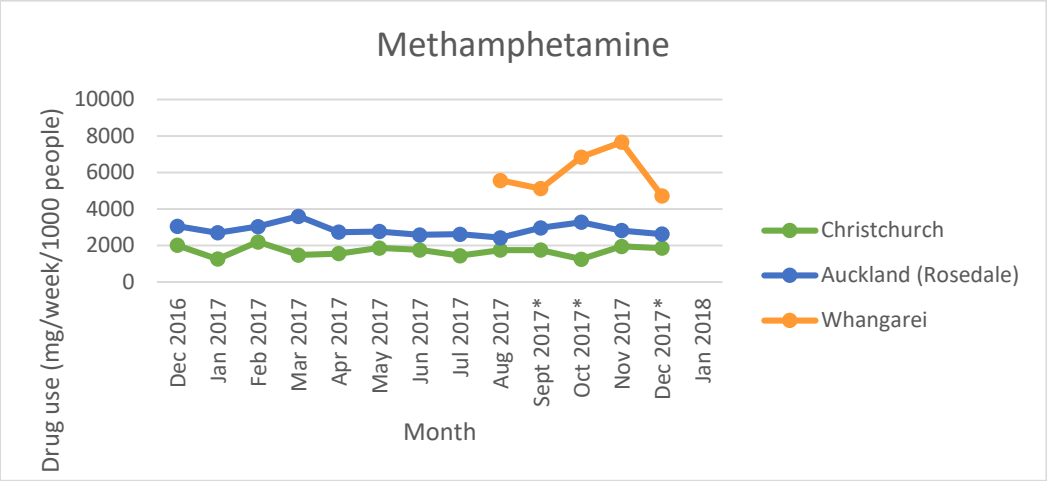


Figure 5 Cocaine use for the week sampled in December 2016 to December 2017

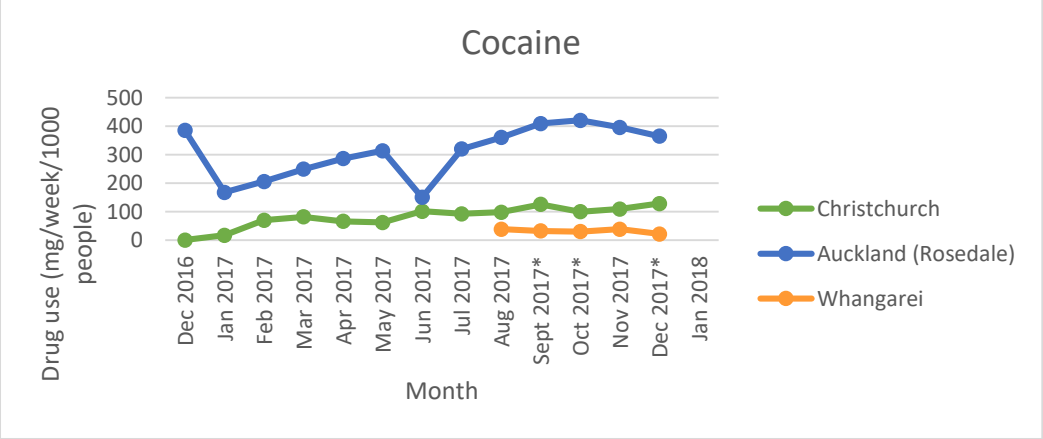
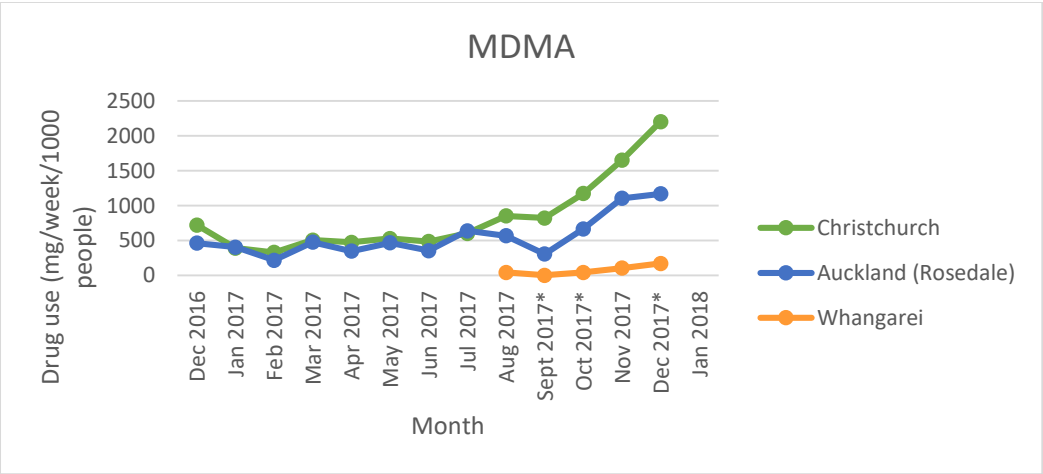


Figure 6 MDMA use for the week sampled in December 2016 to December 2017



* December 2017 – only 6 out of 7 samples analysed for Whangarei. No sample provided for day 5
* October 2017 – only 6 out of 7 samples analysed for Christchurch. No sample provided for day 2
* September 2017 – only 6 out of 7 samples analysed for Whangarei. No sample provided for day 1

3.3 WEEKLY TOTAL DRUG LOAD

The total load or amount of drug used in the population in Christchurch, Auckland (Rosedale) and Whangarei during the week sampled in December (g/week) is shown in Table 2. The data is the summation of the drug load for each of the seven days sampled, to give g/week.

Table 2 Total weekly drug load (grams per week) for Christchurch, Auckland (Rosedale) and Whangarei

	Weekly Total Drug Load (g/week)		
Drug	**Christchurch**	**Auckland (Rosedale)**	**Whangarei [4]**
Methamphetamine	675	631	222
Cocaine	47	88	1
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	799	281	8

[4] Only six out of seven samples analysed for Whangarei, no sample provided for day four

APPENDIX A: DECEMBER RESULTS BY SAMPLE

In December 2017 the project studied five drugs and their associated metabolites suitable for use in the project.

Creatinine was analysed as a human biomarker. The creatinine data generated over the course of the project will be reviewed in the future once trends and patterns in its concentration in wastewater are established.

The concentration of drugs, metabolites and creatinine in the wastewater were determined by LC-MS/MS. The presence of a drug or metabolite above the limit of detection has been quantified and shown in Table 4 to Table 10.

Terminology used in Table 4 to Table 10:

Trace = the drug or metabolite was present in the wastewater sample at a concentration that is discernible, but the quantity was too small to be accurately measured.

Not Detected (ND) = the concentration of drug or metabolite in the wastewater sample was below the method limit of detection.

Table 4: Samples day 1 – Wednesday 6th December 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.265	0.804	1.275	0.0025
4-hydroxy-N-methylamphetamine	0.182	0.083	0.090	0.0025
Cocaine	0.004	0.036	ND	0.0025
Benzoylecgonine	0.015	0.080	0.004	0.0025
Ecgonine methyl ester	ND	ND	ND	0.0025
α-PVP	ND	ND	ND	0.0025
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.0025
Morphine	0.219	0.228	0.440	0.0025
MDMA	0.044	0.105	0.022	0.0025
HMMA	ND	0.009	ND	0.0025
Creatinine	260	420	100	10

Table 5: Samples day 2 – Thursday 7th December 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.268	0.799	1.469	0.0025
4-hydroxy-N-methylamphetamine	0.181	0.096	0.094	0.0025
Cocaine	0.005	0.037	ND	0.0025
Benzoylecgonine	0.011	0.074	0.003	0.0025
Ecgonine methyl ester	ND	ND	ND	0.0025
α-PVP	ND	ND	ND	0.0025
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.0025
Morphine	0.217	0.256	0.459	0.0025
MDMA	0.028	0.063	0.024	0.0025
HMMA	ND	ND	ND	0.0025
Creatinine	220	600	90	10

Table 6: Samples day 3 – Friday 8th December 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.281	0.888	1.459	0.0025
4-hydroxy-N-methylamphetamine	0.141	0.083	0.115	0.0025
Cocaine	0.005	0.036	ND	0.0025
Benzoylecgonine	0.013	0.093	0.006	0.0025
Ecgonine methyl ester	ND	ND	ND	0.0025
α-PVP	ND	ND	ND	0.0025
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.0025
Morphine	0.195	0.227	0.443	0.0025
MDMA	0.026	0.068	0.013	0.0025
HMMA	ND	ND	ND	0.0025
Creatinine	210	530	150	10

Table 7: Samples day 4 – Saturday 9th December 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.282	0.793	No Sample	0.0025
4-hydroxy-N-methylamphetamine	0.199	0.068	No Sample	0.0025
Cocaine	0.004	0.032	No Sample	0.0025
Benzoylecgonine	0.016	0.097	No Sample	0.0025
Ecgonine methyl ester	ND	ND	No Sample	0.0025
α-PVP	ND	ND	No Sample	0.0025
Heroin	ND	ND	No Sample	0.0025
6-acetylmorphine	ND	ND	No Sample	0.0025
Morphine	0.166	0.232	No Sample	0.0025
MDMA	0.044	0.078	No Sample	0.0025
HMMA	ND	0.004	No Sample	0.0025
Creatinine	90	660	No Sample	10

Table 8: Samples day 5 – Sunday 10th December 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.297	0.748	1.492	0.0025
4-hydroxy-N-methylamphetamine	0.256	0.110	0.085	0.0025
Cocaine	0.008	0.060	ND	0.0025
Benzoylecgonine	0.026	0.152	0.009	0.0025
Ecgonine methyl ester	ND	ND	ND	0.0025
α-PVP	ND	ND	ND	0.0025
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.0025
Morphine	0.198	0.185	0.528	0.0025
MDMA	0.412	0.192	0.032	0.0025
HMMA	0.040	0.017	ND	0.0025
Creatinine	160	300	20	10

Table 9: Samples day 6 – Monday 11th December 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.278	0.781	1.280	0.0025
4-hydroxy-N-methylamphetamine	0.148	0.183	0.082	0.0025
Cocaine	0.009	0.057	ND	0.0025
Benzoylecgonine	0.036	0.195	0.010	0.0025
Ecgonine methyl ester	ND	ND	ND	0.0025
α-PVP	ND	ND	ND	0.0025
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.0025
Morphine	0.205	0.179	0.456	0.0025
MDMA	0.395	0.425	0.027	0.0025
HMMA	0.044	0.042	ND	0.0025
Creatinine	260	380	10	10

Table 10: Samples day 7 – Tuesday 12th December 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.233	0.714	1.064	0.0025
4-hydroxy-N-methylamphetamine	0.175	0.090	0.079	0.0025
Cocaine	0.004	0.036	ND	0.0025
Benzoylecgonine	0.021	0.110	0.008	0.0025
Ecgonine methyl ester	ND	ND	ND	0.0025
α-PVP	ND	ND	ND	0.0025
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.0025
Morphine	0.182	0.189	0.462	0.0025
MDMA	0.136	0.226	0.019	0.0025
HMMA	0.009	0.021	ND	0.0025
Creatinine	300	400	90	10

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