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Wastewater Analysis for Illicit Drugs Monthly Report January 2018

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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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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 January 2018 taken from Christchurch, Rosedale in Auckland, and Whangarei.

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 10th January to Tuesday 16th January 2018. In total, seven samples from Christchurch, seven samples from Auckland (Rosedale), and seven samples from Whangarei were collected in January. All 21 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. 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 January is shown in Table 1.

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

Drug	Weekly Drug Use (mg/week/1000 people)		
	Christchurch	Auckland (Rosedale)	Whangarei
Methamphetamine	1668	2285	4862
Cocaine	68	238	45
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	1926	1141	269

The total load or amount of drug used in the population in Christchurch, Auckland (Rosedale) and Whangarei during the week sampled in January (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.

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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
Methamphetamine	605	548	229
Cocaine	25	57	2
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	699	274	13

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. 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. 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 January 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 January 2018

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)

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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 10th January to Tuesday 16th January 2018.

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 21 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.

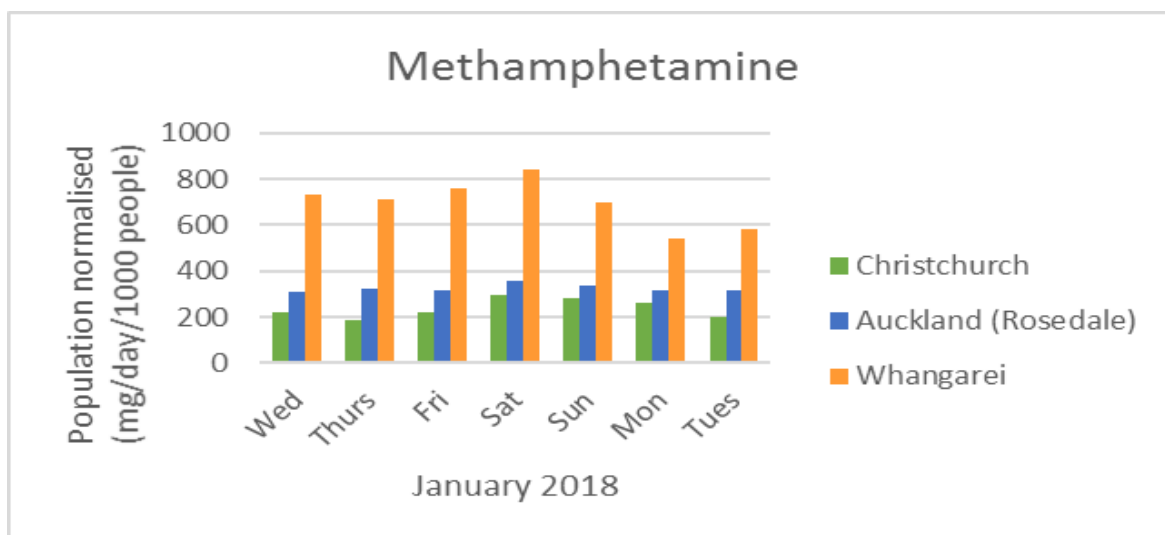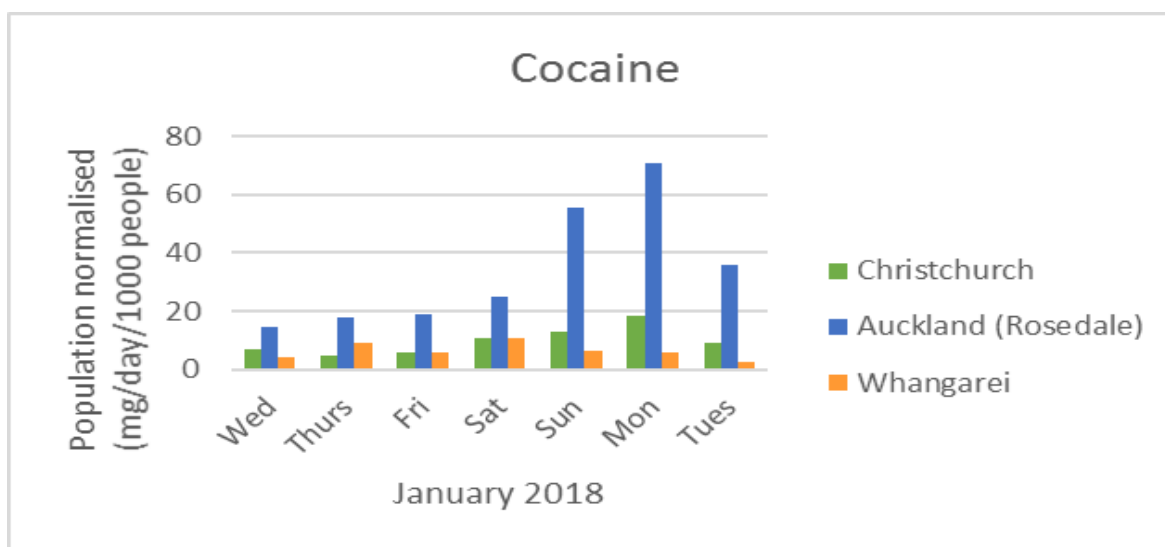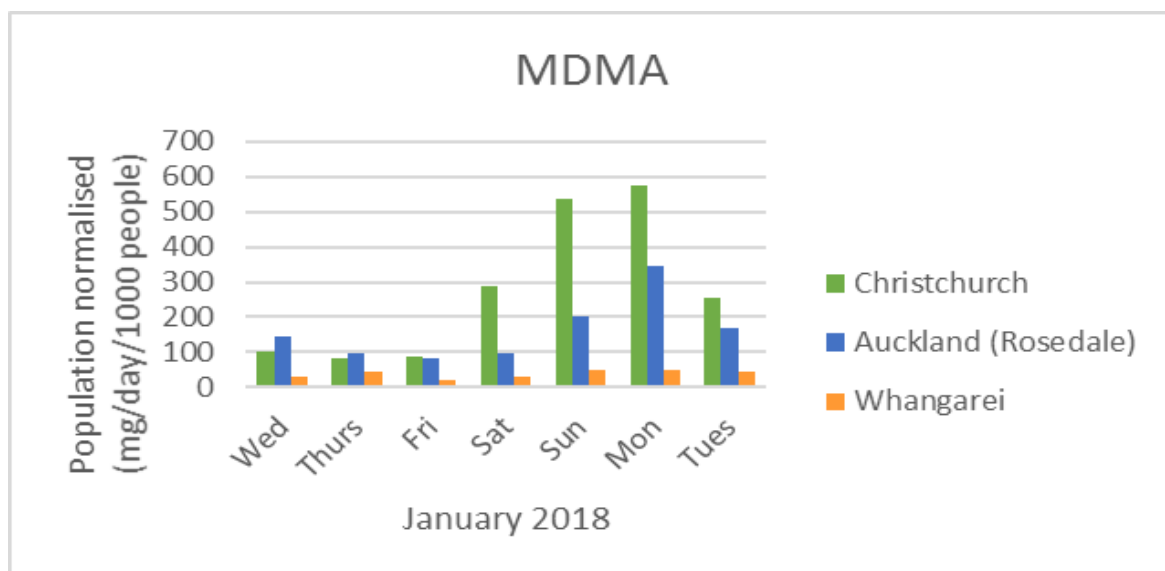**Figure 1 Methamphetamine use normalised to per 1000 people**

Figure 2 Cocaine use normalised to per 1000 people

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Figure 3 MDMA use normalised to per 1000 people

3.2 WEEKLY DRUG USE

The drug use in the population during the week sampled in January 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.

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

Drug	Weekly Drug Use (mg/week/1000 people)		
	Christchurch	Auckland (Rosedale)	Whangarei
Methamphetamine	1668	2285	4862
Cocaine	68	238	45
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	1926	1141	269

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.

Figure 4 Methamphetamine use for the weeks sampled in December 2016 to January 2018 [*]
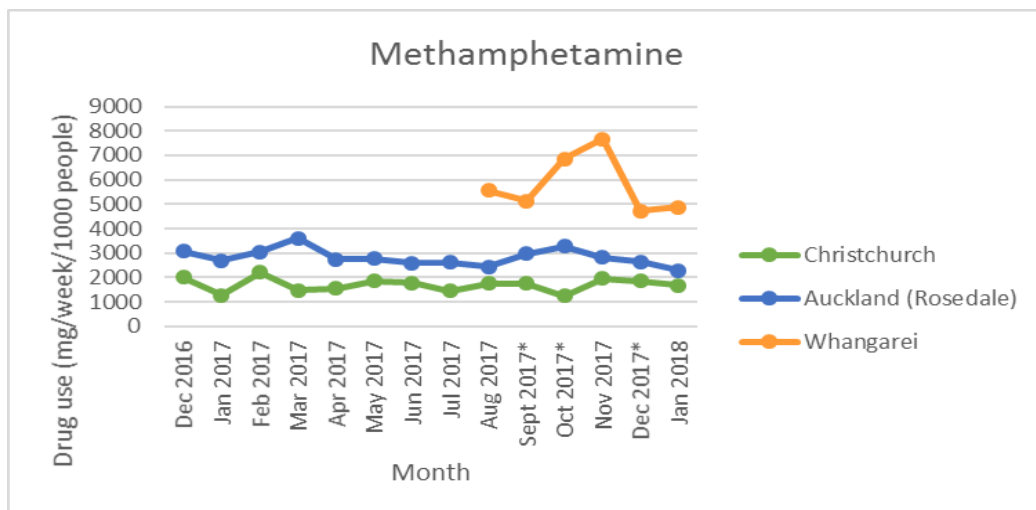
Figure 5 Cocaine use for the week sampled in December 2016 to January 2018 [*]
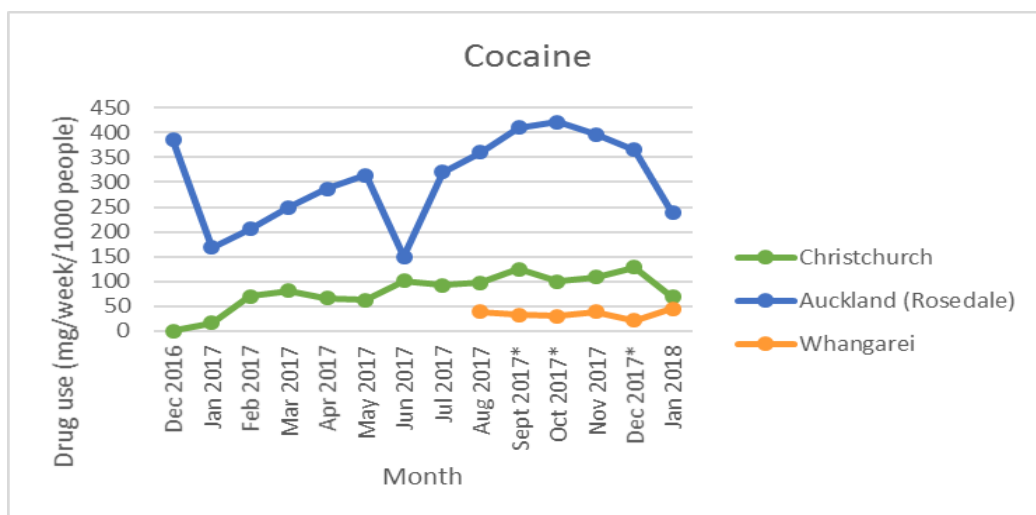
Figure 6 MDMA use for the week sampled in December 2016 to January 2018 [*]

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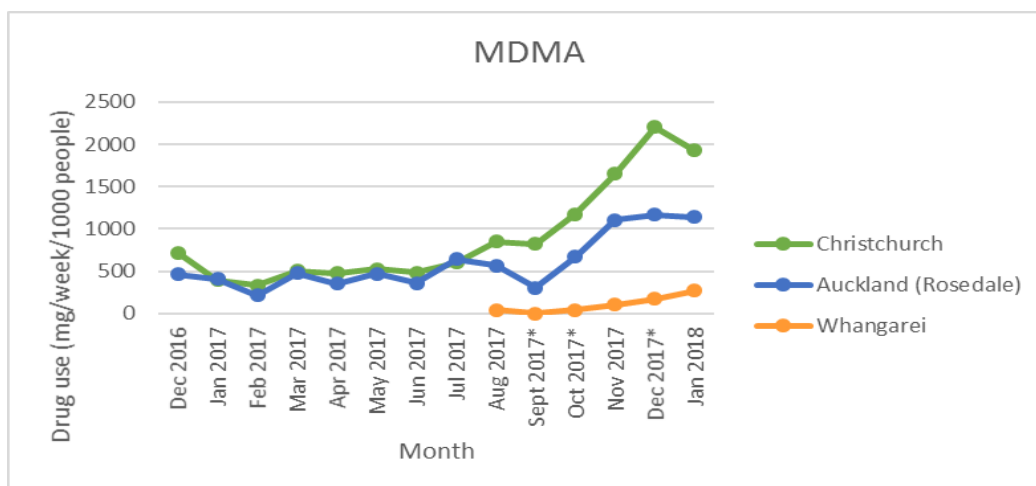
[*] December 2017 – only 6 out of 7 samples analysed for Whangarei. No sample provided for day 5
* October 2017 – only 6 out of 7 samples analysed for Christchurch. No sample provided for day 2
* September 2017 – only 6 out of 7 samples analysed for Whangarei. No sample provided for day 1

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 January (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

Drug	Weekly Total Drug Load (g/week)		
	Christchurch	Auckland (Rosedale)	Whangarei
Methamphetamine	605	548	229
Cocaine	25	57	2
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	699	274	13

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APPENDIX A: JANUARY RESULTS BY SAMPLE

In January 2018 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 10th January 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.224	0.662	1.289	0.00125
4-hydroxy-N-methylamphetamine	0.214	0.073	0.167	0.00125
Cocaine	0.002	0.025	0.003	0.00125
Benzoylecgonine	0.007	0.033	0.008	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.192	0.223	0.512	0.00125
MDMA	0.048	0.146	0.027	0.00125
HMMA	ND	ND	ND	0.00125
Creatinine	270	600	90	10

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Table 5: Samples day 2 – Thursday 11ᵗʰ January 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.155	0.717	1.281	0.00125
4-hydroxy-N-methylamphetamine	0.162	0.245	0.127	0.00125
Cocaine	0.002	0.015	0.004	0.00125
Benzoylecgonine	0.004	0.040	0.017	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.146	0.188	0.454	0.00125
MDMA	0.032	0.102	0.038	0.00125
HMMA	ND	ND	ND	0.00125
Creatinine	290	180	140	10

Table 6: Samples day 3 – Friday 12ᵗʰ January 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.099	0.707	1.431	0.00125
4-hydroxy-N-methylamphetamine	0.089	0.223	0.142	0.00125
Cocaine	0.001	0.024	0.003	0.00125
Benzoylecgonine	0.003	0.044	0.011	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.008	0.179	0.453	0.00125
MDMA	0.019	0.089	0.019	0.00125
HMMA	ND	ND	ND	0.00125
Creatinine	400	80	40	10

Table 7: Samples day 4 – Saturday 13th January 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.148	0.789	1.373	0.00125
4-hydroxy-N-methylamphetamine	0.172	0.081	0.138	0.00125
Cocaine	0.005	0.045	0.003	0.00125
Benzoylecgonine	0.005	0.058	0.018	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.108	0.226	0.457	0.00125
MDMA	0.068	0.099	0.024	0.00125
HMMA	ND	ND	ND	0.00125
Creatinine	390	300	30	10

Table 8: Samples day 5 – Sunday 14th January 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.195	0.729	1.332	0.00125
4-hydroxy-N-methylamphetamine	0.233	0.113	0.143	0.00125
Cocaine	0.005	0.059	0.004	0.00125
Benzoylecgonine	0.009	0.125	0.013	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.128	0.194	0.461	0.00125
MDMA	0.176	0.206	0.043	0.00125
HMMA	ND	ND	ND	0.00125
Creatinine	600	180	30	10

Table 9: Samples day 6 – Monday 15th January 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.205	0.685	1.158	0.00125
4-hydroxy-N-methylamphetamine	0.185	0.129	0.125	0.00125
Cocaine	0.006	0.058	0.004	0.00125
Benzoylecgonine	0.015	0.160	0.013	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.117	0.225	0.502	0.00125
MDMA	0.214	0.351	0.049	0.00125
HMMA	0.017	0.033	ND	0.00125
Creatinine	460	140	30	10

Table 10: Samples day 7 – Tuesday 16th January 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.172	0.681	1.157	0.00125
4-hydroxy-N-methylamphetamine	0.206	0.094	0.180	0.00125
Cocaine	0.002	0.030	0.001	0.00125
Benzoylecgonine	0.008	0.080	0.005	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.167	0.198	0.350	0.00125
MDMA	0.101	0.173	0.041	0.00125
HMMA	ND	ND	ND	0.00125
Creatinine	710	270	30	10

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