Science for Communities

Wastewater Analysis for Illicit Drugs Monthly Report April 2018

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1. EXECUTIVE SUMMARY

The Drugs in Wastewater project is funded by the New Zealand Police 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 April 2018 taken from Christchurch, Rosedale in Auckland, and Whangarei.

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 11th April to Tuesday 17th April 2018. In total, seven samples from Christchurch, seven samples from Auckland (Rosedale), and seven samples from Whangarei were collected in April. 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. 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 April 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**
Methamphetamine	2038	2958	6613
Cocaine	47	254	49
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	1237	761	284

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

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	739	710	311
Cocaine	17	61	2
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	449	183	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. 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. 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 April 2018 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 April 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)

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 11th April to Tuesday 17th April 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 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.

After completion of 12 months of sampling, a full report will consider including biomarker data and additional biophysical factors to further refine the back calculations

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

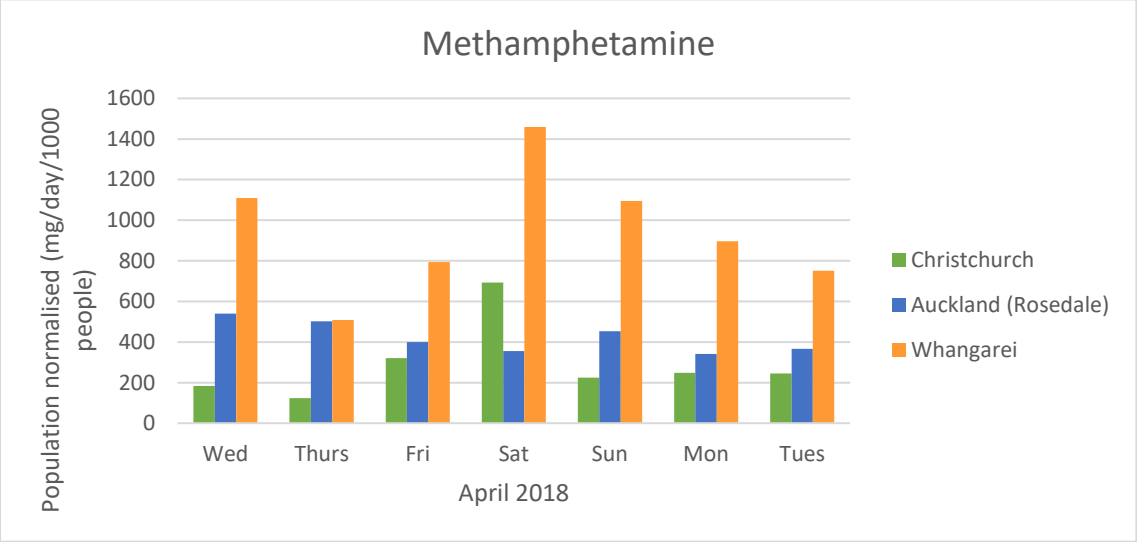


Figure 2 Cocaine use normalised to per 1000 people

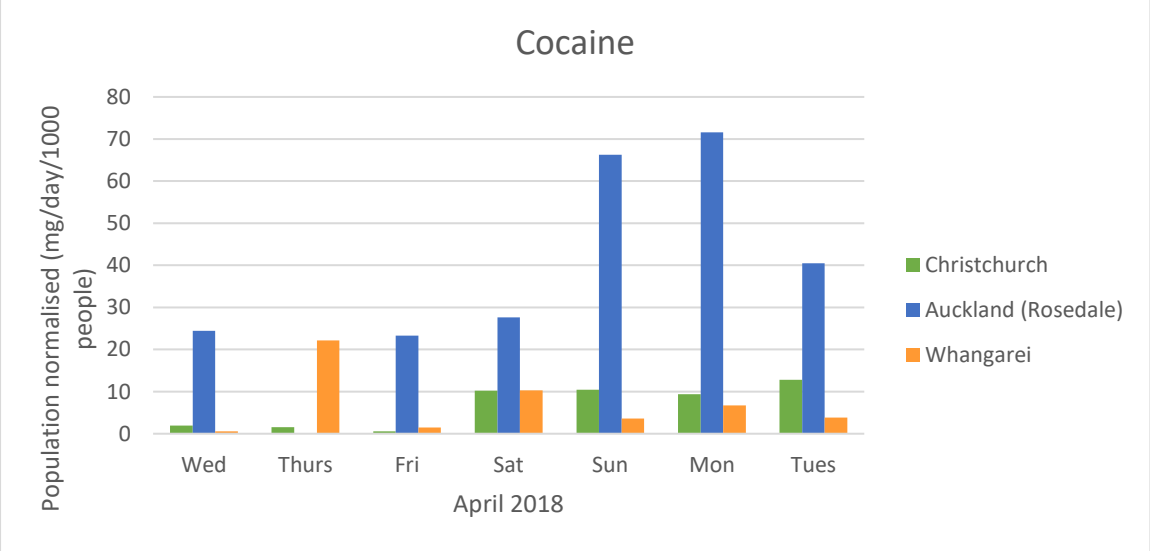
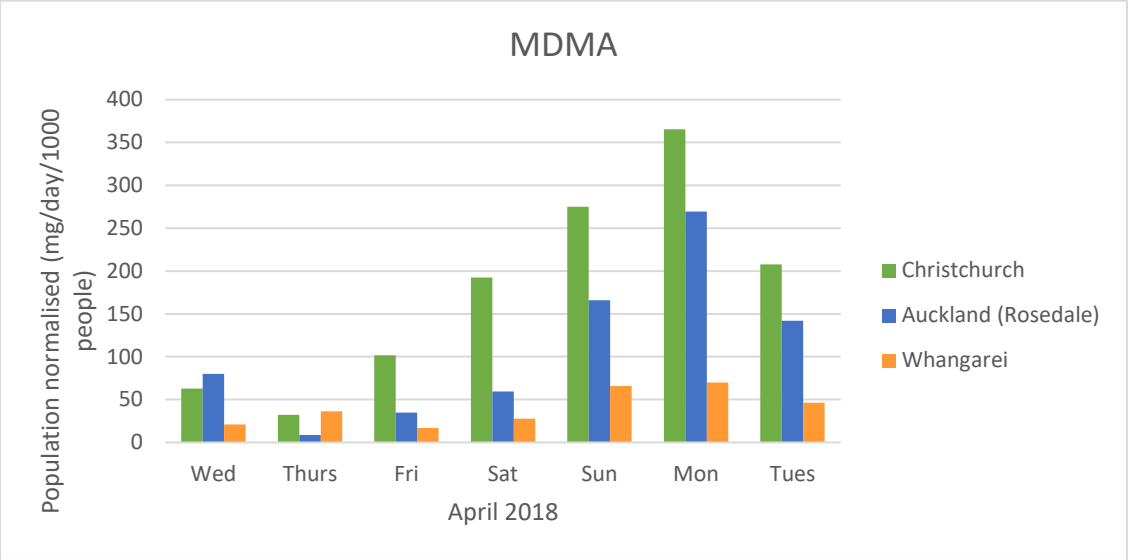


Figure 3 MDMA use normalised to per 1000 people



3.2 WEEKLY DRUG USE

The drug use in the population during the week sampled in April 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

	Weekly Drug Use (mg/week/1000 people)		
Drug	**Christchurch**	**Auckland (Rosedale)**	**Whangarei**
Methamphetamine	2038	2958	6613
Cocaine	47	254	49
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	1237	761	284

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.

In April 2018, the samples provided were also analysed for fentanyl. No fentanyl was detected in any samples. This is not unexpected, as ESR toxicologists have advised that fentanyl is almost completely metabolised before excretion.

Figure 4 Methamphetamine use for the weeks sampled in December 2016 to April 2018 *

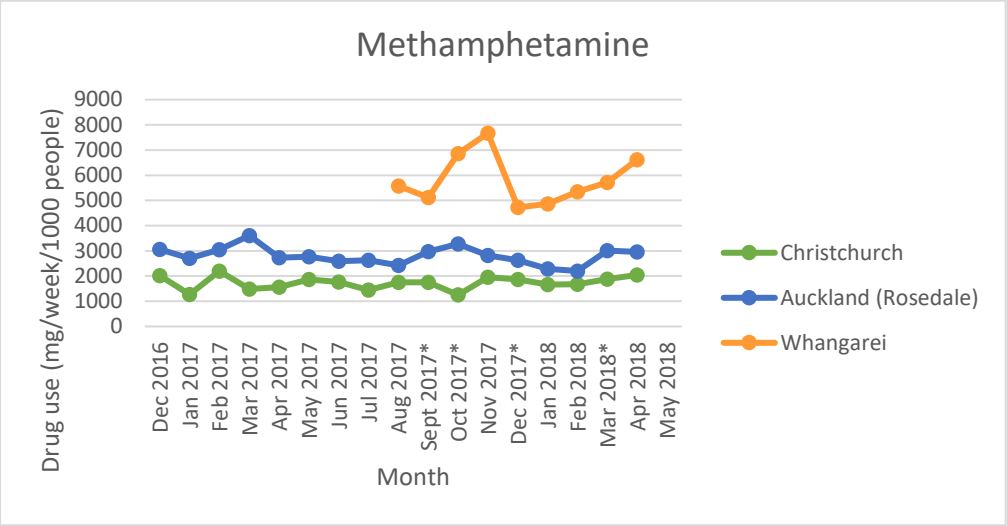


Figure 5 Cocaine use for the week sampled in December 2016 to April 2018 *

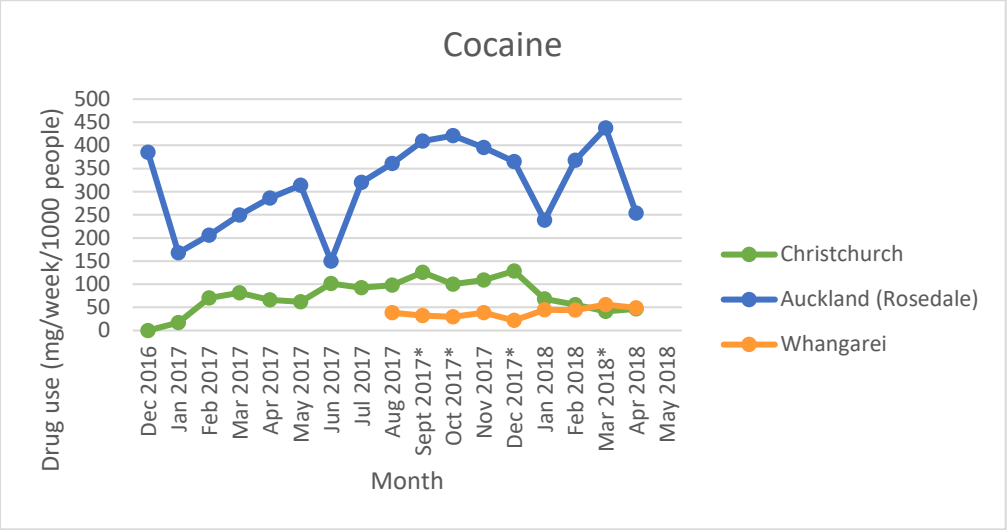
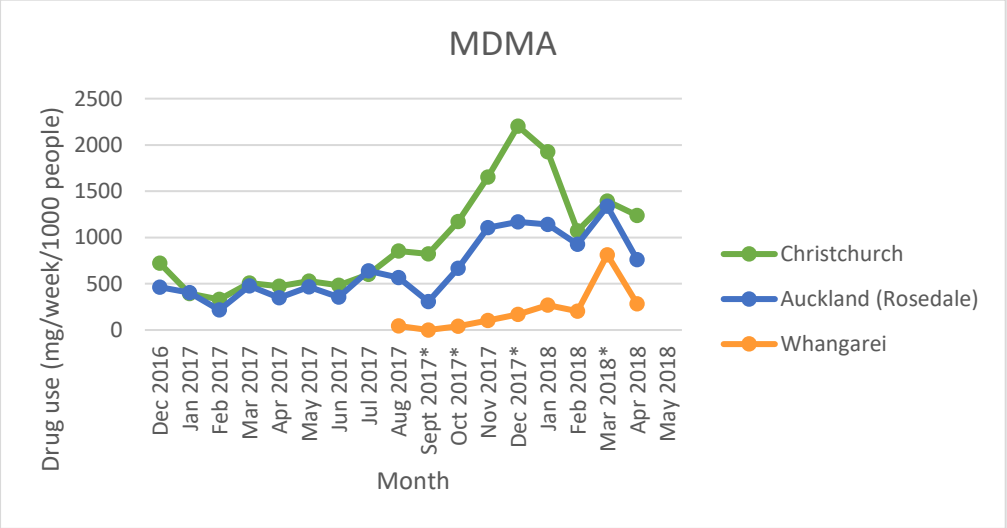


Figure 6 MDMA use for the week sampled in December 2016 to April 2018



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 April (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**
Methamphetamine	739	710	311
Cocaine	17	61	2
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	449	183	13

* September 2017, December 2017 and March 2018: 6 out of 7 samples were provided for Whangarei. October 2017: 6 out of 7 samples were provided for Christchurch.

APPENDIX A: APRIL RESULTS BY SAMPLE

In April 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 11th April 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.147	0.963	1.589	0.00125
4-hydroxy-N-methylamphetamine	0.159	0.092	0.086	0.00250
Cocaine	ND	0.009	ND	0.00125
Benzoylecgonine	0.002	0.046	ND	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00250
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00250
6-acetylmorphine	ND	ND	ND	0.00250
Morphine	ND	0.239	0.215	0.01250
MDMA	0.024	0.067	0.014	0.00125
HMMA	ND	0.006	ND	0.00250
Creatinine	520	670	450	10

Table 5: Samples day 2 – Thursday 12th April 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.084	0.708	0.714	0.00125
4-hydroxy-N-methylamphetamine	0.060	0.063	0.030	0.00250
Cocaine	ND	ND	0.008	0.00125
Benzoylecgonine	ND	ND	0.033	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00250
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00250
6-acetylmorphine	ND	ND	ND	0.00250
Morphine	0.070	0.215	0.081	0.01250
MDMA	0.010	0.006	0.024	0.00125
HMMA	ND	ND	ND	0.00250
Creatinine	630	870	450	10

Table 6: Samples day 3 – Friday 13th April 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.142	0.729	1.206	0.00125
4-hydroxy-N-methylamphetamine	0.077	0.107	0.116	0.00250
Cocaine	ND	0.012	ND	0.00125
Benzoylecgonine	ND	0.045	0.002	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00250
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00250
6-acetylmorphine	ND	ND	ND	0.00250
Morphine	0.161	0.084	0.157	0.01250
MDMA	0.021	0.030	0.012	0.00125
HMMA	ND	ND	ND	0.00250
Creatinine	700	1450	340	10

Table 7: Samples day 4 – Saturday 14th April 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.354	0.548	2.326	0.00125
4-hydroxy-N-methylamphetamine	0.509	0.053	0.125	0.00250
Cocaine	0.003	0.012	0.007	0.00125
Benzoylecgonine	0.005	0.045	0.017	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00250
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00250
6-acetylmorphine	ND	ND	ND	0.00250
Morphine	0.312	0.115	0.245	0.01250
MDMA	0.046	0.043	0.021	0.00125
HMMA	ND	ND	ND	0.00250
Creatinine	610	860	300	10

Table 8: Samples day 5 – Sunday 15th April 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.172	0.451	1.870	0.00125
4-hydroxy-N-methylamphetamine	0.410	0.046	0.065	0.00250
Cocaine	0.002	0.018	0.002	0.00125
Benzoylecgonine	0.008	0.069	0.007	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00250
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00250
6-acetylmorphine	ND	ND	ND	0.00250
Morphine	0.094	0.074	0.235	0.01250
MDMA	0.099	0.078	0.053	0.00125
HMMA	ND	0.012	0.006	0.00250
Creatinine	1100	600	20	10

Table 9: Samples day 6 – Monday 16th April 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.240	0.440	1.459	0.00125
4-hydroxy-N-methylamphetamine	0.190	0.082	0.156	0.00250
Cocaine	ND	0.019	0.002	0.00125
Benzoylecgonine	0.009	0.096	0.012	0.00125
Ecgonine methyl ester	ND	0.177	ND	0.00250
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00250
6-acetylmorphine	ND	ND	ND	0.00250
Morphine	0.097	0.046	0.216	0.01250
MDMA	0.166	0.164	0.054	0.00125
HMMA	0.028	0.033	ND	0.00250
Creatinine	1050	1640	60	10

Table 10: Samples day 7 – Tuesday 17th April 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.188	0.482	1.193	0.00125
4-hydroxy-N-methylamphetamine	0.188	0.035	0.036	0.00250
Cocaine	0.001	0.012	ND	0.00125
Benzoylecgonine	0.010	0.056	0.006	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00250
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00250
6-acetylmorphine	ND	ND	ND	0.00250
Morphine	0.054	0.099	0.118	0.01250
MDMA	0.075	0.088	0.035	0.00125
HMMA	0.012	0.021	ND	0.00250
Creatinine	830	1070	60	10

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