Wastewater Analysis for Illicit Drugs Monthly Report October 2017

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DISCLAIMER

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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 October 2017 taken from Christchurch, Rosedale in Auckland, and Whangarei.

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 4th October to Tuesday 10th October 2017. In total, six samples from Christchurch, seven samples from Auckland (Rosedale), and seven samples from Whangarei were collected in September. 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 October 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	1251	3278	6852
Cocaine	100	421	30
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	1173	667	41

The total load or amount of drug used in the population in Christchurch, Auckland (Rosedale) and Whangarei during the week sampled in October (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	454	787	322
Cocaine	36	101	1.4
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	426	160	2.0

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 October 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 October 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 4th October to Tuesday 10th October 2017.

There were problems with the autosampler at the Christchurch site on day two of sampling in October. On day two, no wastewater was collected. It should be noted that combined weekly calculations (such as in tables 1 and 2) are only a sum of the 6 days collected in Christchurch, and as such are lower than the true weekly figures. No attempt was made to adjust for the contribution from the missing day.

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. Note that no sample was provided to ESR for day two in Christchurch, so there is no bar in the graphs below for Thursday.

Figure 1 Methamphetamine use normalised to per 1000 people

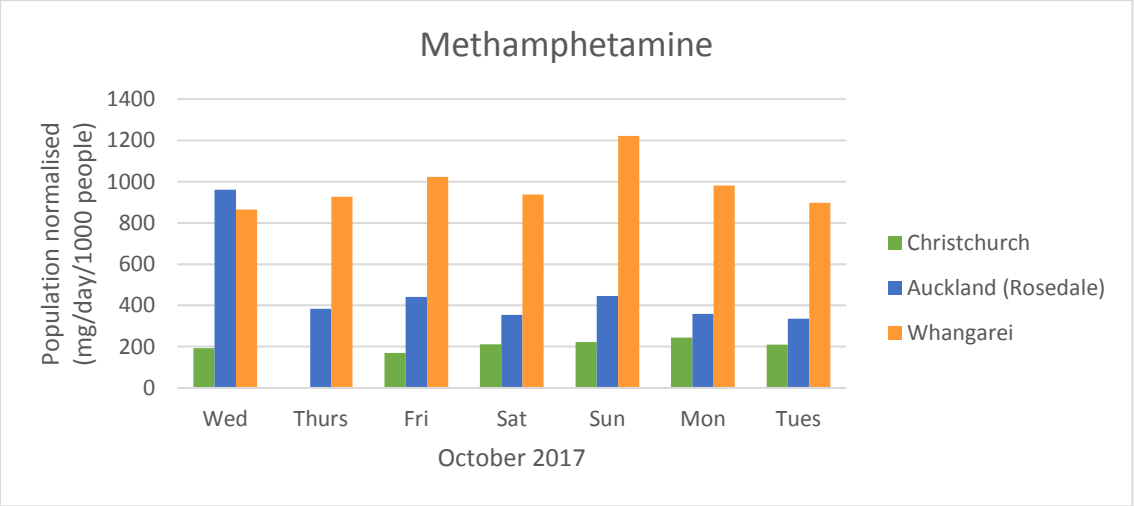


Figure 2 Cocaine use normalised to per 1000 people

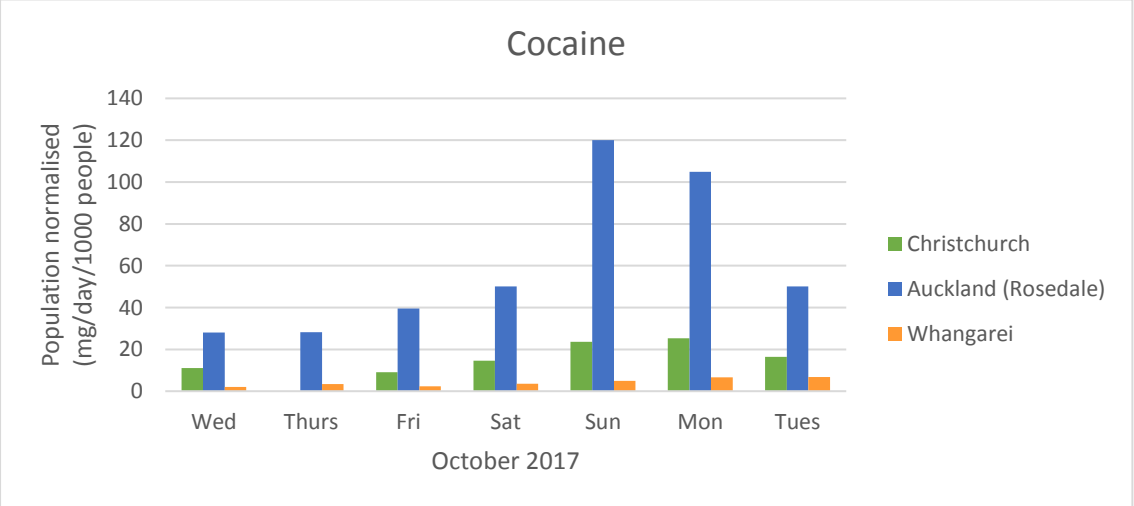
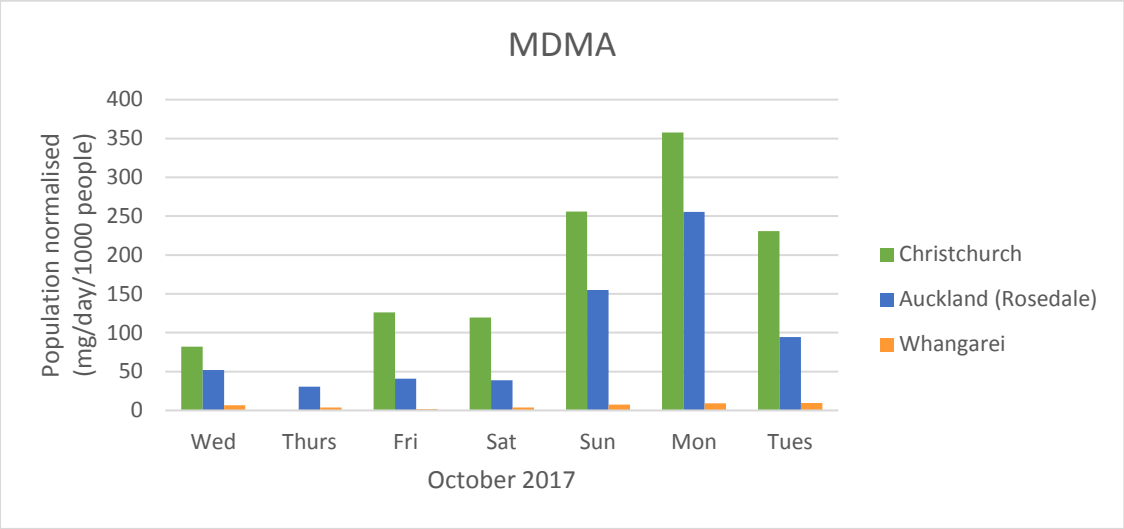


Figure 3 MDMA use normalised to per 1000 people



3.2 WEEKLY DRUG USE

The drug use in the population during the week sampled in October 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 Christchurch in October. 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**
Methamphetamine	1251	3278	6852
Cocaine	100	421	30
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	1173	667	41

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 October 2017

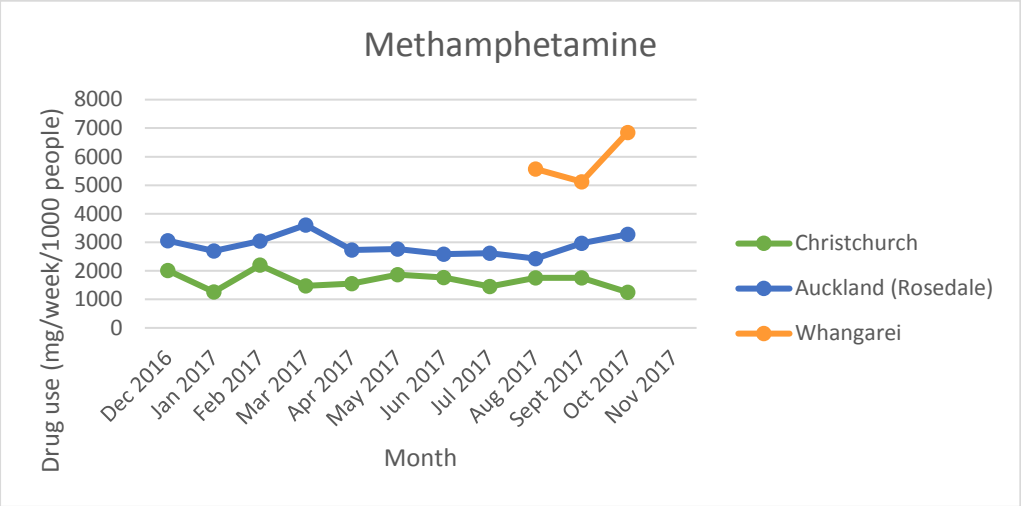


Figure 5 Cocaine use for the week sampled in December 2016 to October 2017

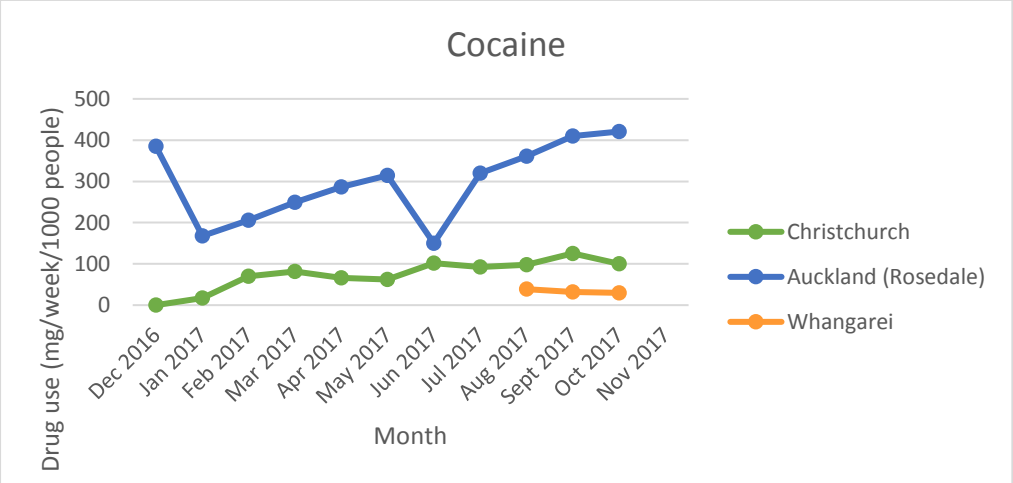
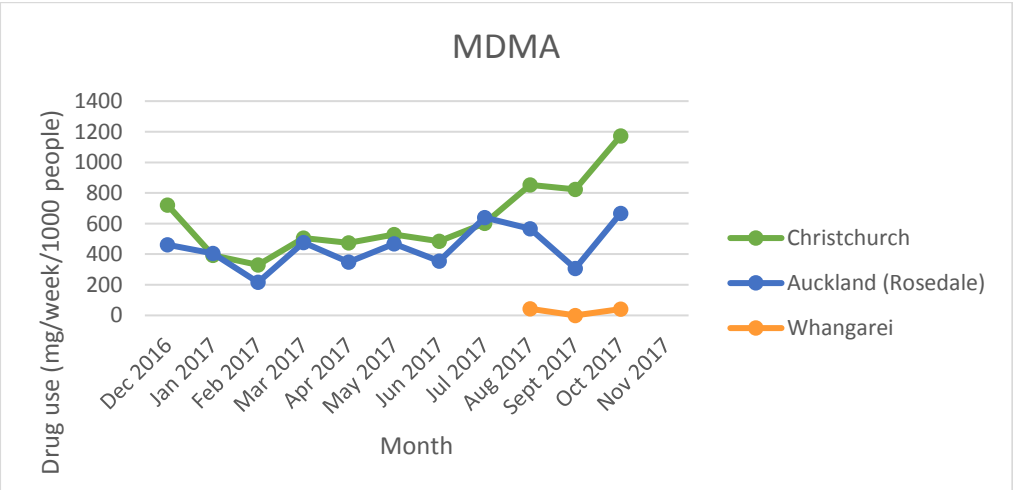


Figure 6 MDMA use for the week sampled in December 2016 to October 2017



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 October (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	454	787	322
Cocaine	36	101	1.4
α-PVP	Not Detected	Not Detected	Not Detected
Heroin	Not Detected	Not Detected	Not Detected
MDMA	426	160	2.0

APPENDIX A: OCTOBER RESULTS BY SAMPLE

In October 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 4th October 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.170	1.588	1.052	0.00125
4-hydroxy-N-methylamphetamine	0.382	0.173	0.060	0.00125
Cocaine	0.004	0.019	Trace	0.00125
Benzoylecgonine	0.010	0.049	0.003	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.218	0.136	0.406	0.00125
MDMA	0.034	0.040	0.004	0.00125
HMMA	0.003	ND	ND	0.00125
Creatinine	705	1355	315	10

Table 5: Samples day 2 – Thursday 5th October 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	No Sample	0.784	1.200	0.00125
4-hydroxy-N-methylamphetamine	No Sample	0.201	0.080	0.00125
Cocaine	No Sample	0.029	Trace	0.00125
Benzoylecgonine	No Sample	0.060	0.005	0.00125
Ecgonine methyl ester	No Sample	ND	ND	0.00125
α-PVP	No Sample	ND	ND	0.00125
Heroin	No Sample	ND	ND	0.0025
6-acetylmorphine	No Sample	ND	ND	0.00125
Morphine	No Sample	0.118	0.387	0.00125
MDMA	No Sample	0.029	0.002	0.00125
HMMA	No Sample	ND	ND	0.00125
Creatinine	No Sample	1370	195	10

Table 6: Samples day 3 – Friday 6th October 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.154	0.831	1.385	0.00125
4-hydroxy-N-methylamphetamine	0.335	0.201	0.086	0.00125
Cocaine	0.003	0.023	Trace	0.00125
Benzoylecgonine	0.009	0.078	0.003	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.221	0.174	0.425	0.00125
MDMA	0.054	0.036	Trace	0.00125
HMMA	0.003	ND	ND	0.00125
Creatinine	685	760	115	10

Table 7: Samples day 4 – Saturday 7th October 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.188	0.697	1.284	0.00125
4-hydroxy-N-methylamphetamine	0.508	0.121	0.127	0.00125
Cocaine	0.005	0.036	Trace	0.00125
Benzoylecgonine	0.014	0.103	0.005	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.267	0.120	0.449	0.00125
MDMA	0.051	0.036	0.002	0.00125
HMMA	0.007	ND	ND	0.00125
Creatinine	600	845	90	10

Table 8: Samples day 5 – Sunday 8th October 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.171	0.740	1.630	0.00125
4-hydroxy-N-methylamphetamine	0.302	0.124	0.086	0.00125
Cocaine	0.004	0.060	0.002	0.00125
Benzoylecgonine	0.019	0.209	0.007	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.185	0.164	0.411	0.00125
MDMA	0.093	0.122	0.005	0.00125
HMMA	0.009	0.016	ND	0.00125
Creatinine	505	875	75	10

Table 9: Samples day 6 – Monday 9th October 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.139	0.428	1.136	0.00125
4-hydroxy-N-methylamphetamine	0.249	0.087	0.072	0.00125
Cocaine	0.003	0.036	0.002	0.00125
Benzoylecgonine	0.015	0.131	0.008	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.109	0.106	0.352	0.00125
MDMA	0.096	0.144	0.005	0.00125
HMMA	0.012	0.015	ND	0.00125
Creatinine	510	640	55	10

Table 10: Samples day 7 – Tuesday 10th October 2017

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.118	0.539	1.150	0.00125
4-hydroxy-N-methylamphetamine	0.226	0.195	0.134	0.00125
Cocaine	0.003	0.023	Trace	0.00125
Benzoylecgonine	0.010	0.084	0.009	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
α-PVP	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.122	0.157	0.346	0.00125
MDMA	0.061	0.072	0.006	0.00125
HMMA	0.006	0.010	ND	0.00125
Creatinine	740	1175	70	10

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