Science for Communities

Wastewater Analysis for Illicit Drugs Monthly Report June 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 June 2018 taken from Christchurch, Rosedale in Auckland, and Whangarei.

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 6th June to Tuesday 12th June 2018. In total, seven samples from Christchurch, seven samples from Auckland (Rosedale), and seven samples from Whangarei were collected in June. 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. Low levels of fentanyl were detected on some days in samples from Christchurch and Whangarei. Heroin was not detected in any samples. The drug use in mg/week/1000 people, during the week sampled in June 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	2101	2990	7138
Cocaine	72	363	24
Fentanyl	6	Not Detected	17
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2001	1046	277

The total load or amount of drug used in the population in Christchurch, Auckland (Rosedale) and Whangarei during the week sampled in June (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	762	718	335
Cocaine	26	87	1
Fentanyl	2	Not Detected	1
Heroin	Not Detected	Not Detected	Not Detected
MDMA	726	251	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.

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 June 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 June 2018

Drug	Metabolite(s)
Methamphetamine	4-hydroxy-N-methylamphetamine
Cocaine	Benzoylecgonine Ecgonine methyl ester
Fentanyl	Norfentanyl
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 June to Tuesday 12th June 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, back calculations are performed using a value of half the limit of detection.

In this monthly report the back calculations for cocaine are based on levels of metabolite benzoylecgonine, fentanyl is based on the levels of metabolite norfentanyl, 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. Fentanyl is also prescribed legitimately and is used in health care. Levels of fentanyl in wastewater will represent both licit and illicit consumption.

3. RESULTS

3.1 DAILY DRUG USE

In Figure 1 to Figure 4, 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.

Heroin was not detected in any samples and is therefore not represented in a graph below.

Figure 1 Methamphetamine use normalised to per 1000 people

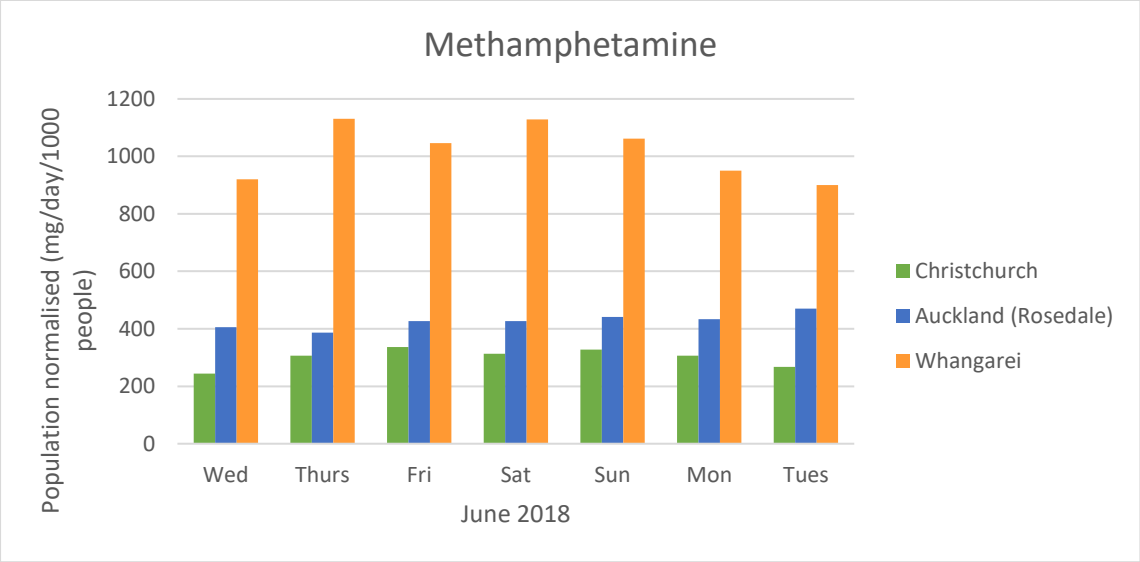


Figure 2 Cocaine use normalised to per 1000 people

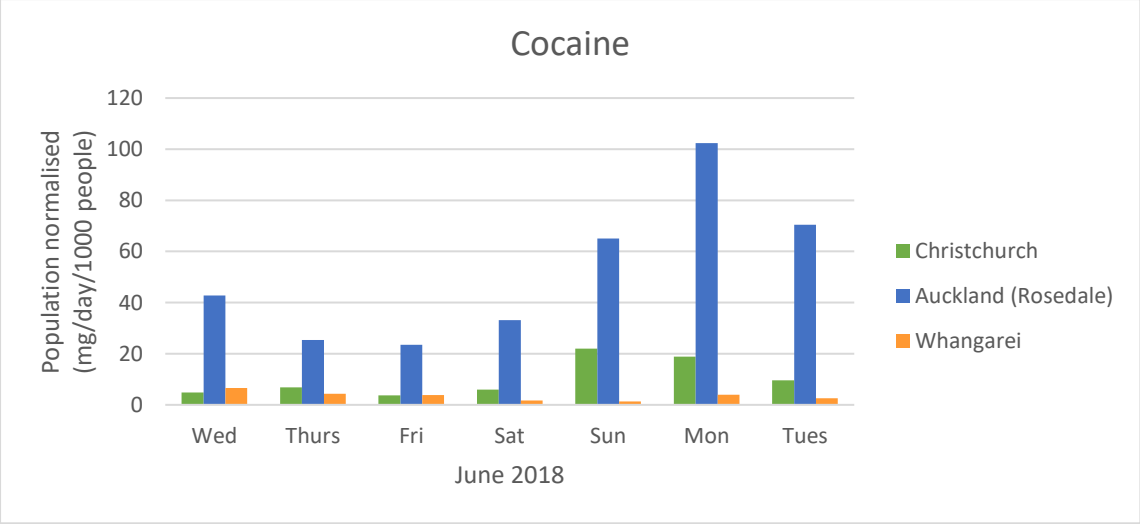


Figure 3 MDMA use normalised to per 1000 people

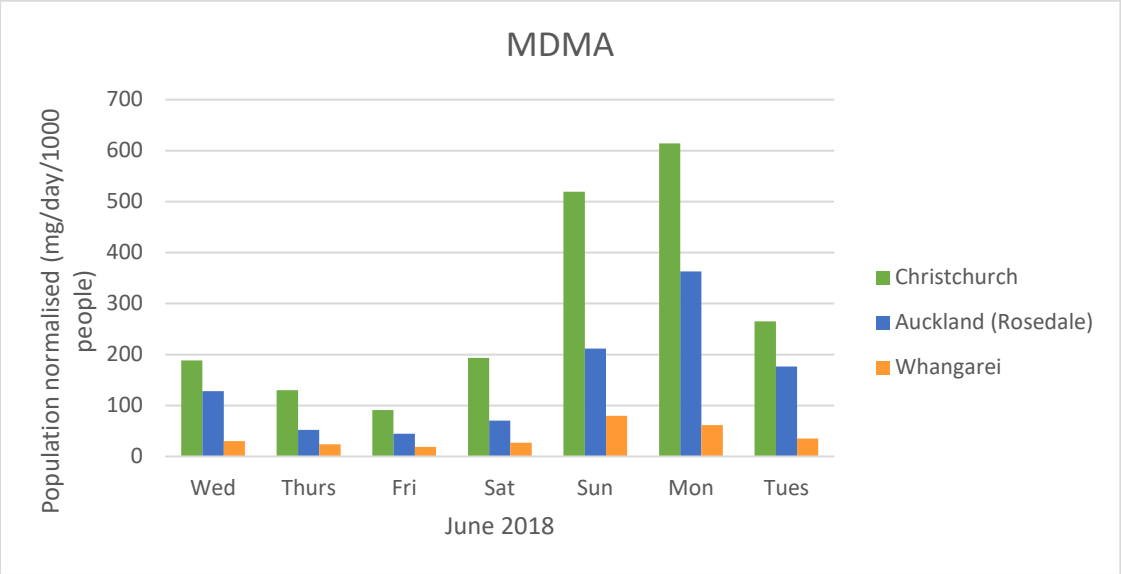
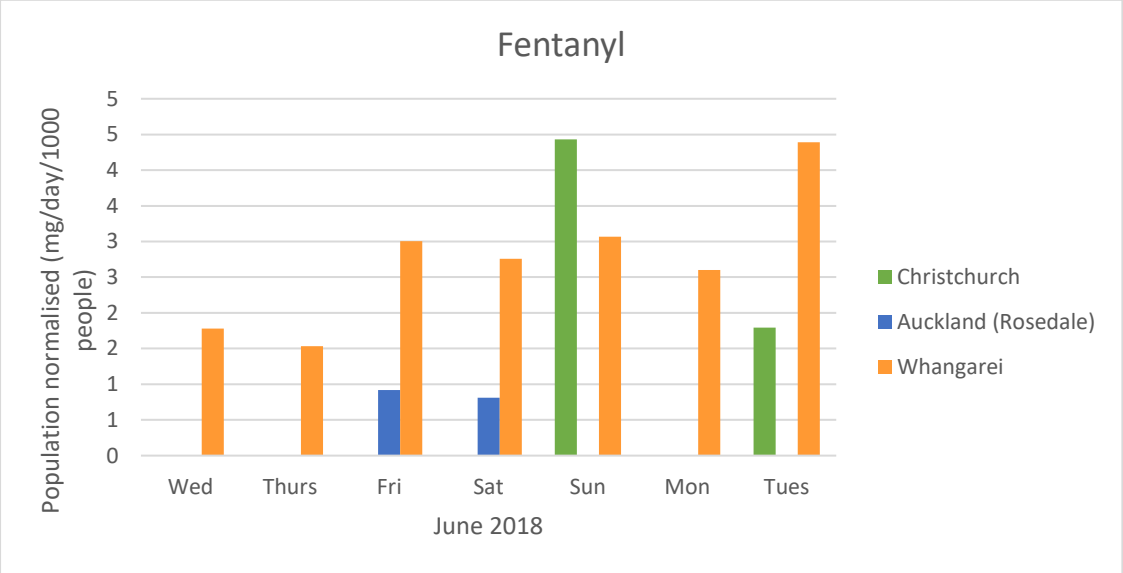


Figure 4 Fentanyl use normalised to per 1000 people



NB: Levels of fentanyl in wastewater will represent both licit and illicit consumption.

3.2 WEEKLY DRUG USE

The drug use in the population during the week sampled in June 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	2101	2990	7138
Cocaine	72	363	24
Fentanyl	6	Not Detected	17
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2001	1046	277

Heroin was not detected in any samples and is therefore not represented in a graph below. As sampling continues, the graphs in Figure 5 to Figure 8 will be updated to monitor trends throughout the year. Heroin was not detected in any samples and is therefore not represented in a graph below.

Figure 5 Methamphetamine use for the week sampled in December 2016 to June 2018 *

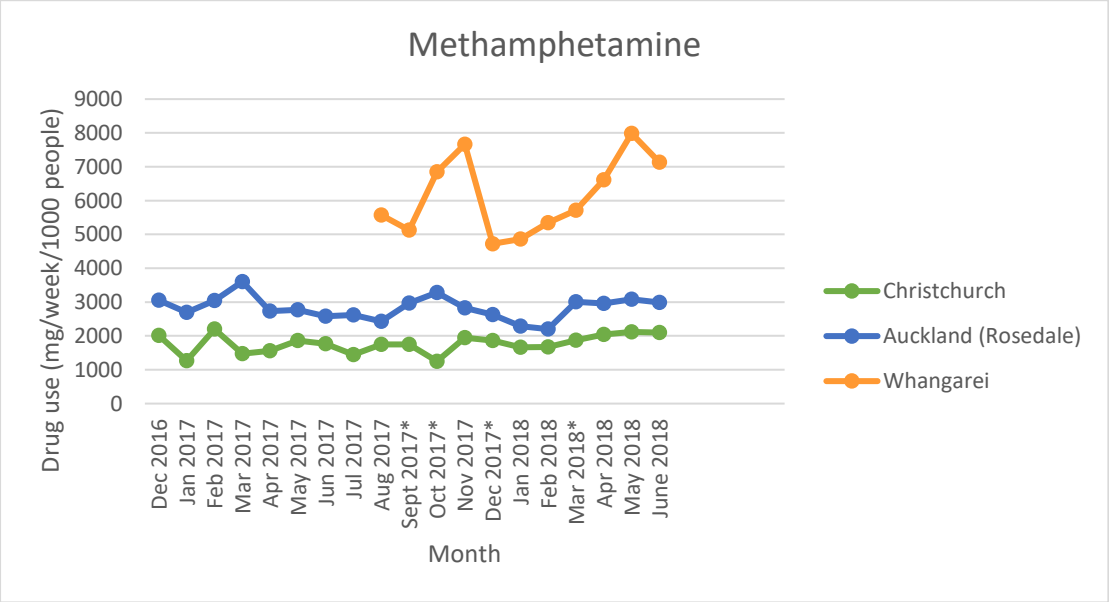


Figure 6 Cocaine use for the week sampled in December 2016 to June 2018 *

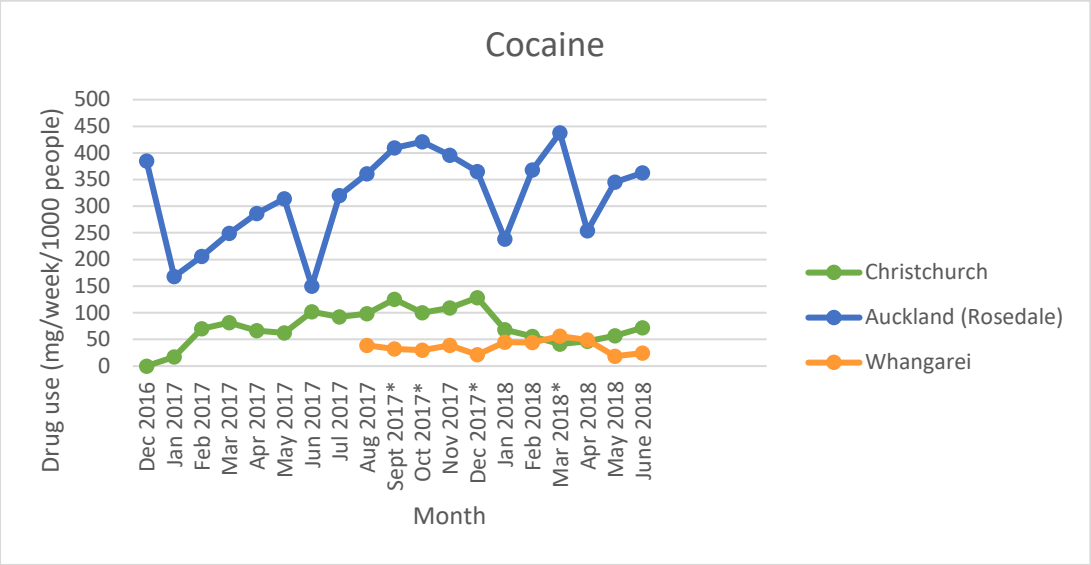
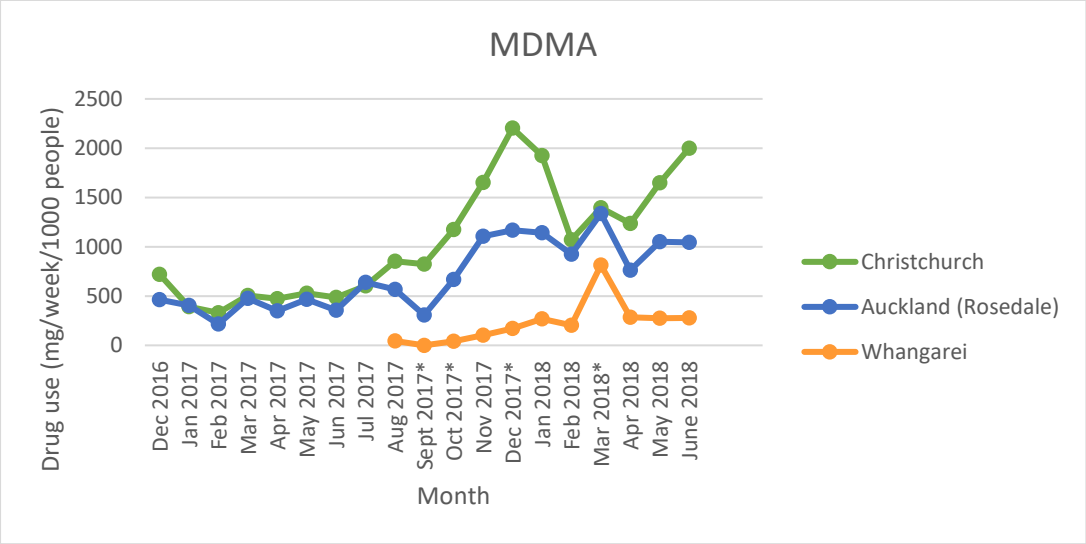
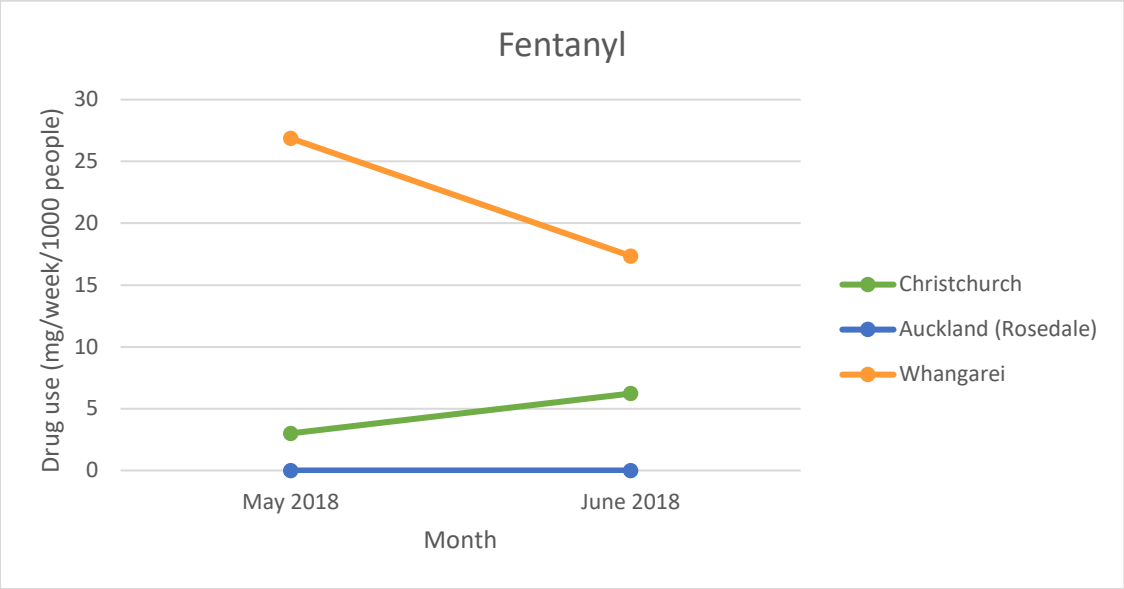


Figure 7 MDMA use for the week sampled in December 2016 to June 2018 *



* 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.

Figure 8 Fentanyl use for the week sampled in May 2018 to June 2018



NB: Levels of fentanyl in wastewater will represent both licit and illicit consumption.

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 June (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	762	718	335
Cocaine	26	87	1
Fentanyl	2	Not Detected	1
Heroin	Not Detected	Not Detected	Not Detected
MDMA	726	251	13

APPENDIX A: JUNE RESULTS BY SAMPLE

In June 2018 the project studied five drugs and their associated metabolites suitable for use in the project.

Creatinine was studied in previous months, but has been shown to be unsuitable as a biomarker for estimating population in a catchment area. For this reason, from May 2018 the creatinine concentration in samples provided are no longer measured.

The concentration of drugs and metabolites 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 June 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.147	0.371	0.671	0.00125
4-hydroxy-N-methylamphetamine	0.173	0.087	0.033	0.00125
Cocaine	0.002	0.017	ND	0.00125
Benzoylecgonine	0.003	0.041	0.005	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.046	0.064	0.105	0.00125
MDMA	0.053	0.055	0.010	0.0025
HMMA	ND	0.005	0.001	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	Trace	0.00125

Table 5: Samples day 2 – Thursday 7th June 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.114	0.483	0.956	0.00125
4-hydroxy-N-methylamphetamine	0.079	0.151	0.033	0.00125
Cocaine	ND	0.012	ND	0.00125
Benzoylecgonine	0.003	0.033	0.004	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.032	0.101	0.142	0.00125
MDMA	0.023	0.031	0.010	0.0025
HMMA	ND	0.003	Trace	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	Trace	0.00125

Table 6: Samples day 3 – Friday 8th June 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.168	0.601	0.998	0.00125
4-hydroxy-N-methylamphetamine	0.104	0.155	0.083	0.00125
Cocaine	ND	0.017	ND	0.00125
Benzoylecgonine	0.002	0.035	0.004	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.056	0.079	0.127	0.00125
MDMA	0.021	0.030	0.009	0.0025
HMMA	ND	0.002	ND	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	Trace	0.001	0.00125

Table 7: Samples day 4 – Saturday 9th June 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.194	0.682	1.192	0.00125
4-hydroxy-N-methylamphetamine	0.288	0.134	0.045	0.00125
Cocaine	0.002	0.022	ND	0.00125
Benzoylecgonine	0.004	0.056	0.002	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.137	0.147	0.210	0.00125
MDMA	0.057	0.053	0.014	0.0025
HMMA	0.002	0.004	ND	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	Trace	0.001	0.00125

Table 8: Samples day 5 – Sunday 10th June 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.228	0.722	1.204	0.00125
4-hydroxy-N-methylamphetamine	0.156	0.169	0.049	0.00125
Cocaine	0.008	0.038	ND	0.00125
Benzoylecgonine	0.016	0.112	0.002	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	0.035	ND	ND	0.00125
Morphine	0.522	0.149	0.241	0.00125
MDMA	0.170	0.163	0.043	0.0025
HMMA	0.018	0.018	0.004	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	0.001	ND	0.002	0.00125

Table 9: Samples day 6 – Monday 11th June 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.235	0.754	1.090	0.00125
4-hydroxy-N-methylamphetamine	0.133	0.221	0.036	0.00125
Cocaine	0.005	0.055	ND	0.00125
Benzoylecgonine	0.015	0.186	0.005	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	0.023	ND	ND	0.00125
Morphine	0.333	0.161	0.226	0.00125
MDMA	0.222	0.298	0.033	0.0025
HMMA	0.018	0.034	0.007	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	0.001	0.00125

Table 10: Samples day 7 – Tuesday 12th June 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.193	0.610	1.037	0.00125
4-hydroxy-N-methylamphetamine	0.138	0.146	0.055	0.00125
Cocaine	0.003	0.032	ND	0.00125
Benzoylecgonine	0.007	0.095	0.003	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	0.007	ND	ND	0.00125
Morphine	0.393	0.133	0.292	0.00125
MDMA	0.091	0.108	0.019	0.0025
HMMA	0.011	0.015	0.004	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	Trace	ND	0.002	0.00125

REFERENCES

Baker DR, Barron L, Kasprzyk-Hordern B. (2014) Illicit and pharmaceutical drug consumption estimated via wastewater analysis. Part A: Chemical analysis and drug use estimates. Science of the Total Environment; 487: 629-41.

Baker DR, Kasprzyk-Hordern B. (2011) Multi-residue analysis of drugs of abuse in wastewater and surface water by solid-phase extraction and liquid chromatography-positive electrospray ionisation tandem mass spectrometry. Journal of Chromatography A; 1218(12): 1620-31.

Tscharke BJ, Chen C, Gerber JP et al. (2016) Temporal trends in drug use in Adelaide, South Australia by wastewater analysis. Science of the Total Environment; 565: 384-91.

van Nuijs ALN, Castiglioni S, Tarcomnicu I et al. (2011) Illicit drug consumption estimations derived from wastewater analysis: A critical review. Science of The Total Environment; 409(19): 3564-77.

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