Science for Communities

Wastewater Analysis for Illicit Drugs Monthly Report September 2018

19 September 2018

Prepared by:

Andrew Chappell, Ellen Ashmore

PREPARED FOR:	**The New Zealand Police**
CLIENT REPORT No:	**FW18049**
REVIEWED BY:	**Dr Brent Gilpin**

ACKNOWLEDGEMENTS

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

Manager	Peer reviewer	Author
		
Maxie Christison	Dr Brent Gilpin	Andrew Chappell
Manager Chemistry and NCRS Group	Science Leader Food, Water & Biowastes Group	Scientist Chemistry Group

CONTENTS

LIST OF TABLES

LIST OF FIGURES

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

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 5th September to Tuesday 11th September 2018 in Christchurch, Rosedale and Whangarei. In total, seven samples from Christchurch, seven samples from Auckland (Rosedale), and seven samples from Whangarei were collected in September. 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 Whangarei. Heroin was not detected in any samples. The drug use in mg/week/1000 people, during the week sampled in September 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	2736	3215	6231
Cocaine	73	189	7
Fentanyl	Not Detected	Not Detected	16
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2043	1174	462

The total load or amount of drug used in the population in Christchurch, Auckland (Rosedale) and Whangarei during the week sampled in September (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	993	772	293
Cocaine	26	45	0.3
Fentanyl	Not Detected	Not detected	0.8
Heroin	Not Detected	Not Detected	Not Detected
MDMA	741	282	22

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 September 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 September 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 5th September to Tuesday 11th September 2018 in Christchurch, Rosedale and Whangarei.

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

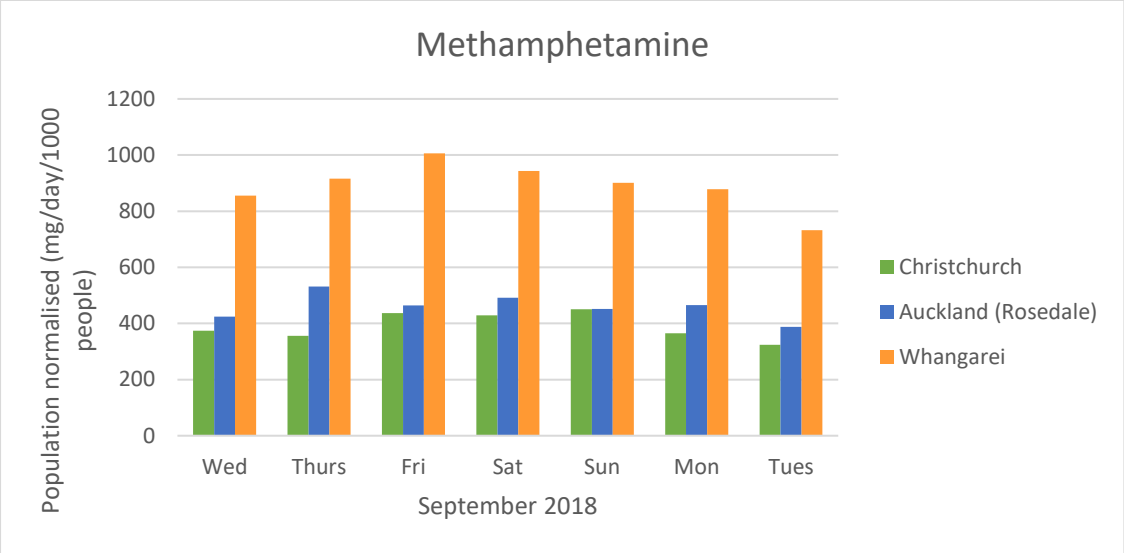


Figure 2 Cocaine use normalised to per 1000 people

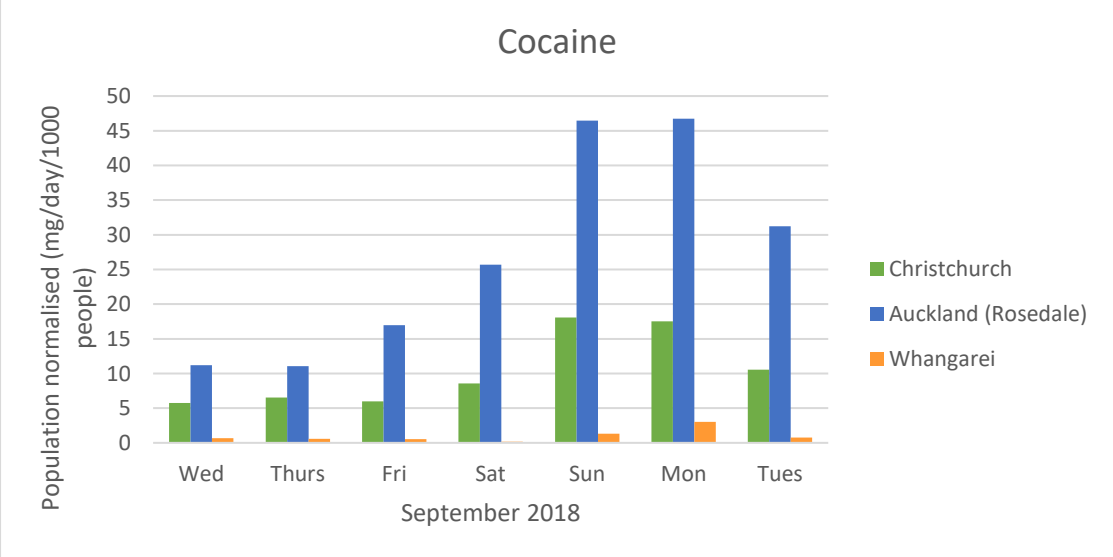


Figure 3 MDMA use normalised to per 1000 people

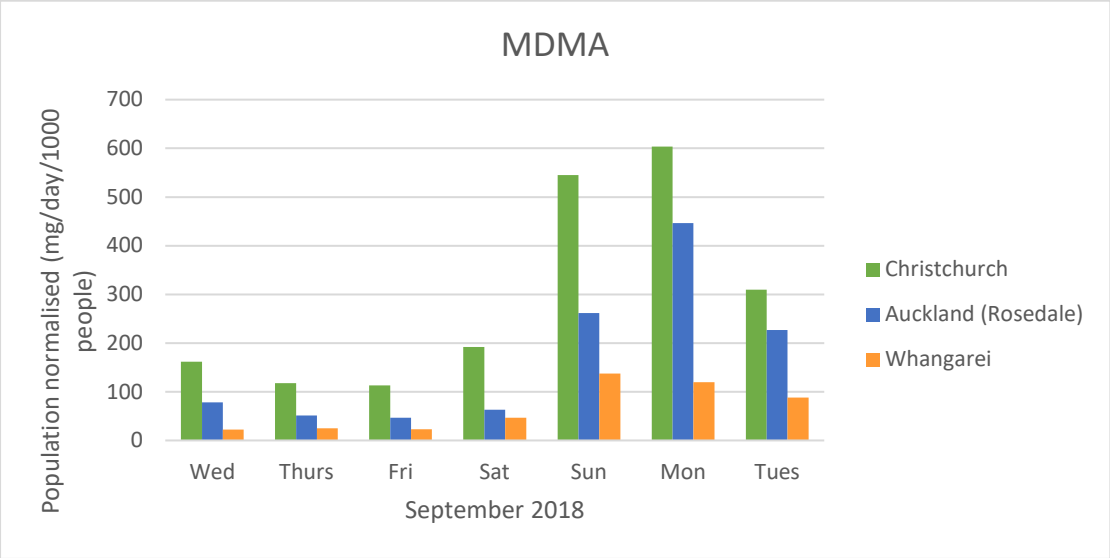
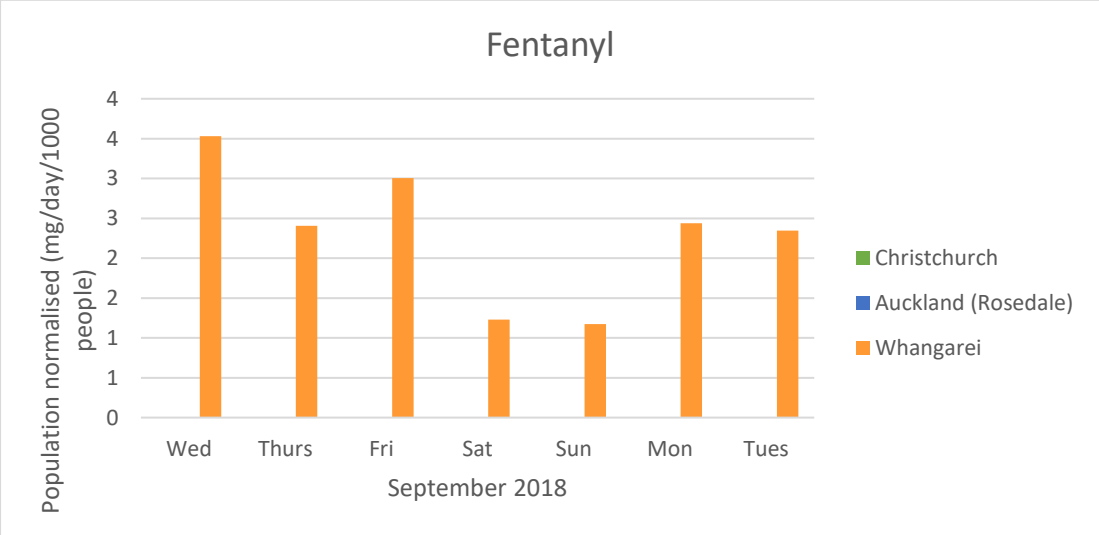


Figure 4 Fentanyl use normalised to per 1000 people



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 September 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	2736	3215	6231
Cocaine	73	189	7
Fentanyl	Not Detected	Not Detected	16
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2043	1174	462

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 September 2018 *

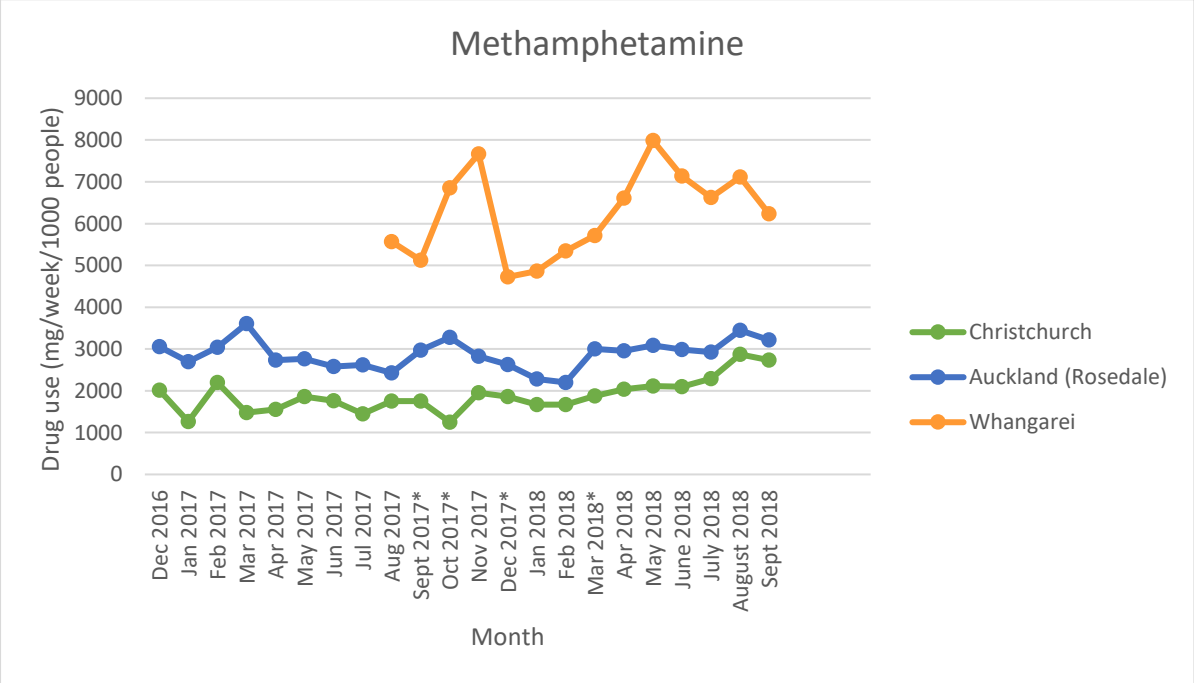


Figure 6 Cocaine use for the week sampled in December 2016 to September 2018 *

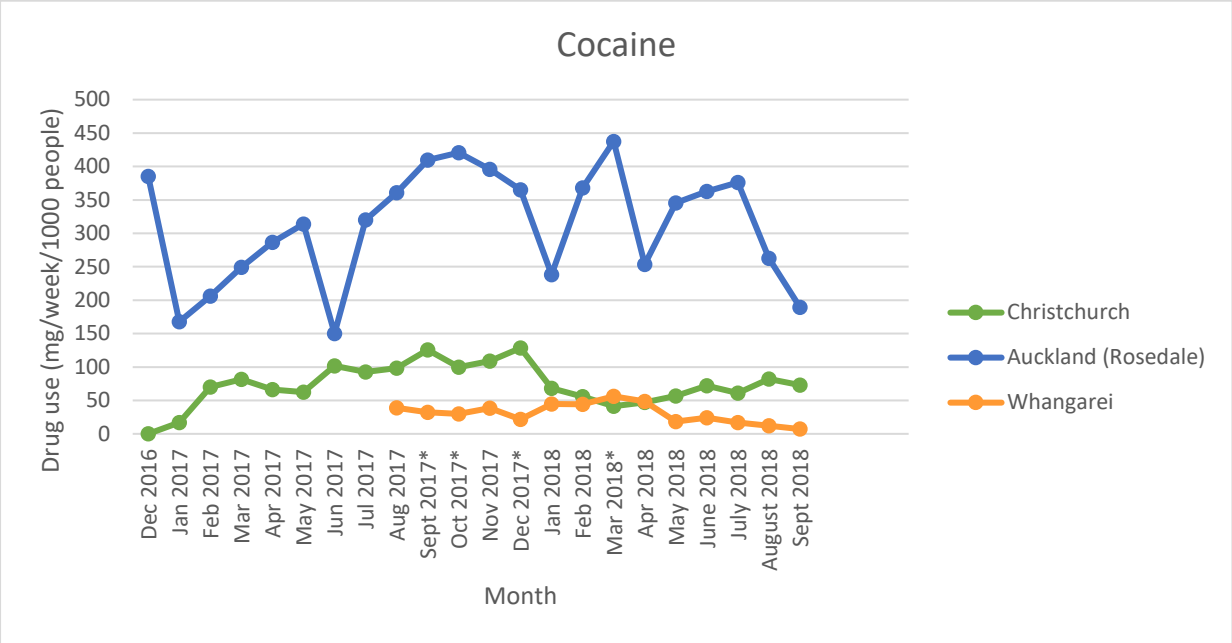
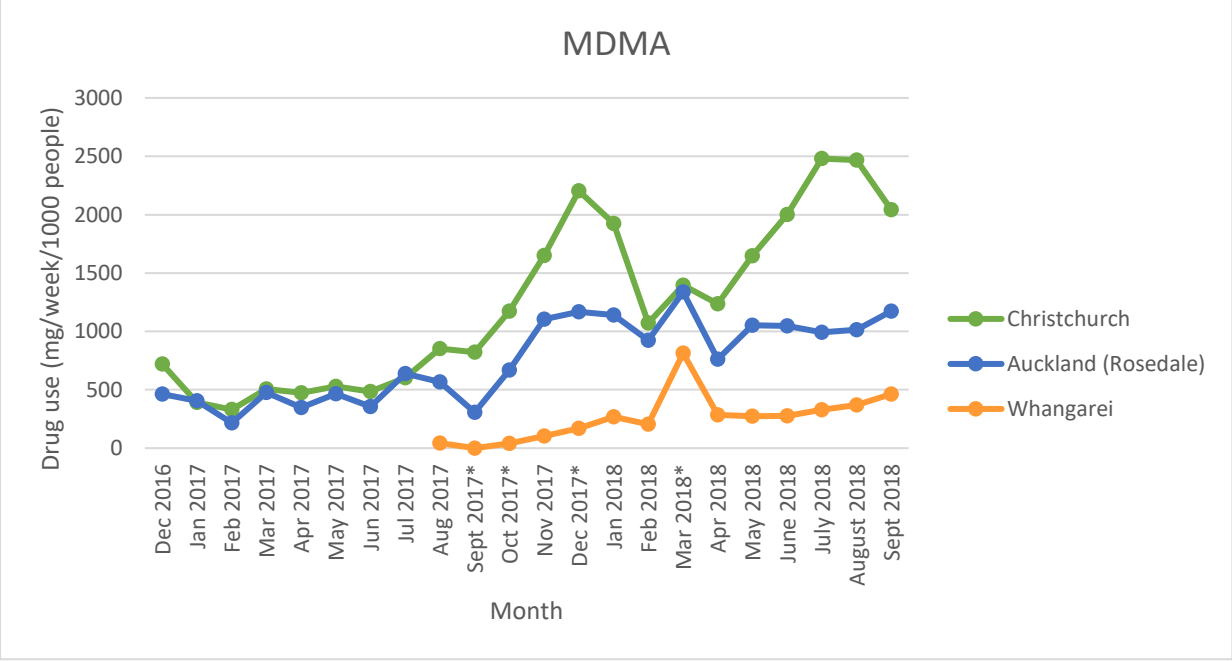
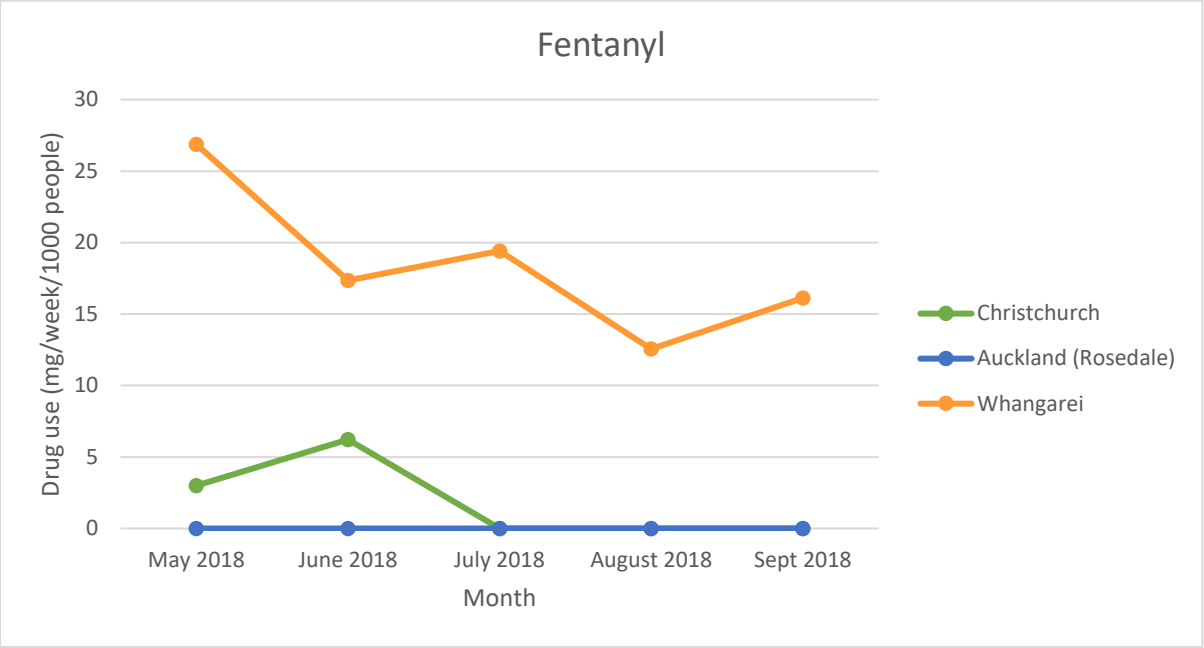


Figure 7 MDMA use for the week sampled in December 2016 to September 2018 *



* 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 September 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 September (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	993	772	293
Cocaine	26	45	0.3
Fentanyl	Not Detected	Not detected	0.8
Heroin	Not Detected	Not Detected	Not Detected
MDMA	741	282	22

APPENDIX A: SEPTEMBER RESULTS BY SAMPLE

In September 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 5th September 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.262	0.705	1.177	0.00125
4-hydroxy-N-methylamphetamine	0.017	0.027	0.045	0.00125
Cocaine	ND	0.006	Trace	0.00125
Benzoylecgonine	0.004	0.019	Trace	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.377	0.245	0.615	0.0025
MDMA	0.053	0.061	0.015	0.0025
HMMA	0.004	0.007	ND	0.0025
Fentanyl	ND	ND	0.001	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 5: Samples day 2 – Thursday 6th September 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.284	0.945	1.307	0.00125
4-hydroxy-N-methylamphetamine	0.018	0.031	0.058	0.00125
Cocaine	ND	0.009	Trace	0.00125
Benzoylecgonine	0.005	0.021	Trace	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.446	0.273	0.543	0.0025
MDMA	0.044	0.043	0.017	0.0025
HMMA	0.004	0.004	ND	0.0025
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 6: Samples day 3 – Friday 7th September 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.375	0.769	1.232	0.00125
4-hydroxy-N-methylamphetamine	0.020	0.024	0.052	0.00125
Cocaine	0.001	0.010	Trace	0.00125
Benzoylecgonine	0.005	0.029	Trace	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.488	0.265	0.530	0.0025
MDMA	0.046	0.037	0.013	0.0025
HMMA	ND	0.003	ND	0.0025
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 7: Samples day 4 – Saturday 8th September 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.378	0.855	1.312	0.00125
4-hydroxy-N-methylamphetamine	0.024	0.028	0.040	0.00125
Cocaine	0.003	0.014	Trace	0.00125
Benzoylecgonine	0.008	0.047	Trace	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.548	0.295	0.519	0.0025
MDMA	0.080	0.052	0.031	0.0025
HMMA	0.008	0.005	ND	0.0025
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	Trace	0.00125

Table 8: Samples day 5 – Sunday 9th September 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.411	0.774	1.283	0.00125
4-hydroxy-N-methylamphetamine	0.013	0.027	0.052	0.00125
Cocaine	0.007	0.021	ND	0.00125
Benzoylecgonine	0.017	0.083	0.002	0.00125
Ecgonine methyl ester	ND	0.076	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.590	0.234	0.513	0.0025
MDMA	0.234	0.212	0.092	0.0025
HMMA	0.022	0.022	0.010	0.0025
Fentanyl	ND	ND	Trace	0.00125
Norfentanyl	ND	ND	Trace	0.00125

Table 9: Samples day 6 – Monday 10th September 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.344	0.852	1.217	0.00125
4-hydroxy-N-methylamphetamine	0.010	0.033	0.058	0.00125
Cocaine	0.008	0.023	Trace	0.00125
Benzoylecgonine	0.017	0.090	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	0.538	0.261	0.503	0.0025
MDMA	0.269	0.386	0.078	0.0025
HMMA	0.032	0.049	0.015	0.0025
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 10: Samples day 7 – Tuesday 11th September 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.301	0.719	0.869	0.00125
4-hydroxy-N-methylamphetamine	0.015	0.023	0.039	0.00125
Cocaine	0.002	0.013	ND	0.00125
Benzoylecgonine	0.010	0.061	Trace	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.0025
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.529	0.261	0.493	0.0025
MDMA	0.136	0.199	0.049	0.0025
HMMA	0.014	0.022	0.008	0.0025
Fentanyl	ND	ND	Trace	0.00125
Norfentanyl	ND	ND	0.001	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.

Science for Communities

INSTITUTE OF ENVIRONMENTAL SCIENCE AND RESEARCH LIMITED

Kenepuru Science Centre
34 Kenepuru Drive, Kenepuru, Porirua 5022
PO Box 50348, Porirua 5240
New Zealand
T: +64 4 914 0700 **F:** +64 4 914 0770

Mt Albert Science Centre
120 Mt Albert Road, Sandringham, Auckland 1025
Private Bag 92021, Auckland 1142
New Zealand
T: +64 9 815 3670 **F:** +64 9 849 6046

NCBID – Wallaceville
66 Ward Street, Wallaceville, Upper Hutt 5018
PO Box 40158, Upper Hutt 5140
New Zealand
T: +64 4 529 0600 **F:** +64 4 529 0601

Christchurch Science Centre
27 Creyke Road, Ilam, Christchurch 8041
PO Box 29181, Christchurch 8540
New Zealand
T: +64 3 351 6019 **F:** +64 3 351 0010

www.esr.cri.nz