

Wastewater Analysis for Illicit Drugs Monthly Report July 2018

19 July 2018

Prepared by:

Andrew Chappell, Ellen Ashmore

PREPARED FOR:	The New Zealand Police
CLIENT REPORT No:	FW18035
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



Maxie Christison
Manager
Chemistry and NCRS Group

Peer reviewer



Dr Brent Gilpin
Science Leader
Food, Water & Biowastes Group

Author



Andrew Chappell
Scientist
Chemistry Group

CONTENTS

1. EXECUTIVE SUMMARY	4
2. METHODOLOGICAL APPROACH	6
2.1 WASTEWATER-BASED EPIDEMIOLOGY APPROACH.....	6
2.2 DRUGS AND METABOLITES.....	6
2.3 SAMPLING AND ANALYSIS	7
2.4 BACK-CALCULATIONS	7
3. RESULTS.....	8
3.1 DAILY DRUG USE	8
3.2 WEEKLY DRUG USE.....	10
3.3 WEEKLY TOTAL DRUG LOAD	12
APPENDIX A: JULY RESULTS BY SAMPLE	13

LIST OF TABLES

TABLE 1 WEEKLY DRUG USE (MG/WEEK/1000 PEOPLE) FOR CHRISTCHURCH, AUCKLAND (ROSEDALE) AND WHANGAREI.....	4
TABLE 2 TOTAL WEEKLY DRUG LOAD (GRAMS PER WEEK) FOR CHRISTCHURCH, AUCKLAND (ROSEDALE) AND WHANGAREI.....	5
TABLE 3: DRUGS AND METABOLITES STUDIED IN JULY 2018	6
TABLE 4: SAMPLES DAY 1 – WEDNESDAY 4 TH JULY 2018.....	13
TABLE 5: SAMPLES DAY 2 – THURSDAY 5 TH JULY 2018.....	14
TABLE 6: SAMPLES DAY 3 – FRIDAY 6 TH JULY 2018	14
TABLE 7: SAMPLES DAY 4 – SATURDAY 7 TH JULY 2018	15
TABLE 8: SAMPLES DAY 5 – SUNDAY 8 TH JULY 2018.....	15
TABLE 9: SAMPLES DAY 6 – MONDAY 9 TH JULY 2018.....	16
TABLE 10: SAMPLES DAY 7 – TUESDAY 10 TH JULY 2018.....	16

LIST OF FIGURES

FIGURE 1 METHAMPHETAMINE USE NORMALISED TO PER 1000 PEOPLE.....	8
FIGURE 2 COCAINE USE NORMALISED TO PER 1000 PEOPLE.....	8
FIGURE 3 MDMA USE NORMALISED TO PER 1000 PEOPLE	9
FIGURE 4 FENTANYL USE NORMALISED TO PER 1000 PEOPLE	9
FIGURE 5 METHAMPHETAMINE USE FOR THE WEEK SAMPLED IN DECEMBER 2016 TO JULY 2018 *	10
FIGURE 6 COCAINE USE FOR THE WEEK SAMPLED IN DECEMBER 2016 TO JULY 2018 *	11
FIGURE 7 MDMA USE FOR THE WEEK SAMPLED IN DECEMBER 2016 TO JULY 2018 *	11
FIGURE 8 FENTANYL USE FOR THE WEEK SAMPLED IN MAY 2018 TO JULY 2018....	12

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

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 4th July to Tuesday 10th July 2018. In total, seven samples from Christchurch, seven samples from Auckland (Rosedale), and seven samples from Whangarei were collected in July. 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 its 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 July 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	2289	2927	6628
Cocaine	61	376	17
Fentanyl	Not Detected	Not Detected	19
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2480	992	327

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

Drug	Weekly Total Drug Load (g/week)		
	Christchurch	Auckland (Rosedale)	Whangarei
Methamphetamine	830	702	312
Cocaine	22	90	0.8
Fentanyl	Not Detected	Not detected	0.9
Heroin	Not Detected	Not Detected	Not Detected
MDMA	900	238	15

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 July 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 July 2018

Drug	Metabolite(s)
Methamphetamine	4-hydroxy-N-methylamphetamine
Cocaine	Benzoyllecgonine 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 4th July to Tuesday 10th July 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 its 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); Tschärke *et al.* (2016); van Nuijs *et al.* (2011).

$$\text{Drug use} = \frac{\text{Concentration} \times \text{Flow rate} \times \text{Excretion factor}}{\text{Population adjustment}}$$

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

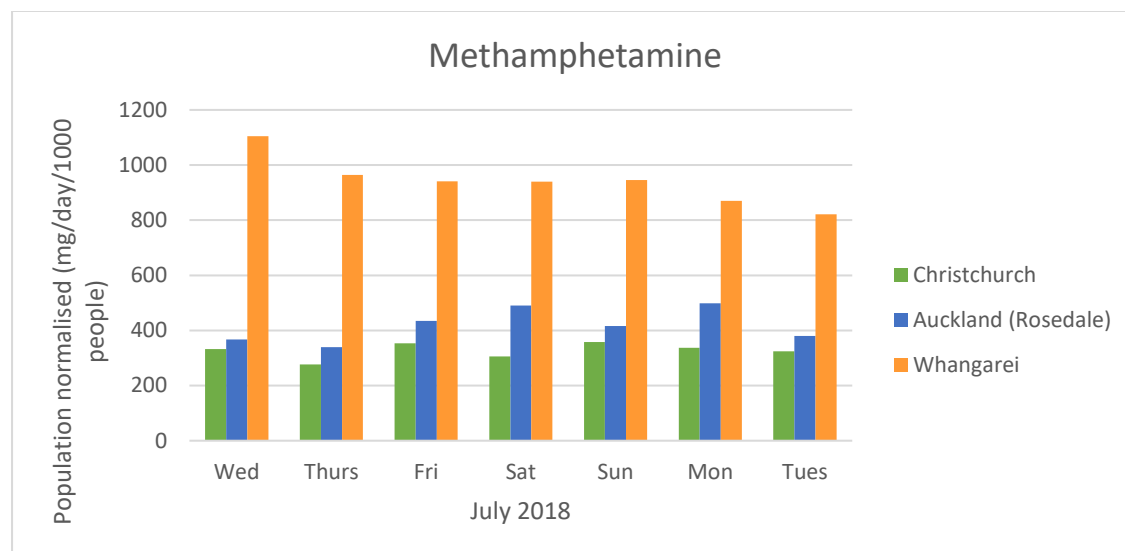


Figure 2 Cocaine use normalised to per 1000 people

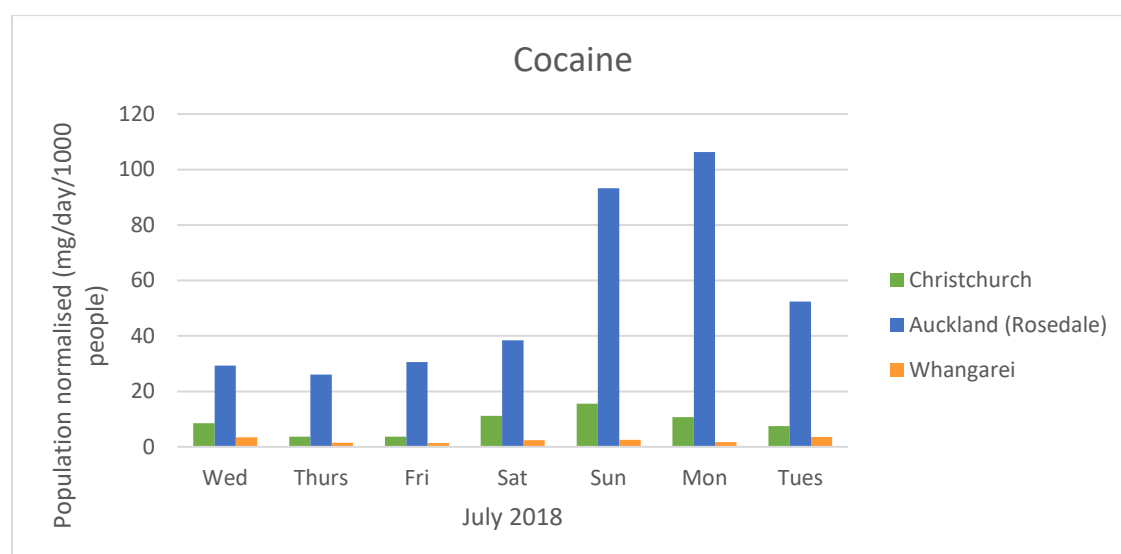


Figure 3 MDMA use normalised to per 1000 people

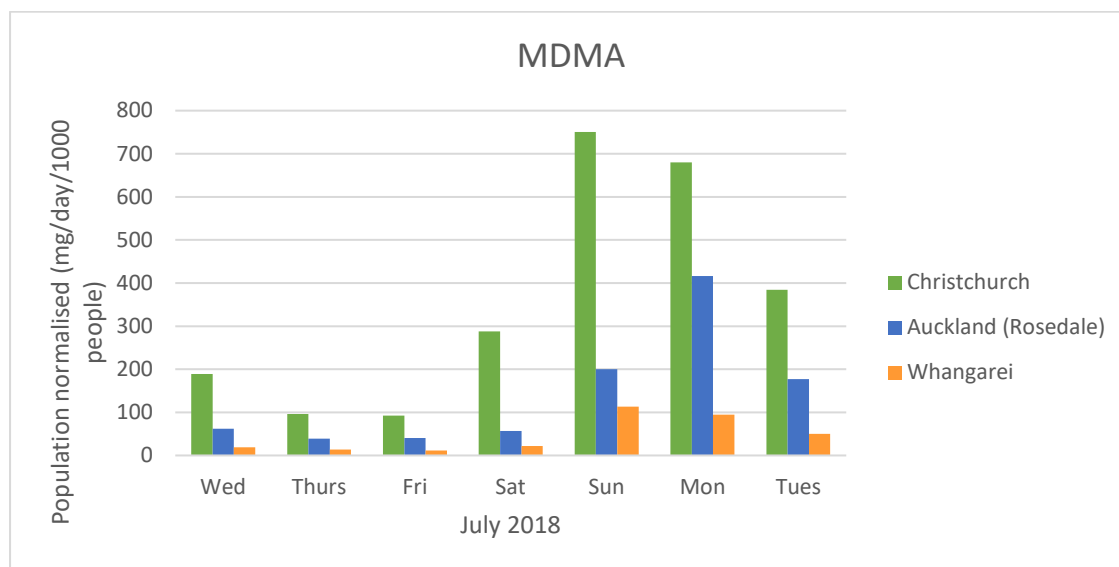
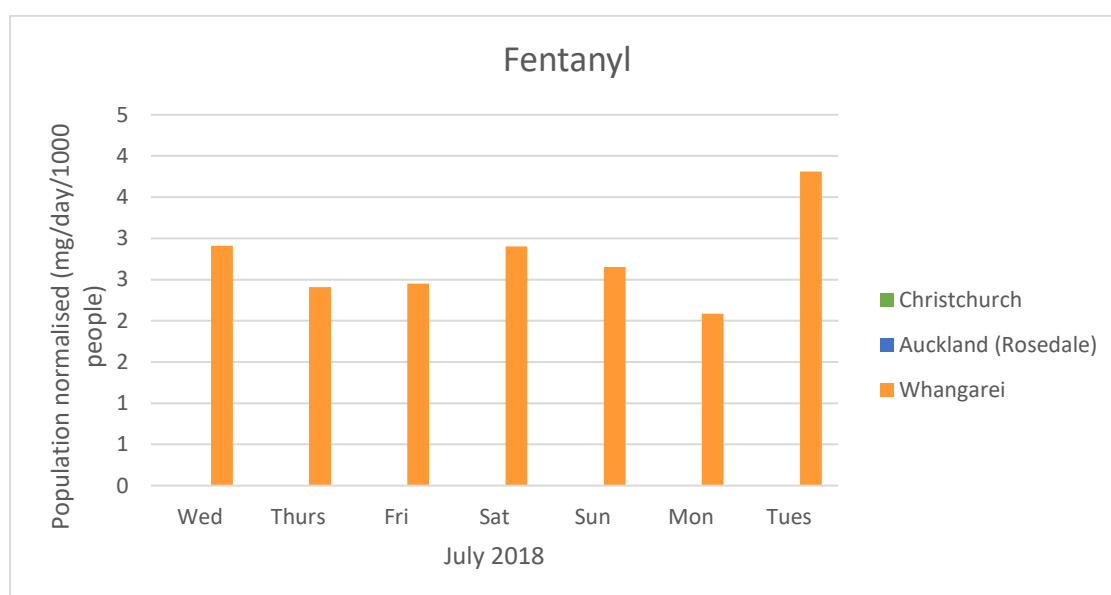


Figure 4 Fentanyl use normalised to per 1000 people



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 July 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	2289	2927	6628
Cocaine	61	376	17
Fentanyl	Not Detected	Not Detected	19
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2480	992	327

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 July 2018 *

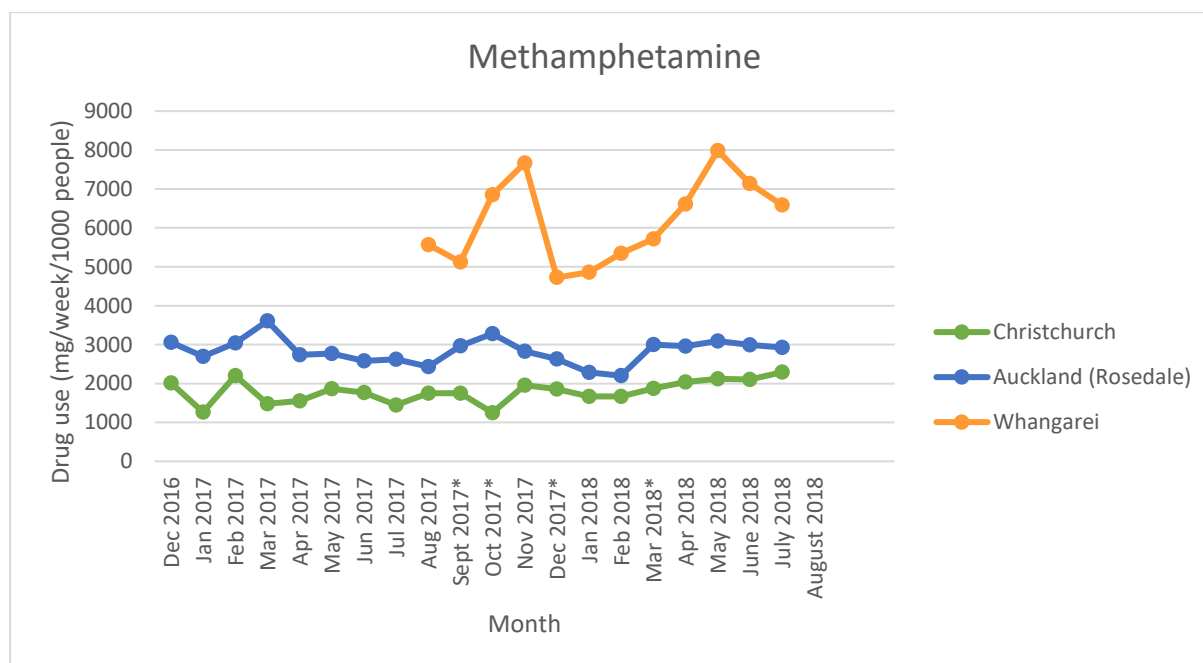


Figure 6 Cocaine use for the week sampled in December 2016 to July 2018 *

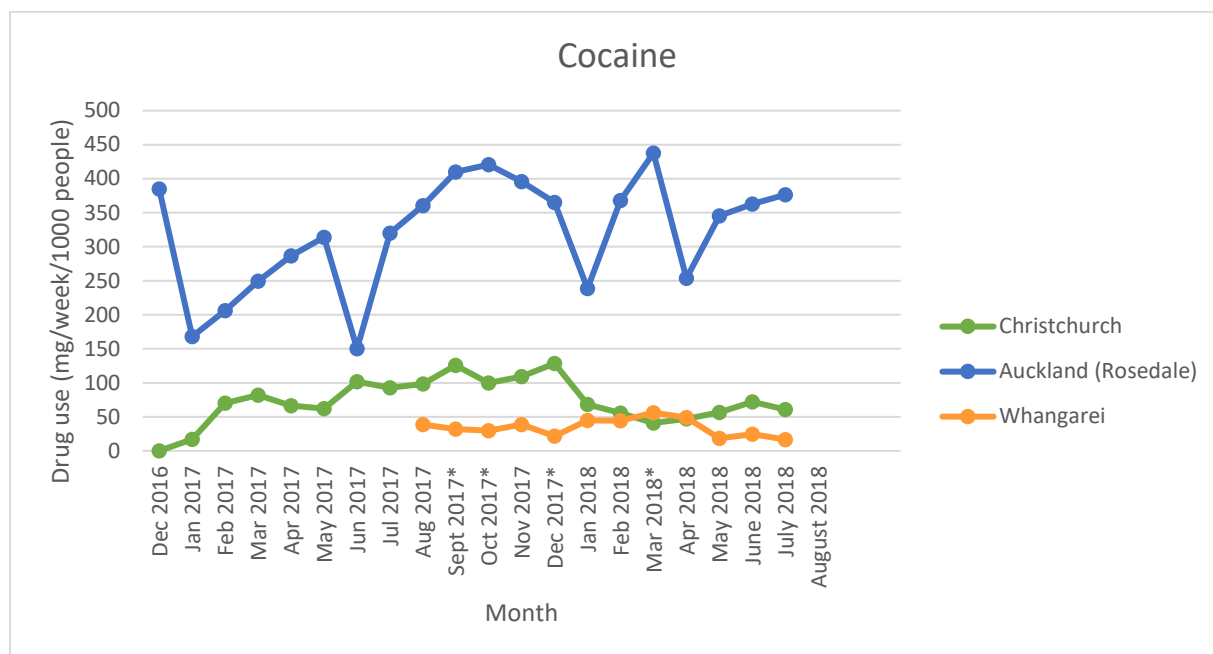
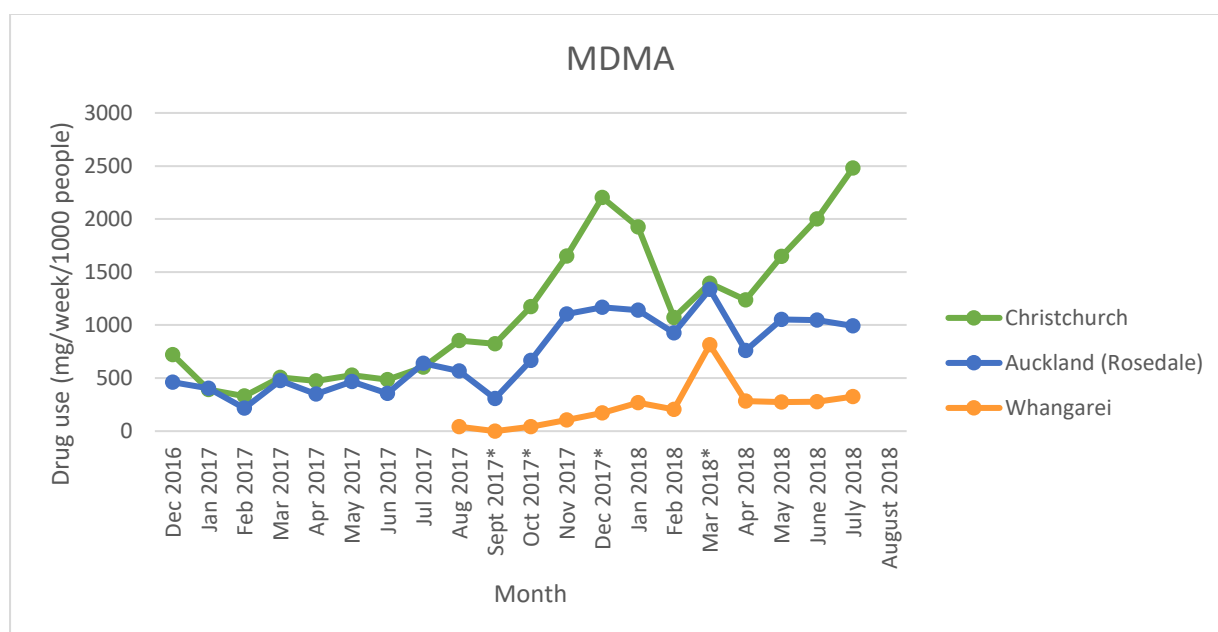
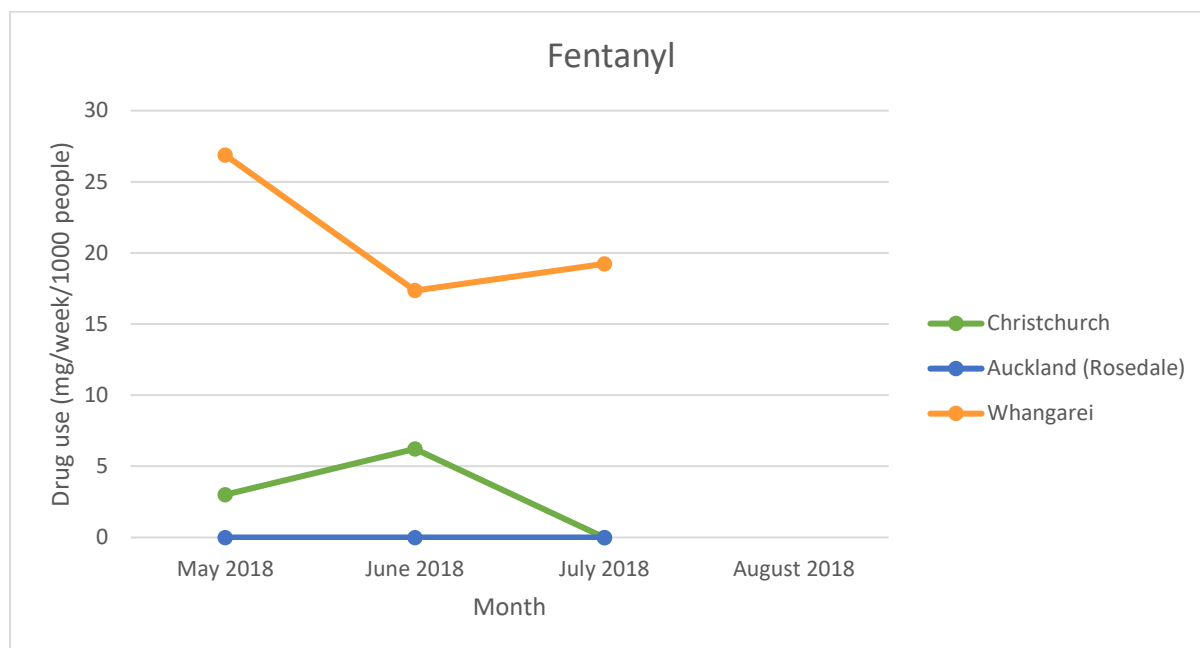


Figure 7 MDMA use for the week sampled in December 2016 to July 2018 *



* 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 July 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 July (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	830	702	312
Cocaine	22	90	0.8
Fentanyl	Not Detected	Not Detected	0.9
Heroin	Not Detected	Not Detected	Not Detected
MDMA	900	238	15

APPENDIX A: JULY RESULTS BY SAMPLE

In July 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 4th July 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.285	0.602	1.208	0.00125
4-hydroxy-N-methylamphetamine	0.263	0.102	0.098	0.00125
Cocaine	0.002	0.023	Trace	0.00125
Benzoyllecgonine	0.008	0.050	0.004	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.684	0.227	0.402	0.0025
MDMA	0.077	0.048	0.010	0.00125
HMMA	0.008	0.006	ND	0.00125
Fentanyl	Trace	Trace	Trace	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 5: Samples day 2 – Thursday 5th July 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.241	0.591	1.111	0.00125
4-hydroxy-N-methylamphetamine	0.212	0.124	0.062	0.00125
Cocaine	Trace	0.017	Trace	0.00125
Benzoylecgonine	0.003	0.048	0.002	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.700	0.662	0.349	0.0025
MDMA	0.039	0.032	0.008	0.00125
HMMA	ND	ND	ND	0.00125
Fentanyl	Trace	ND	Trace	0.00125
Norfentanyl	ND	ND	0.001	0.00125

Table 6: Samples day 3 – Friday 6th July 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.312	0.792	1.141	0.00125
4-hydroxy-N-methylamphetamine	0.168	0.108	0.070	0.00125
Cocaine	0.003	0.020	Trace	0.00125
Benzoylecgonine	0.003	0.058	0.002	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.692	0.678	0.416	0.0025
MDMA	0.038	0.035	0.007	0.00125
HMMA	ND	ND	ND	0.00125
Fentanyl	Trace	ND	Trace	0.00125
Norfentanyl	ND	ND	0.001	0.00125

Table 7: Samples day 4 – Saturday 7th July 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.272	0.899	1.173	0.00125
4-hydroxy-N-methylamphetamine	0.346	0.079	0.079	0.00125
Cocaine	0.004	0.033	Trace	0.00125
Benzoylecgonine	0.010	0.074	0.003	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.712	0.610	0.473	0.0025
MDMA	0.121	0.049	0.013	0.00125
HMMA	0.010	ND	ND	0.00125
Fentanyl	Trace	ND	Trace	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 8: Samples day 5 – Sunday 8th July 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.308	0.772	1.238	0.00125
4-hydroxy-N-methylamphetamine	0.245	0.093	0.076	0.00125
Cocaine	0.004	0.058	Trace	0.00125
Benzoylecgonine	0.014	0.181	0.003	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.205	0.682	0.401	0.0025
MDMA	0.305	0.175	0.070	0.00125
HMMA	0.029	0.021	0.009	0.00125
Fentanyl	Trace	ND	0.003	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 9: Samples day 6 – Monday 9th July 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.312	0.874	1.095	0.00125
4-hydroxy-N-methylamphetamine	0.159	0.125	0.057	0.00125
Cocaine	0.003	0.059	Trace	0.00125
Benzoyllecgonine	0.010	0.195	0.002	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.185	0.696	0.349	0.0025
MDMA	0.297	0.345	0.056	0.00125
HMMA	0.038	0.044	0.011	0.00125
Fentanyl	Trace	ND	0.001	0.00125
Norfentanyl	ND	ND	0.001	0.00125

Table 10: Samples day 7 – Tuesday 10th July 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.289	0.599	0.921	0.00125
4-hydroxy-N-methylamphetamine	0.144	0.073	0.056	0.00125
Cocaine	0.001	0.033	Trace	0.00125
Benzoyllecgonine	0.007	0.086	0.004	0.00125
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00125
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.195	0.560	0.300	0.0025
MDMA	0.161	0.132	0.027	0.00125
HMMA	0.016	0.018	0.005	0.00125
Fentanyl	Trace	Trace	Trace	0.00125
Norfentanyl	ND	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.



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