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

Samples were taken as 24-hour composites for seven consecutive days from Wednesday 1st August to Tuesday 7th August 2018 in Christchurch and Rosedale, and Wednesday 8th August to Tuesday 14th August in Whangarei. In total, seven samples from Christchurch, seven samples from Auckland (Rosedale), and seven samples from Whangarei were collected in August. 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 August 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	2871	3446	7117
Cocaine	82	262	12
Fentanyl	Not Detected	Not Detected	13
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2468	1014	370

The total load or amount of drug used in the population in Christchurch, Auckland (Rosedale) and Whangarei during the week sampled in August (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	1042	827	334
Cocaine	30	63	0.6
Fentanyl	Not Detected	Not detected	0.6
Heroin	Not Detected	Not Detected	Not Detected
MDMA	895	243	17

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 August 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 August 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 1st August to Tuesday 7th August 2018 in Christchurch and Rosedale, and Wednesday 8th August to Tuesday 14th August in 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

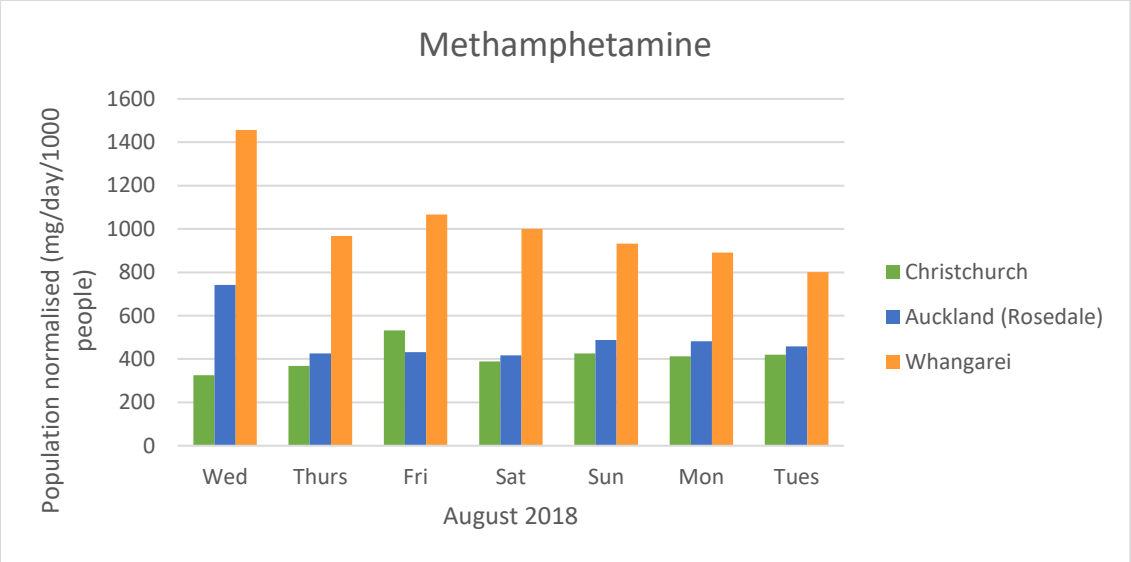


Figure 2 Cocaine use normalised to per 1000 people

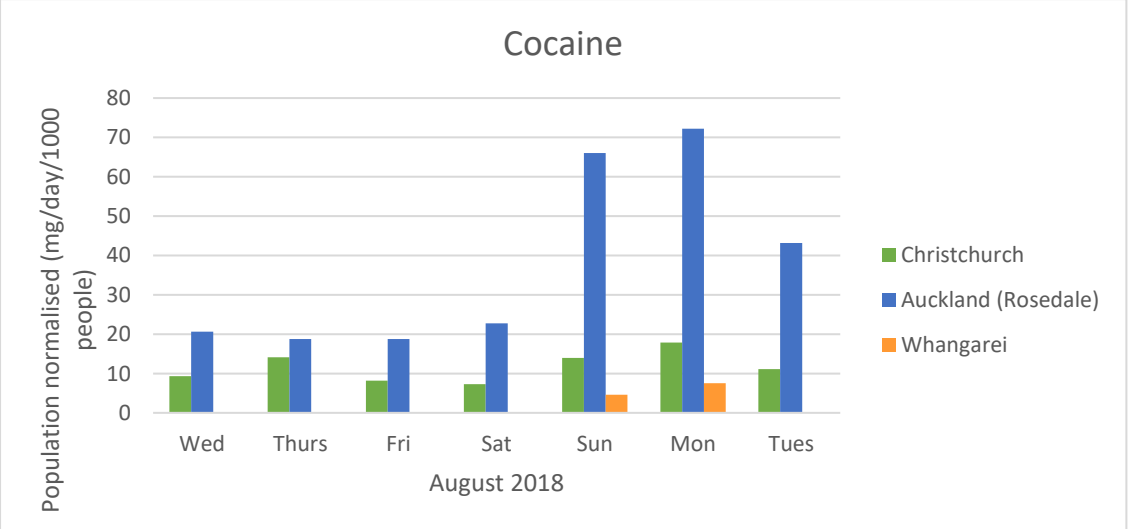


Figure 3 MDMA use normalised to per 1000 people

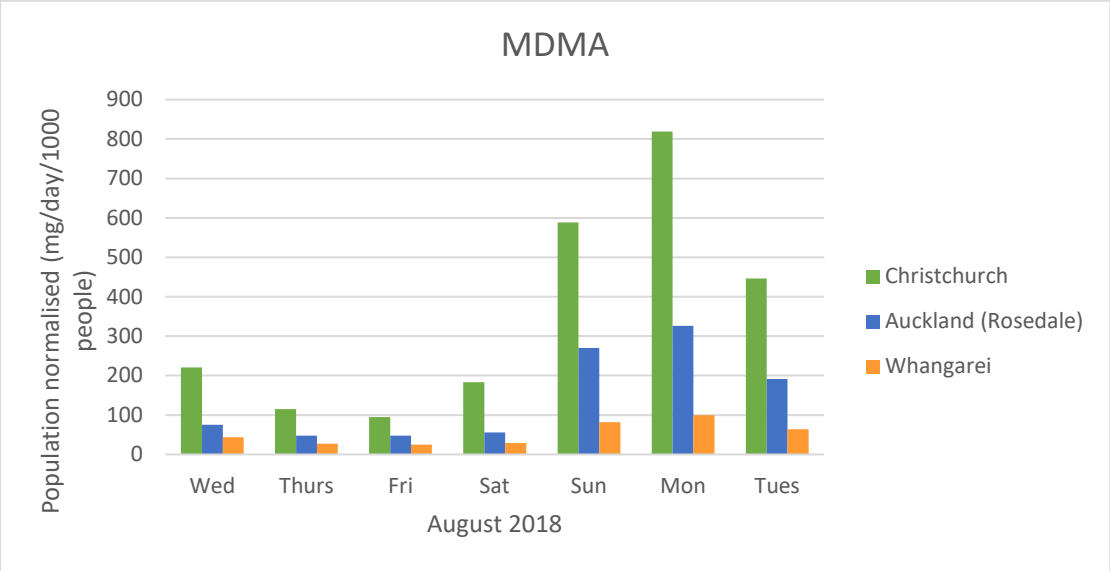
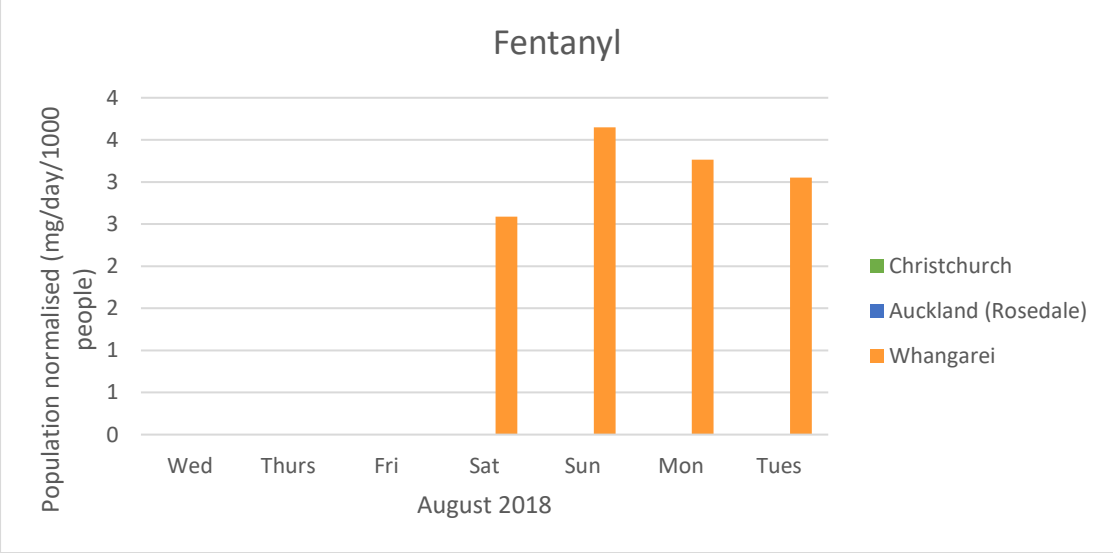


Figure 4 Fentanyl use normalised to per 1000 people



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 August 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	2871	3446	7117
Cocaine	82	262	12
Fentanyl	Not Detected	Not Detected	13
Heroin	Not Detected	Not Detected	Not Detected
MDMA	2468	1014	370

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 August 2018 *

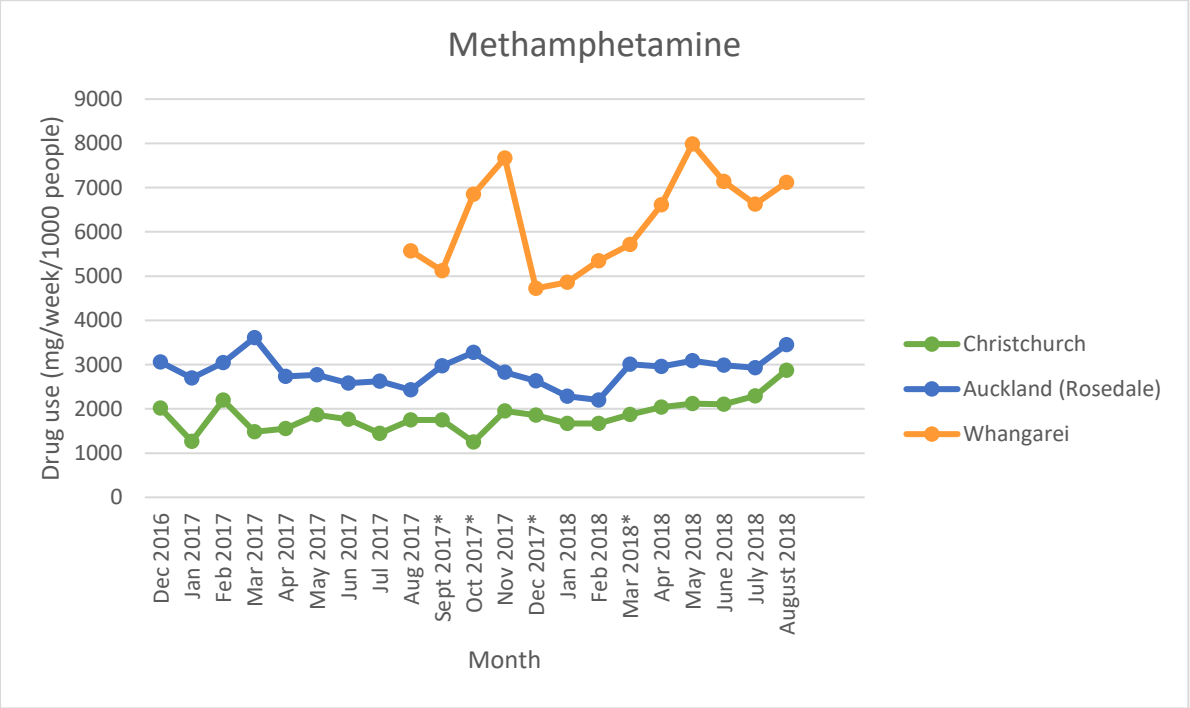


Figure 6 Cocaine use for the week sampled in December 2016 to August 2018 *

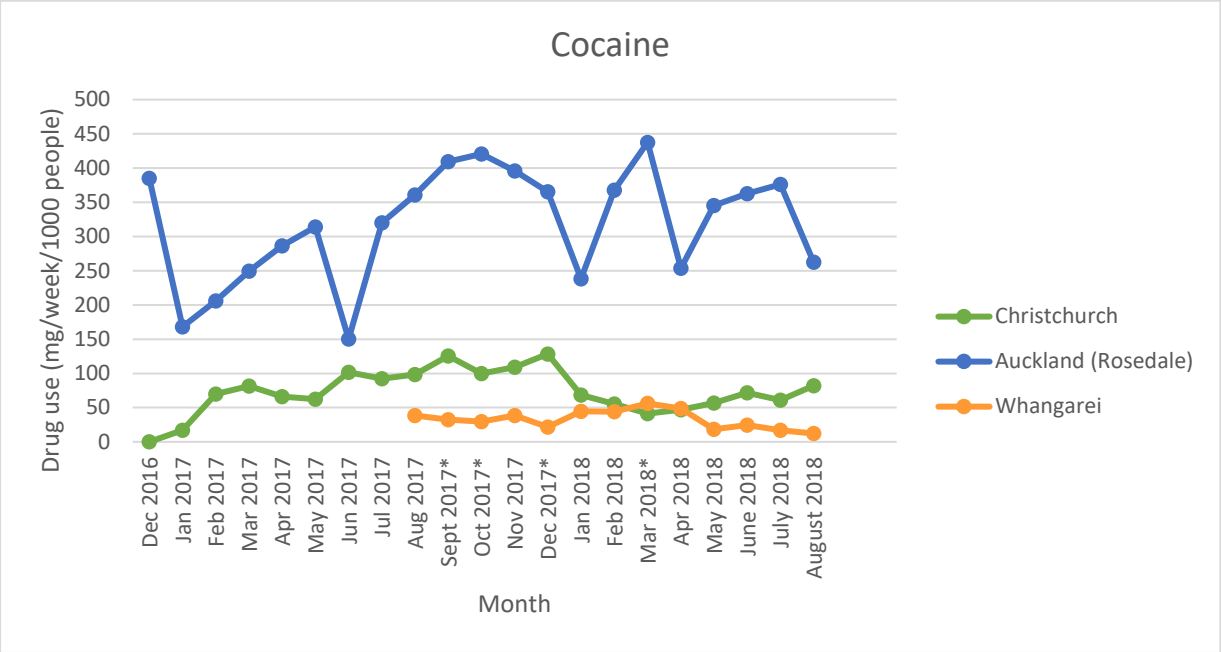
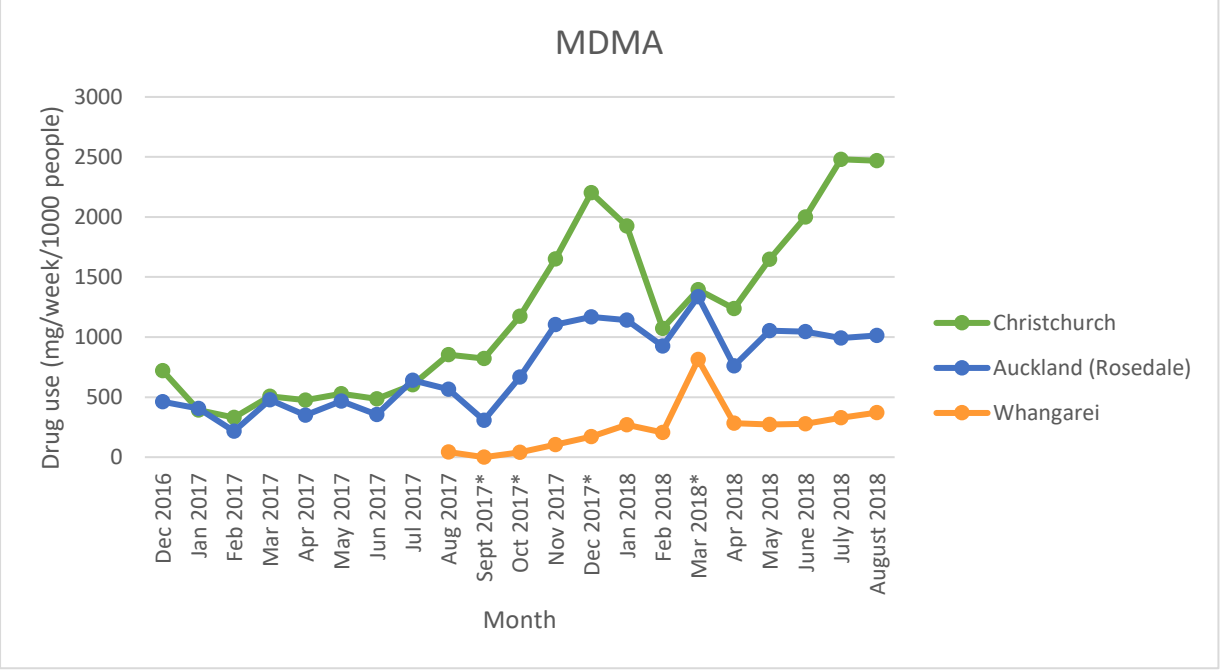
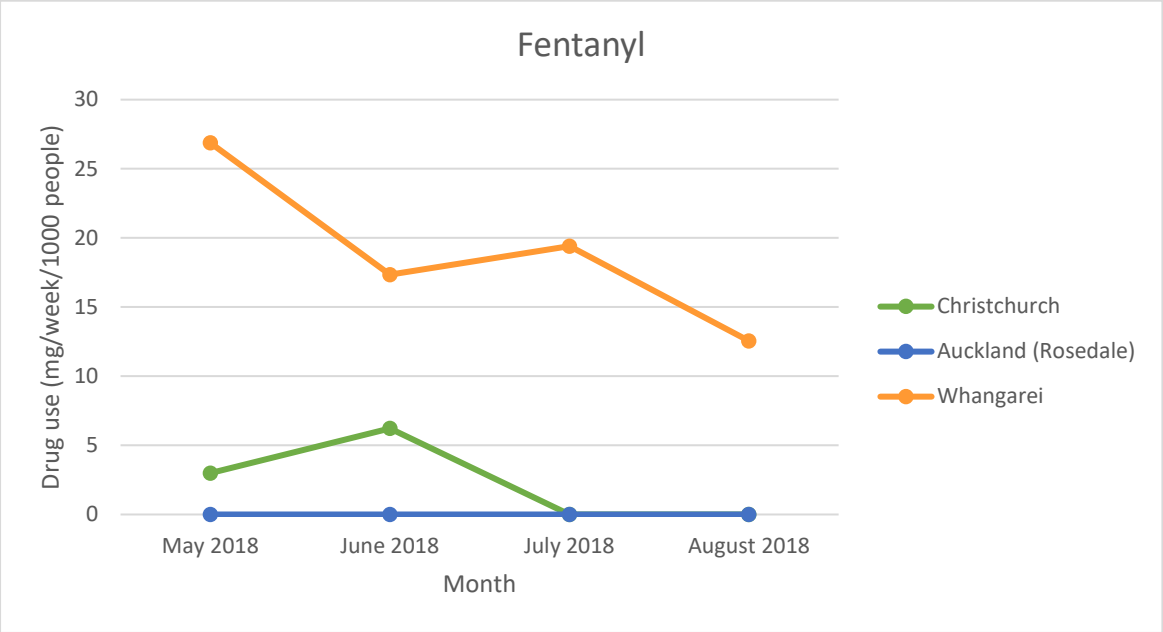


Figure 7 MDMA use for the week sampled in December 2016 to August 2018 *



* 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 August 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 August (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	1042	827	334
Cocaine	30	63	0.6
Fentanyl	Not Detected	Not detected	0.6
Heroin	Not Detected	Not Detected	Not Detected
MDMA	895	243	17

APPENDIX A: AUGUST RESULTS BY SAMPLE

In August 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 1st/8th August 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.303	1.434	2.177	0.00125
4-hydroxy-N-methylamphetamine	0.391	0.033	0.087	0.00125
Cocaine	ND	0.017	ND	0.00125
Benzoylecgonine	0.009	0.042	ND	0.0025
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00625
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.731	1.601	1.074	0.0125
MDMA	0.097	0.069	0.031	0.00125
HMMA	0.005	0.011	ND	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	ND	0.00125

Table 5: Samples day 2 – Thursday 2nd/9th August 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.346	0.802	1.399	0.00125
4-hydroxy-N-methylamphetamine	0.205	0.025	0.060	0.00125
Cocaine	ND	0.014	ND	0.00125
Benzoylecgonine	0.014	0.037	ND	0.0025
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00625
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	1.461	2.812	0.803	0.0125
MDMA	0.051	0.042	0.018	0.00125
HMMA	0.005	0.005	ND	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	ND	0.00125

Table 6: Samples day 3 – Friday 3rd/10th August 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.509	0.838	1.587	0.00125
4-hydroxy-N-methylamphetamine	0.340	0.027	0.057	0.00125
Cocaine	ND	0.019	ND	0.00125
Benzoylecgonine	0.008	0.038	ND	0.0025
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00625
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	1.234	3.785	0.855	0.0125
MDMA	0.043	0.043	0.018	0.00125
HMMA	ND	0.005	ND	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	ND	0.00125

Table 7: Samples day 4 – Saturday 4th/11th August 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.364	0.780	1.520	0.00125
4-hydroxy-N-methylamphetamine	0.606	0.016	0.056	0.00125
Cocaine	ND	0.019	ND	0.00125
Benzoylecgonine	0.007	0.045	ND	0.0025
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00625
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	1.451	3.516	0.969	0.0125
MDMA	0.081	0.049	0.021	0.00125
HMMA	0.009	0.006	ND	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 8: Samples day 5 – Sunday 5th/12th August 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.408	0.891	1.532	0.00125
4-hydroxy-N-methylamphetamine	0.021	0.028	0.063	0.00125
Cocaine	ND	0.031	ND	0.00125
Benzoylecgonine	0.014	0.126	0.008	0.0025
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00625
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.542	2.900	0.722	0.0125
MDMA	0.266	0.233	0.063	0.00125
HMMA	0.002	0.004	0.010	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	0.003	0.00125

Table 9: Samples day 6 – Monday 6th/13th August 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.409	0.896	1.296	0.00125
4-hydroxy-N-methylamphetamine	0.015	0.030	0.052	0.00125
Cocaine	ND	0.026	ND	0.00125
Benzoylecgonine	0.019	0.141	0.011	0.0025
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00625
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.534	0.325	0.646	0.0125
MDMA	0.384	0.287	0.068	0.00125
HMMA	0.041	0.035	0.010	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	0.002	0.00125

Table 10: Samples day 7 – Tuesday 7th/14th August 2018

Drug or metabolite	Concentration in wastewater (µg/L)			Method Limit of Detection (LOD) (µg/L)
	Christchurch	Auckland (Rosedale)	Whangarei	
Methamphetamine	0.381	0.873	1.016	0.00125
4-hydroxy-N-methylamphetamine	0.014	0.025	0.040	0.00125
Cocaine	ND	0.027	ND	0.00125
Benzoylecgonine	0.011	0.086	ND	0.0025
Ecgonine methyl ester	ND	ND	ND	0.00125
Heroin	ND	ND	ND	0.00625
6-acetylmorphine	ND	ND	ND	0.00125
Morphine	0.472	3.416	0.566	0.0125
MDMA	0.191	0.172	0.038	0.00125
HMMA	0.018	0.022	ND	0.00125
Fentanyl	ND	ND	ND	0.00125
Norfentanyl	ND	ND	0.002	0.00125

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