The Presence of Illicit Compounds in the Hawkesbury-Nepean River System

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Key Points

- Illicit drugs concentrations discharged into the environment through treated wastewater are becoming a growing concern worldwide
- Illicit drugs were found in all samples taken from surface water in western Sydney.
- Drug loads from wastewater treatment plants varied between sites but ranged from an estimated of 31 g/day and an upper estimate of 999 g/day at individual sites with a combined total of between 0.9 kg/ day and 1.8 kg/day of illicit drugs being discharged into the Hawkesbury-Nepean system.
- This study highlights that the wastewater treatment methods in western Sydney need to improve due to an increase in both drug use and population growth in the Sydney region.

Abstract

Emerging environmental pollutants include compounds that are not routinely monitored but which have the potential to cause adverse ecological impacts. Here we report on the presence and environmental fate of illicit compounds in the Hawkesbury-Nepean river system. The occurrence of illicit compounds including; amphetamine, cocaine, MDMA, and associated metabolites were found in WTP discharge locations at levels that were in some instances, above those reported in similar international studies. The persistence of these compounds is not limited to the immediate discharge area, with detectable levels measured at distances downstream. Our results highlight that the management of WTP discharge requires an increased understanding of the fate of these emerging environmental pollutants in the rapidly urbanising Sydney landscape.

Keywords

Emerging environmental pollutants, wastewater treatment plant, urbanisation

Introduction

Following the wastewater treatment process, it is common for WTPs to discharge treated wastewater into nearby surface waters. International research has shown that these receiving waters contain concentrations of illicit drugs (Jones-Lepp et al. 2004; Zuccato et al 2005; Zuccato et al. 2008; Kasprzyk-Horden et al. 2008; Baker and Kasprzyk-Horden 2013). Surprisingly, very few studies have been conducted in Australia (Yadav et al. 2016). In Sydney alone, over 150 ML/day of treated wastewater are discharged into river and creek systems with over 130 ML/day directly into the Hawkesbury Nepean River system which is the largest river in the Sydney Basin (Sydney Water 2018a;b).

Monitoring the use of illicit drugs by a population through investigation of untreated influent wastewater is a growing trend by law enforcement (Metcalf et al 2010; van Nuijs et al. 2011; ACIC 2017). From an Australian wastewater context, methamphetamine and cocaine are the most widely consumed, and thereby these compounds and their metabolites are of interest as potential environmental contaminants. Since there is no requirement for WTPs to remove these illicit compounds concern is growing worldwide about the presence of

these compounds in the discharge of treated waste water and the impact that this has on both the environment and human health.

Studies have shown that the proper use of activated sludge in wastewater treatment process can remove up to 100% of some illicit substances such as amphetamine (Castiglioni et al. 2006) and methamphetamine (Baker & Kasprzyk-Horden 2013), other drugs are removed at slightly lower rates, such as benzoylecgonine 81% - 100% (Baker & Kasprzyk-Horden 2013; Bones et al 2007; Castiglioni et al. 2006), cocaine 91% - 100% (Baker & Kasprzyk-Horden 2013; Castiglioni et al. 2006), ephedrine 70% (Baker & Kasprzyk-Horden 2013) and MDMA 13% (Baker & Kasprzyk-Horden 2013). The perception is that the resultant effluent following wastewater treatment should have low to nil concentration of illicit compounds. This investigation sought to test that hypothesis and put into context the daily amounts of illicit drugs discharged into the Hawkesbury Nepean river system.

Methodology

Study sites

Water samples were collected at the discharge point of four WTPs that discharge tertiary treated wastewater into tributaries of the Hawkesbury River, New South Wales, Australia (Figure 1). Sample waters were collected as close to the discharge outlet as possible. The average daily discharge from the plants varies from 0.9 ML/day at North Richmond WTP discharged into Redbank Creek, 23.4 ML/day from Penrith WTP discharged into Boundary Creek to 40 ML/day at Quakers Hill WTP discharged into Breakfast Creek 7 ML/day at Castle Hill WTP discharged into Cattai Creek (Sydney Water 2018a:b).

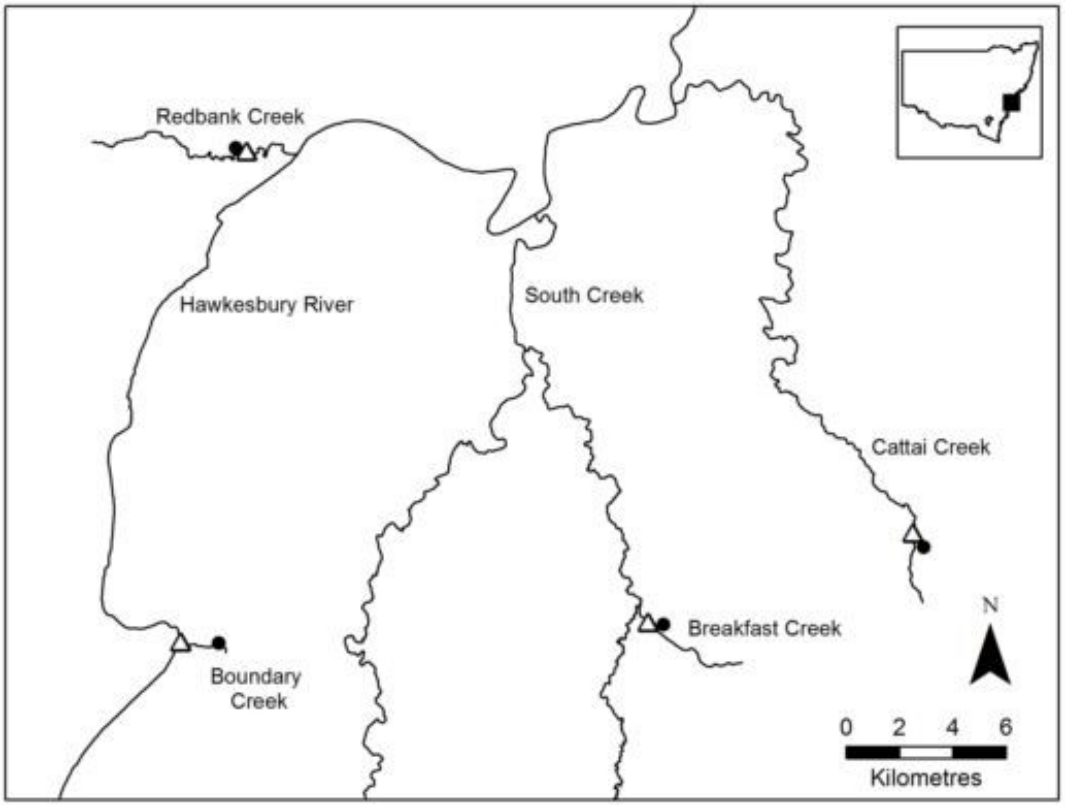

Figure 1: The locations of sampling sites (triangles) and wastewater treatment plants (circles) sampled in Western Sydney, New South Wales, for concentrations of illicit drugs.

Illicit drug sampling

Duplicate 500 ml grab samples were collected (Baker & Kasprzyk-Horden 2013) at each discharge point on two occasions, Saturday 6th May 2017 and Saturday 5th August 2017. Samples were filtered, transported to a NATA accredited laboratory (Envirolab Services, Sydney) and all analysis undertaken within 72 hours. The method tested for the presence of the following illicit drugs, their metabolites and precursors: cocaine, benzoylecgonine, amphetamine, methamphetamine, 3,4-methyl- enedioxymethamphetamine (MDMA),3,4-methylenedioxyamphetamine (MDA), pseudoephedrine and ephedrine. Daily loads of the residues of illicit drugs were calculated in the receiving creeks from the mean concentrations of illicit drugs in the water (g/l) and the reported water discharge rate of each water treatment plant (Sydney Water 2018a:b).

Results

Daily loads
All WTP's were discharging illicit drugs in detectable concentrations. Extrapolation based on discharge rate from each individual WTP is present in Table 1. The lowest daily load of a single drug was amphetamine at Breakfast Creek of 0.05 – 0.15 g/day and the highest daily load of a single drug was 264 – 371 g/day of pseudoephedrine also at Breakfast creek.

Table 1: The estimated illicit drug load in creeks (g/day) in western Sydney.

	Redbank Creek	Boundary Creek	Breakfast Creek	Cattai Creek
Benzoylecgonine	3.8 – 19	25 – 76	57 – 210	113 – 123
Cocaine	0.57 - 2.6	1.7 - 15	4.7 - 26	5.1 - 5.6
Ephedrine	1.6 - 1.9	9.8 - 26	0 - 15	11 - 12
Pseudoephedrine	10 - 12	68 - 151	264 - 371	77 - 95
Amphetamine	0.05 - 0.15	0.67 - 13	1.3 - 2.9	0.88 - 1.3
Methamphetamine	13 - 22	71 - 174	155 - 363	35 - 41
MDA	0.19 - 1.3	1.3 - 13	0 – 1.2	4.7 - 5.2
MDMA	1.01 - 1.3	9.8 - 13	1.2 - 7.8	8.2 - 8.3

As shown in Figure 2, the greatest contributor to the illicit drug load from all the sample sites are the drugs pseudoephedrine and methamphetamine and the metabolite of cocaine, benzoylecgonine. A sum total of the daily loads from individual WTPs provides a lower estimate of 31 g/day (Redbank Creek) and an upper estimate of 999 g/day (Breakfast Creek) of illicit drugs being discharged into the environment (Figure 2) This sum total only takes into account the illicit drugs measured in this study.

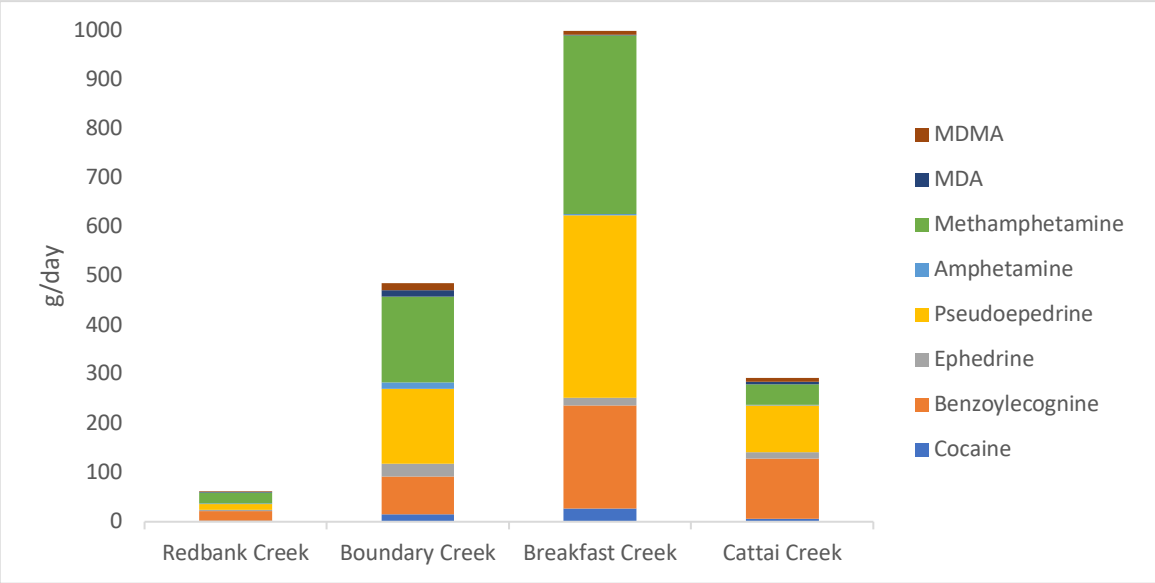

Figure 2: The maximum daily loads (g/day) of illicit being discharged in the Hawkesbury Nepean river Sydney calculated during this study.

Discussion

Despite the use of activated sludge in the wastewater treatment process at all the WTPs sampled, illicit drugs are not being removed during the wastewater treatment process in western Sydney and are being discharged into the environment. Worldwide, studies have reported between 81 – 100% removal of methamphetamine (Baker & Kasprzyk-Horden 2013) and benzoylecgonine (Baker & Kasprzyk-Horden 2013; Bones et al 2007; Castiglioni et al. 2006) using activate sludge, however, the greatest contributors to the illicit drug load from all the sample sites are the drugs methamphetamine, benzoylecgonine and pseudoephedrine. Our findings show that the activated sludge treatment by wastewater treatment plants in Sydney is not achieving the same removal rates.

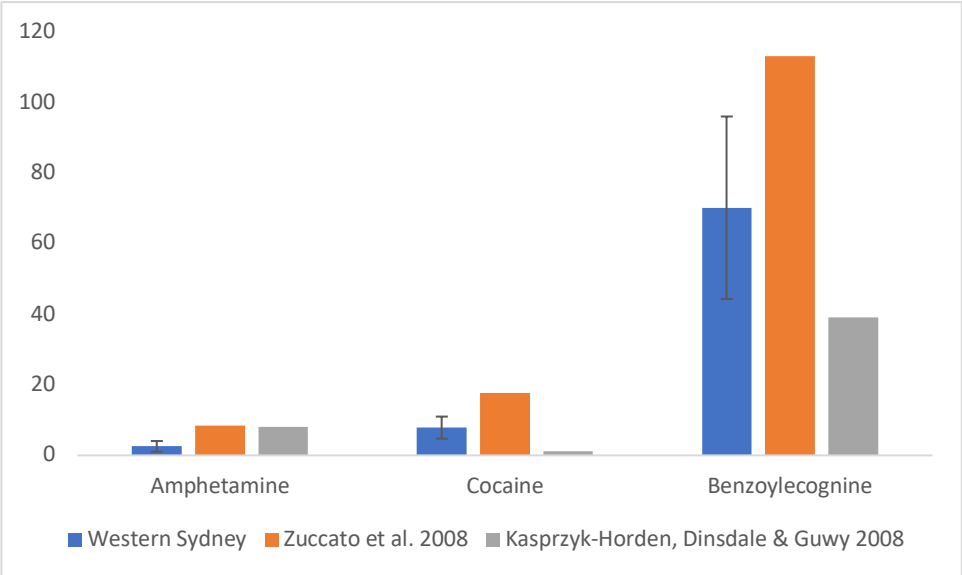

Figure 3: The mean daily drug load in grams per day from our study in western Sydney (plus standard error), from rivers in Italy (Zuccato et al. 2008) and from rivers in the UK (Kasprzyk-Horden, Dinsdale & Guwy 2008).

The mean daily loads calculated from this study fall within the very few studies that have been published on daily discharge loads (Figure 3). The Western Sydney population is expected to grow by 1.7 million in the next 20 years (NSW DPE 2017). Currently, drug use in Sydney is significant with The Australian Criminal Intelligence Commission (ACIC 2017) reporting that in Sydney methylamphetamine use is currently between 200 to 1500 mg / 1000 people / Day, cocaine use between 400 and 2100 mg / 1000 people / Day, MDMA use between 20 to 500 mg / 1000 people / Day and MDA up to 25 mg / 1000 people / Day. With an increase in population, it is expected that there will also be an increase in daily loads of illicit drugs. Increases in illicit drug use coupled with population growth in the Western Sydney region may place significant pressure on the Hawkesbury-Nepean river system. For the Hawkesbury-Nepean system, the NSW EPA are the regulators and should be empowered to monitor and report on these emerging pollutants as part of WTP licensing.

The effect of illicit drugs in surface water is currently unknown. There is potential for these continual drug loads to have an adverse effect both aquatic vegetation, macroinvertebrates and aquatic vertebrates (Corcoran, Winter & Tyler 2010; Binelli et al. 2012; Brodin et al. 2013; Parolini et al. 2013; Garcia-Cambero et al. 2015; de Solla et al. 2016). There is also the potential for these illicit drugs to bioaccumulate (Maruya et al. 2012; de Solla et al. 2016) and have an impact on human health. Our study estimates that from just these four WTP's the illicit drug load in treated wastewater being discharged into the Hawkesbury River system is up to 1.8kg/day. Our data fits within two worldwide published studies on total daily loads, Zuccato et al. (2005) reported a daily load of 4 kg of cocaine-equivalents entering Italy's largest river the Po River and in the River Taff in the UK, Kasprzyk-Horden et al. (2008) report of daily illicit drug load of >40g/day. The data presented here for the Hawkesbury-Nepean system is lower in total load, but larger from a per capita perspective. This is cause for concern as the population will continue to rapidly grow in the Western Sydney region over the next 20 years. The Hawkesbury-Nepean system is used as both a drinking water source and for recreational activities. The continued introduction of these emerging environmental contaminants into this river system will increase human health exposure risks.

Conclusions

There are detectable levels of illicit drugs in wastewater being discharged into the Hawkesbury-Nepean system. The load of illicit drugs entering the environment through treated wastewater is similar to existing international studies. However, the load from a per capita perspective is greater than existing studies and therefore it can be expected that the overall load will increase with the growth of western Sydney. Further work needs to be undertaken to determine why the current treatment methods used by wastewater treatment operators in western Sydney are not adequately removing illicit compounds. This may present an environmental and potential human health risk.

Acknowledgments

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