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Short Communication

Association between purity of drug seizures and illicit drug loads measured in wastewater in a South East Queensland catchment over a six year period

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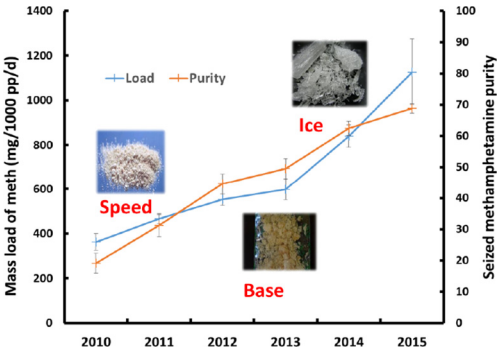
HIGHLIGHTS

- Purity of seized illicit drugs were assessed against their loads measured in wastewater for 6 years.
- Increase in purity of methamphetamine was associated with increase in its wastewater loads.
- Similar phenomenon was not observed for MDMA and cocaine.
- Information about purity could add value to the overall interpretation of WBE data.

GRAPHICAL ABSTRACT



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ABSTRACT

This study aimed to examine associations between the annual average purity of seized illicit drugs and their corresponding load measured in wastewater. Daily loads (averaging 81 samples/year) and purity of seized methamphetamine (average 287 samples/year), cocaine (50/year) and MDMA (70/year) were collected from a catchment that serviced approximately 220,000 persons in Queensland, Australia during 2010–2015. Using regression models for mass load and purity data, we found a strong linear increase in the mass load of methamphetamine detected across study years (363–1126 mg/1000 people/day, $R^2 = 0.89$). Strong linear increases in methamphetamine purity were also apparent (19–69%), and were closely correlated with detected mass load ($r > 0.9$). When differences in purity were controlled for, the linear trend in mass load over time was no longer significant ($p > 0.27$). For cocaine and MDMA there were no statistically significant trends in either mass load or drug purity over the study period. Our study demonstrates that purity changes may have accounted for a substantial proportion of increases of methamphetamine load measured in wastewater of the studied catchment. Wherever possible, when examining temporal trends in drug loads, or when making comparisons between

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Population harm
Wastewater analysis

geographic regions, purity trends should also be examined, as this can aid appropriate interpretation of findings by stakeholders and policy makers.

1. Introduction

The prevalence of illicit drug consumption in the population has been traditionally monitored by surveys (Adams et al., 2008; AIHW, 2011; Flatley and Smith, 2011; NSDUH, 2011). Such information is essential for the development and evaluation of evidence-based public health and law enforcement policies.

Over the last decade, wastewater analysis, or wastewater-based epidemiology (WBE), has been introduced as a complimentary method for assessing the extent of population illicit drug consumption (Castiglioni et al., 2014). The method is applied extensively internationally to obtain objective information on the population consumption of key illicit drugs, including amphetamines, cocaine, and 3,4-methylenedioxymethamphetamine (MDMA). In the latest review commissioned by the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA, 2016) >300 studies around the world have applied wastewater analysis, e.g. (Baz-Lomba et al., 2016; Kim et al., 2015; Lai et al., 2016a; Ort et al., 2014; Subedi and Kannan, 2014; Zuccato et al., 2008), primarily reporting daily load of illicit residues measured in wastewater samples.

Using WBE, Lai et al. (2016b) have reported trends in cocaine, MDMA and methamphetamine consumption in an urban catchment in South East Queensland, Australia between 2009 and 2015. A notable finding of the study is that there was a clear increase in methamphetamine mass load between 2009 and 2015 while there was no such trend observed for cocaine and MDMA over this period. The increase in methamphetamine mass load in wastewater reflected an approximately three-fold increase in total methamphetamine consumed in 2015 compared with that in 2010.

While it provides objective quantification of drug loads in sewers, WBE is silent as to the cause of any change. It is not possible to tell from WBE whether the change in total consumption arose from: (1) a change in the number or type of drug consumers (e.g. more people using similar drug quantities at similar purity or similar numbers of people using increased quantity at similar purity); (2) a change in purity of the drugs being consumed (e.g. the same number of users consuming similar quantities of a purer drug), or (3) a combination of these possibilities (e.g. more people using larger doses of a purer drug, and using it more often). Drug purity is not considered in the calculation of mass load in WBE, as the data reflects an estimate of consumption of pure drug. In order to interpret the factors contributing to changes in load, as well as spatial differences, it is important to integrate drug purity data into the assessment of reasons for changes in drug consumption trends estimated by WBE over time (Bruno et al., 2014).

A recent study in Victoria, Australia reported an increase in purity of methamphetamine during 2009–2013 (Scott et al., 2015). Given this, increased methamphetamine purity may be a substantial contributor to the dramatic increase in methamphetamine measured in wastewater by Lai et al. (2016b). In this study, we examined whether purity changes could account for the trends in sewer loads. Specifically, the aims were to gather the purity data of three illicit drugs, methamphetamine, cocaine and MDMA, from police seizures in the same area as the studied sewer catchment for the same period of 2010–2015 and then identify if there is any association between sewer loads and purity levels over time.

2. Methods

2.1. Drug load data

We used daily drug loads of influent wastewater at a major treatment plant in South East Queensland (Australia) for the period 2010–2015, as previously reported by Lai et al. (2016b). The data consisted of an average of 81 samples per annum: 2010 (21 days), 2011 (160 days), 2012 (188 days), 2013 (61 days), 2014 (49 days) and 2015 (7 days). More detailed description of sampling procedures and the limitations arising from the variation in number of annual sampling days are available in Lai et al. (2016b). The smaller number of samples in 2013 onwards represents a change from near bi-daily to near weekly sampling. The smaller number of sampling days in 2010 and 2015 mean that these data points may be more influenced by short term fluctuations in consumption. To describe the overall method briefly, 24-hour composite samples were collected and analysed by high-performance liquid chromatography coupled to a triple quadrupole tandem mass spectrometer to provide the concentrations of illicit drug residues excreted after consumption (methamphetamine, MDMA, and benzoylecgonine for cocaine) as described previously in Lai et al. (2016b). Catchment population was estimated from Census data. The daily loads of those residues (mg/day/1000 people) were then estimated using measured concentrations and daily flows provided by WWTP personnel.

2.2. Purity data

Data on purity of seized illicit drugs in South East Queensland in the period covered in this study were provided by the Queensland Health Forensic Chemistry laboratory. This is the sole laboratory in Queensland responsible for the analysis of illicit drug seizures submitted by law enforcement in the State. Numbers of seizures conducted by law enforcement in the studied catchment are tabulated for each drug in Fig. 1. All the seizures were drugs likely intended to be sold to consumers and did not include seizures from customs. These represent an average of 286, 75 and 50 samples per annum for methamphetamine, MDMA and cocaine respectively. All drugs seized are analysed for purity. Law enforcement identifies both end user "street level" small seizures (item weight ≤ 2 g) as well as higher level "wholesale" seizures (item weight > 2 g). These were analysed separately in order to avoid any purity differences across these seizure types biasing results (Fig. S1). For methamphetamine, however, there were no statistically significant differences in purity between these seizure sizes (≤2 g: mean = 50.0%, SD = 28.5%; >2 g: mean = 49.4%, SD = 28.8%: bootstrapped $t(694) = 0.26$, $p = 0.786$, Cohen's $d = 0.02$). There were small to moderate magnitude differences in purity for the large and small seizures for cocaine (≤2 g: mean = 30.1%, SD = 17.4%; >2 g: mean = 40.0%, SD = 21.7%: bootstrapped $t(107) = 3.71$, $p = 0.003$, Cohen's $d = 0.51$), and for MDMA (≤2 g: mean = 22.3%, SD = 20.9%; >2 g: mean = 16.6%, SD = 16.5%: bootstrapped $t(258) = 3.01$, $p = 0.003$, Cohen's $d = 0.30$).

2.3. Consumer data

In order to determine if there were changes in typical doses of drugs used by consumers over the study period, data from the Ecstasy and Related Drug Reporting system were reviewed. The methodology of this