

# 1 Occurrence of illicit drugs in water and wastewater, and their removal during wastewater 2 treatment

3 Meena K. Yadav <sup>a</sup>, Michael D. Short <sup>a,b</sup>, Rupak Aryal <sup>a</sup>, Cobus Gerber <sup>c</sup>, Ben van den Akker <sup>a,d</sup>, Christopher P.  
4 Saint <sup>a,b,e</sup> \*

5  
6 <sup>a</sup> Natural and Built Environments Research Centre, School of Natural and Built Environments, University of  
7 South Australia, Mawson Lakes, SA 5095, Australia (E-mail: [meena.yadav@mymail.unisa.edu.au](mailto:meena.yadav@mymail.unisa.edu.au);

8 [michael.short@unisa.edu.au](mailto:michael.short@unisa.edu.au); [rupak.aryal@unisa.edu.au](mailto:rupak.aryal@unisa.edu.au))

9 <sup>b</sup> Future Industries Institute, University of South Australia, Mawson Lakes, SA 5095, Australia

10 <sup>c</sup> School of Pharmacy and Medical Science, City East Campus, North Terrace, Playford Building, Level 4,  
11 Room 47, Adelaide SA 5000, Australia (E-mail: [cobus.gerber@unisa.edu.au](mailto:cobus.gerber@unisa.edu.au))

12 <sup>d</sup> Australian Water Quality Centre, SA Water, 250 Victoria Square, Adelaide SA 5000; GPO Box 1751,  
13 Adelaide SA 5001 (Email: [Ben.vandenAkker@sawater.com.au](mailto:Ben.vandenAkker@sawater.com.au))

14 <sup>e</sup> Division of Information Technology, Engineering and the Environment, University of South Australia,  
15 Mawson Lakes, SA 5095, Australia (E-mail: [Christopher.Saint@unisa.edu.au](mailto:Christopher.Saint@unisa.edu.au))

16  
17 \*Corresponding Author: Professor Christopher P. Saint

## 18 19 Highlights:

- 20 • Levels of illicit drugs are increasing in wastewater, surface and drinking water
- 21 • Regional variations in drug consumption are reflected in their detection patterns
- 22 • Conventional wastewater treatment shows variable efficacy for drug removal
- 23 • Little is known on the removal efficacy of alternative or natural treatment systems
- 24 • Almost nothing is known about the environmental fate and toxicity of illicit drugs

## 25 26 Abstract

27 This review critically evaluates the types and concentrations of key illicit drugs (cocaine, amphetamines,  
28 cannabinoids, opioids and their metabolites) found in wastewater, surface water and drinking water sources  
29 worldwide and what is known on the effectiveness of wastewater treatment in removing such compounds. It is  
30 also important to amass information on the trends in specific drug use as well as the sources of such compounds