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Sewage epidemiology – assessing community health factors by wastewater monitoring

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Drug abuse has devastating social and economic consequences on an individual, community, and national level. Therefore, epidemiologists make a lot of efforts i) to assess the nature and magnitude of drug abuse and emerging problems timely and ii) to closely monitor trends within and across communities. Recently, the environmental monitoring of illicit drugs in surface and wastewaters has emerged as a new field with an appealing idea: objective evidence-based data on drug-use can be obtained in real-time and at only a fraction of the cost of population surveys, which are often criticized for being inaccurate. Thanks to tandem mass spectrometry, new questions regarding the (eco)toxicological effects of residuals of drugs and pharmaceuticals are being answered, but it is not clear whether these technologies also allow for a better understanding of health-related processes in the society. Specifically, it is unclear how useful the environmental monitoring data are regarding the reliable back-calculation of community-wide prevalence levels of (illicit) drug use: First, current models make a variety of strong assumptions regarding drug use characteristics and metabolism and completely neglect relevant transport and transformation processes in the aquatic system as well as monitoring errors. Second, no rigorous uncertainty analysis of prevalence estimation from wastewater monitoring data has been reported yet.

In this contribution, we present a method to investigate the representativeness of drug load measurements in wastewater systems and suggest two innovations: First, we establish a simple but useful model to predict spatio-temporal patterns of drug residues in sewer networks from generally available data. Second, we develop tools to perform statistical inference from point wastewater measurements on spatially distributed pa-

rameters in the connected drainage area (i.e., prevalence levels or indicators of drug use). In addition, we rigorously assess the overall uncertainty in the obtained results. We demonstrate the usefulness of our methodology on an investigation of cocaine loads and metabolites in an urban catchment in the greater San Diego area, CA, USA.

In conclusion, our results show that an accurate analysis of drug loads in wastewater systems (and back-calculation of use levels) is incomplete if only epidemiological or analytical-chemical aspects are considered. The reliable interpretation of aquatic monitoring data in a community-health context also requires an understanding of the environmental system and the involved processes.