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A modelling approach to estimate the number of people contributing to a wastewater sample using population biomarkers

Jake O'Brien, *University of Queensland, Brisbane, Queensland, Australia*
Phong Thai, *Queensland University of Technology, Brisbane, Queensland, Australia*
Christoph Ort, *EAWAG, Dübendorf, Switzerland*
Kevin Thomas, *Norwegian Institute for Water Research (NIVA), Oslo, Norway*
Malcolm Reid, *Norwegian Institute for Water Research (NIVA), Oslo, Norway*
José Antonio Baz Lomba, *Norwegian Institute for Water Research (NIVA), Oslo, Norway*
Yeonsuk Ryu, *Norwegian Institute for Water Research (NIVA), Oslo, Norway*
Foon Yin Lai, *University of Antwerp, Antwerp, Belgium*
Jochen Mueller, *University of Queensland, Brisbane, Queensland, Australia*

An important uncertainty of wastewater-based epidemiology (WBE) is the size and variability of the de facto population in the catchment of interest. In the absence of a day-specific direct population count, an indirect surrogate model to estimate population size is required. Such a model requires the use of population markers which should be 1) specific to human consumption; 2) quantifiable within wastewater samples; 3) representative of the population and 4) resistant to in-sewer degradation. In an earlier study we proposed and preliminarily showed that a suite of pharmaceuticals and personal care products (PPCPs) including caffeine and an artificial sweetener satisfy the first 3 of the 4 criteria and could be used as population markers. The de facto population was then estimated through Bayesian inference by updating the population size provided by WWTP staff (prior knowledge) with measured chemical mass loads of the PPCPs. Cross validation showed that large populations can be estimated fairly accurately with a few chemical mass loads quantified from 24-h composite samples. In contrast, the prior knowledge for small population sizes cannot be improved substantially despite the information of multiple chemical mass loads. A follow up study was conducted on the in-sewer stability of these 14 PPCPs to assess their applicability as population markers against the fourth criteria and their applicability for future population models. Our data analysis will also provide some new quantitative parameters of what makes a good population marker as well as their impact to the model. Recommendations on using these markers to better estimate the population size and potential sources of variability in the data set will also be provided.