SEWAGE SOCIOLOGY*

ICRA established a team which will bring together technology and imagination to mine socioeconomic information of neighbourhoods from the chemical and microbiological analysis of their citizens' sewage, the so-called "sewage sociology".

What is sewage sociology?

Sewage sociology is defined as: "the science of society, social institutions, and social relationships viewed through the eyes of a sewer." So far, the term sewage sociology has been used within the frame of studies that analyze flows in sewers to mine the daily rhythm of people's lives (Enfinger and Stevens, 2014). The concept of sewage sociology goes beyond the analysis of flows. For instance, the measurement of the concentration of selected chemicals can provide information about the lifestyle habits and health status from communities. This practice is called "Sewage Information Mining (SIM)" or sewage chemical information mining (SCIM), when the focus is on chemicals. Embodiments of SIM include sewage epidemiology or wastewater-based epidemiology. The approach was proposed in Daughton (2001), and since then hundreds of studies have been conducted to proof the concept. Large progress has been made in the analysis of illicit drugs concentration in sewage, and the subsequent estimation of the per capita consumption. The method has also been applied to estimate the exposure of population to pesticides, to quantify prescribed pharmaceuticals, biomarkers that can reflect lifestyle habits, and overall health status of the population (Ort et al., 2014; Senta et al. 2015; van Nuijs et al.,2015; Castiglioni et al., 2015; Bijlsma et al., 2016; Ryu et al., 2016; Thomaidis et al., 2016; Rousis et al., 2017; Daughton, 2018).

Sewage sociology is becoming a hot topic

The outcomes and insights of sewage sociology are not only restricted to the scientific community. In fact, a range of news headlines like: *"What human waste can tell us about income, diet and health"* (Celina Ribeiro, Oct 2019, BBC), "*There's a Depressing Difference Between The Sewage of Wealthy Areas And Poorer Ones"* (Michelle Starr, Oct 2019, Science Alert), *"Scientists can tell how wealthy you are by examining your sewage"* (Peter Hess, Oct 2019, Inverse) and *"Study of sewage gives clues about socioeconomic status, habits"* (Bob Yirka, Oct 2019, Phys.org), to only name a few, got published in 2019. Thus, sewage sociology can become a powerful tool to identify threats, needs, health and wealth of human beings and the society.

What is the contribution of ICRA on sewage sociology?

At ICRA we believe that sewage sociology can be used for the monitoring of health risk factors and health status of communities. Such approach can become a valuable complement to existing methods which show some limitations. For instance, questionnaire surveys have limitations due to the lack of veracity in participants' responses and budget constraints, which restrict the spatiotemporal coverage. Population databases (e.g. census) and medical records often lack socio-economic data and lifestyle habits, they are not fully reliable or complete, and are infrequently updated (only once every year in the best situations).

ICRA is currently involved in two international projects dealing with sewage sociology. The SCOREwater project (https://www.scorewater.eu/) aims at mining socio-economic information from sewage samples: i) from the engineering point of view by the development of approaches for the selection of sampling points and design of sampling strategies; ii) from the chemistry view with the deployment of target and non-target analytical methods; and iii) from the microbiology perspective with the estimation of microbiome diversity from sewage samples and the quantification of antibiotic resistant genes. SCOREwater counts on several complementary Catalan partners (ICRA, BCASA, s::can iberia, IERMB, EURECAT) working all together in the case-study of Barcelona where 3 neighbourhoods will be monitored during 1 year. All the analytical data will be analysed in tandem with information collected from health databases (prescribed drugs, lifestyle habits and health status), with information on the socio-economic status of the inhabitants, and with information obtained from telephone surveys (lead by IERMB). SCHEME project focuses on the development of multi-residue analytical methodology for the determination of biomarkers of human exposure to chemical pollutants derived from personal care products and industrial chemicals. Applicability of the developed SCHEME methodology will be assessed using sewage samples from 4 European cities.

The real value of sewage sociology information

It is clear that sewage sociology is a hot topic. However, researchers should be realistic about which stakeholder needs the method can fulfil. The following applications are currently possible:

- Monitoring the consumption of illicit drugs: Normally, those types of monitoring are conducted based on seizures, surveys, drug treatment demands and drug-related hospital admissions. However, SCIM can provide the mass loads of the illicit drugs released in a specific sewer catchment. This approach has been conducted for 7 years in several European

and other cities. With this, it was possible to find trends and specific profiles of illicit drugs use much earlier than with other sources of information (González-Mariño et al., 2020). SCIM has proved to be an extremely flexible tool for application at different spatial and temporal scales and can trigger mitigation measures nearly in real time (González-Mariño et al., 2020).

- Monitoring prescribed drug consumption: These sales are usually recorded in databases of difficult access and they are not updated as frequently as needed. SCIM has shown to be accurate in reflecting illicit and prescribed drug consumption (van Nuijs et al., 2015)(Choi et al., 2018).
- Track disease outbreaks. Examples of successful applications are provided within the Underworlds project from North-America.

Figure 1. Workshop held at ICRA on sewage sociology in November 2019

What's next? The opinion of ICRA-Tech, the consolidated research group from AGAUR

So far, the field of sewage sociology has been led by analytical chemists. In order to realize the full potential of sewage sociology we need to engage other scientists such as epidemiologists, environmental engineers, sociologists, medical doctors, and public agencies (e.g. health public

agencies). Also, as the possibilities of sewage sociology applications are countless, work needs to be done on defining value propositions engaging the key stakeholders. In that sense at ICRA we ran a dedicated workshop about sewage sociology. The workshop consisted in introducing the topics of sewage sociology to water researchers of diverse fields and, later, having a brainstorming about potential future applications. In less than 30 minutes, a few promising ideas were collected. Some of these ideas had a value for society, others had a mere scientific value, and others had a commercial value. Following this, we raised discussions about the applicability, usefulness, and ethics of some of the ideas. The main outcome was that research in this field should be always conducted in partnership with stakeholders to ensure that the mined information is useful. Finally, in the workshop we also discussed that besides chemicals, sewage also contains a myriad of microorganisms coming from human feces and microbiome diversity could potentially be associated to health status of communities. However, collecting reliable information from these complex microbial communities is not straightforward, especially for the identification of gene biomarkers for health and disease. Assuming that sewage is a mixture of the microbiota from the source community (thousands of individuals differing in their dietary habits and health status), winnowing of genetic data from metagenomic datasets is challenging and requires both a high computational power and to master different bioinformatic tools. At ICRA we are enthusiastic about sewage sociology and will address the identified methodological challenges within the two European projects.

****This article has been written by ICRATech***

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