Towards a healthier water environment: the IC Sewage collaboration

Identifying the extent and source of faecal pollution is a critical first step in addressing the huge health burden related to unsafe water, inadequate sanitation and poor hygiene. **ASLI ASLAN-YILMAZ, WARISH AHMED, ANDREAS FARNLEITNER, YOSHIFUMI MASAGO, HUW TAYLOR** and **JOAN ROSE** outline the International Collaboratory for Sewage, an international collaboration which aims to see new tools such as microbial source tracking put to wider use.

An International Collaboratory for Sewage (IC Sewage)[1] has been established as a part of the International Water Association's Health-Related Water Microbiology Specialist Group. The overall mission of IC Sewage is to advance our understanding of the impact of wastewater on water quality and health worldwide. As a part of this collaboration, the group is working on developing a tool box to be used for microbial source tracking (MST) to characterize, quantify and map human faecal pollution in waters across the globe. We hope to assist in obtaining high resolution data that will further decision-making for improving the quality of the water environment and human health.

Exploitable water resources on our planet are decreasing to a critical level. Today, 840 million people still suffer from undernourishment, while billions are affected by damaged water resources. The problem is further amplified by the rapidly growing world population. According to the World Health Organization (WHO), approximately 60% of the world's population is expected to live in urban areas by 2030, which means that most ambient waters will be at risk of heavy consumption and pollution.

A well in Malawi providing water free from contamination. Credit: Asli Aslan-Yilmaz.

The statistics are stated often but remain startling: 88% of diarrhoeal deaths worldwide are linked to unsafe water, inadequate sanitation and poor hygiene (UNICEF/WHO, 2009). Sewage is a significant source of contaminants in water, adding excessive amounts of nutrients, pharmaceuticals and important water-borne disease-causing bacteria, viruses and parasites. According to the latest available figures, an estimated 2.5 billion people lack improved sanitation facilities, and nearly one billion people do not have access to safe drinking water. (UNICEF/WHO, 2009) (see Figure 1). The sanitation coverage rates are lowest in sub-Saharan Africa (see Figure 2), but most of the people without clean water live in Asia (almost 1.8 billion people; 70%), whereas more than half a billion people (22%) live in sub-Saharan Africa (WHO/UNICEF, 2008). The recent widespread cholera epidemics in Africa are testimony to the severe problems of sewage contamination where the only recourse for water purveyors was to add more chlorine to the water supplies.

The United Nations Millennium Development Goals include targets to reduce child mortality by two thirds between 1990 and 2015. Each year, 2.5 billion diarrhoea cases occur among children, mostly under five years of age, and nearly 1.5 million of them die (UNICEF/WHO, 2009), which corresponds to 4900 deaths each day. (UNESCO, 2007).

Issues with water quality monitoring

One of the critical first steps in breaking the disease cycle is to identify the extent and source of the faecal pollution so that appropriate intervention and control strategies can be used.

Microbiological water quality monitoring is a challenging issue as no standard method covers both quantification and identification of the source of pollution. Current culture-based microbiological water quality measurement techniques predominantly focus on traditional indicator bacteria *Escherichia coli* and enterococcus spp. The culture-based methods have limitations, starting from sampling to data processing, so alternative indicators and culture-

independent methodologies are being developed to overcome this problem.

MST is a developing field that has produced new methods to differentiate various sources of faecal contamination. However, there is a need for a consensus approach and standardization of methodologies to act as a yardstick whereby comparative studies can be undertaken for all water resources, including freshwater, marine and groundwater. The US Environmental Protection Agency (EPA) is expected to publish new bacterial criteria in October 2012 for recreational waters. The new criteria will likely use emerging rapid molecular techniques, such as quantitative polymerase chain reaction (qPCR) for the quantitative detection of enterococci. However, an important issue with the progress towards using MST methods would be the implementation of these tools globally.

The need for an organized effort

The overall mission of IC Sewage is to advance our understanding of the impact of wastewater on water quality and health throughout the world, and to set the stage to meet and document improved sanitation, sewerage, and wastewater treatment for the global community. As a part of this collaboration, the group will develop and demonstrate how new tools such as MST methodologies can be used to characterize and quantify human faecal pollution in water in order to advance understanding of the impacts of wastewater and sanitation on human health. In addition to developing a 'global toolbox' of microbial methods for sewage pollution mapping, IC Sewage is also examining how to display the information via mapping tools. Key scientific groups around the world (current members of IC Sewage) have already been working on developing these methodologies for water quality evaluations. IC Sewage will bring this expertise together.

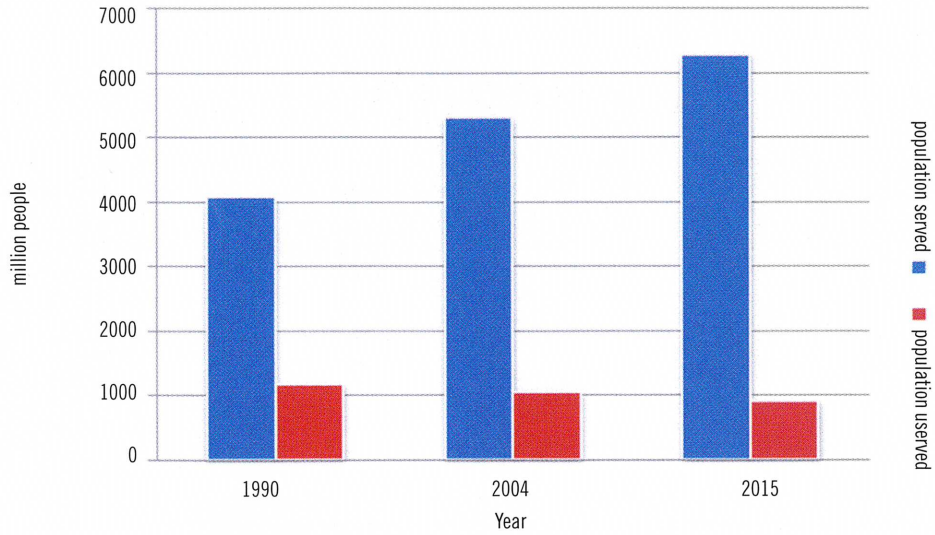


Figure 1: World population with and without access to an improved drinking water source in 1990, 2004 and estimated number in 2015. (Reproduced from WHO/UNICEF 2006).

Currently there are many MST and microbial water quality methodologies under development, and this collaborative effort is expected to form a discussion platform and a network between the scientists working on this topic. During the evaluation of these methodologies, cost effectiveness will also be one of the parameters to be analyzed. IC Sewage is in the process of developing a database of over 300 papers on MST methods and applications published over the past 15 years and will be sharing these lists on the website.

Primary goals

The primary goals of the IC Sewage initiative are set out below.

Develop a diagnostic for sewage pollution to address public health risk

Evaluate and compare existing MST methods; develop, test, review and standardize a toolbox of effective methods; evaluate watershed pollution levels using conventional *E. coli* and the alternative novel methods in pilot areas.

Implement a technology transfer programme

This programme is open to any individual / group who is interested in learning about or contributing to new monitoring technologies, including users of the technologies, laboratories and users of the information. This includes, but is not limited to, universities, water utilities and health departments all over the world, to help to provide improved and appropriate microbiological resources that will benefit all. IC Sewage will be organizing a series of workshops designed to cover how various groups might implement new technology and use the information gained from the development of the 'toolbox' approach. Most importantly, a standard guide and protocol will be a key product from this group. The workshops will be webcast and archived so that they can be accessed online at any time. An online video and podcasts discussing various methods and results from the project will be designed. The results will be disseminated through the more traditional scientific outlets,

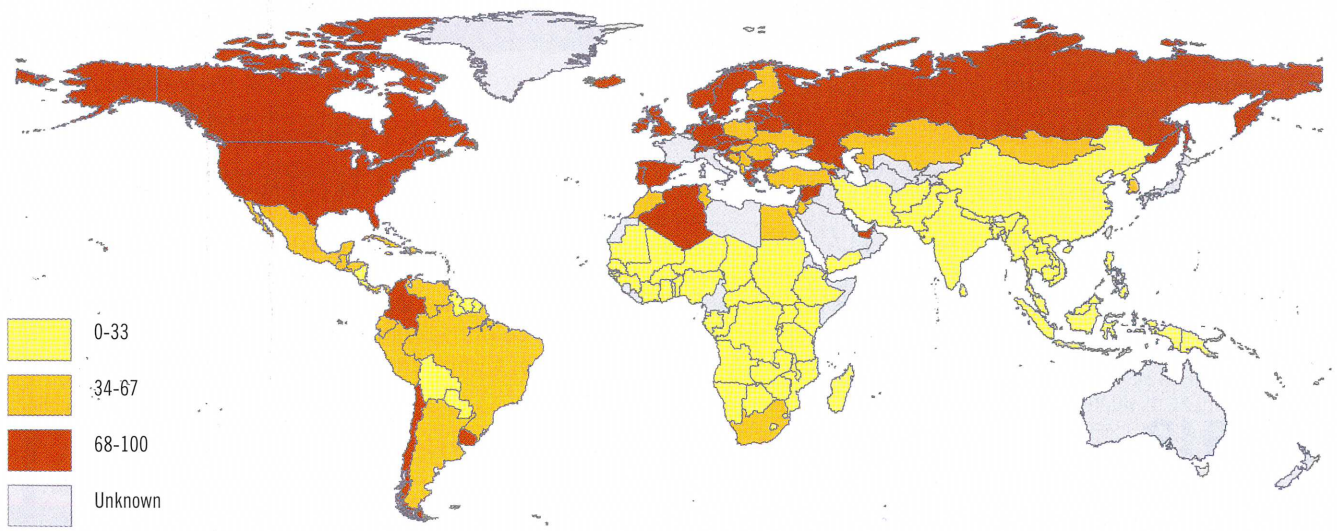


Figure 2: Worldwide percentage of household connections to sanitation (Dreelin et al., 2008).

conferences and publications. All products will be available on the IC Sewage website.

Create a global map of pollution

Global monitoring projects have been implemented before (i.e. Joint Global Ocean Flux Study, Global Environmental Monitoring System) and they historically have provided important knowledge to better understand the marine and freshwater ecosystems. However, there is lack of information on the contribution that sewage makes to many watersheds throughout the world.

The ultimate goal of IC Sewage is to map the sewage and water quality in these watersheds. Currently, pilot programmes on selected watersheds will be targeted and added to, as the efforts grow. The combination of GIS and mapping of sewage pollution in time and space will be a key tool for diagnosing water pollution problems and will help to better understand local and transboundary water contamination issues. The global map is envisioned to have databases that include geological, physicochemical, and general field data, in addition to the quantitative information regarding the level of sewage that is found in the various samples tested from diverse watersheds. The map will cover pollution from a global view with the ability to 'zoom in' to the regions and watersheds that are being studied. Watersheds will be sampled across seasons (e.g., rainy seasons versus dry seasons) and will be evaluated according to local conditions, with the help of our collaborative laboratories that have experience and knowledge in their respective regions. The connectedness between land use, climate and water quality will ultimately be able to be highlighted and then linked to health.

Current membership

The IC Sewage initiative has gained great interest worldwide from scientists who are pioneers in the fields of water quality and public health risk assessment and management. The initiative also has members from water utilities, government and private laboratories.

Currently there are 41 laboratories from 28 different countries (Austria, Australia, Botswana, Brazil, Canada, Denmark, Germany, Greece, India, Ireland, Israel, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Singapore, South Africa, South Korea, Spain, Swaziland, Thailand, Turkey, UK, USA, Venezuela and Zambia) who have agreed to collaborate. These laboratories are affiliated with universities (25), government laboratories (eight), water utilities (two), public agencies (four) and other non-profit organizations (two).

There are four different categories for membership:

- Level I members: Core labs are laboratories that are currently using molecular MST methods and have the capabilities and partial financial support to evaluate protocols and testing water samples.
- Level II members are laboratories interested in technology transfer and learning molecular MST methods, have access to instruments and may be interested in collecting samples.
- Level III members are laboratories that are interested in technology transfer but do not currently have access to specific instruments such as qPCR machines.
- Level IV members are water utilities, private industries, public agencies, scientists and / or government groups that are interested in the technology and using the technology to provide information on sewage pollution.

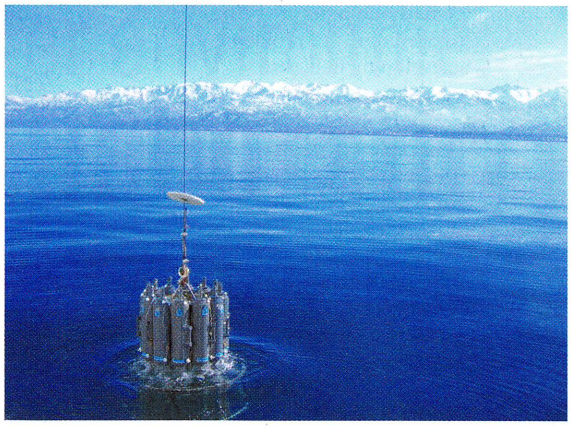
Future perspectives

IC Sewage is currently in the process of initiating several projects, such as documentation and assessment of MST protocols and identification of pilot studies for mapping indicator bacteria and sewage marker data.

The IC Sewage website is aimed to be a resource that will serve as a network connecting studies as well as participants all over the world with password protected pages for members to exchange protocols and data. The website is also being designed to have open access pages that will present recent and past studies in MST, current projects worldwide, upcoming events for training purposes, and contact information of member laboratories.

IC Sewage welcomes all parties in the world working on water pollution monitoring and looks forward to expanding this initiative globally. Becoming a member is as easy as filling out the form on the website. Also we recently launched a discussion group (Faecal source tracking in environmental waters) on Facebook for outreach and to share ideas. People who have joined the group so far are discussing applications of innovative tools for MST globally.

IC Sewage envisions a future where safe water and protection of the aquatic environment will be a priority and solutions developed with a full understanding of local social and economic needs. As the global water resources pollution map is developed through the efforts of this initiative and brought to the attention of national and international policy makers, IC Sewage will aid in the further improvement of water quality and protection of human health. ●



Water quality monitoring in the Black Sea, Turkey. Photo credit: Asli Aslan-Yilmaz.

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Note

[1] http://cws.msu.edu/IC-Sewage.htm

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