2015 UN-Water Annual International Zaragoza Conference
15–17 January 2015
Water and Sustainable Development
From vision to action
UN WATER
WATER FOR LIFE 2005-2015

A Microbial Fuel Cell (MFC) biosensor for water quality monitoring in Dar es Salaam, Tanzania

Sharon Velasquez, University of NewCastle

Short summary

Urbanisation is rapidly occurring across the developing world especially in Africa, it is expected that 45.3% of Africa's population will live in cities by 2015. And since the majority of the population are using on-site sanitation systems i.e., pit latrines and septic tanks; this has led to a rise in anthropogenic groundwater pollution through chemicals i.e. increased nitrate ($NO3^-$) and pathogens. The unacceptable pollution levels have caused water pollution related diseases which have significant costs. For example the Tanzanian government spends an estimate of US$ 600 million annually to help people with water related diseases. Tanzania is a low income country with a rapidly increasing population; present estimates are at just over 40 million people. Tanzania has adopted the Millennium Development Goals' sanitation target of halving the number of people without improved sanitation by 2015. The country will continue implementing solutions according to new Sustainable Development Goals. Additionally, under its Vision 2025, Tanzania has pledged to provide improved sanitation to 95% of the population by 2025. The existing poor sanitation is partly attributed to poor sitting, construction and maintenance of systems. This is exacerbated in urban areas due to population densities and population growth. Domestic wastewater is the most serious source of water pollution. The majority of the population use pit latrines and septic tanks for sanitation with walls which are not water tight and as such groundwater can flow freely in and out of the pit or tank.

Dar es Salaam, where this case study is based, is one of the fastest-growing cities in Africa, after Bamako and Lagos (4). In 2011, about four million people lived in densely populated unplanned settlements. Many of these areas are located near river valleys, flood-prone areas and hill slopes. Experience has shown that waterborne disease outbreaks particularly in Dar es salaam City are usually triggered by the rains. This is thought to be caused by the washing of faecal matter into groundwater drinking water sources such as shallow wells, which has been noted in other countries (14). Lack of water quality routine testing results is a major challenge for the management of public health. For most communities, monitoring the state of groundwater drinking water sources is extremely expensive and technically challenging; the cost of analysing one sample for faecal contamination is approximately £2 per sample (for thermotolerant coliforms). Because of high costs, water sampling is not continuous so often misses pollution events and time trends indicating deteriorating water quality. This case study aims to tackle this problem by the development of a Microbial Fuel Cell (MFC) biosensor for the continuous monitoring of microbial and

nutrient contamination in groundwater used for drinking water. The in situ MFC bio-sensor has been built at a cost of approximately £10 and does not require energy or high maintenance. It is estimated that it would be a suitable device to monitor groundwater pollution continuously.

Issues addressed:

WASH (inequalities, schools, health centers, refugee camps, women and girls)

The quality of the water being supplied to people varies according to the area where they are located. People using pit-latrines and leaving in unsettled areas are more likely to have polluted water. However due to cost they may be unable to monitor pollution.

Water resources management (water-use efficiency, integrated water resources management, transboundary cooperation, sustainable extraction and supply of freshwater)

The use of a biosensor in this proposal is being developed in cooperation with Ardhi University. This blends the expertise of Newcastle University with the local knowledge of Archi University. Together we will aim to monitor groundwater contamination.

Water quality (pollution, dumping of toxic materials, wastewater management, recycling, reuse, restore ecosystems and aquifers)

Due to urbanization there is low interest and knowledge on the effects that increased pollution this is causing to rivers and groundwater. A proper monitoring system should be able to provide insights on organic matter pollution.

Risks (mortality, economic losses caused by natural and human-induced disasters)

Children are the most prone to high risk water related illnesses.

Tools for implementation

Technology: The construction of a novel biosensor that has low maintenance and does not require energy.

Who is involved?: Newcastle University and Ardhi University.

What were the objectives of the intervention?:

- To develop an affordable prototype MFC bio-sensor
- To test the bio-sensor in-situ in Tanzania
- To test the bio-sensor by collecting data on groundwater quality in an urban area with poor on-site sanitation systems
- To improve the user-friendliness of the sampler by involving potential end-users in Tanzania in the design and testing of the biosensor
- To interpret the groundwater quality data assembled with the biosensors and traditional methods by modelling contaminant spreading from pit latrines to groundwater, and by pin-pointing likely pollution sources in the survey area using correlation analysis.

Implementation challenges: The amount of organic matter present in groundwater and river water will be different. Additional sources of contamination might decrease the sensitivity of the biosensor as well as changes in water quality might preclude obtaining a baseline.

Main task/activities undertaken:

- Laboratory trials of the biosensor.
- Field trials of the biosensor will be done in the future.

Main outcomes / impacts (what has changed?): This project is still in development so the impact has not yet been finally evaluated. However expected impacts are:

- Increase monitoring of water quality in the region
- Knowledge of how pollution affects water quality by the people leaving in the area.
- Knowledge on how the water resources are being deteriorated by water managers and the community.
- Self-constructed and self-maintained water pollution biosensor. Creation of new local jobs.

Lessons learned

Triggers: Academic interest in bringing solutions to the developing world.

Drivers: Funds provided by research institutions such as NERC.

Barriers: Communication might be poor between partners.

What has worked well?: Written an agenda every time there is a meeting as well as some minutes when the meeting is over.

What can be improved?:

- The administration and finalization of collaborative agreement could be faster to allow the project to progress at a good speed.
- The involvement of other ONG in this topic could facilitate deployment of the technology.

The way forward: This project will continue all 2015 and results will be available to complete the case study. A series of workshops will be conducted to involve people in the area.

Links:

http://up-gro.org
http://upgro.files.wordpress.com/2014/02/in-ground_inexpensive-monitoring-of-groundwater-pollution-in-urban-african-districts.pdf