Going with the flow:

Water quality and community health in Costa Rica

Water quality is one of the most pressing issues facing the world, with solutions to combat poor water quality remaining elusive. This is what makes the work of Dr Shahady and fellow researchers at the University of Lynchburg and the University of Georgia Costa Rica so important. Their pioneering work in promoting community engagement with a macroinvertebrate index to ensure effective water resource management has the potential to drive governmental agencies to react to water pollution. This work in Costa Rica has the potential to ensure both river and community health in the future.

Water quality is one of the most important issues facing Latin America today. In Costa Rica, issues such as agricultural development, pollutant runoff, inadequate sanitation and legislation all contribute to water pollution. These problems are compounded by seasonable patterns in rainfall, challenging terrain, a lack of effective water quality monitoring and ineffective water resource management. Solutions to these problems remain elusive due to centralised governmental control of decision making. Often information about local water bodies is scarce, the needed environmental testing complex, changes across landscapes rapid and local control minimal. However, the need to find solutions to poor water quality is paramount. Climate change is estimated to significantly alter water quantity and quality in the future as a result of its effect on environmental services, agricultural activities and biodiversity.

Dr Shahady of the University of Lynchburg and fellow researchers at the University of Georgia are at the forefront of researching solutions to these problems.

Researcher José Montero discusses water quality observations with Dr Shahady.

With a background in understanding the relationship between water quality, community health and water use and funded by the University of Georgia Costa Rica, the University of Lynchburg and Bosqueterno S.A, Dr Shahady is well placed to conduct this research.

A BACKGROUND TO WATER QUALITY ISSUES IN COSTA RICA

While the availability of potable water in Costa Rica is good, serving over 99% of the population, wastewater treatment is highly lacking. Mounting concern with septic tanks and agricultural waste contributing significantly to water pollution in the country is increasing. Although on paper water quality is managed by the central government in San Jose and through a variety of five government agencies, due to disparities in clear regulatory authority and unclear governmental responsibility, wastewater and greywater generally remain unregulated.

To make matters worse, the physical terrain of Costa Rica and seasonal rains also significantly contributes to the ineffective management of water quality. Steep and rugged slopes often limit accessibility for stream monitoring, Heavy seasonal rains wash away existing roads and prevent access to waterways unless individuals have experienced knowledge of local infrastructure. Wet and dry seasons limit consistent application of water quality indices. Without effective water monitoring, water quality problems cannot be pinpointed. To further compound the issue, equipment, adequate laboratory space and analytical knowledge are also limited. As a result, local communities often use anecdotal assumptions regarding their local water quality, which leads to poor decision making concerning local sources of water.

Measuring discharge and water depth in a stream.

Dr Shahady and his research team suggest that their trialled macroinvertebrate index is a vehicle to this awareness and change.

USING INSECTS TO MEASURE WATER QUALITY

To solve this problem, a clear, usable, affordable and easily measurable methodology is needed for water quality prediction that takes into consideration the concerns and abilities of local communities. One possible solution is the use of a macroinvertebrate index. This is a methodology whereby the ecological condition of water bodies is inferred using information about what insects live there. This is already a well-established technique for assessing the quality of natural water bodies. The government of Costa Rica implemented such an index in 2007. Known as the BMWP-CR Index, this methodology standardises the use of aquatic insects for water quality detection. However, there are issues associated with using this index. Its use requires certain ways of collecting insects and demands expertise in insect identification skills. Dr Shahady and his team therefore set about testing whether an alternative and more appropriate macroinvertebrate index (known as the PMA Index) could be used by communities that required less expertise and knowledge.

Dr Shahady and fellow researchers set out to compare these two indices, by conducting research as part of a larger water quality monitoring project in the Bellbird Biological Corridor in Costa Rica. They tested 16 sampling sites between 2015 and 2016. The sampling sites traversed different elevations, and different land-use types. At each site, water quality was measured in three ways: using a water quality metre for chemical analysis, and collecting insects for the BMWP-CR index and simpler PMA index simultaneously. This simpler PMA index was used by volunteers from local areas who used a worksheet which explained insect identification based on descriptions and drawings.

The simpler PMA index was found to be better at predicting water contamination than the more complex BMWP-CR index, suggesting that the simpler index, which locals can use, is practical as a predictor of water quality. This further suggests that community volunteers can provide water quality index calculations similar to more sophisticated scientific studies.

CONTAMINATED WATER AND THE FUTURE OF COMMUNITY HEALTH

During their study, Dr Shahady's team found that several of the sites they tested were contaminated with bacteria such as *E. coli*, especially during the wet season, likely as a result of pollution from the inadequate collection and treatment of wastewater. Inadequate sanitation burdens health care systems, but solutions to this problem remain elusive.

Unfortunately, building and maintaining wastewater treatment plants is not

Water Quality Laboratory on Campus of UGA – Costa Rica.

www.researchoutreach.org

Using nets to collect aquatic macroinvertebrates for the index.

Using the metre to measure water chemistry in the streams.

a solution. Current ones already in place in Costa Rica are currently not well maintained and future construction is very expensive. They often have unrepairable structural damage and are blocked by build-ups of sewage sludge. To make matters worse, there is not one specific government agency, programme or law directly assigned to protect rivers from inadequate sanitation, despite strong evidence suggesting that improved water quality leads to reductions in disease occurrences.

Compounding the issue, climate change is expected to have a significant impact on water quality and river health in Costa Rica in the future. Models suggest that predicted increases and variability in precipitation will alter the ways that rivers flow, which means that water bodies that are currently considered to be healthy may become contaminated in the future. Contaminated surface water exchange with groundwater is unknown. There is a real possibility that drinking water contamination may occur in Costa Rica in the next few decades.

The bottom line is that communities need engagement with water issues to drive local and collective governments to react in order to aid public health. Dr Shahady and his research team think that community science and their simplified index used for water quality monitoring will do just that.

CITIZEN SCIENCE TO ENSURE COMMUNITY HEALTH

In Costa Rica, one method in place to protect water quality are payments for environmental services (PSA). These are incentives offered to landowners in exchange for managing their land to provide some sort of environmental service. PSA programmes focus on maintaining adequate supplies of water for purposes valued by the community such as hydroelectric power. Decisions to create PSA programmes are locally made and driven by economic factors that make sense to local land-owners. But indirectly, these programmes provide improved water quality management for entire communities.

People that live in areas with PSA programmes are more likely to think positively about the environment, and therefore expect better water quality. However, outside of PSA areas, locals have very different ideas about water quality. While they have may have concerns, they perceive government programmes as being responsible for water quality maintenance. With this perception, sources of water pollution are generally ignored, and disease risk significantly increased. However, if these pollutants were to be monitored, water quality concerns could be heightened, and residents would become more concerned about the water they are actually drinking.

Community volunteers are capable of providing water quality index calculations similar to more sophisticated scientific studies.

If locals are aware of the benefits to be gained from maintaining good water quality, it is likely that they would make decisions to benefit themselves, just as with areas with PSA programmes.

Dr Shahady and his research team suggest that their trialled macroinvertebrate index is a vehicle to this awareness and change. Using their tested simplified index, a community group would be able to provide information otherwise unavailable to residents that may make them care more about their water quality and make local decisions about how to deal with water pollution. Areas of contamination could be identified, and this information could be used to begin an improved legal framework for river protection. Locals involved could begin to establish long-term monitoring stations and organise efforts to improve water quality.

THE FUTURE

Although drinking water in Costa Rica is in adequate supply, sanitation management, particularly in rural areas, is highly lacking. Rivers carry high levels of pollutants and could be a significant source of disease. A simple index to measure water quality, as trialled by Dr Shahady and his team's work, may be the catalyst to change this. By monitoring their own water, Dr Shahady and his team hope that communities will work together to install management practices for agricultural and sanitary wastewater, in order so that water quality can be improved. They believe that engagement and support for water monitoring practices is the only way forward in ensuring the future of water health in Costa Rica.

Behind the Research

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Research Objectives

Dr Shahady's research focus centres on understanding the relationship between water quality, community health and water use in Costa Rica.

Detail

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Bio

Dr Shahady is an Environmental Scientist and Researcher. He earned his PhD from North Carolina State University in Zoology and his master's of science in public health and engineering from UNC – Chapel Hill.

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Collaborators

- Jose' Montero – Researcher UGA-CR
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References

Arias, A. (2010). 'Situación de Potabilización y Saneamiento en Costa Rica'. *En: Decimosexto In- forme Estado de la Nación en Desarrollo Humano Sostenible*, pp. 36.

Bower, K. (2014) 'Water supply and sanitation of Costa Rica'. *Environmental Earth Sciences*, Vol. 71, pp. 107-123.

Cairns, J. & Pratt, J. (1993). 'A history of biological monitoring using benthic macroinvertebrates', in Rosenburg, D. & Resh, V. (eds.) *Freshwater biomonitoring and benthic macroinvertebrates.* New York: Chapman and Hall.

Karmalkar, A., Bradley, R & Diaz, H. (2011). 'Climate change in Central America and Mexico: regional climate model validation and climate change projections'. *Climate Dynamics*, Vol. 37, pp. 605-629.

Kuzdak, C. & Wiek, A. (2014). 'Governance scenarios for addressing water conflicts and climate change impacts'. *Environmental Science and Pollution Research*, Vol. 42, pp. 181-196.

Schwarzenbach, R., Egli, T., Hofstetter, T., von Gunten, U. & Wehrli, B. (2010). 'Global water pollution and human health'. *Annual Review of Environment and Resources*, Vol. 35, pp. 109-136.

Wood, M., Sheridan, R., Feagin, R., Castro, J. & Lacher, T. (2017). 'Comparison of land use change in payments for environmental services and National Biological Corridor programs'. *Land Use Policy*, Vol. 63, pp. 440-449.

Personal Response

What made you so interested in researching and analysing water quality in Costa Rica in particular?

"Teaching students of all ages and the discovery of needs in local communities. The people of Costa Rica are wonderful and have helped me teach, learn and enjoy everything about Costa Rica. I wanted to give something back and use my expertise to help them solve problems. The streams also piqued my interest in tropical stream ecology and patterns of insect worldwide distribution. Discoveries in nature, ecological response to both natural and human disturbance, and teaching about living sustainably with these amazing natural resources are some of my greatest interests."