Toxic chemical water contaminants in low and middle income countries

WASH-Toxics Symposium

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Session I: A global grand challenge for the WASH development sector

In recent decades rates of toxic chemical production and diversification, particularly within the developing world, have outpaced other major drivers of global environmental change. As a result, environmentally ubiquitous chemical pollutants such as pesticide runoff, pharmaceutical and personal care product residues, industrial effluents, manufacturing additives, disinfection byproducts, and substances deriving from the breakdown of consumer wastes increasingly impact water sources and threaten public health around the world. To-date, the water-sanitation hygiene (WASH) development sector has focused on microbiological threats to human health, but increasingly evidence suggests that toxic chemical exposures are a major contributor to global burden of disease.

Presenters will define the global scale and scope of toxic chemical exposures from water in low and middle income countries (LMICs), and set an agenda for applied research on mitigation technologies that protect public health and the environment.

Presenters

Emily Bernhardt (Duke) "Synthetic chemicals as agents of global change"

Anna Aceituno (RTI) “Shifting exposures, shifting paradigms: global trends warrant a focus on chemical contaminants in the WASH Sector”

Donna Womack (RTI) “Minimizing potential groundwater and surface water exposures associated with agricultural practices”

Session I of this two-part symposium will address the global scale and scope of toxic chemical exposures from water in LMICs, and identify priority individual chemicals/chemical classes and regional "hotspots." Josh Kearns (NCSU) will make brief introductory remarks, "The mission and objectives of the WASH-Toxics Working Group." The session will include the annual open meeting of the WASH-Toxics Working Group. The meeting will review accomplishments of the Working Group during 2017 and will conduct an interactive group exercise for agenda setting in 2018.

Session II: Analytics, risk analysis, and mitigation strategies

Toxic chemical water pollution is often more severe in developing countries compared to affluent regions as many substances are produced, used, and disposed of throughout the developing world in an unregulated manner. Furthermore, communities in low and middle income countries (LMICs) are limited in their resources to adequately address the health impacts from toxic pollution, which further marginalizes those most in need. Advancements are urgently needed in laboratory analytics, field sensing through biomonitoring, risk analysis, and practically feasible yet affordable mitigation strategies. The challenges and constraints of LMICs are different from affluent regions and require robust yet fieldable analytical methods as well as scalable interventions that utilize local materials and capacities for sustainability. This Session will present field and laboratory analytical capabilities, risk analysis approaches to evaluating chemical hazards, and mitigation strategies and technologies applied in resource constrained LMIC settings.

Presenters

Jennifer Hoponick Redmon (RTI) "Using a risk-based approach to rank toxic chemicals in drinking water to support prioritization of risk mitigation strategies in low resource settings"

Keith Levine (RTI) “Cost-effective, scalable field and laboratory approaches for quantitation of established and emerging chemicals in the environment”

Meththika Vithanage (Institute for Fundamental Studies, Sri Lanka) “Municipal solid waste biochar for mitigation of carcinogenic VOCs in municipal-industrial landfill leachate”

Jamie DeWitt (ECU) “A potential never-ending story of chemical water pollution in LMICs: proliferation of legacy and replacement PFAS”

Matthew Bentley (CU-Boulder) “Activation of biochar adsorbents with base and ash leachates for the removal of organic micropollutants in low-cost water treatment”

ABSTRACTS
Session I: A global grand challenge for the WASH development sector

Emily Bernhardt (Duke) "Synthetic chemicals as agents of global change"

Around 100 million unique synthetic chemicals have been produced over the past six decades, recently at a rate of about 10 million per year. Since 2000 there has been a clear increase in the rate of global production of chemical substances, with a particularly large increase in low- and middle- income countries. This presentation examines the rate of change in the production and variety of pesticides, pharmaceuticals, and other synthetic chemicals over the past four decades. We show that chemical production and diversification, particularly within the developing world, have outpaced other major drivers of global environmental change such as CO_2 emissions, nutrient pollution, habitat destruction and biodiversity loss. Sufficient evidence shows stresses on ecosystem and human health at local to global scales suggesting that conditions are transgressing the safe operating space delimited by a planetary boundary for chemical pollution. Though concerns about the proliferation of synthetic chemicals – including pesticides – gave rise to the modern environmental movement in the early 1960s, synthetic chemical pollution has not been included in most analyses of global change. However, despite these trends, mainstream ecological journals, ecological meetings, and ecological funding through the US National Science Foundation devote less than 2% of their journal pages, meeting talks, and science funding, respectively, to the study of synthetic chemicals. Similarly, despite large implied environmental, economic, and human health costs, chemical pollutants have been overlooked in the international development agenda and pollution control currently receives <0.5% of global development spending.

Anna Aceituno (RTI) "Shifting exposures, shifting paradigms: global trends warrant a focus on chemical contaminants in the WASH Sector"

WASH is the collective term for Water, Sanitation and Hygiene. Because access to and quality of water, sanitation, and hygiene are interrelated, they are grouped together in a collective sector. Traditionally, health impacts related to improvements in WASH infrastructure focused on the incidence of diarrhea in children under five years of age (under-5). This is because diarrhea is one of the major single causes of under-5 mortality, surpassed only by acute respiratory infections. As many international WASH organizations aim to reduce under-5 diarrhea and related mortality, WASH research and infrastructure improvements traditionally focused on stopping fecal-oral transmission of microbial pathogens that cause diarrhea, namely enteric bacteria, viruses, and protozoan pathogens. However, over the past two decades, international efforts to reduce under-5 mortality have been successful, and both the rate and number of child deaths were reduced more than half from 1900 and 2015. Second, globalization and various development activities have contributed to a rise in chemical contamination of water sources. Low- and middle-income countries (LMICs) without resources to identify and mitigate chemical water quality problems specifically need support to improve water quality and reduce acute and chronic morbidities from chemical exposures. A shift in the focus of the burden of disease related to WASH is warranted that focuses on exposures to both microbial pathogens and chemical contaminants. This shift has begun, as evidenced by the United Nations' Sustainable Development Goal 6, to ensure availability and sustainable management of water and sanitation for all, which has targets including reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials. It is critical that future research and innovation in the WASH sector shift to focusing on both chemical and microbial improvements in water quality.

ABSTRACTS

Session I: A global grand challenge for the WASH development sector

Donna Womack (RTI) "Minimizing potential groundwater and surface water exposures associated with agricultural practices"

Variability in agricultural practices in developing countries can pose unanticipated surface water and groundwater impacts. For example, these water sources can become impacted through leaching and runoff and erosion when soil amendments or fertilizers are misapplied to crops and fields. Human exposures can occur if these water sources are used for domestic proposes. This presentation will review typical agricultural practices and provide recommendations for minimizing water impacts and associated human exposures. Examples will be provided on how US applied techniques and models can be adapted to assess exposures and evaluate mitigation strategies. These examples will draw from best management practices and modeling techniques used to evaluate soil amendments and fertilizers.

Session II: Analytics, risk analysis, and mitigation strategies

Jennifer Hoponick Redmon (RTI) "Using a risk-based approach to rank toxic chemicals in drinking water to support prioritization of risk mitigation strategies in low resource settings"

Risk analysis is critically important in facilitating evidence-based, transparent decision making. Risk ranking is the systematic analysis and ordering of hazards in terms of the likelihood and severity of adverse impacts. The results can provide a scientific basis to characterize water quality problems, issue advisories, make informed regulatory decisions, and prioritize risk mitigation strategies to improve water quality. While probabilistic risk assessment methods are the gold standard for chemical risk characterization, it is often infeasible in low to middle income countries (LMICs) given a lack of available financial, technical, and informational resources. The objective of this presentation is to provide an example of a multi-staged risk-based approach that can be used to rank risks associated with toxic chemicals in water, and allow for the prioritization of effective risk mitigation approaches in resource-constrained settings. The first stage is to define the scope, which includes identifying the purpose, selecting what will be ranked (e.g., chemicals, water sources, and geographical region), and screening for relevance on the overall risk potential. This stage often includes a literature review and discussion with local experts to identify which chemical contaminants may be present in specific water sources and regions. The second stage is to develop the approach, which consists of selecting the risk ranking method, choosing metrics to characterize likelihood of exposure and severity, and collecting applicable data and information. The final stage isconducting the analysis and reporting results, assumptions, and limitations. Risk ranking results can be incorporated into risk prioritization efforts that consider other factors such as mitigation feasibility in a systematic manner. As new data and information become available, this approach can be iteratively refined to more effectively identify and mitigate toxic chemical exposures and risks.

ABSTRACTS
Session II: Analytics, risk analysis, and mitigation strategies

Keith Levine (RTI) "Cost-effective, scalable field and laboratory approaches for quantitation of established and emerging chemicals in the environment"

Globalization has resulted in increased income and has provided economic growth opportunities across the developing world, stemming in large part from the relocation of chemical, pharmaceutical, waste disposal, and other manufacturing activities from established to emerging economies. Despite the economic opportunities that this manufacturing diversification has provided, it has also led to the unintended proliferation of chemical pollutants, including industrial effluents, electronic waste, agrochemicals, pharmaceuticals, and personal care products, in the environment. Unfortunately, low and middle income countries (LMIC) often lack the regulatory infrastructure and the needed resources to adequately assess and address the impact of these increasingly ubiquitous pollutants. Easy to use, cost-effective and scalable advances are desperately needed in laboratory and field analytics to enable LMIC's to monitor, mitigate, and ultimately prevent the release of toxic chemicals. This presentation will describe field and laboratory analytical capabilities presently applied in resource-constrained LMIC settings for the monitoring of environmentally relevant chemicals and highlight several emerging technological approaches that could extend analytical capacity. Advances in 'gold standard' laboratory-based approaches will be described, along with novel sampling approaches that could significantly reduce logistical costs and barriers. In addition, the potential utility of inexpensive paper and silicon-based sensors will be described for application in monitoring environmental contaminants.

Jamie DeWitt (ECU) "A potential never-ending story of chemical water pollution in LMICs: proliferation of legacy and replacement PFAS"

Per- and polyfluoroalkyl substances (PFAS) are organofluorine compounds with widespread applications in industrial and consumer products. They have been in production for decades and more than 3,000 are thought to be on the global market. Most of these compounds lack a comprehensive understanding of their environmental and human exposure routes due to a lack of information on their life cycles. PFAS enter source waters through industrial releases, wastewater treatment plant discharges, stormwater runoff, use of PFAS-containing firefighting foams, and land application of contaminated biosolids. They are highly persistent and can be widely transported through atmospheric deposition and water currents and as a result, have been detected in myriad waters throughout the world. Past and ongoing production and use of PFAS has led to, and will continue to lead to, global distribution of PFAS in the environment, wildlife, and humans. The very high persistence of PFAS also leads to poorly reversible human exposure. While production and use of legacy compounds, including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), has declined, production of fluorinated alternatives has increased, ensuring that continued presence of PFASs in the aquatic environment. Compounding the problem is the lack of toxicity data on these alternatives, an understanding of their environmental fate and transport, including distribution into humans, and inefficient treatment processes for contaminated waters. Therefore, PFAS represent a potentially never-ending chemicals management issue.

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Session II: Analytics, risk analysis, and mitigation strategies

Meththika Vithanage (Institute for Fundamental Studies, Sri Lanka) "Municipal solid waste biochar for mitigation of carcinogenic VOCs in municipal-industrial landfill leachate"

Open dumps are the method of solid waste disposal in most developing countries including Sri Lanka. Volatile organic compounds (VOCs) are carcinogenic priority pollutants that are released to the environment through the open dumping sites. This study intended to assess the VOCs in leachates of open dumps in Sri Lanka and evaluate the potential of municipal solid waste biochar (MSW-BC) for remediating VOCs. Pyrolyzed MSW-BC was characterized for its physicochemical properties. Furthermore, benzene, toluene and xylene (50 µg/L) were investigated for removal based on pH, kinetics and sorbent (1-10 g/L), sorbate (10-300 µg/L) concentrations. The analytical setup for experiment followed by EPA 524 and concentration of VOCs in aqueous media were measured by static head-space GC-MS. Results explore that, textural properties of the biochar, pore volume (0.013 Cm3g-1) and specific surface area (108 m2/g) indicated its potential for higher adsorption capacity. Electrostatic interactions cannot be omitted, as can be seen from the dynamic adsorption behaviors in edge experiment at room temperature for benzene, toluene and xylene removal. Maximum VOCs removal were obtained at pH>7 whereas, highest adsorption at 24 hours reaction time on pH 9.0, 8.3 and 9.0 recorded as 85.4, 87.0 and 89% (42.7, 43.5 and 44.6 µg/g) respectively for benzene, toluene and xylene. Freundlich fitting could explain isotherm data with good accuracy for both benzene and toluene (R2= 0.955, 0.988) while for xylene it was the Langmuir. Besides, recorded maximum adsorption capacity was about 218.2, 257.7 and 670 µg/g for benzene, toluene and xylene. Moreover, well fitted kinetics model of pseudo first order supposed non-dissociate molecular adsorption into adsorbent. Hence, a heterogeneous process involved with physisorption between adsorbate molecules and biochar surface can be suggested as the removal mechanism for benzene and toluene while chemisorptions and physisorption both are responsible for xylene removal. The results indicated the potential of MSW-BC as an efficient material for removing low concentrations of VOCs like benzene, toluene and xylene from landfill leachete or wastewater.

Matthew Bentley (CU-Boulder) "Activation of biochar adsorbents with base and ash leachates for the removal of organic micropollutants in low-cost water treatment"

Biochar produced by pyrolysis of waste biomass is a local alternative to activated carbon for the removal of organic micropollutants in low cost water treatment. In this study, biochars were prepared in the laboratory and field with a novel activation process using base and ash leachates to improve sorption capacity. The objective of this study was to quantify the increase in sorption capacity gained through activation, and compare sorption by activated biochar with a commercial activated carbon (AC) reference sorbent. The effects of feedstock and pyrolysis temperature (500 – 800 ˚C) were also investigated. Field biochars were produced using a Top-Lit-Up-Draft (TLUD) Gasifier manufactured from 200 L surplus metal drums. Batch mode uptake of anionic human/veterinary antibiotic sulfamethoxazole (SMX) from DI water, lake water, wastewater effluent, stormwater, and combined sewer overflow water was quantified for biochars and AC. Base and ash activation showed an increase in SMX sorption by 2-5 times compared to raw biochar in all waters tested, and the performance of ash activated biochar met or exceeded the performance of AC in all waters tested. These results suggest that base and ash activation are effective in increasing sorption of organic micropollutants in low-cost water treatment scenarios. Ash and base activation of biochar has the potential to provide high quality treatment for waters impaired by organic micropollutants in low-cost settings such as developing communities and small systems.

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Questions should be addressed to the chair of the symposium organizing committee:

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For more information about the WASH-Toxics Working Group, including how to join, see aqueous2016.wixsite.com/wash-toxics-wg