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Health impact study of the biosand filter in Bonao, Dominican Republic.

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sources, common in the southern portion of MV, may serve as a basis for prolonged environmental persistence of *F. tularensis* Type A and thus the unusual prevalence of pneumonic tularemia there.

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**DRIVERS OF VARIABILITY IN WATER QUALITY AND DIARRHEAL DISEASE IN NORTHERN COASTAL ECUADOR**

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The safety of recreational and drinking waters is commonly measured using indicators of fecal contamination. However, spatiotemporal variability of these indicator organisms makes interpretation of data difficult. We explore sources of variability in water quality (WQ) as measured by E. coli concentrations in source and household water samples at varying timescales over the course of 1 year in a rural Ecuadorian village that suffers from higher rates of diarrheal disease. For surface source waters, we observe just as much hourly variability as daily or weekly variability (range: 0-45,000 CFU/100 mL). In the wet season, week-to-week variability can be explained by rainfall patterns. A 1" increase in rainfall is associated with an 8% increase in E. coli counts (p<0.0001). In the dry season, peaks in contamination appear to occur mostly independently of rainfall pulses. Number of people in the river can also explain hour-to-hour variability in both seasons. This suggests that a "runoff effect," influenced by peak rainfall events, operates at a seasonal time scale, whereas a "concentration effect," influenced by local contamination events, operates at a daily time scale. For household water samples, both seasonality and household level factors such as water source, container type, and capping of container affect variability in WQ. Interestingly, rainfall protects against contamination in the household, perhaps due to seasonal changes in hygiene, water replacement rate in containers, or reliance on rain and well water. Uncertainty in WQ measurements drive the remaining sources of variability, suggesting that geometric means of indicator counts from multiple samples taken at different times would be a more appropriate measure of WQ. This analysis suggests that, in addition to established household-level factors, climatic variables interact with contamination sources, such as poor sanitation, in explaining variability in WQ. We discuss these findings in the context of factors that can increase variability in hydrological patterns, such as climate change and deforestation.

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**RECONTAMINATION OF HOUSEHOLD DRINKING WATER: A CONTROLLED EXPERIMENT IN NORTHERN COASTAL ECUADOR**

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Waterborne diseases are still responsible for approximately 2.5 million deaths each year. We describe the results of a controlled experiment to assess contamination of drinking water between the source and point-of-use in northern coastal Ecuador. Samples of source waters were taken at the time that household members filled their drinking water containers, and a control container was filled at the same time and kept in controlled conditions to avoid recontamination. Household and control containers were then resampled daily until the household water was finished to evaluate water quality as measured by E. Coli and enterococci. This experimental design allows for a controlled assessment of die-off and recontamination events, comparing source waters to both control and household samples, and to our knowledge is the first study to use paired samples or controls in assessing recontamination between source and point-of-use drinking water quality. We observed on average a more than half-log reduction of indicator organisms between the source of drinking water to its point-of-use, followed by an average 0.2-log increase during storage. While this confirms that recontamination is occurring, the overall reduction of contamination between the source and the point-of-use seen here contradicts the trend seen in the literature showing that water in the home is generally more contaminated than at the source. We suggest that this may be due to the poor initial source water quality stemming from the reliance of these villages on untreated surface water and simple piped water systems for their drinking water. In most other studies documenting contamination between source and point-of-use improved source waters are tested. The results of this study argue for the importance of paying attention to source water quality and the factors that affect it such as sanitation.

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**HOUSEHOLD-SCALE DRINKING WATER TREATMENT IN CAMBODIA: A RANDOMIZED, CONTROLLED TRIAL OF LOCALLY MADE CERAMIC FILTERS**

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Household drinking water treatment has been shown to be an effective intervention to reduce diarrheal diseases in developing countries. Improvements in household drinking water quality and associated health impacts of low-cost ceramic water filters, one promising technology for point-of-use water treatment, have not been adequately characterized. A randomized, controlled intervention trial of two locally produced ceramic drinking water filters was conducted in the rural/peri-urban village of Prek Thmey, Cambodia. Outcomes of interest were diarrheal disease and dysentery in all individuals and particularly in children under 5 years of age during the 22 week trial (18 weeks post-randomization). Interventions were a locally-produced porous clay pot filter, called the ceramic water purifier (CWP), manufactured and implemented by the NGO Resource Development International (the CWP1) and a modified version of it employing an alternative base clay mixture (the CWP2). Major findings were that: (i), use of either filter resulted in a significant decrease (>40%) in diarrheal disease, an effect that was observed in all age groups and both sexes after controlling for clustering within households and within individuals over time; (ii), CWP1 filter was associated with a substantial reduction in dysentery (61%), an effect not observed with the CWP2; and (iii), both filters reduced E. coli in water up to 99.9999%, with mean reductions of 99% to 99.9%. These results suggest that locally produced ceramic filters as implemented in Cambodia are effective interventions for the improvement of household drinking water quality and they significantly reduce the risk of diarrheal diseases in users.

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**HEALTH IMPACT STUDY OF THE BIOSAND FILTER IN BONAO, DOMINICAN REPUBLIC**

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More than 1 billion people in the developing world lack access to improved sources of drinking water; even more lack microbiologically safe drinking water. Annually, 3-5 billion cases of diarrhea result in 1.6 million deaths. A number of household water treatment and safe storage technologies such as chlorine disinfection, solar disinfection and ceramic filtration have been documented for their ability to reduce diarrheal disease and improve microbial water quality. A promising technology is the biosand filter (BSF), a household-scale, intermittently operated slow sand filter. While an estimated 80,000 BSFs are in use globally, there is little scientific evidence of their ability to improve microbiological water quality in the field and reduce diarrheal disease in users. The purpose of this research was to document the ability of BSFs to reduce diarrheal disease in user as compared to non-user households. A randomized controlled trial of the biosand filter was performed in two areas of the city of Bonao, Dominican Republic in 2005-2006. Approximately 150 households were
enrolled in the study and from September 2005 to February 2006, they were asked to report cases of diarrheal disease each week as baseline (pre-intervention) illness rates. In February 2006, 50% of the households were randomized to receive the BSF intervention and all intervention and control households were visited weekly for diarrheal disease surveillance from February 2006 to August 2006. Initial results indicate 45% less diarrheal disease in filter households compared to non-filter households. This observed reduction in diarrheal disease is within the range reported for other effective household water treatment processes such as chlorine disinfection or ceramic filtration. This is the first study to rigorously document the ability of the biosand filter to reduce diarrheal disease and it provides critical evidence to support the continued implementation of the biosand filter in the developing world.

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A LONG-LIFE, POINT-OF-USE HOUSEHOLD DRINKING WATER PURIFICATION DEVICE BASED ON HALOGEN CHARGING OF POLYSTYRENEHYDANTOIN BEADS (HALOPURE)

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HaloPure®, a hydantoin-based, insoluble, derivatized polystyrene disinfection medium, can be brominated or chlorinated to generate contact biocidal activity against microbial contaminants in a single pass flow of water. The halogen content can be maintained by constant exposure to a low level of free halogen provided by a replaceable activator tablet, extending biocidal effectiveness in routine use for long periods, probably years. This unique feature has been designed into an in-home, gravity-feed, point-of-use (POU) water purification device consisting of a collection basin, integral activator tablet slot, tablet life indicator, and disinfection chamber containing HaloPure® beads. Inserted between canisters of a typical ceramic candle water filter system, the device adds potent disinfecting functionality to basic suspended particle filtration systems that have been used in many tropical countries for over 100 years. Appropriately configured, the device achieves high performance against bacterial and viral contaminants, sufficient to raise the prospect of compliance with the USEPA purifier guide standard for drinking water when using cyst-reducing ceramic candles in the upper canister prefilter. Devices are challenged with rotavirus, poliovirus and Klebsiella terrigena. Disinfection byproducts measured in the first 300 L of water were below USEPA MCLs, with subsequent decreasing levels. TTHM were 0.062 mg/L. HAAS were 0.0028 mg/L. In a simulated home use pattern, the activator tablet eluted 1.9 mg/L bromine into the water, subsequently captured by the HaloPure® beads. Mean residual bromine was 0.49 mg/L (range 0.24-0.76) in >300 L treated water from one tablet. The tablet alone does not effectively disinfect, but as a slow-eluting halogen source to repopulate binding sites on the HaloPure®, device efficacy is enhanced and prolonged. By upgrading commonplace water clarifying filters to disinfecting/purifying status, this device enables the provision of convenient, clean safe water for longer periods and lower cost than previously possible with the POU approach.

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Efficacy of One Drop Point-of-Use Chemical Disinfectant to Inactivate Waterborne Microorganisms

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In many regions of the world, microbial contamination of drinking water requires point-of-use treatment in order to be made safe to drink. Of the chemical treatments, chlorine remains the most widely used to disinfect drinking water. Although its strong oxidizing properties make chlorine effective at inactivating waterborne microorganisms, it is often rejected by users due to taste and odor problems and toxic disinfection by-products. An alternative is One Drop, an aqueous solution of natural ionic minerals, including silver, gold, aluminum, zinc and copper believed to have microbiocidal properties when added in small quantities to contaminated water. In small quantities, One Drop is harmless to humans and does not affect taste or odor, providing an advantage over chlorine and other chemical disinfectants. The purpose of this study was to test One Drop for its ability to inactivate both indicator and pathogenic microorganisms in raw surface water. Different volumes of One Drop (0, 1, 2, or 4 drops) were added to one-liter volumes of raw surface water spiked with E. coli B, Klebsiella terrigena, MS-2 coliphage, Salmonella typhimurium WG-45, and Vibrio cholerae. Concentrations of each microbe were measured both initially and after 10, 30, 90, and 240 minutes at ambient (room) temperatures of 23-25°C. Reductions of >6 log<sub>10</sub> (>99.999%) were achieved for E. coli B and Klebsiella terrigena. Reductions of both S. typhimurium WG-45 and V. cholerae were also great, at >4.5 and >4.8 log<sub>10</sub>, respectively. Reductions generally increased over time and with increasing number of drops added. Microbe reductions with One Drop were more rapid and extensive than natural reductions in the same test water without One Drop. Initial evidence suggests that virus reductions are also achieved, based on >3.7 log<sub>10</sub> inactivation of coliphage MS2. We conclude that One Drop reduces concentrations of important pathogenic bacteria and perhaps viruses in raw water and may serve as an effective and low-cost means of household or other point-of-use water treatment.

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The Insights of Managing Insecticide Resistance in Malaria Vectors with the Plant Extracts in Tropical Africa

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This study aimed at evaluating the repellency and feeding inhibition of Ocimum suave (OS) and O. kilimandscharicum (OK) extracts against mosquitoes in the field and laboratory. In the laboratory, the comparison was done with standard natural product (Citronella) while in the field they were compared to standard synthetic repellent 20% (DEET). In the field, human landing catches were done and results showed that O. suave had highest repellency (89.3%) against Anopheles arabiensis and 83.9% against Culex quinquefasciatus. O. kilimandscharicum had 86.3% efficacy against An. arabiensis and 86.6% against Cx. quinquefasciatus. In the feeding inhibition tests, OS had a range between 83.5%-88.9% and OK repelled between 71.2% and 85.3% in the two mosquitoes species. The results are discussed with reference to the other related studies conducted on Ocimum species essential oils. It is recommended that these products to be produced on commercial scale and adopted as complementary control method against malaria vectors.

(ACMCIP Abstract)

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Climate Change and Vector Borne Disease in the United States: Quo Vadis

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Ongoing climate warming has the potential to impact spatial patterns of vectors, vector-borne pathogens, or incidence of vector-borne disease. Although well-designed empirical studies determine the effect of climate variables on vector life history quickly was identified as a priority area, the fledging research field focusing on the effect of climate change on vectors and vector-borne pathogens instead has been characterized by the development of a plethora of models predicting future change based