# A Bibliography of Selected Articles on Household Water Treatment and Safe Storage, 2009.

This bibliography contains citations and abstracts to 24 journal articles published in 2009. It will be updated on a periodic basis and posted on the Environmental Health at USAID website at: http://www.ehproject.org/eh/eh_topics.html. Please contact **Environmental Health at USAID** if you have additional studies to add or any suggestions to make the bibliography more useful.

Entries are arranged alphabetically by journal title.

**Latest Additions – August 5, 2009**

*Physics and Chemistry of the Earth, Parts A/B/C, July 2009, ISSN 1474-7065, DOI: 10.1016/j.pce.2009.07.001.*

## Potential of using plant extracts for purification of shallow well water in Malawi

M. Pritchard, T. Mkandawire, A. Edmondson, J.G. O'Neill, G. Kululanga,

There has been very little scientific research work into the use of plant extracts to purify groundwater. Research studies on the purification of groundwater have mainly been carried out in developed countries and have focused on water purification systems using aluminium sulphate (a coagulant) and chlorine (a disinfectant). Such systems are expensive and not viable for rural communities due to abject poverty. Shallow well water, which is commonly available throughout Africa, is often grossly contaminated and usually consumed untreated. As a result, water-related diseases kill more than 5 million people every year worldwide. This research was aimed at examining natural plant extracts in order to develop inexpensive ways for rural communities to purify their groundwater. The study involved creating an inventory of plant extracts that have been used for water and wastewater purification. A prioritisation system was derived to select the most suitable extracts, which took into account criteria such as availability, purification potential, yield and cost of extraction. Laboratory trials were undertaken on the most promising plant extracts, namely: Moringa oleifera, Jatropha curcas and Guar gum. The extracts were added to water samples obtained from five shallow wells in Malawi. The trials consisted of jar tests to assess the coagulation potential and the resulting effect on physico-chemical and microbiological parameters such as temperature, pH, turbidity and coliforms. The results showed that the addition of M. oleifera, J. curcas and Guar gum can considerably improve the quality of shallow well water. Turbidity reduction was higher for more turbid water. A reduction efficiency exceeding 90% was achieved by all three extracts on shallow well water that had a turbidity of 49 NTU. A reduction in coliforms was about 80% for all extracts. The pH of the water samples increased with dosage, but remained within acceptable levels for drinking water for all the extracts. Overall, M. oleifera powder produced superior results, followed by Guar gum and lastly J. curcas. There is a need to carry out further more detailed tests, which include toxicity to guarantee the safety of using plant extracts as a coagulant in the purification of drinking water for human consumption.

**Bibliography Additions, January – July 2009**

Am J Trop Med Hyg. 2009 May; 80(5):819-23.

**Laboratory assessment of a gravity-fed ultra-filtration water treatment device designed for household use in low-income settings.**

Clasen T, Naranjo J, Frauchiger D, Gerba C.

Department of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, London, England. thomas.clasen@lshtm.ac.uk

Interventions to improve water quality, particularly when deployed at the household level, are an effective means of preventing endemic diarrheal disease, a leading cause of mortality and morbidity in the developing world. We assessed the microbiologic performance of a novel water treatment device designed for household use in low-income settings. The device employs a backwashable hollow fiber ultrafiltration cartridge and is designed to mechanically remove enteric pathogenic bacteria, viruses, and protozoan cysts from drinking water without water pressure or electric power. In laboratory testing through 20,000 L (approximately 110% of design life) at moderate turbidity (15 nephelometric turbidity unit [NTU]), the device achieved log(10) reduction values of 6.9 for Escherichia coli, 4.7 for MS2 coliphage (proxy for enteric pathogenic viruses), and 3.6 for Cryptosporidium oocysts, thus exceeding levels established for microbiological water purifiers. With periodic cleaning and backwashing, the device produced treated water at an average rate of 143 mL/min (8.6 L/hour) (range 293 to 80 mL/min) over the course of the evaluation. If these results are validated in field trials, the deployment of the unit on a wide scale among vulnerable populations may make an important contribution to public health efforts to control intractable waterborne diseases.

*Am J Trop Med Hyg. 2009 Apr; 80(4):640-5.*

**Cholera outbreak in Kenyan refugee camp: risk factors for illness and importance of sanitation**.

Shultz A, Omollo JO, Burke H, Qassim M, Ochieng JB, Weinberg M, Feikin DR, Breiman RF.

Centers for Disease Control and Prevention, Nairobi and Kisumu, Kenya.

An outbreak of watery diarrhea struck within the Kakuma refugee camp in Kenya in April 2005; 418 people were treated, and 4 persons died. Vibrio cholerae O1 was isolated from 33 patients. In June 2005, we conducted a retrospective matched case-control study to define risk factors associated with cholera among camp residents and identify interventions that could prevent further cases and future outbreaks. We identified cases of cholera through medical records at the main health facility in the camp and matched controls (without watery diarrhea since November 2004) to the cases by age category (< 2, 2-4, 5-14, and > 14 years) and location of residence within the camp. Cases were defined as any person of any age with profuse, effortless watery diarrhea (three or more stools in 24 hours). A multivariate model showed that storing drinking water at home in sealed or covered containers was

protective against cholera (matched odds ratio [MOR] = 0.49 [0.25, 0.96]), whereas "sharing a latrine with at least three households" (MOR = 2.17 [1.01, 4.68]) and arriving at the Kakuma camp on or after November 2004 (MOR = 4.66 [1.35, 16.05]) were risk factors. Improving sanitation and promoting methods to ensure safe drinking water are likely to be effective measures in moderating future cholera outbreaks in this setting. Higher risks for cholera illness among refugees recently "in-migrated" suggest that there may be value in targeting new arrivals in the camp for risk reduction messages and interventions, such as covered water storage containers, to prevent cholera.

*Am J Trop Med Hyg. 2009 Feb;80(2):286-93.*

(Erratum in: Am J Trop Med Hyg. 2009 Apr;80(4):686.)

**A randomized controlled trial of the concrete biosand filter and its impact on diarrheal disease in Bonao, Dominican Republic.**

Stauber CE, Ortiz GM, Loomis DP, Sobsey MD.

Department of Environmental Science and Engineering, School of Public Health, The University of North Carolina, Chapel Hill, North Carolina 27599-7431, USA. cstauber@gsu.edu

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. The biosand filter (BSF) is a promising household water treatment technology in use by > 500,000 people globally. The purpose of this research was to document the ability of BSFs to improve water quality and to reduce diarrheal disease in user compared with non-user households in a randomized controlled trial in Bonao, Dominican Republic, during 2005-2006. During the 6-month intervention period, 75 BSF households had significantly improved drinking water quality on average compared with 79 control households ($P < 0.001$). Based on random intercepts logistic regression, BSF households had 0.53 times the odds of diarrheal disease as control households, indicating a significant protective effect of the BSF against waterborne diarrheal disease.

*Environ. Sci. Technol., DOI: 10.1021/es803444t, July 17, 2009*

**Effect of Groundwater Iron and Phosphate on the Efficacy of Arsenic Removal by Iron-Amended BioSand Filters.**

Hannah Chiew, M.L. Sampson, Sokhan Huch, Sreymom Ken† and Benjamin C. Bostick

PDFHi-Res PDF[2481 KB] <http://pubs.acs.org/doi/pdf/10.1021/es803444t>
PDFPDF w/ Links[221 KB] <http://pubs.acs.org/doi/pdfplus/10.1021/es803444t>
Supporting Info <http://pubs.acs.org/doi/suppl/10.1021/es803444t>
References <http://pubs.acs.org/doi/full/10.1021/es803444t#references>

Naturally occurring arsenic in groundwater in Cambodia is a serious health concern. This study tested the efficacy of a BioSand filter amended with iron nails, Kanchan filter, as a household water treatment option with three natural arsenic-bearing

groundwater sources of varying compositions and spiked with lab cultured E. coli and MS2. The effectiveness of arsenic and pathogen removal was not constant over time and was highly dependent on the influent composition. The filter was relatively ineffective in treating arsenic contaminated groundwater and effluent arsenic concentrations were between 74 and 226 μg L−1, which is higher than accepted drinking water standards. The overall average arsenic removal was 39.4, 74.9, and 45.4%, respectively, and the extent of arsenic removal was not related to the influent arsenic concentration. The main reasons for poor arsenic removal was due to the combination of high influent P (>0.5 mg L−1) and low Fe (<5 mg L−1) concentrations and that the added iron nails were largely ineffective due to insufficient contact time with the water. The findings suggest that such amended filters should not be widely deployed until improvements are made to address the consistency and efficacy of treatment. In addition, the filter poses some potential health risk associated with the production of elevated nitrate levels in the effluent within the filter, possibly due to nitrification and high levels of ammonia in the groundwater.

*Environ Sci Technol. 2009 Feb 15; 43(4):986-92.*

**Household water treatment in poor populations: is there enough evidence for scaling up now?**

Full-text **-** http://pubs.acs.org/doi/pdfplus/10.1021/es802232w

Schmidt WP, Cairncross S.

Environmental Health Group, London School of Hygiene and Tropical Medicine.
Wolf-Peter.Schmidt@lshtm.ac.uk

Point-of-use water treatment (household water treatment, HWT) has been advocated as a means to substantially decrease the global burden of diarrhea and to contribute to the Millennium Development Goals. To determine whether HWT should be scaled up now, we reviewed the evidence on acceptability, scalability, adverse effects, and nonhealth benefits as the main criteria to establish how much evidence is needed before scaling up. These aspects are contrasted with the evidence on the effect of HWT on diarrhea. We found that the acceptability and scalability of HWT is still unclear, and that there are substantial barriers making it difficult to identify populations that would benefit most from a potential effect. The nonhealth benefits of HWT are negligible. Health outcome trials suggest that HWT may reduce diarrhea by 30-40%. The problem of bias is discussed. There is evidence that the estimates may be strongly biased. Current evidence does not exclude that the observed diarrhea reductions are largely or entirely due to bias. We conclude that widespread promotion of HWT is premature given the available evidence. Further acceptability studies and large blinded trials or trials with an objective health outcome are needed before HWT can be recommended to policy makers and implementers.

*Environ. Sci. Technol.*, 2009, *43* (14), pp 5542–5544, June 12, 2009

**Comment on "Household Water Treatment in Poor Populations: Is There Enough Evidence for Scaling up Now?"**

Full-text - http://pubs.acs.org/doi/abs/10.1021/es9008147

Thomas Clasen, Jamie Bartram, John Colford, Stephen Luby, Robert Quick, Mark Sobsey

In their recent paper, Schmidt and Cairncross argue that promotion of household water treatment (HWT) among poor populations is premature (*1*). The paper makes useful points about the challenge of minimizing bias in assessing diarrheal disease that are relevant to studies of all water, sanitation, and hygiene interventions. However, their particular contention that the evidence does not support scaling up HWTis puzzling, not least because they reached the opposite conclusionsthat it "should be strongly encouraged"sin a 2006 Cochrane review based mainly on the same evidence (*2*). Moreover, their assertion that HWT has not yet been shown to be acceptable and scalable on a sustained basis is difficult to reconcile with the fact that more than 850 million people in 58 low- and middle income countries already report usually treating their water at home before drinking it.

**Response** to Comment on "**Household Water Treatment in Poor Populations: Is There Enough Evidence for Scaling up Now**?" by Wolf-Peter Schmidt and Sandy Cairncross, *Environ Scii Technol, June 2009.*

Full-text – http://pubs.acs.org/doi/abs/10.1021/es901311c

We thank Clasen and colleagues for their response to our article on scaling up household water treatment. This is the sort of debate we were hoping to encourage, and we are sure will help policy makers in making the right decisions on this issue. We would like to emphasize that nowhere in the article do we reject household water treatment altogether. There may well be situations in which it could potentially deliver health benefits (as we emphasize repeatedly).

*Environ Technol. 2009 Apr 1;30(4):379-91.*

**Ceramic media amended with metal oxide for the capture of viruses in drinking water.**

Brown J, Sobsey MD.

Department of Biological Sciences, University of Alabama, Box 870229, Tuscaloosa, AL 35487-0299, USA. joebrown@as.ua.edu

Ceramic materials that can adsorb and/or inactivate viruses in water may find widespread application in low-tech drinking-water treatment technologies in developing countries, where porous ceramic filters and ceramic granular media filters are increasingly promoted for that purpose. We examined the adsorption and subsequent inactivation of bacteriophages MS2 and (phiX-174 on five ceramic media in batch adsorption studies to determine media suitability for use in a ceramic water filter application. The media examined were a kaolinitic ceramic medium and four kaolinitic ceramic media amended with iron or aluminium oxides that had been

incorporated into the kaolinitic clays before firing. Batch adsorption tests indicate increased sorption and inactivation of surrogate viruses by media amended with Fe and Al oxide, with FeOOH-amended ceramic inactivating all bacteriophages up to 8 log10. Unmodified ceramic was a poor adsorbent of bacteriophages at less than 1 log10 adsorption-inactivation and high recovery of sorbed phages. These studies suggest that contact with ceramic media, modified with electropositive Fe or Al oxides, can reduce bacteriophages in waters to a greater extent than unmodified ceramic.

*Int J Epidemiol. 2009 Jul 2.*

**Evaluation of a pre-existing, 3-year household water treatment and handwashing intervention in rural Guatemala.**

Arnold B, Arana B, Mäusezahl D, Hubbard A, Colford JM Jr.

Division of Epidemiology, University of California, Berkeley, CA, USA.

BACKGROUND: The promotion of household water treatment and handwashing with soap has led to large reductions in child diarrhoea in randomized efficacy trials. Currently, we know little about the health effectiveness of behaviour-based water and hygiene interventions after the conclusion of intervention activities.

METHODS: We present an extension of previously published design (propensity score matching) and analysis (targeted maximum likelihood estimation) methods to evaluate the behavioural and health impacts of a pre-existing but non-randomized intervention (a 3-year, combined household water treatment and handwashing campaign in rural Guatemala). Six months after the intervention, we conducted a cross-sectional cohort study in 30 villages (15 intervention and 15 control) that included 600 households, and 929 children <5 years of age.

RESULTS: The study design created a sample of intervention and control villages that were comparable across more than 30 potentially confounding characteristics. The intervention led to modest gains in confirmed water treatment behaviour [risk difference = 0.05, 95% confidence interval (CI) 0.02-0.09]. We found, however, no difference between the intervention and control villages in self-reported handwashing behaviour, spot-check hygiene conditions, or the prevalence of child diarrhoea, clinical acute lower respiratory infections or child growth.

CONCLUSIONS: To our knowledge this is the first post-intervention follow-up study of a combined household water treatment and handwashing behaviour change intervention, and the first post-intervention follow-up of either intervention type to include child health measurement. The lack of child health impacts is consistent with unsustained behaviour adoption. Our findings highlight the difficulty of implementing behaviour-based household water treatment and handwashing outside of intensive efficacy trials.

*Int J Environ Health Res. 2009 Feb; 19(1):17-29.*

**Flocculant-disinfectant point-of-use water treatment for reducing arsenic exposure in rural Bangladesh.**

Norton DM, Rahman M, Shane AL, Hossain Z, Kulick RM, Bhuiyan MI, Wahed MA, Yunus M, Islam MS, Breiman RF, Henderson A, Keswick BH, Luby SP.

Centers for Disease Control and Prevention, Atlanta, GA 30333, USA.

We introduced flocculant-disinfectant water treatment for 12 weeks in 103 households in Bangladesh to assess if drinking water would be chemically and microbiologically improved and the body burden of arsenic reduced. The median concentration of arsenic in tubewell water decreased by 88% after introduction of the flocculant-disinfectant from 136 microg/l at baseline to 16 ($p < 0.001$). The median concentration of total urinary arsenic decreased 42% from 385 microg/g creatinine at baseline to 225 microg/g creatinine after intervention ($p < 0.001$). Among 206 post-intervention drinking water samples that were reportedly treated on the date the sample was collected, 99 (48%) lacked residual free chlorine and 100 (49%) were contaminated with thermotolerant coliforms. The flocculant-disinfectant markedly reduced arsenic in drinking water, but treated drinking water was frequently contaminated with fecal organisms. The lesser reduction in urinary arsenic compared to water arsenic and the health consequences of this reduction require further research.

*Int. J. Epidemiol., 2009, Advance Access DOI:10.1093/ije/dyp241*

**Evaluation of a pre-existing, 3-year household water treatment and handwashing intervention in rural Guatemala.**

Arnold, B.; Arana, B.; Mausezahl, D.; Hubbard, A. & Colford, John M., J.

Background: The promotion of household water treatment and handwashing with soap has led to large reductions in child diarrhoea in randomized efficacy trials. Currently, we know little about the health effectiveness of behaviour-based water and hygiene interventions after the conclusion of intervention activities.
Methods: We present an extension of previously published design (propensity score matching) and analysis (targeted maximum likelihood estimation) methods to evaluate the behavioural and health impacts of a pre-existing but non-randomized intervention (a 3-year, combined household water treatment and handwashing campaign in rural Guatemala). Six months after the intervention, we conducted a cross-sectional cohort study in 30 villages (15 intervention and 15 control) that included 600 households, and 929 children 5 years of age.

Results: The study design created a sample of intervention and control villages that were comparable across more than 30 potentially confounding characteristics. The intervention led to modest gains in confirmed water treatment behaviour [risk difference = 0.05, 95% confidence interval (CI) 0.02-0.09]. We found, however, no difference between the intervention and control villages in self-reported handwashing behaviour, spot-check hygiene conditions, or the prevalence of child diarrhoea, clinical acute lower respiratory infections or child growth.

Conclusions: To our knowledge this is the first post-intervention follow-up study of a combined household water treatment and handwashing behaviour change intervention, and the first post-intervention follow-up of either intervention type to include child health measurement. The lack of child health impacts is consistent with unsustained behaviour adoption. Our findings highlight the difficulty of implementing behaviour-based household water treatment and handwashing outside of intensive efficacy trials.

*Int J Hyg Environ Health. 2009 Feb 19.*

**Safe drinking water and clean air: An experimental study evaluating the concept of combining household water treatment and indoor air improvement using the Water Disinfection Stove (WADIS).**

Christen A, Navarro CM, Mäusezahl D.

Swiss Tropical Institute, Department of Public Health and Epidemiology, Socinstrasse 57, 4051 Basel, Switzerland.

Indoor air pollution and unsafe water remain two of the most important environmental risk factors for the global burden of infectious diseases. Improved stoves and household water treatment (HWT) methods represent two of the most effective interventions to fight respiratory and diarrhoeal illnesses at household level. Since new improved stoves are highly accepted and HWT methods have their drawbacks regarding sustained use, combining the two interventions in one technical solution could result in notable positive convenience and health benefits. A WAter DIsinfection Stove (WADIS) based on a Lorena-stove design with a simple flow-through boiling water-treatment system was developed and tested by a pilot experimental study in rural Bolivia. The results of a post-implementation evaluation of two WADIS and 27 Lorena-stoves indicate high social acceptance rather due to convenience gains of the stove than to perceived health improvements. The high efficacy of the WADIS-water treatment system, with a reduction of microbiological contamination load in the treated water from 87600 thermotolerant coliform colony forming units per 100mL (CFU/100mL) to zero is indicative. The WADIS concept unifies two interventions addressing two important global burdens of disease. WADIS' simple design, relying on locally available materials and low manufacturing costs (approx. 6 US) indicates potential for spontaneous diffusion and scaling up.

*J Environ Health. 2009 Apr; 71(8):48-53*.

**An observational study on the effectiveness of point-of-use chlorination.**

McLaughlin LA, Levy K, Beck NK, Shin GA, Meschke JS, Eisenberg JN.

University of Washington, Seattle, WA 98195, USA.

Although the efficacy of chlorine disinfection under controlled laboratory conditions is well known, the effectiveness of chlorine under field point-of-use (POU) conditions is still not clearly understood and may be impacted by a variety of factors. This study evaluated the effectiveness of POU chlorine disinfection in rural Ecuador under typical use conditions and compared this effectiveness with the efficacy in controlled laboratory conditions. While reductions of indicator organisms were slightly higher in

households that used chlorination, no significant differences were seen between households employing POU chlorination and the households with no chlorination (1-1.5 log10 median reductions for chlorinating households and 0.31-0.55 log10 for nonchlorinating households, depending on the indicator organism). In contrast, significant reduction of all test organisms was found when simulating POU conditions in the laboratory. This study demonstrates that POU chlorination can be considerably less effective under actual field conditions than would be predicted based on its laboratory efficacy (3-5 log10 median reductions for chlorinated and 0-0.3 log10 for nonchlorinated samples). Human factors (including improper storage and chlorine dosing) and uncontrolled water quality effects are hypothesized to impact significantly the effectiveness of chlorine disinfection.

*Jnl Health Popula Nutr Oct 2009*

**Technical and Social Evaluation of Arsenic Mitigation in Rural Bangladesh**.

Full-text - http://www.icddrb.org/images/1213-Shafiquzzaman.pdf

Md. Shafiquzzaman1, Md. Shafiul Azam1, Iori Mishima2, and Jun Nakajima1

1Department of Environmental Systems Engineering, Ritsumeikan University, 1-1-1 Nojihigashi, Kusatsu,Shiga 525-8577, Japan and 2Center for Environmental Science in Saitama, 914 Kamitanadare,Kisai-machi, Kita-Saitama-gun, Saitama 347-0115, Japan

Technical and social performances of an arsenic-removal technology—the sono arsenic filter—in rural areas of Bangladesh were investigated. Results of arsenic field-test showed that filtered water met the Bangladesh standard (<50 μg/L) after two years of continuous use. A questionnaire was administrated among 198 sono arsenic filter-user and 230 non-user families. Seventy-two percent of filters (n=198) were working at the time of the survey. Another 28% of the filters were abandoned due to breakage. The abandonment percentage (28%) was lower than other mitigation options currently implemented in Bangladesh. Households were reluctant to repair the broken filters on their own. High cost, problems with maintenance of filters, weak sludge-disposal guidance, and slow flow rate were the other demerits of the filter. These results indicate that the implementation approaches of the sono arsenic filter suffered from lack of ownership and long-term sustainability. Continuous use of arsenic-contaminated tubewells by the non-user households demonstrated the lack of alternative water supply in the survey area. Willingness of households to pay (about 30%) and preference of household filter (50%) suggest the need to develop a low-cost household arsenic filter. Development of community-based organization would be also necessary to implement a long-term, sustainable plan for household-based technology.

*J Water Health, July 2009*

**Turbidity and chlorine demand reduction using locally available physical water clarification mechanisms before household chlorination in developing countries**

Nadine Kotlarz, Daniele Lantagne, Kelsey Preston and Kristen Jellison

Over 1.1 billion people in the world lack access to improved drinking water. Diarrhoeal and other waterborne diseases cause an estimated 1.9 million deaths per year. The Safe Water System (SWS) is a proven household water treatment intervention that reduces diarrhoeal disease incidence among users in developing countries. Turbid waters pose a particular challenge to implementation of SWS programmes; although research shows that a 3.75mgl21 sodium hypochlorite dose effectively treats turbid waters, users sometimes object to the strong chlorine taste and prefer to drink water that is more aesthetically pleasing. This study investigated the efficacy of three locally available water clarification mechanisms—cloth filtration, settling/decanting and sand filtration—to reduce turbidity and chlorine demand at turbidities of 10, 30, 70, 100 and 300 NTU. All three mechanisms reduced turbidity (cloth filtration 21–60%, settling/decanting 78–88% and sand filtration 57–99%). Sand filtration (P ¼ 0.002) and settling/decanting ( P ¼ 0.004), but not cloth filtration (P ¼ 0.30), were effective at reducing chlorine demand compared with controls.

*J Water Health. 2009 Jun;7(2):324-31.*

**Faecal contamination of drinking water in a Brazilian shanty town: importance of household storage and new human faecal marker testing.**

Copeland CC, Beers BB, Thompson MR, Fitzgerald RP, Barrett LJ, Sevilleja JE, Alencar S, Lima AA, Guerrant RL.

University of Virginia Center for Global Health, Charlottesville, VA 22908, USA.

Worldwide, contaminated drinking water poses a major health threat, particularly to child development. Diarrhoea represents a large part of the water-related disease burden and enteric infections have been linked to nutritional and growth shortfalls as well as long-term physical and cognitive impairment in children. Previous studies detailed the frequency of infection and the consequences for child health in a shanty town in north-east Brazil. To determine the frequency of contaminated water, we measured faecal contamination in primary drinking water samples from 231 randomly selected households. Risk for contamination was compared across source and storage types. Nearly a third of the study households (70/231: 30.3%) had contaminated drinking water; the source with the highest frequency of contamination was well water (23/24: 95.8%). For tap water, the type of storage had a significant effect on the susceptibility to contamination (chi(2) = 12.090; p = 0.007). The observed pattern of contamination demonstrated the relative potential contributions of both source and storage. With evidence that supports the inclusion of source and storage in water quality surveys, this study, like others, suggests that contaminated drinking water in storage vessels may be an important factor for the documented diarrhoea disease burden in the Brazilian shanty town.

*J Water Health. 2009 Mar; 7(1):145-54.*

**Is fecal contamination of drinking water after collection associated with household water handling and hygiene practices? A study of urban slum households in Hyderabad, India**.

Eshcol J, Mahapatra P, Keshapagu S.

Roy J. and Lucille A. Carver College of Medicine, University of Iowa, 1216 MERF, Iowa City, IA 52317, USA. jayasheel-eshcol@uiowa.edu

Water-borne illness, primarily caused by fecal contamination of drinking water, is a major health burden in the state of Andhra Pradesh, India. Currently drinking water is treated at the reservoir level and supplied on alternate days, necessitating storage in households for up to 48 hrs. We hypothesized that fecal contamination occurs principally during storage due to poor water handling. In this study we tested for coliform bacteria in water samples collected at distribution points as household storage containers were filled, and then tested containers in the same households 24-36 hours after collection. We also conducted an observational survey to make an assessment of water handling and hygiene. Ninety-two percent (47/51) of samples tested at supply points were adequately chlorinated and bacterial contamination was found in two samples with no residual chlorine. Samples collected from household storage containers showed an increase in contamination in 18/50 houses (36%). Households with contaminated stored samples did not show significant differences in demographics, water handling, hygiene practices, or sanitation. Nevertheless, the dramatic increase in contamination after collection indicates that until an uninterrupted water supply is possible, the point at which the biggest health impact can be made is at the household level.

*Physics and Chemistry of the Earth, Parts A/B/C, Volume 34, Issues 1-2, Sustainable Water Solutions, 2009, Pages 36-42*

**Assessing the sustainability of the silver-impregnated ceramic pot filter for low-cost household drinking water treatment**

D. van Halem, H. van der Laan, S.G.J. Heijman, J.C. van Dijk, G.L. Amy

A low-cost technology to treat water at the household level is the ceramic silver-impregnated pot filter (CSF). The CSF consists of a pot-shaped filter element that is placed in a plastic receptacle. The ceramic pot filter is a promising treatment system to supply safe drinking water especially to people living in rural areas. The focus of this study was to assess the sustainability of a household drinking water treatment system based on five criteria: (i) accessibility, (ii) water quality, (iii) water production, (iv) functionality, and (v) environmental footprint. The removal of Escherichia coli and protozoan (oo)cysts was found to be significant, which was supported by the reduction in diarrhoea cases observed by CSF users in a recent field study. The retention of MS2 bacteriophages as an indicator for virus removal was, however, found to be unsatisfactory. It is therefore recommended that research on virus removal by CSF continues, especially in relation to the colloidal silver application and other potential additives. The criterion of water production was shown to be the limiting factor, because it reduced substantially during treatment of surface water. The fast clogging of the CSF during the first hours of use was caused neither by inorganic nor organic fouling, but by colloidal particles. Two direct effects

may be identified from the decreasing flow rate: frequent scrubbing and higher water prices. Frequent scrubbing results in a higher risk of recontamination and breakage. Based on this finding the authors recommend an optimization study to increase the initial flow rate without sacrificing the removal efficiency.

*Renewable Energy, Volume 34, Issue 6, June 2009, Pages 1651-1654*

**Assessing the use of simple dye-sensitized solar cells for drinking water chlorination by communities with limited resources**

Steve Appleyard

Dye-sensitized ZnO and TiO2 photoelectrochemical cells were constructed using recycled waste materials and readily accessible household chemicals to assess whether it would be feasible for low-income communities to utilise solar energy for drinking water chlorination. Prussian Blue sensitized ZnO cells utilising ferro/ferricyanide and iron/copper redox couples for charge transfer produced open circuit potentials of between 0.19 and 0.53 V, and short circuit currents in the range 0.3-1.5 mA cm-2. Although the power output from these cells was significantly lower than those using the iodide/triiodide redox couple for charge transfer, the significantly lower cost of construction of cells using alternative electrolytes could make these cells accessible to poor communities for producing small amounts of solar electricity for drinking water chlorination.

*Science of The Total Environment, Volume 407, Issue 8, 1 April 2009, Pages 2621-2624*

**Estimating the impact on health of poor reliability of drinking water interventions in developing countries,**

Paul R. Hunter, Denis Zmirou-Navier, Philippe Hartemann

Recent evidence suggests that many improved drinking water supplies suffer from poor reliability. This study investigates what impact poor reliability may have on achieving health improvement targets. A Quantitative Microbiological Risk Assessment was conducted of the impact of interruptions in water supplies that forced people to revert to drinking raw water. Data from the literature were used to construct models on three waterborne pathogens common in Africa: Rotavirus, Cryptosporidium and Enterotoxigenic E. coli. Risk of infection by the target pathogens is substantially greater on days that people revert to raw water consumption. Over the course of a few days raw water consumption, the annual health benefits attributed to consumption of water from an improved supply will be almost all lost. Furthermore, risk of illness on days drinking raw water will fall substantially on very young children who have the highest risk of death following infection. Agencies responsible for implementing improved drinking water provision will not make meaningful contributions to public health targets if those systems are subject to poor reliability. Funders of water quality interventions in developing countries should put more effort into auditing whether interventions are sustainable and whether the health benefits are being achieved.

*Trans R Soc Trop Med Hyg. 2009 Aug;103(8):819-22.*

**Killing of enteric bacteria in drinking water by a copper device for use in the home: laboratory evidence.**

Sudha VB, Singh KO, Prasad SR, Venkatasubramanian P.

Centre for Pharmacognosy and Pharmaceutics, Foundation for Revitalisation of Local Health Traditions (FRLHT), 74/2, Jarakabande kaval, Yelahanka via Attur, Karnataka, India.

Water inoculated with 500-1000 colony forming units/ml of Escherichia coli, Salmonella Typhi and Vibrio cholerae was stored overnight at room temperature in copper pots or in glass bottles containing a copper coil devised by us. The organisms were no longer recoverable when cultured on conventional media, by contrast with water stored in control glass bottles under similar conditions. The amount of copper leached into the water after overnight storage in a copper pot or a glass bottle with a copper device was less than 475 parts per billion, which is well within the safety limits prescribed by the WHO. The device is inexpensive, reusable, easy to maintain, durable, does not need energy to run and appears to be safe. It has the potential to be used as a household water purification method for removing enteric bacteria, especially in developing countries.

*Trop Med Int Health. 2009 Jun; 14(6):696-702.*

**Risk factors for typhoid in Darjeeling, West Bengal, India: evidence for practical action.**

Sharma PK, Ramakrishnan R, Hutin Y, Manickam P, Gupte MD.

National Institute of Epidemiology, Chennai, India.

OBJECTIVE: To identify risk factors for typhoid and propose prevention measures.

METHODS: Case-control study; we compared hospital-based typhoid cases defined as fever>38 degrees C for >or=3 days with four-fold rise in 'O' antibodies on paired sera (Widal) with community, age and neighbourhood matched controls. We obtained information on drinking water, fruits, vegetables, milk products and sanitation; and calculated matched odds ratios (MOR) and attributable fractions in the population (AFP) for the risk factors or failure to use prevention measures.

RESULTS: The 123 typhoid cases (median age: 25 years, 47% female) and 123 controls did not differ with respect to baseline characteristics. Cases were less likely to store drinking water in narrow-mouthed containers (MOR: 0.4, 95% CI: 0.2-0.7, AFP 29%), tip containers to draw water (MOR: 0.4, 95% CI: 0.2-0.7, AFP 33%) and have home latrines (MOR: 0.5, 95% CI: 0.3-0.8, AFP 23%). Cases were more likely to consume butter (OR: 2.3, 95% CI: 1.3-4.1, AFP 28%), yoghurt (OR: 2.3, 95% CI: 1.4-3.7, AFP 34%) and raw fruits and vegetables, including onions (MOR: 2.1, 95% CI: 1.2-3.9, AFP 34%), cabbages (OR: 2.8, 95% CI: 1.7-4.8, AFP 44%) and unwashed guavas (OR: 1.9, 95% CI: 1.2-3, AFP 25%).

CONCLUSION: Typhoid was associated with unsafe water and sanitation practices as well as with consumption of milk products, fruits and vegetables. We propose to chlorinate drinking water at the point of use, wash/cook raw fruits and vegetables and ensure safer preparation/storage of local milk products.

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**Bacterial treatment effectiveness of point-of-use ceramic water filters.**

Bielefeldt AR, Kowalski K, Summers RS.

Department of Civil, Environmental, and Architectural Engineering, University of Colorado at Boulder, 428 UCB, Boulder, CO 80309-0428, USA.
Angela.Bielefeldt@colorado.edu

Laboratory experiments were conducted on six point-of-use (POU) ceramic water filters that were manufactured in Nicaragua; two filters were used by families for ca. 4 years and the other filters had limited prior use in our lab. Water spiked with ca. 10(6)CFU/mL of Escherichia coli was dosed to the filters. Initial disinfection efficiencies ranged from 3 - 4.5 log, but the treatment efficiency decreased with subsequent batches of spiked water. Silver concentrations in the effluent water ranged from 0.04 - 1.75 ppb. Subsequent experiments that utilized feed water without a bacterial spike yielded 10(3)-10(5)CFU/mL bacteria in the effluent. Immediately after recoating four of the filters with a colloidal silver solution, the effluent silver concentrations increased to 36 - 45 ppb and bacterial disinfection efficiencies were 3.8-4.5 log. The treatment effectiveness decreased to 0.2 - 2.5 log after loading multiple batches of highly contaminated water. In subsequent loading of clean water, the effluent water contained <20-41 CFU/mL in two of the filters. This indicates that the silver had some benefit to reducing bacterial contamination by the filter. In general these POU filters were found to be effective, but showed loss of effectiveness with time and indicated a release of microbes into subsequent volumes of water passed through the system.

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**Decentralized systems for potable water and the potential of membrane technology**

Maryna Peter-Varbanets, Chris Zurbrugg, Chris Swartz, Wouter Pronk,

Decentralized drinking-water systems are an important element in the process of reaching the Millennium Development Goals, as centralized systems are often deficient or non-existent in developing and transition countries (DC and TC). Most water-quality problems are due to hygiene factors and pathogens. A range of decentralized systems is available to counter these problems, including thermal and/or UV methods, physical removal and chemical treatment.

This review focuses on decentralized systems that treat the potable water (drinking and cooking) of a single household (point-of-use systems) or a community (small-scale systems). For application in DC and TC, important boundary conditions for decentralized systems include low costs, ease of use, sustainability, low maintenance and independence of utilities (energy sources). Although some low-cost systems are available, their application is limited by time-consuming daily operation and

maintenance. Other systems are too expensive for the poor populations of DC and TC and in most cases do not fulfill the system requirements described above. Point-of-use systems based on membranes are commercially available and are designed to operate on tap pressure or gravity.

Membrane systems are attractive since they provide an absolute barrier for pathogens and remove turbidity, thus increasing the palatability of the water. The costs of membrane have decreased rapidly during the last decades and therefore membrane systems have also become within reach for application in low-cost applications in DC and TC. Some membrane systems rely on gravity as a driving force, thereby avoiding the use of pumps and electricity. On the basis of the present literature data, no small-scale systems could be identified which meet all the requirements for successful implementation. Furthermore, in the available literature the performance of highly fouling water types has not been reported. For such cases, more extensive studies are required and a need for suitable pre-treatment was identified.

It can be concluded that there are good prospects for decentralized systems based on membranes, but that a need exists for research and development of systems with low costs and low maintenance, specifically designed for DC and TC.