Viable Household Water Treatment Methods

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Policy Brief Series # 25
May 2011

A publication of the Sustainable Development Policy Institute (SDPI).

Sustainable Development Policy Institute is an independent, non-profit research institute on sustainable development.

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First Edition: May 2011

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Table of Content

1. Background 1
2. Importance of Household Water Treatments (HWTs) 2
3. Available Household Water Treatment (HWTs) for Disinfecting Microbial Contamination 3
4. Solar Water Disinfection (SODIS) 4
5. SODIS Pilot Project in Pakistan 7
6. Policy Recommendations 7
7. References 9

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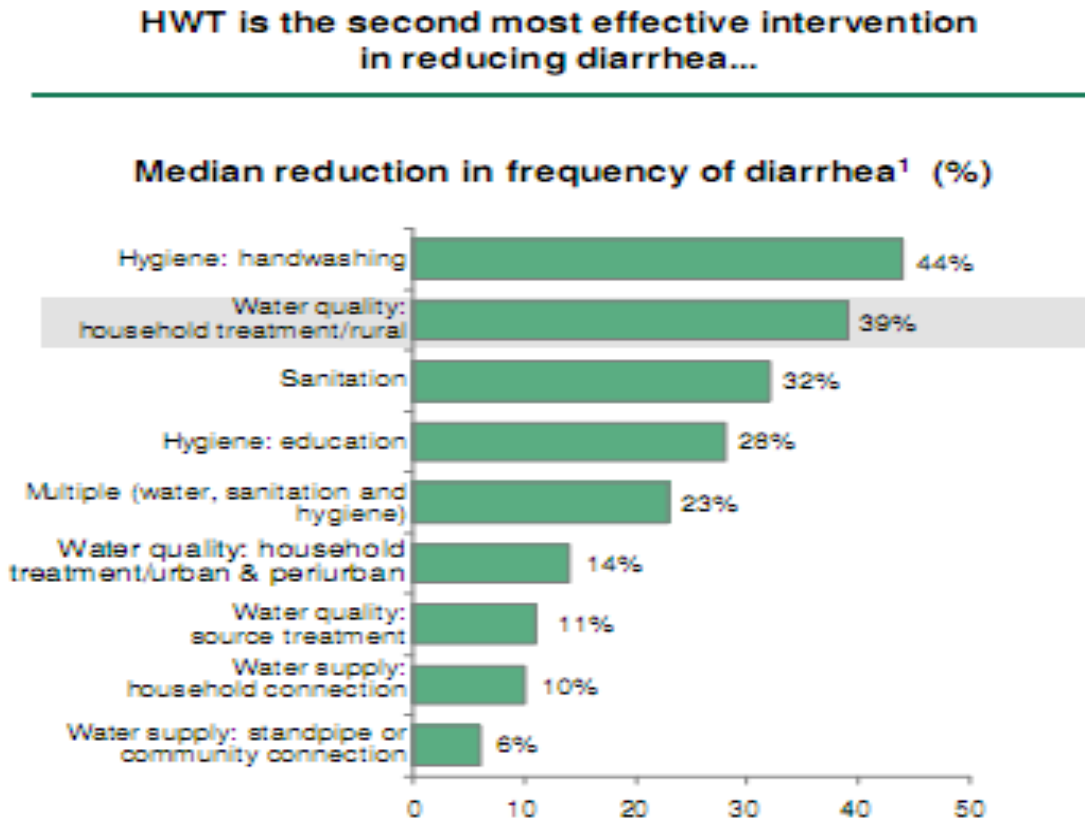
1. Background

Access to safe drinking water is inadequate in Pakistan. Moreover public health authorities have not been able to reduce the frequency of waterborne diseases resulting from microbial disinfection. Empirical evidence shows that people with sustainable access to quality drinking water is barely 25% *(Nils, 2005)*. According to the *Pakistan Council of Research and Water Resources (PCRWR),* water related diseases form 40% of all reported illnesses. Further it is projected that in Pakistan diarrheal diseases alone cause the death of 200,000 children each year. Following these estimations it is noted that 600 rural and urban poor suffer from different ailments and water allied diseases daily due to bad quality/contaminated water. On the contrary drinking water quality is deteriorating persistently as a result of biological contamination i.e. human waste. On the contrary the problem of water contamination is further exacerbated by chemical pollutants from industries and agricultural inputs. The centralized distribution system for drinking water through pipes and the drainage system (sewerage lines) lie very close to each other hence any damage to either of the two results into water flowing from one into the other consequentially contaminating the water. Open drains in close vicinity of the drinking water pipelines also result in contamination of water and cause many serious water borne diseases. In Pakistan 45% of infant deaths are attributed to diarrhea and 60% to overall infectious waterborne diseases. The Public Health System is over burdened with water borne diseases such as cholera, diarrhea, dysentery and typhoid hence causing considerable economic losses. In this context estimates show that only diarrheal diseases are costing the country Rs. 55 to 84 billion annually.

Malnutrition is one of the basic health problems in developing countries. Non availability of food and lack of food absorption (Consumption of food) are reasons for food insecurity among the masses in the country. Food absorption being the third indicator of food security is directly linked to the quality of drinking water. Water borne diseases on the other hand restrict the nutrients in the food to fully mix with the blood stream to get maximum energy. Diarrhea causes loss of nutrients from the body as does persistent vomiting. Malnourishment in turn makes the human body susceptible to diseases and early death.

Table 1:



Source: REACH Ending Child Hunger and Undernutrition, Acting at Scale: Intervention Guide, Household Water Treatment, August 2008

Types of Contamination:

There are four broad categories of contamination;

Microbiological	Chemical	Physical/Aesthetic
Bacteria	Organic/Inorganic	Turbidity
Viruses	Naturally occurring/	Odor
Protozoa	anthropogenic	Taste
Helminthes		Smell
		Appearance

2. Importance of Household Water Treatments (HWTs)

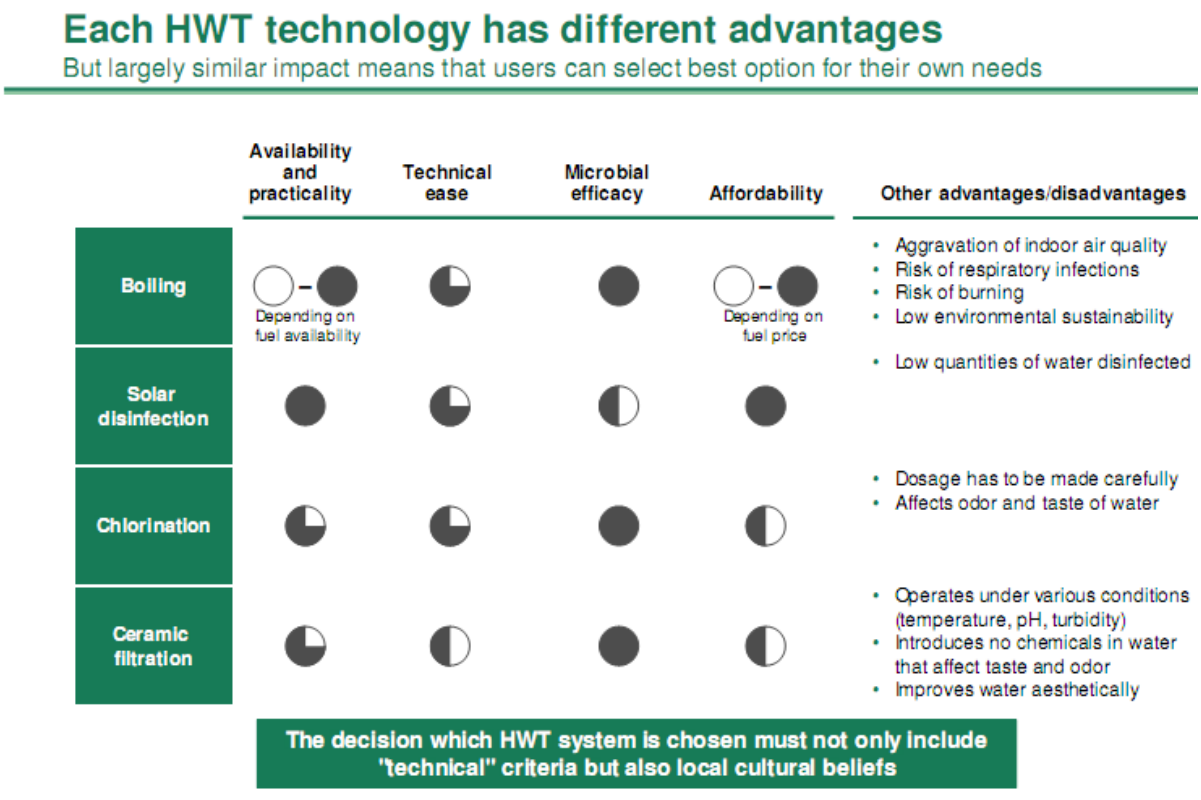
Household Water Treatments (HWTs) facilitate the users in providing clean and safe water at the point-of-use as they helps remove contaminants during distribution, collection and storage of drinking water. Therefore subsequent to hygiene i.e. washing hands, HWTs are the most effective in reducing diarrhea i.e. 39% and other waterborne diseases. Moreover, HWTs are cost-

effective and reduce the incidence of water borne diseases at places with low quality water. A WHO report entitled *'Managing water in the home: accelerating health gains from improved water supply'*, endorse the capability, effectiveness and acceptability of low-cost, point-of-use interventions at the household and community level. According to *Mark D. SobseyProfessor, Department of Environmental Sciences and Engineering Director, Environmental Microbiology Laboratory, 2002,* with the use of HWTs, the storage of water becomes free of microbial contamination hence reducing the incidence of lethal disease i.e. diarrhea. Various technologies seek to achieve significant improvements in health and they are acceptable to consumers in terms of cost and change of taste (widespread sustained use).

3. Available Household Water Treatment (HWTs) for disinfecting microbial contamination

In Pakistan there is no dearth of empirically tested water treatment methods. The existing low cost technologies that have been recommended as Household Water Treatment (HWTs) methods include Chlorination, Safe Storage, Solar Disinfection, Filtration, Combined Flocculation/ Disinfection systems, Boiling, UV Disinfection and Domestic Small-size Filters.

Table 2:



Source: REACH Ending Child Hunger and Undernutrition, Acting at Scale: Intervention Guide, Household Water Treatment, August 2008

Several points have to be kept in mind while proposing options for HWTs to the masses. The appropriate HWT option is directly linked to the existing water and sanitation conditions at a particular place. Water quality, cultural acceptability, implementation feasibility and other local conditions are intrinsic to selection of well suited HWT. Water treatment technologies have a more or less similar impact with a few differences regarding affordability, easy access and use, practicality, technical simplicity and microbial efficacy.

The World Health Organization (WHO) in its 2009 report entitled *"Scaling-up Household Water Treatment among Low-Income Populations"* recognizes solar water disinfection-SODIS as one of the viable household water treatment methods among the six most effective and widely used HWTs. The effectiveness was measured, based on its ability to cleanse water from disinfectants, easy/friendly use especially for females (water bearers of the family), cost effectiveness (low cost) and less energy consuming. Other HWTs mentioned and recognized in the report include SWS (Sodium Hypochlorite), F-D Sachets, Solar Disinfection, Bio-sand Filters, Ceramic Filters, NaDCC Tablets.

The effectiveness of Boiling as compared to other HWTs is very high. However, this paper will focus primarily on Solar Water Disinfection SODIS as a viable cost effective technology to disinfect water from microbial contamination.

4. Solar Water Disinfection (SODIS)

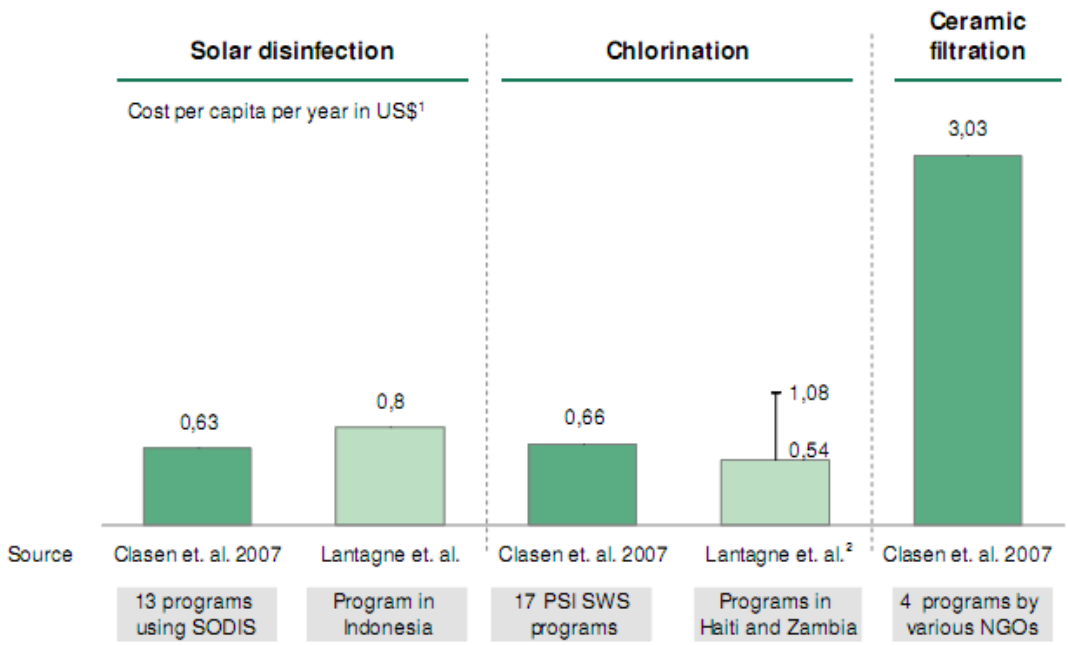
One of the viable options that best suits Pakistan's weather, economic conditions and culture is Solar Disinfection (SODIS). Poor financial means adversely affect the preference of the community to perform water treatments such as Filtration or chlorination in order to improve the quality of drinking water. Further the change of taste resulting from the use of chlorine is also a reason for rejection. Water boiling for drinking purposes is not always practicable considering the global energy deficient and environmental degradation (climate change) due to burning of inefficient fuels. In the case of Pakistan energy resources are mostly absent due to the prevailing energy crises. "*Burning carbon-based fuels indoors in poorly ventilated dwellings can also have a significant impact on lung disease" (Joyce and Conroy, 1999).*

Reed has identified the conditions under which the SODIS method is one of the best available alternatives to untreated drinking water. These are summarized as follows: (Reed, 1997)

1. Rural villages and urban shanty communities with access only to sewage contaminated water.
2. Dispersed rural populations or semi-nomadic communities where chemical treatment is too costly.
3. Refugee camps/settlements at the time of natural disasters or in war zone.
4. A locality facing an outbreak of cholera or bacterial diarrhea where the water source gets contaminated with pathogenic bacteria or any place where no reliable safe water supply exists.

Table 3:

Solar disinfection and chlorination tend to be less expensive HWT technologies



Source: REACH Ending Child Hunger and Undernutrition, Acting at Scale: Intervention Guide, Household Water Treatment, August 2008

Solar Disinfection is a water treatment known as SODIS. It requires an initial expense and running cost as low as 1 $ per annum and is invaluable to the population vulnerable to water borne disease (table-2). Solar water disinfection (SODIS) is performed under direct sunlight/solar heating/UV rays to kill the waterborne pathogens in apparently clear but microbial contaminated water. *(Joyce and Conroy, 1999)* The technique is recognized by the WHO and simply requires Polyethylene Terephthalate (PET) bottles. PET bottles filled with clear water are left in the sunlight on a light reflecting surface (corrugated iron sheets) for 6 hours to deactivate the microorganisms. *(SODIS, 2009)* According to Joyce and Conroy, no study illustrates the degeneration of water quality due to solar exposure even under cloudy conditions in moderate climates.

A range of microbiological studies have tested that the SODIS method is effective against a number of germs including bacteria (typhus, cholera, dysentery, etc.), viruses (polio, causes of hepatitis, diarrhea etc.) and parasites (diarrhea, fever, stomach cramps etc.)
According to EAWAG, a Swiss Institute of Environmental Sciences,

"Bacteria are highly sensitive to UV-A radiation (wavelength 320-400nm) and are quickly killed by sunlight. The viruses are slightly more resistant, but are also killed within the recommended 6 hours. Parasites are less sensitive to sunlight. While giardia cysts are rendered inactive within 6 hours, cryptosporidia cysts must be exposed to direct sunlight for at least 10 hours before they are neutralized. Amoebas do not die until the water temperature has been warmer than 50°C for over an hour."

(SODIS, 2010) The tests performed in laboratory as well as in the field show the SODIS method to effectively kill pathogens. The following table is a summary of these research results.

Table 4:

Bacteria		
	Disease	**Reduction with SODIS method (6h, 40°C)**
Escherichia coli	Indicator for water quality & enteritis	99.999%
Vibrio cholera	Cholera	99.999%
Salmonella species	Typhus	99.999%
Shigella flexneri	Dysentery	99.999%
Campylobacter jejuni	Dysentery	99.999%
Yersinia enterocolitica	Diarrhea	99.999%
Virus		
	Disease	**Reduction with SODIS method (6h, 40°C)**
Rotavirus	Diarrhea, dysentery	99.9 - 99.99%
Polio virus	Polio	99.9 - 99.99%
Hepatitis virus	Hepatitis	Reports from users
Parasites		
	Disease	**Reduction with SODIS method (6h, 40°C)**
Giardia species	Giardiasis	Cysts rendered inactive
Cryptosporidium species	Cryptosporidiasis	Cysts rendered inactive after> 10h exposure
Amoeba species	Amibiasis	Not rendered inactive. Water temperature must be above 50 °C for at least 1h to render inactive!

Source: Tobler M., Wegelin M., Luzi S., Cavin., Meierhofer R.Solar Water Disinfection SODIS, Eawag: Swiss Federal Institute of Aquatic Science and Technology, web: 13th April 2011. http://www.sodis.ch/news/material/flyer_poster/poster_research_e.pdf

SODIS has been field-tested in Columbia, Thailand and Jordon and has expanded to several countries in Asia, Africa and South America after that, in coordination with local partners. An experimental, scientific study on the impact of the SODIS method has not been undertaken in Pakistan due to financial constraints of private institutes and lack of knowledge of the method among the relevant stakeholders. However, tests from India in this context are closest to Pakistan considering the similarity of environment and region. The scientific experiment conducted in India was entitled *'Solar disinfection of water for diarrheal prevention in southern India'*. The experiment was conducted with 100 children who were dispensed water treated by the SODIS

method in polyethylene terephthalate (PET) bottles. The follow up period was six months hence a visible and drastic reduction in the incidence, duration, and severity of diarrhea among the sampled children receiving solar disinfected water was observed. The results of the study concluded that SODIS of drinking water is cost effective and a suitable method to increase water quality in dwellings with limited resources leading to a drastic decline in diarrhea and resultant child mortality.

5. SODIS Pilot Project in Pakistan

SODIS was introduced in 2002 as a low cost, easy and convenient technology for getting pathogen free drinking water at the point-of-use initially by Community Action Program (CAP, local NGO in Faisalabad) in collaboration with, Swiss Federal Institute of Environmental Sciences and Technology (EAWAG). Later the project was taken up by the Department of Water and Sanitation in Developing Countries (SANDEC) and the National Program for FP and PHC, Ministry of Health (MoH) on a limited scale in Chiniot. The Swiss agency for development and cooperation (SDC) and EAWAG undertook demonstration/pilot projects in several countries including Bangladesh and Pakistan to study the acceptance and efficiency of SODIS by involving several local and national organizations. In Pakistan, the project was conducted in Faisalabad and Hyderabad districts where 40 Health facilities in Faisalabad and 10 in Hyderabad were covered in the intervention area which included 150,000 households and 1000 Lady Health Workers. The Lady Health Workers were employed for the project because they have direct access to the community. The aims of the project were to assess diarrhea reduction in SODIS users, 150,000 household aware of the SODIS technique and assessing its acceptability in the community and lastly, developing water quality profile in SODIS intervention areas. The project was scaled up in Faisalabad and Hyderabad in 2008 with the help of Community Action Program (CAP) and so far 600,000 households in district Faisalabad, Jhang and Hyderabad have been reached thus bringing down the incidence of Diarrhea among children above 5 years of age in Faisalabad by 40.1% in 2008 as compared to the statistics of 2007. In Hyderabad, the results showed 24.8% decrease in the diarrhea incidence among children below 5 years of age and 19.4% decrease among the children above the age of 5 years *(CAPS, 2009).*

6. Policy Recommendations

- Public awareness about the three broad categories (microbial, turbidity and arsenic/chemical contaminations) of drinking water contamination and an emphasis on the fact that clear water is not always clean is necessary.
- A variety of empirically tested Household Water Treatment technologies (HWTs) from which recipients can select should be offered. That can help;
  a- Increase implementation by empowering users
  b- Better kowtow to available local resources, prevailing circumstances & cultural practices
  c- In the prevalence of power shortages, viable, cost effective HWTs such as SODIS, Nadi filters etc should be promoted

- The Ministry of environment (MoE) and Ministry of Health (MoH) should work in close liaison to reduce health hazardous resulting from environmental degradation etc. especially regarding water borne diseases to reduce the incidence of diarrhea among children.
- The Public Health Model is the front of line force i.e. LHWs is practicable to spread awareness about viable and cost effective Household Water Treatment (HWTS) such as SODIS.
- The Ministry of Environment in collaboration with the Ministry of Education should allocate funds to encourage research on new HWTs among university students and faculty for having empirically tested viable HWTs.
- Communication mediums should be selected based on the access, costs and potential impact on the beneficiaries including print and electronic media.
- The media should be extensively engaged in bringing change in the hygiene behavior of people especially regarding water contamination through public awareness campaigns/messages.
- The Government should encourage public/private partnerships. Private/public sector advancement will enhance and facilitate public investment to spotlight on lowest income populations. It will also ensure sustainability of the program thus implemented.
- Schools and colleges should also be focused upon for the purpose of dissemination of information by incorporating information in the curriculum.

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