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User acceptance: the key to evaluating SODIS and other methods for household water treatment and safe storage

S. Luzi, P. Gurung, R. Meierhofer & M. Wegelin, Switzerland

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Household water treatment has been identified as one effective strategy to interrupt transmission routes of diarrhoea-causing pathogens, and thus to mitigate the global burden of water-borne diseases. And yet, the commitment of governments and international organizations to integrate household water treatment and safe storage (HWTS) into their water supply, sanitation, and hygiene promotion programmes remains limited. More efforts are required to scale up the initial successes in the promotion of HWTS methods, and to achieve sustainable application at user level. This article illustrates the experience with the promotion of one particular HWTS approach - solar water disinfection (SODIS) - as an input to the debate on effectiveness, user acceptance, and integrated planning in the context of HWTS approaches.

The high incidence of diarrhoea in developing countries, particularly among children under the age of five, calls for concerted action to improve access to and quality of drinking water, sanitation, and hygiene practices. Findings from pilot projects indicate that the promotion of household water treatment and safe storage (HWTS) is a viable strategy to interrupt transmission routes of diarrhoea-causing pathogens. Substantial efforts are required, however, to replicate the initial successes and to achieve a sustainable application of different HWTS technologies at larger scale. This article provides an analysis of application rates for one particular HWTS option - solar water disinfection (SODIS) - in 12 projects as an input for the debate on the effectiveness, user acceptance, and integrated planning in the context of HWTS approaches.

The framework for decision-making regarding the promotion of HWTS

Decisions regarding the adoption of household water treatment technologies to improve the quality of drinking water are taken at different levels: a) governments formulate and implement strategies for safe drinking water supply that may or may not integrate HWTS options; b) health professionals, community leaders, and development agencies evaluate and promote specific methods of drinking water treatment; c) water users decide whether or not to apply a household water treatment system, and make choices as for the most suitable technology. Decisions at these levels are interlinked: potential user acceptance is a key factor in a government agency's decision to promote HWTS technologies, and the users' choice is influenced by the recommendations of the health authorities and other trusted institutions. In order to evaluate the potential impact of a HWTS approach, decision makers have to consider the following factors:

1. The overall effectiveness of HWTS in terms of reducing diarrhoea incidence (i.e. in comparison to interventions targeting to improve water quality at the source, sanitation, or hygiene practices): Fewtrell et al. (2005) have shown that, on average, 35% of all diarrhoea cases are prevented by interventions to improve water quality at the point of use (household). This is similar to the average effect of interventions to improve sanitation and to promote hand-washing, and is clearly more effective on average than interventions to improve water quality at the source (11% diarrhoea reduction). This discrepancy is explained by the high risk of re-contamination of water during transport and storage.
2. The 'technical' efficiency of different HWTS methods: Besides boiling, the most common household water treatment methods are chlorination, solar water disinfection (SODIS), ceramic filtration, slow sand

filtration, and flocculation/disinfection. Extensive tests have shown that all these methods substantially reduce concentrations of diarrhoea causing bacteria (average reduction: 3-4log), viruses (SODIS and chlorination are particularly effective) and protozoa (household filters are particularly effective).

3. The potential user acceptance of a method (considering different promotion scenarios and the prospects of establishing reliable supply chains for required materials): Given the high 'technical' efficiency of the all common HWTS methods, the key question regarding the potential success of a HWTS strategy is whether or not water users will adopt and sustainably apply HWTS methods at large scale. So far, none of the mentioned HWTS methods has emerged as a self-diffusing 'silver bullet' technology (Clasen 2008). But then again, arguably none of these methods has been promoted in an 'ideal' manner yet.

The knowledge regarding the determinants of user acceptance and sustainable application of different HWTS methods is still limited. The following sections provide an overview of application data from 12 SODIS projects, and discuss different factors influencing of the observed application rates.

SODIS: method and application rates

Solar water disinfection (SODIS) is a simple method to treat drinking water contaminated with pathogens. The UV-A radiation of sunlight is used to inactivate bacteria, viruses, and different types of protozoa (see www.sodis.ch for references). Contaminated water is exposed to direct sunlight in colourless PET or glass bottles. At a water temperature of 30°C, a solar radiation intensity of 500 W/m2 (all spectral light) is sufficient to achieve a reduction in the concentration of faecal coliforms by a factor of 10,000 within 5 hours. Relatively flat containers (1-2 litre bottles), and low turbidity (<30 NTU) guarantee a sufficient penetration of UV-A light for effective disinfection. Importantly, SODIS bottles also provide safe storage of the treated water. In comparison to other HWTS methods, SODIS is very cost-effective (Clasen et al. 2007) and only requires resources that are readily available for many water users (sunlight, bottles).

Table 1 shows SODIS application rates in 12 projects in Asia and Africa. More than 750,000 households were trained in the use of SODIS in these projects, and more than 200,000 households (or 1 million people, assuming 5 family members per household) regularly applied SODIS at the end of the project, i.e. typically after about 12 months of promotion. The total number of SODIS users worldwide (more than 2 million, including other countries in Asia, Africa, and Latin America) is comparable to the global application of other 'modern' HWTS methods, while boiling is far more widely practiced (Clasen 2008).

Factors determining the acceptance of SODIS

The SODIS projects analyzed in this article were implemented by local NGOs, often in collaboration with additional partners (other NGOs, government agencies, international development agencies), and were coordinated by the Swiss Federal Institute of Aquatic Science and Technology (Eawag). The highest application rates were achieved in relatively small pilot projects, where ideal conditions for the promotion of SODIS could be established (repeated community and household-level trainings through motivated promoters with locally adapted training materials, reliable bottle supply). In contrast, projects primarily run through a governmental agency - while reaching higher numbers of households - produced lower application rates. This can be explained by the difficulties for governmental extension systems to achieve a high promotion intensity (e.g., due to limited capacities), and by the fact that a blanket promotion also covers communities that are not likely to adopt any household water treatment system (e.g., because the quality of drinking water is good, or because another water treatment method is already extensively used).

Factors determining the dissemination of SODIS (or other HWTS options) can be grouped as follows:

1. Inherent advantages and disadvantages of the standard SODIS method:

- The low costs of the method and the fact that bottles and sunlight are widely available favours the application of SODIS also among the poorest households.
- PET bottles can be scarce in remote areas, in which case the establishment of a sustainable bottle marketing or supply system may be required.
- (Re-)using PET bottles is sometimes considered a 'poor man's solution', which lowers the aspirational appeal of SODIS. At the same time, SODIS bottles may also be at risk of theft if left unattended.
- The low potential profit margin from the sale of PET bottles for SODIS has so far prevented a significant engagement of the private sector in the dissemination of the method.

2. *Promotion strategy:*

- The promotion of SODIS mainly aims at a change in the water users' behaviour (comparable to the promotion of hand-washing), rather than at the distribution and marketing of a specific product (as in the case of other HWTS options, e.g., chlorine products, filters). The quality of the promotion itself (i.e. the training of users through motivated promoters, the frequency of reminders over an extended period) and the societal dynamics characterizing the dissemination of SODIS as a new practice in a community are hence of particular importance (e.g., Heri et al. 2008).
- The users' perception of a method and readiness to adopt it depends on the scale at which it is promoted, and the trust users have in the institutions promoting it. The common approach of HWTS promotion - NGOs promoting a single method in geographical 'pockets' - is less likely to turn SODIS or other HWTS methods into a common practice than a country-wide promotion through, e.g., the health authorities.

3. Lack of a favourable environment:

- The awareness of both the preventability of diarrhoea and the linkage between water quality and diarrhoea incidence is often very low, partly due to low education levels.
- Governments are reluctant to adopt and promote SODIS and other HWTS approaches due to capacity constraints, priorities assigned to centralized water supply programmes, the confusing multiplicity of HWTS technologies promoted by different organizations, and concerns that other contaminants (e.g. arsenic or fluoride) are not effectively removed by any of the most common HWTS technologies.
- Institutional constraints include the low levels of collaboration between health agencies and the private sector on the development and promotion of HWTS methods, the lack of widely-recognized standards or certification procedures for HWTS products, the orphan status of HWTS and water quality programmes at public-sector level, and the lack of focused international efforts and commitment (see Clasen 2008).

The multiplicity of different factors influencing the acceptance of SODIS and other HWTS methods makes it difficult to extrapolate the potential application levels of these technologies from the application data available to date. Application rates observed in pilot projects may either underestimate (i.e., as compared to a situation where influential institutions effectively promote HWTS at large scale) or overestimate the potential acceptance of a technology (i.e., considering the above mentioned challenges of scaling up).

Concluding remarks

This paper shows that SODIS has the potential to gain acceptance of many water users worldwide who decide to apply the method for its advantages in terms of effectiveness, low cost, as well as availability and affordability of required materials. This is true in spite of challenges to scaling up that presently constrain the diffusion of all HWTS approaches. The full recognition and effective promotion of SODIS through large scale WASH programmes would help to further enhance the application rates of this method.

Given the comparative advantages of different water treatment methods and the different preferences and capacities of users, an integrated approach that presents water users with a choice of different water treatment options - rather than the promotion of a single technology - might be a promising strategy to institutionalize HWTS in programmes of governments and international development agencies. Decision makers in the health or water sector should: 1) acknowledge the importance of household water treatment and safe storage in health and water policies, 2) adopt a strategy to promote different HWTS options as a part of health, safe water, and hygiene promotion programmes, 3) support initiatives by different organizations to promote HWTS methods, and coordinate these projects in order to exploit synergies and minimize counter-productive competition, 4) identify regions that are at risk of geogenic or industrial pollution; prioritize these regions with regard to water quality testing and the provision of communal drinking water treatment plants, but still encourage water treatment at household level.

Table 1: Application of SODIS after a promotion period of 12 months or less

	Year	Area[b]	Promotion through[c]	Bottles supplied (p: partly)	Trained households	SODIS user HHs (not specified if regular or irregular)	%	Regular SODIS user households[d]	%	Irregular SODIS user households[d]	%
South India											
Phase I	02/03	r	SHG	yes	9689			8023	*83*	1666	*17*
Phase II	03/04	r	SHG	yes	43833			21812	*50*	20653	*41*
Phase III	2005	r	SHG	yes	16852			9900	*59*	6412	*38*
Phase IV	06	u	NGO	p	13834			7470	*54*	5257	*38*
Pakistan											
Phase I	02/03	r,u	V	no	9161	1832	*20*				
Phase II	03/04	r,u	NGO,G,V	yes	25991	11796	*45*				
Phase III	04/05	u	NGO,G	p	15500	6600	*43*				
Phase IV	05/06	u	G	p	35000			10600[a]	*30*	10300[a]	*29*
Phase V	06/07	r,u	G	no	400000			69000[a]	*17*	156000[a]	*39*
Nepal											
Phase I	03/04	r, u	NGO,C	p	5500			2035	*37*	330	*6*
Phase II	04/05	pu,u	NGO,C	p	16937			9337	*55*		*12*
Phase III	05/06	r,u	NGO,G,C	no	28125			11531[a]	*41*	6188[a]	*22*
Phase IV	06/07	r,u	NGO,G,C	no	22975	8871	*37*				
North East India											
Phase I	03/04	r	CBO, SHG	yes	23911			15060	*63*	3370	*14*
Phase II	04-06	r	NGO,CBO	p	27528			12324	*45*	5725	*21*
Phase IIa	06/07	r, u	NGO	p	7365	4278	*58*				
Cambodia											
Phase I	04/05	r	NGO,CBO	yes	225	159	*70*				
Phase II	05-07	r	C,V	p	4062	572	*14*				
Uzbekistan											
Phase I	02/03	r	NGO,V	no	800	178	*22*				
Phase II	03/04	r	NGO,V	no	2272	1434	*63*				
Phase III	04-06	r	NGO,V	no	47000			14711	*31*	5781	*12*
Kenya A											
Phase I	02/03	r	NGO	yes	90	90	*100*				
Phase II	04/05	pu	NGO,V	yes	9373			5692	*61*	850	*9*
Kenya B											
Phase I	04/05	u	NGO, C	yes	19500			16760	*86*	1053	*5*
Afghanistan											
Phase I	06/07	r	C	yes	2372	485	*20*				
Tanzania											
Phase I	06	pu	C	no	1200	431	*36*				
South Africa											
Phase I	02/03	r	C	no	5929			2162	*37*	1472	*25*
Sri Lanka											
Phase I	02/03	r	NGO	yes	2288			2148	*94*	97	*4*
TOTAL households trained					**797312**						
Total SODIS user households (not specified)					**92013**	**36726**	***40***				
Total SODIS user households (regular/irreg.)					**705299**			**218565**	***31***	**225154**	***32***
User households (promotion through NGOs)					**270299**			**138965**	***51***	**58854**	***22***
User households (promotion through Gov.)					**435000**			**79600**	***18***	**166300**	***38***

[a] extrapolation from survey
[b] r: rural; u: urban; pu: peri-urban
[c] NGO: paid NGO staff ; C: paid community workers; V: unpaid volunteers; G: paid gov. extension workers; SHG: self-help groups; CBO: community-based organizations
[d] Regular users: apply SODIS more than 25days/month; irregular users: apply SODIS less than 25days/month)

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Contact details

Samuel Luzi
Eawag-Sandec, P.O. Box 611, 8600 Dübendorf, Switzerland.
Tel: 0041 (0) 44 823 54 98
Email: samuel.luzi@eawag.ch
www: www.eawag.ch