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WATER, SANITATION AND HYGIENE: CHALLENGES OF THE MILLENNIUM

SODIS - an arsenic mitigation option ?

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ABOUT 95% OF the population in Bangladesh is supplied by groundwater from five million wells. Several survey programmes revealed that arsenic might be found in three million wells affecting up to 70 million people. Currently, alternative water resources and water treatment processes for the arsenic removal are being developed. One considered option is to return from the groundwater to surface water which, however, in most cases is not safe for consumption and, therefore, requires disinfection.

SODIS (Solar Water Disinfection) is a simple and low-cost water treatment method to improve the microbiological quality of drinking water at household level. PET plastic bottles are filled with polluted water and exposed to sunlight for 1 day. The microorgansisms are inactivated by the UV-A radiation and the increased water temperature. SODIS applied world-wide is described in www.sodis.ch and has been field tested in Bangladesh to study its effciency and socio-cultural acceptance.

SODIS within the WPP

The WATSAN PARTNERSHIP PROJECT (WPP) is designed and led by the Swiss Agency for Development and Cooperation (SDC) and comprises three major components: community management, improvement of health & hygiene behavior practice and development & marketing of affordable technology for safe drinking water. The international partners: DASCOH, CARE and IDE are responsible for these three main areas of attention. The project involves around 200,000 households in one thousand villages of 11 Thanas in Rajshahi and Chapai Nawabganj. It uses 16 Partner NGOs (PNGO) in planning and implementing water and sanitation services directly through Village Development Committee (VDC) initiated by the partnership.

In the context of arsenic contamination in groundwater, WPP is, together with other activities, also interested to implement low cost methodologies into arsenic-affected areas (villages) and has placed the supply of safe drinking water to the people as top priority. Until now, no reliable, affordable and socially acceptable solutions are available to treat the contaminated water or to introduce alternative water source at household level. WPP has started different action research studies on potential household level water treatment processes and alternatives water sources. SODIS constitutes one of several processes to treat water from arsenic free sources. Other water treatment options include the two bucket method, safi filter and pitcher filter or the development of alternative water sources such as rainwater harvesting, open and close dugwells etc.

SDC in collaboration with WB/RWSG introduced SODIS through WPP to meet the challenge of providing safe drinking water specifically to areas of arsenic grondwater contamination. The SODIS experiences in rural villages of Indonesia as well as other semi tropical countries were considered in designing the SODIS implementation plan. Within that frame work, a one day SODIS workshop was held in September 1998 involving all the partners of WPP at Rajshahi, Bangladesh.

CARE in cooperation with other partners designed a Training of Trainers Manual on SODIS and organised a Training for Trainers Workshop for the PNGO staff to introduce the SODIS process and the planning of related activities. Within the villages, participating households were selected during VDC meetings, and subsequent training for the users to apply SODIS adequately was arranged by the PNGOs.

A mission from SANDEC reviewed the field situation and emphasized on water quality testing of the raw and treated water and to conduct a health impact study on SODIS user and non-user. WPP established a field-level laboratory for bacteriological and arsenic water quality testing which is now functioning properly. By the end of September 1999, the Swiss Tropical Institute (STI) in cooperation with WPP started with the preparation of a health impact study and, for that purpose, conducted different monitoring programs. The results of these studies provided comprehensive insight information on the acceptance, efficiency and practical application of SODIS in the WPP area.

SODIS Field Experiences in Bangladesh

16 villages within WPP participated in the SODIS project. In each village, 10 households were selected during the first phase of SODIS implementation in the area. Only 3 out of 16 villages were affected by Arsenic. Tubewell water in the other villages were not affected or not tested for arsenic content. Villages differed widely from each othe in terms of water availability, arsenic affection, and economic situation.

Methodologies

Water quality tests in sentinel households were performed to assess SODIS efficacy in the field. Additional water quality tests have been performed in households of regular SODIS

users. Samples of treated water from SODIS bottles, as well as samples of the corresponding raw water was examined for faecal coliforms with the DelAgua field test kit (OXFAM) in the WPP Laboratory. In the sentinel households, water temperature was measured 3 times a day over an average period of 4.5 hours which is the minimum duration of sunlight exposure to ensure an efficient water disinfection. Tests were performed during the period of January-April 2000.

Interviews and general observations as well as informal discussions were carried out in order to assess SODIS use and villager's understanding, water use and perception of the arsenic crisis. In-depth interviews were performed with a semi-structured questionnaire in randomly selected 7 villages with a total of 100 households (50 SODIS users and 50 Non-users). Topics of the questionnaire included general concerns, health concerns, causation, water usage pattern, and perception of SODIS, water quality and arsenic contamination. Furthermore, a monitoring of air- and water temeperatures was conducted 7 times daily for one year (Apr. 99 to Apr. 00) using 2-3 SODIS bottles on the roof of the office building in Rajshahi.

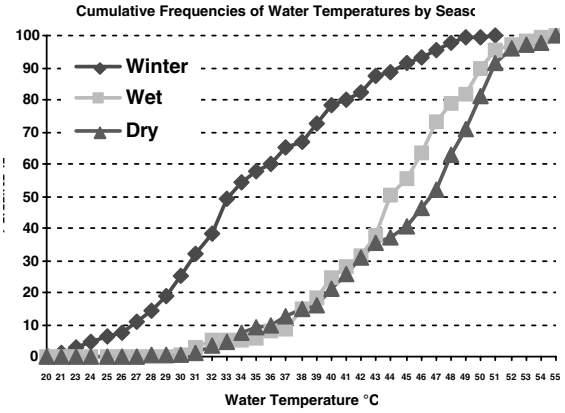

Fig.1 Frequency of Water Temperature by season. Only for sunny days. Time range of measurement: 14.00 - 16.00. Seasons: *Winter*. Oct - Jan; *Wet*: June - Sept; *Dry*: Feb - May.

Results and Interpretations

a) technical aspects

In 84% of the measurements, sun was at least partly present, showing that the amount of sunshine in the study area does not seem to be a restricting factor for SODIS-use as shown in Fig. 1. Water temperature within the SODIS bottles reached 50°C and more in 20 % of all measurements in the dry seaso. In winter, approx. 80 % of the measurements indicated temperatures barely reaching 40°C. Considering all seasons and weather conditions, a water temperature of 50°C could be reached in 11.4% of all cases (82 / 718). In the wet season, approx. 75 % of the measurements were over 40°C, though fully clouded sky or rain occurred during 28.1% of the measurements. This shows the dry season to be the best season to use SODIS. Though temperatures were also high during wet season, frequent clouding and rain might hamper proper SODIS use. In addition, periodical floods notoriously affect local people making issues other than SODIS an existential priority during the wet season. In the dry season, tubewells often run dry, in few cases leaving the people with pond water as the only alternative drinking water source.

Bacteriological examination showed various results. In general, findings show tubewell water to be of low contamination if any (<20/100ml), where dugwell water is more contaminated (>80/100ml). Ponds and rivers were highly contaminated (>3000/100ml) by faecal coliforms. In a large part of the samples examined, SODIS was not able to disinfect the water completely, though a reduction was most often achieved. Smaller efficiencies were often caused by inadequate application of SODIS.

Temperature, degree of contamination, time and duration of exposure were not found to correlate. This might have partly be due to the small sample size, the use of SODIS in the field or unidentified problems during water analysis. Focussing on regular and consistent users of SODIS, results of the bacteriological ananlysis were more convincing than the findings in the sentinel samples, as illustrated in Fig. 2. The user samples were collected in dry season (May), where the sentinel samples were collected in winter season (Jan / Feb). Although higher in the user samples, mean water temperature

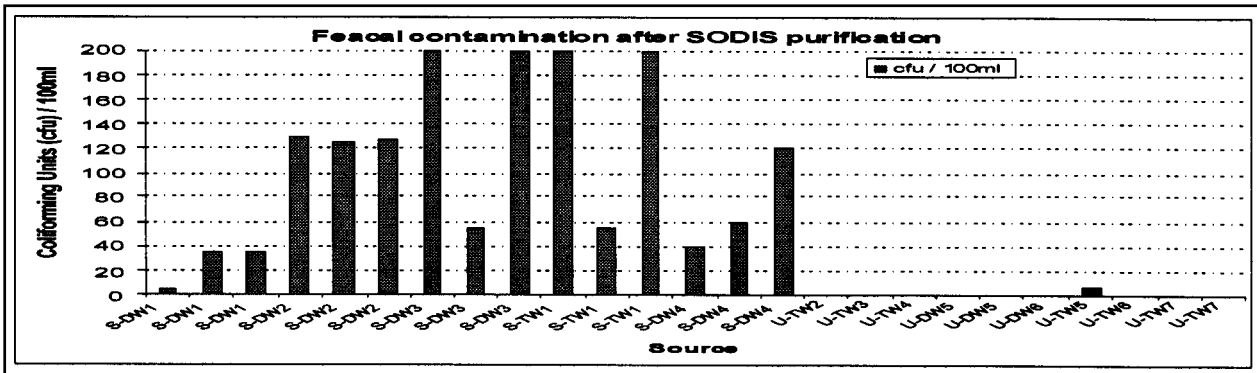

Fig.2. SODIS efficiency in the field: Comparison between sentinel (S-) and user (U-) households. TW: Tubewell; DW: Dugwell; The numbers describe the different sources, moving to the right of the x-axes also moves with date of measurements

Table 1. Frequency of expressed problems with bottles or reasons for exchanging bottles. In brackets: Proportions. (Source: In-depth interviews, Dec 1999)

Problem or Reason of exchange	Frequency (mentioned as problem)	Frequency (reason for exchange)
Cap Loss	77.8% (35/45)	—
Smell	4.4% (2/45)	—
Colour loss	77.8% (35/45)	—
Deformation (cracking) due to heat	20% (9/45)	52.4% (11/21)
Dirty	11.1% (5/45)	33.3% (7/21)
Cracking due to roof fall	8.9% (4/45)	23.8% (5/21)
Transparency loss	2.2% (1/45)	23.8% (5/21)
No Problem	11.1% (5/45)	—

between the 2 groups did not differ significantly (U-sample: 44.1°C / S-Sample: 39.8°C; F=0.8, p=0.3842).

This suggests that the seriousness and practise by which people use SODIS (bottles exposed in the shade, incomplete bottle cleaning) might also play an important role in the efficacy of SODIS. Further factors included correct training and close supervision as was previously observed in Indonesia.

Two thirds of the users claimed to need more bottles. Their estimate number of bottles needed was in average 10.5 per family, resulting in a coverage rate of 2.33 per person. Availability of PET bottles in the region is scarce, hampering the proper supply to the villages. Only bigger Hotels in Rajshahi can provide used PET bottles. This constrains further implementation of SODIS in the villages and longterm, sustainable use of SODIS.

The extensive heat and its effects on the the bottles during exposure were ementioned as a reason to exchange bottles in more than 50 % of the responses. Allthough temperature was not shown to rise above 50°C very often, it might already be enough to damage bottles after long or repeated exposure. Deformation is further problematic as the cap can loosen resulting in leaks and cap-loss. Furthermore, cap-loss considerably hampers SODIS use. In addition to the problems listed in Table 1, socio-cultural problems contribute significantly to the acceptability of SODIS in the field.

b) socio-cultural aspects

Sex, Age and Arsenic-status of the villageare given in brackets after each citation (As: Arsenic-affected; nAs: not Arsenic affected)

"We will learn every method from you, maybe we can use it one time" (fem, ~50y, nAs), was an answer of a women, when asked why she learnt to use SODIS. It reflects the attitude of most of the people that were introduced to SODIS.

The introduction of SODIS was not based on a felt-need on part of the communities as illustrated in the observed irregular usage patterns of SODIS. *"There is no difference between Tubewell water and SODIS"* (fem, ~20y, nAs).

Most often people state they use SODIS because *"it frees from disease"* (fem, ~30y, nAs), *"Good for Health, reduces illness"* (fem, ~50y, nAs), *"Free from diarrhoea and dysentery"* (fem, ~30y, nAs) and *"is Arsenic-free and no iron"* (fem, ~30y, As). The fear for arsenic in most communities was high and often a major motivation to use SODIS, even if the village is not affected by arsenic contamination of groundwater.

One Arsenic-affected village stopped SODIS use completely due to ponds being the only alternative water source, and also due to fatalistic view points of the villagers. *"Everything will be alright by the grace of Allah"* (male, 69y, As), *"We don't go to NGO meetings"* (fem, ~25y, nAs). In all cases, participants refused to use pond water for SODIS, mainly because it is *"…dirty, with fertiliser.."* (fem, ~30y, nAs), showed to have *"… no good taste"* (fem, ~35y, nAs) and is *"…not hygienic"* (fem, ~25y, As), *"...open, dirty, not good"* (fem, 21, 2), *".with faeces.."* (fem, 26y, nAs). Pond water for SODIS use is sometimes considered *"..only when tubewells are not functioning.."* (fem, ~23y, nAs). Most of the time, some of the tubewells in the village operated during the whole year. Since establishment of tubewells, community people changed their habits and use of pond water. Today, pond water is used for cooking and bathing mainly because it is easy and has no iron.

In the remaining 2 Arsenic-affected villages, SODIS was welcomed as a part time solution to the problem. Only in one village, dugwells were present as alternative water sources. In the other case, arsenic-free tubewells were used for SODIS, as they had no platform to protect the groundwater from faecal contamination. This explanation was stated from PNGOs and users alike.

When confronted with the question how long they would continue with SODIS, participants answered "*we are asking ourselves the same question*" (fem, ~55y, As); indicating that SODIS might be applicable as a short time solution to the Arsenic problem only. On the other hand, in another village, SODIS users claimed they would use it *"always and forever"* (fem, ~60y, nAs) and "*could not live without SODIS"* (fem, ~60y, nAs). Users from the second not arsenic affected village were regular users, using tubewell water for SO

Considering all villages, 81% of the households under study claimed to drink tubewell water, 14.5% consumed dugwell water and 4.4% SODIS water at the time of interview (April 2000).

Five villages completely stopped with SODIS, and in the remaining villages, only few regular users remained. Major reasons of the households to stop with SODIS were the following:

- Women told they felt SODIS to "disturb normal works" (fem, ~50y, nAs) or be *"too much work"* (fem, ~30y, nAs), indicating difficulties in changing their time management.

- *Family conflict* as reason to stop had often to do with the husband who refused the technology either because of fundamentalism or because he did not like the woman to be busy with SODIS and neglect other work: *"My husband does not like SODIS"* (fem, ~30y, As); *"..did not take SODIS because of family problem.."* (fem, ~30y, As).
- *Critics from outsiders* had to be endured for a long time, mostly from neighbours, including bad look of SODIS, questioning the benefits of SODIS and general critical remarks, challenging participant and SODIS as a new technology: *" ..Does SODIS really reduce illness?"* (fem, ~25y, As), *"..They criticise SODIS and laugh at it"* (fem, ~22y, nAs), *"..They say SODIS makes us look fat"* (fem, ~20y, nAs), *"Nobody likes this (SODIS)"* (fem, ~45y, nAs).
- If *no acceptable alternative water source* was present in the village, such as dugwells or arsenic-free tubewells, SODIS was rejected .
- As most villages were not Arsenic affected, participants stated there was *no need* for SODIS: *"we have tubewell, No need to use"* (fem, ~40y, nAs), *"Own tubewell has no Arsenic"* (male, 52y, nAs), *"is all the same, drink it or not"* (fem, ~20y, nAs). This was also related to the outside critics, explaining why normal Dugwell users would also stop to use SODIS: *"Before our generation, everybody drank dugwell water"* (fem, 24y, nAs), *"No villagers use this (SODIS)"* (fem, 18y, nAs).

Most often, reason to stop SODIS involves more than one of the above statements mentioned in addition to technical problems (Table 1). Supportive statements to maintain SODIS for water purification were few as regular users were not frequent and often, people would answer to please the visitors.

- *Some Participants claimed to get benfits from SODIS: "For maintaining health"* (fem, 32y, nAs), *"Our family must be safe from water diseases"* (fem, 36y, nAs), *"getting good results"* (fem, 25y, nAs), *"For pure drinking water and for good health"* (fem, 22y, nAs), *".useful, no diarrhoea"* (fem, 29y, nAs), *"We will be free from Arsenic"* (fem, 26y, As). Though, getting benefit, might also mean to be closer to the PNGOs and being more involved.
- *No other alternative* was often present, despite hopes from the participants. *"If I get own Tubewell, then no more SODIS"* (fem, 21y, nAs).
- Participants claimed that SODIS was *habit* now, and would not disturb them anymore, being included in their daily work. This was independent of their water source used for SODIS.
- *Good for health* was most frequently stated, though often only to satisfy the visitor.

Lessons Learned

People in WPP area are using different water sources. Drinking water is normally drawn from dugwells and tubewells. For arsenic mitigation purposes, the population is asked to return to their surface water sources used for generations before groundwater has been promoted by large well construction programmes. However, the people now appreciate the clear and appealing groundwater drawn from tubewells usually located next to their houses. Therefore, they show a strong resistance to use the polluted surface water especially in (so far) non arsenic-affected villages.

People were not interested to apply SODIS to treat tubewell water which they correctly consider as clean and safe with regard to the bacteriological quality. Treatment of dugwell water by SODIS has been generally accepted as the respective users understood that this water might possibly be polluted. But application of SODIS to pond water failed as the people do hardly accept turbid pond water as drinking water source. Furthermore, they felt SODIS application to be cumbersome as turbid water requires pretreatment through sedimentation, flocculation or filtration prior to its use.

The promotion of SODIS was also hampered by the scarcity of bottles and by their inadequate quality. The locally available PET bottles could not be supplied in sufficient numbers (e.g. 2 - 4 bottles per person) and they lasted for a period of 4 - 6 months only as they were deformed by heat, got dirty or lost their caps. In addition, the target population did not recognised SODIS as a substitute for firewood in areas where cow dung is widely used as energy source.

In conclusion, SODIS will only be accepted by the target population in arsenic-affected villages where they are able to shift from tubewell to dugwell water and in villages where dugwell water is predominantly used. However, they refuse to draw their drinking water from ponds and other surface water sources to which SODIS should actually be applied as a possible disinfection method. Finally, successful application of SODIS requires a strong felt-need on part of the community, comprehensive awareness building, a close monitoring and supervision and a sufficient supply of adequate plastic bottles. However, in the context of arsenic pollution in groundwater in Bangladesh, SODIS still has the potential as an alternative option for treating water with limited available source (e.g. dugwells) and specific period of the year. Accordingly, further field testing of SODIS in Bangladesh should be planned in considering the limitations of its application.

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