Environment-Community-Human-Oriented (ECHO) Design: A Context-Appropriate Design-Thinking Process for the Well-Being of Individuals, Communities, and the Local Environment

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Abstract This work builds upon the user-centric "design-thinking" methodology to form environment-community-human-oriented (ECHO) design, a process that strives to create solutions that not only meet the needs of the potential users but also create positive experiences and meaningfully influence their communities and the environment. As important as the users, the environment and communities are also key design considerations and target beneficiaries of the design outcomes. ECHO design was applied to solve the lack-of-safe-drinking-water problem in under-resourced communities. The resulting solution was an integration of products and services, consisting of an inexpensive, easy-to-use-and-maintain, aesthetically pleasing, and environmentally friendly water-disinfecting device; a model to fit the use of the device into the local daily routines, skills, resources, communities' cultures, social conducts, spending habits, health understanding, and environmental settings; and a business model aiming to sustain the use of the product, health-oriented mind-set, and positive long-term impacts on the individuals, communities, and the environment.

Keywords Design thinking • Human-centered design • Environmentally conscious design • Solar water disinfection

1 Introduction

Design has been practiced in many disciplines, subjected to various interpretations, and given different definitions. It can be described as "a plan for arranging elements to accomplish a particular purpose" [1]. Designers seek to "match human needs with available technical resources within the practical constraints of business" [2]. Design can also be considered a problem-solving process for finding solutions

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Fig. 1 Remote controls [3]

Fig. 2 Ticketing service of a mass transport system

that meet human needs. The resulting solutions are typically in forms of products and/or services. Some designs, however, might result in solutions that can deliver the required functionalities to satisfy the users' needs, but fail to further create positive experiences for or meaningful impacts on the users. For example, the remote controls in Fig. 1 might satisfy the users' basic needs: to be able to operate devices, e.g., televisions or cable boxes, from a distance away from the devices. However, many of the existing remote controls, like those in Fig. 1, are unintuitive, difficult to master, and sometimes even frustrating to use.

Another example is the ticketing services of some urban mass transport systems that primarily have ticket machines that only take coins. Consequentially, many passengers who do not have the right amount of coins have to line up at the customer service windows to buy tickets or, in some systems, to exchange for coins first so that they could then go use the ticket machines, making the experience significantly and unnecessarily stressful during rush hours (Fig. 2).

Such products or services fail to create positive user experiences often because the designers (1) did not comprehensively understand the root problems and/or (2) did not exhaustively explore potential solutions before selecting and implementing one. Consequently, the delivered solutions might solve only the symptoms of the real problems, leaving the users not completely satisfied or with a negative experience.

This paper presents a design process that strives to create solutions that meet the needs of and create positive experiences for the potential users, as well as meaningfully influence the users' communities and the natural environment. A case study that used this design process is also discussed.

2 Design Thinking

Design thinking is a methodology that is intended to avoid the shortfalls such as those in the abovementioned examples. Instead of trying to solve the given problems right away, design thinking involves first determining the right problems to solve and then exploring a wide range of potential solutions to deliver the right one [4]. Design thinking is user centric, aiming to not only meet the needs of the users but also improve their experiences and lives [2]. It is about bringing key design constraints—technical feasibility, business viability, and desirability to users—into a harmonious balance. Design thinking is not a rigid design process, and there are several variations of design thinking. While they may differ in detailed descriptions, they all involve similar elements: divergent-convergent thinking, iterative and nonlinear processes, exploration, experimentation, and, most importantly, user-centric mind-set.

One variation of design thinking is the British Design Council's Double Diamond model of design (DDMD). Based on 25 design methods, DDMD consists of four stages: *discover* and *define* phases for determining the right problem and *develop* and *deliver* phases for providing the right solution [5]. Figure 3 illustrates the phases of DDMD. The *discover* phase is meant for the designers to keep their perspectives wide, notice new things, and gather insights. In the *define* phase, the designers narrow down the actable possibilities and identify the fundamental problem. Then, the designers create, prototype, test, and iterate through various possible solutions in the *develop* phase. Finally, the refined solution is finalized and produced in the *deliver* phase. The *discover* and *develop* phases are divergent in nature, as a number of possible ideas are created, while the *define* and *deliver* phases are convergent, as they involve refining and narrowing down to the best idea.

Another design-thinking process is human-centered design (HCD). It involves iteration of four successive activities—observation, ideation, prototyping, and testing—until a satisfactory solution is obtained (Fig. 4) [4]. The process ensures that people's needs are met, that the resulting product is understandable and usable, that it accomplishes the desired tasks, and that the experience of use is positive and enjoyable. HCD can take place within the diverge-converge process of DDMD.

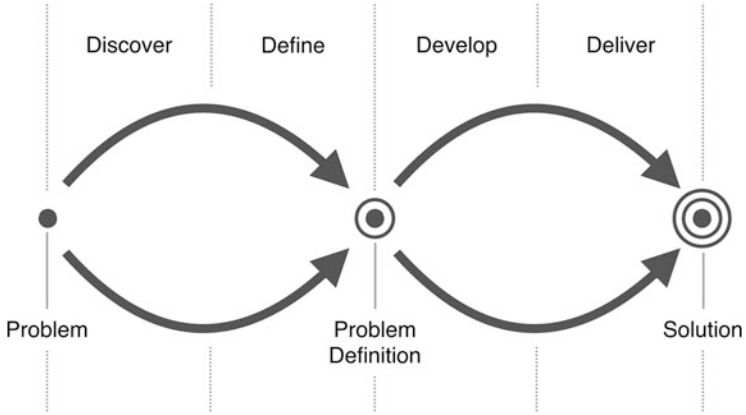

Fig. 3 Double Diamond model of design (DDMD) (Adapted from Ref. [5])

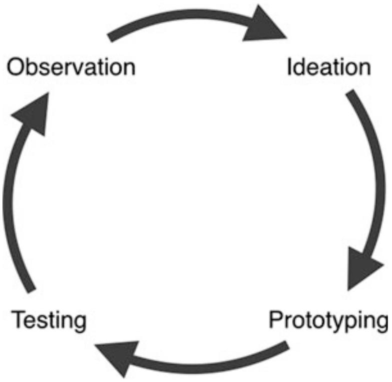

Fig. 4 Iterative cycle of human-centered design (HCD) (Adapted from Ref. [4])

3 Environment-Community-Human-Oriented (ECHO) Design

In many scenarios, focusing on the lives and experiences of the potential users alone is inadequate, and the well-being of the environment and local communities needs to be considered as well, in order to achieve improvement that is effective and sustainable in the long term. In many settings, solutions that are developed solely for the benefits of human, without proper regard to the environment and local communities, could even do more harm than good. Effective solutions in such cases need to be not only user centric but also context appropriate.

This work builds upon design thinking to form environment-community-human-oriented (ECHO) design, a process that strives to create solutions to meet the needs of and create positive experiences for the potential users, as well as meaningfully influence the users' communities and the natural environment. In ECHO design, the

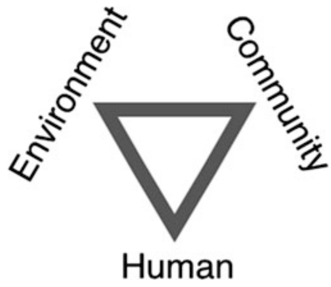

Fig. 5 ECHO core mind-set

environment and communities are key design considerations, but not merely for the benefits of the users' experiences; the environment and communities themselves are also the target beneficiaries of the design outcomes. The interrelations between the users, their communities, and the environment form the core mind-set around which the design goals and activities are oriented (Fig. 5). The subtle difference between the user-centric and environment-community-human-oriented mind-sets may seem trivial but can actually create profound impacts on the design activities and resulting solutions.

Built upon design thinking, ECHO design is, thus, not a rigid process. Indeed, the ECHO mind-set can be flexibly adapted to any variations of design thinking, including DDMD and HCD. The ECHO mind-set can also be used in conjunction with the tools and activities that are typically employed in product design, development, and engineering processes, such as design for assembly, technical specifications, mock-up modeling, etc. Figure 6 illustrates one possible form of ECHO design, in which the ECHO core is integrated into a design process that employs tools from both design thinking and product engineering.

All the tools and activities in the process in Fig. 6 connect to the ECHO core. For example, the *observation* activity is conducted on not only the potential users, their activities, and their capabilities in the actual domains where the solutions will be used; the designers have to also observe the communities of the potential users and their social, cultural, and economic settings, as well as the natural environment and its conditions. The *insights* are gained not only for the sake of the users, e.g., to understand their needs better, or to deliver a product that satisfy the users more effectively. Rather, insights that would lead to solutions that ultimately benefit the communities and environment are needed as well. During *creative thinking* and *brainstorming*, in general design processes, creating numerous ideas without regard for constraints is advised. ECHO design further encourages generating ideas that are in the social or environmental aspects as well, even if they may not be strongly linked to the users. Researching social and environmental issues in the local context can provide new perspectives on the problems. Similarly, creating new ideas from the social and environmental points of view could lead to novel solutions that would have not been realized had the focus been on the potential users only. In *prototyping* and various types of *model making*, mock-ups are created to learn, test, and further refine ideas, which could be of potential problems or solutions. Prototypes, models, and the ideas they embody are tested in ECHO design with respect to not only how

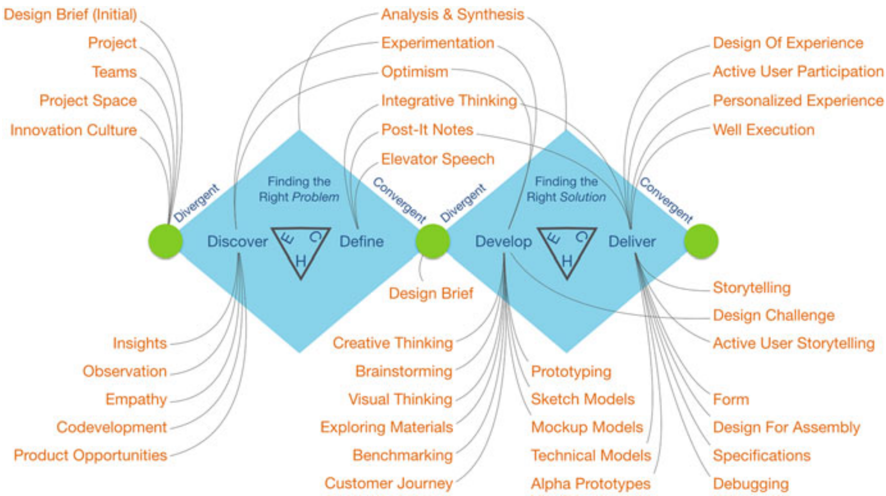

Fig. 6 ECHO design with tools employed from both design thinking and product engineering

well they satisfy the users' needs and experience but also how positively they impact the environment and communities.

ECHO design, like other variations of design thinking, is iterative and nonlinear. Through iteration, the problems can be well defined, and ultimately, well-refined solutions can be developed and delivered to achieve the well-being of individuals, their communities, and the environment.

4 Applications of ECHO Design

ECHO design has been applied by the UpWater project [6] to tackle the problem of lack of access to safe drinking water in under-resourced communities near the Thailand-Myanmar border.

4.1 General Problem Description

Globally, more than 700 million people still lack access to water that is safe enough to drink [7]. Many of them have to rely on surface water and other water sources that are usually contaminated with pathogens that cause diarrheal diseases, which kill as many as 1.5 million people per year, the majority of which are young children in developing countries [8]. The problem affects people in resource-poor areas the most. Over 80 % of the people who lack access to clean drinking water live in rural areas. Moreover, more than one third of people who live in poor countries do not have access to clean drinking water, while almost everyone in rich countries does [9]. These inequities make the problem particularly challenging, as they necessitate an effective, context-appropriate solution that is designed for under-resourced settings of rural and poor areas.

4.2 Discovering Insights into the Users and Problems

First, still during the *discover* phase of ECHO design, in order to gain *insights* into the problems, the UpWater project team set out to identify communities that comprised representative users who could benefit from potential solutions that the project could deliver, i.e., communities whose members were facing the problem of lack of access to safe drinking water. Several communities near the Thailand-Myanmar border in Sangkhlaburi district in Kanchanaburi Province of Thailand were identified as an appropriate starting point. The team then tried to gain as many insights as possible into the potential users themselves, their communities, and the environment (Fig. 7). After several iterations of interviews, *observation*, and *empathizing*, many valuable insights were gained.

The potential users in the communities were mostly Burmese migrants, who had immigrated to Thailand and settled their families in the area since many years or, for some people, decades ago. They did not live in refugee camps, with access to international aids. Instead, they lived in houses that they had built on land that they did not own. Typically, the land belonged to a local temple or local Thai people who allowed the migrants to live there with the conditions that they provided labor for the landowners' nearby rubber plantations or rice farms. They are legally recognized as migrants in Thailand but did not have rights and privileges of permanent residents or citizens. Their incomes were typically low. Most earned their living by working as day laborers and selling non-timber forest products. Those who were more entrepreneurial owned small vegetable or animal farms or convenient stores. Most families had many children, who received basic education at local schools. It could be empathized that the transient nature of the migrants' livelihood (i.e., their limited legal rights and their lack of secure jobs and permanent residences) would have significant impacts on some of the people. Such impacts manifested in many observable forms, such as the temporary nature of their houses.

The sources of drinking water for most of the potential users were wells, small streams, and springs. A small group of people bought drinking water in 20-l containers from local stores. Water samples from those sources were collected and tested, and the results showed that they all contained *Coliform* bacteria that could cause diarrhea. Further discussion with the potential users revealed that they had limited understanding of water safety and diarrheal diseases. Most families drank water without treating it first. Most did not realize that even though the water from the local natural sources may be clear and seem free of contaminants, it still contained pathogens that might not do much harm to the adults but could cause fetal diarrhea to young children.

Fig. 7 Potential users, their communities, and the environment in UpWater project

In addition to gaining insights into the potential users and their problems, the team also observed and tried to understand the communities of the users as well. Four different languages (Thai, Mon, Karen, and Burmese) were spoken in the communities, but most people were fluent in only one or two of them. In each community, the households were typically close, in terms of both space and personal relationship. The members of many households were parts of extended families. Most households in the communities did not have electricity. Some had bought and installed solar panels for lighting and television. Neighbors often gathered at the households with televisions. The community members usually helped one another with construction, farming, and other labors. Many people were members of their community's saving group, which had been helped organize by a local development agency called Pattanarak Foundation. The saving group of each community helped stabilize the members' financial future through saving, provide loans, and make some products that were otherwise expensive or difficult to purchase, such as rice, fertilizers, and animal feeds, available locally at fair prices.

Furthermore, the team studied the natural environment around the communities and found that it predominantly comprised forests, rice farms, and rubber plantations. The forests were abundant with food and non-timber products. During the winter/dry season (around November–February), the temperature could be cold enough to necessitate multiple layers of clothes, and the areas around the household often became dry and dusty. It rained heavily and regularly during the rainy season. There was usually plenty of water in the natural sources except sometimes in the dry season. Sunlight was abundant, sometimes even in the rainy season. The overall natural environment was rich but fragile and at risk of being overexploited.

4.3 Defining a Design Brief

Based on the gathered insights, a clear problem definition that represented the needs of the potential users, their communities, and the environment could be formulated. *Integrative thinking* was employed to incorporate the multiple needs and problems that the team had discovered into a coherent *design brief*. Clearly, there was a need for a solution that could remove pathogens from the drinking water and lower the diarrheal risks for the potential users. However, that alone would not be enough. Simply providing a water treatment to the users would solve one basic need, but it might not create positive experience or meaningful impacts on the users, the environment, and communities in the long term. The solution would need to be inexpensive to obtain, implement, and maintain. It would also need to be easy to use and not require any special knowledge from the users or put extra burden on the limited resources of the environment. The solution also needed to be fit for the way of life of the users and communities. In addition to providing clean drinking water, the solution would also need to impart clear understanding on water safety, hygiene, and related diseases to the all stakeholders in the communities. Moreover, continuity of such understanding and commitment to maintain drinking water safety in the communities needed to be established and fostered. Furthermore, the local environment and natural resources needed to be preserved and, if possible, enriched.

4.4 Exploring and Developing Potential Solutions

Several potential solutions were explored, designed, and developed for different parts of the problem. With respect to water treatment, many potential treatments were explored. Since it was discovered earlier that the water from the local sources contained pathogens but was free of other contaminants, the options could be narrowed down to those that were primarily meant for water disinfection. The aforementioned needs, such as affordability, accessibility, ease of use, ease of maintenance, etc., eliminated many of the remaining options, such as chlorination, leaving two practical options: boiling and solar water disinfection (SODIS). Further exploration discovered that globally only about 20 % of the populations in low-income countries used point-of-use water treatment methods [10]. By far the most popular method was boiling, which in many places could exacerbate existing problems of overuse of locally available fuels, smoke, and poor indoor air quality, which was a major cause of respiratory infections and other health risks such as burning.

Solar water disinfection (SODIS) stood out as an attractive potential solution, as it was simple, affordable, and yet effective. To disinfect water with the SODIS protocol, the user fills the water into a clear container and exposes it to sunlight for 6 h (or approximately one day) on a sunny day or consecutive 2 days if the sky is cloudy [11]. SODIS had been scientifically proven [12, 13], internationally recognized [14–16], and used by many people worldwide [17].

Recently, a new SODIS container design had been developed (Fig. 8). It could disinfect water much more effectively than the original SODIS protocol, yet still maintain its simplicity, affordability, and portability [18]. The method would be able to capitalize on the abundance of sunlight in the environment of the target users, while helping reduce the burden of firewood collection from the nearby forests. SODIS would be proposed as the main water treatment method, while boiling would be promoted alongside it for use during the rainy season.

In addition to water treatment methods, options for education campaigns and training materials were also explored. A number of training materials for water safety, hygiene, and related diseases already existed. Relevant topics were selected and further refined. Additionally, new graphical illustrations were made for all the relevant topics. The illustrations were made relatable to the audience by using drawing of local clothes, objects, and places. Written words were intentionally left out from the graphical materials so that they could be used with all four of the locally spoken languages. To ensure that the education campaign can effectively reach the potential users, local representatives were selected and trained to be field agents. The education activities were designed and planned to be carried out in the evening at the households of the target audience. This would allow the people to be in their comfortable environments and more receptive to the lessons, and more people would be available to attend after returning from their work during the day.

Another part of the solution that was explored, designed, and developed was a plan to involve pilot users from the communities. The water treatment devices

Fig. 8 Improved SODIS [18]

would be provided and integrated into their daily routines. The pilot users would help provide feedback on the usability of the water treatment and hopefully become the agents of change for their communities. This part would leverage the tight-knit nature of the communities. It was assumed that some of the neighbors would be intrigued and follow the lead of the pilot users to adopt the water treatment and safe practice as well, ultimately leading to the overall health betterment of the communities.

The last piece of the solution was designed and developed to help ensure that the solutions would have a sustainable impact. Different distribution models were explored. It was concluded that providing the water treatments to the potential users like a charity would unlikely survive in the long term. Instead, a sustainable distribution and business model was designed. The local saving groups could become the promoters and distributors of products or components related to the water treatments. The new water treatment device was already designed such that no special tools, skills, or materials would be required to produce it. The products could be sold to the members of the communities at prices calculated to be fair based on the costs of materials and labor, as well as typical incomes and expenditures of the people in the communities. Using local people as vendors would generate economic benefits on top of health benefits for the communities and would ensure that products are sold through peers, a model that had often been more effective than NGOs or businesses. Ultimately, the local safe drinking water campaigns should be able to sustain themselves without relying on outside funding.

In summary, the solution that was designed and developed was an integration of several components, consisting of a water treatment method that was inexpensive, compact, easy to use and maintain, easy to understand, and environmentally friendly; a campaign to promote better understanding of drinking water safety and improve the overall health of the communities; and a distribution and plan to ensure long-term positive impacts on the users, their communities, and the environment.

4.5 Implementing the Solutions

The *delivery* of the solution to the potential users was part of the design. Since the ultimate goal was the well-being of the users, their communities, and the environment, the focus of the delivery was not on the water treatment device. Rather, the team spent a lot of time on the education part of the solution. After the local promoters were confident that the potential users had better understanding and awareness on the issues, the water treatment devices were offered to those who were interested. By then many potential users understood the value of the device and viewed it as a tool that could help them achieve the health betterment that they wished for rather than as another charitable donation.

The lead users spurred interest of their neighbors, many of whom followed suit and adopted safe drinking water practices. Many users appreciated the simplicity of SODIS and found it less time-consuming than boiling. Several people also realized that they preferred the taste of water that was solar disinfected to that of boiled water, which smelled of smokes from the firewood. Some people appreciated that they could save their firewood for cooking instead. Consequently, a significant amount of firewood collection from the forest was avoided, reducing burden on the environment.

The local saving groups were presented with the business plans to have them continue the distribution and promotion of the water treatment. Some of the groups already expressed interest.

4.6 Iterations and Improvement

Several insights were gathered as the team proceeded through the ECHO design process. These insights led to the following adjustments to the design and, ultimately, improvement on the solution.

Through trial usage in real use conditions over an extended period, several issues with the design of the SODIS in Fig. 8 could be observed. For instance, if the bags were not hung to dry after each day of use, they would look old and dirty quickly. Also, if the bags were still wet by the next morning, the outer and inner layers would stick together, reducing the effectiveness of the air insulation of the device. To overcome those issues, several new design alternatives were explored, prototyped, and tested. Eventually, the final design, named SODIS X, was developed (Fig. 9). It was much simpler, easier to use, to clean, and to dry, and looked much more refined, which the potential users greatly appreciated.

The education part was also adapted to be a module in training courses that Pattanarak Foundation regularly gave to local people and visitors from other areas. The impact of the campaign could be expanded to a greater audience. A special version of the education campaign was also created to tailor to schoolchildren. New materials, such as coloring sheets, were developed. The lessons were integrated into

Fig. 9 SODIS X

several subjects in school, including science, art, social study, language, and nature conservation.

With regard to sustainable betterment, another distribution and promotion channel was developed. In addition to local business by the community saving groups, other future development training campaigns, such as sustainable food production, would also incorporate the safe drinking water promotion as well.

5 Summary

Built upon design thinking, ECHO design is a design process that strives to create solutions that meet the needs of and create positive experiences for the potential users, as well as meaningfully influence the users' communities and the natural environment. As important as the target users, the environment and communities are also key design considerations and target beneficiaries of the design outcomes. The interrelations between the users, their communities, and the environment form the core mind-set around which the design goals and activities of ECHO design are oriented.

ECHO design was applied to solve the problem of lack of access to clean drinking water in poor communities. The resulting solution was an integration of products and services, consisting of an inexpensive, easy-to-use-and-maintain, compact, easy-to-understand, aesthetically pleasing, and environmentally friendly water-disinfecting device; a model to fit the use of the device into the local daily routines, skills, natural resources, household practices, communities' cultures, social conducts, spending habits, basic health knowledge, and environmental settings; and a business model aiming to sustain the use of the product, health-oriented mind-set, and positive health, economic, and environmental impacts in the long term.

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References

1. Eames Office LLC (2015) Design Q & A text. Retrieved 2015, from http://www.eamesoffice.com/the-work/design-q-a-text/
2. Brown T, Katz B (2009) Change by design: how design thinking transforms organizations and inspires innovation, vol viii. Harper Business, New York, 264 pp
3. Jared, Corin (2006) Remote controls. Retrieved 2015, from https://flic.kr/p/d39sd
4. Norman DA (2013) The design of everyday things, vol xviii. Basic Books, New York, 347 pp
5. The Design Council (2015) The design process: What is the double diamond? Retrieved 2015, from http://www.designcouncil.org.uk/news-opinion/design-process-what-double-diamond
6. Sukkasi S (2014) UpWater. Retrieved 2015, from http://www.upwater.org
7. WHO, UNICEF (2014) Progress on sanitation and drinking-water – joint monitoring programme update 2014. WHO Press, Geneva
8. Prüss-Üstün A, Bos R, Gore F, Bartram J (2008) Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health. WHO Press, Geneva
9. Breu F, Guggenbichler S, Wollmann J (2013) World health statistics 2013. WHO Press, Italy
10. WHO, UNICEF (2011) Drinking water equity safety and sustainability: thematic report on drinking water 2011. WHO Press, Geneva
11. Swiss Federal Institute of Aquatic Science and Technology (2002) Solar water disinfection – a guide for the application of SODIS. Swiss Centre for Development Cooperation in Technology and Management, St. Gallen
12. Acra A, Karahagopian Y, Raffoul Z, Dajani R (1980) Disinfection of oral rehydration solutions by sunlight. Lancet 2:1257–1258
13. Swiss Federal Institute of Aquatic Science and Technology (2013) SODIS: scientific publications. Retrieved 2015, from http://www.sodis.ch/methode/forschung/publikationen/index_EN
14. Swiss Federal Institute of Aquatic Science and Technology (2006) Eawag: Red Cross prize for Sodis. Retrieved 2015, from http://www.novaquatis.eawag.ch/media/20060624/index_EN
15. UNICEF (2009) Soaps, toilets, and taps – a foundation for healthy children. United Nations Children's Fund, New York

16. WHO (2007) Combating waterborne disease at the household level. World Health Organization, Geneva
17. McGuigan KG, Conroy RM, Mosler HJ, du Preez M, Ubomba-Jaswa E, Fernandez-Ibañez P (2012) Solar water disinfection (SODIS): a review from bench-top to roof-top. J Hazard Mater 235/236:29–46
18. Sukkasi S, Terdthaichairat W (2015) Improving the efficacy of solar water disinfection by incremental design innovation. Clean Technol Environ 17(7):1–15