Cumulus Mumbai 2015:
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http://www.cumulusmumbai2015.org/

MoSan - A mobile Sanitation Solution for challenging environments

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Abstract

The sanitation crisis in developing countries leads to unhygienic conditions, health issues, and excessively high mortality rates. "MoSan" is a sanitation solution, which combines a mobile toilet with an ecological sanitation system. The dry-separation toilet used in private households provides people with dignity, safety, and hygiene. The closed-loop service considers human excreta as a valuable resource that can be recycled and reused. The "MoSan" toilet and sanitation system are developed using participatory design methods. Affected people were involved in the design process and became the driving force for the sanitation service. Conventional sanitation solutions often fail in refugee camps and challenging environments that are prone to flooding or do not allow permanent sanitation facilities. Solutions are needed that are rapidly deployable and do not harm the environment. This work describes the development and operation processes of the "MoSan" solution and shows the opportunity it offers for challenging environments.

Key words: Ecological Sanitation, Hygiene, Health, Human-Centered Design, Participatory Design, Recycling, Fertilizer, Biofuel, Kenya, Bangladesh, Slums, Refugee Camps

1. The Sanitation Challenge

With more than 2.5 billion people lacking access to safe and clean sanitation in developing countries, humanity is facing a global sanitation crisis (Sanitation and Water for All, 2014). The consequences are inhumane conditions, health problems and high mortality rates, especially among children. The Centers for Disease Control and Prevention state: "Diarrhea kills 2,195 children every day – more than AIDS, malaria, and measles combined." (CDC, 2015) Human excreta may contain pathogens and spread diseases by contamination of water and the environment. Women and girls are usually affected the

most and become victims of rape and violence when looking for a place to relieve themselves. 40% of the families who attended our pilot study in Kenya in 2013 reported that their daughters dropped out of school when they reached menstruation age. Schools either have no toilets or very unhygienic toilet facilities. By interviewing urban slum residents in in Bangladesh in 2011, I learned that it is a taboo for women to use public toilets and share them with men. Women explained that they limit their eating and drink habits during the day and wait until it is dark to find a private place outside. Children fear the risk of falling into conventional pit latrines and therefore prefer to practice open defecation —defecation on the ground or on the sides of open water bodies. This fear is so common that it is even represented in the movie "Slumdog Millioniare". It depicts a scene where a young boy falls into a latrine and is covered in fecal sludge. Watchers may think this is far fetched, but it is in fact a real threat to children in Indian slums.

Figure 1: Lack of sanitation solutions contaminates water sources. Mymensingh in Bangladesh 2010.
Figure 2: People in a flooded urban slum in Dhaka, Bangladesh 2011. Figure 3 / Figure 4 / Figure 5: Improvised toilets in Bangladesh and Kenya.

2. Ecological Sanitation as a promising solution

Ecological Sanitation (EcoSan) is an approach that considers human excreta not as waste, but as a valuable resource. It is a loop-oriented process that separates, contains, sanitizes and recycles urine and feces. The objective is to protect human health and the environment, reduce water use and recover nutrients to reduce the need for artificial fertilizers in agriculture. Common practices include the composting of human excreta into compost fertilizer, digestion into biogas or drying to produce solid biofuels.

Human excreta contain the macronutrients nitrogen, phosphorus and potassium. Phosphorus is essential for life and is mainly used in fertilizers for agriculture. Researchers assume that within a century, the end of natural phosphorus will cause a crisis with rising food prices, food shortages and geopolitical conflicts (EcoSan Res, 2003). Ecological sanitation with urine separation can therefore be an opportunity to recover nutrients and meet the growing demand for fertilizers and ensure crop production to feed the world population.

Waterless urine-diversion dry toilets, also called UDDTs are one technology for EcoSan systems. The separation of urine and feces allows a variety of reuse and treatment options and offers many benefits for users, stakeholders and the environment. By diverting urine, the toilet will fill more slowly. This will also reduce bad odors and the risk of spreading disease. Dry feces has less volume and weight, and is therefore easier to handle. The separation simplifies the handling and treatment of excreta and enables the recycling and reuse.

Sanergy is a growing Kenyan start-up that collects human excreta from public EcoSan toilets in Nairobi. Trained operators collect toilet containers, transport them to the treatment center where feces and urine is recycled into compost fertilizer. Over the last four years, Sanergy has collected 7,000 metric tons of human excreta, recycled it and sold the fertilizer to local farmers. The public “fresh life” latrines are accessible during the daytime and are operated through franchises. (Sanergy, 2015)

Another challenge in informal settlements in Kenya is the high demand for fuels, which forces women and children to spend up to 5 hours per day gathering firewood (GAFCC, 2015). The demand for fuels leads to deforestation and high expenses. During interviews in 2013 people in the Karagita slum reported spending up to 50% of their daily income on charcoal or firewood. Recycling excreta into alternative fuels may reduce the health risks,

effort, and cost associated with sourcing firewood. EcoSan systems offer multiple opportunities to tackle the sanitation challenge and resource scarcity.

3. Sanitation in emergencies

The sanitation conditions in urban slums in Bangladesh are especially challenging. High ground water levels, flooding and heavy monsoon rains cause conventional latrines to fail. The lack of property rights to the land prevents the installation of permanent toilets. Slum dwellers improvise solutions on their own, e.g. hanging latrines that are built over the sea, a river, or other bodies of water, into which excreta drops directly (WHO/UNICEF, 2013). Water for cooking, drinking and hygiene is often taken from the same source and leads to disease spreading and high mortality rates.

UNHCR estimates that 30 percent of refugee camps worldwide do not have adequate sanitation facilities and services. Dominique Porteaud, UNHCR's senior water and sanitation officer, describes how communal latrines are shared among 500 people per day and unmaintained, as well as the challenge of digging conventional latrines in areas with hard ground (UNHCR, 2009). When sanitation does not meet the hygiene standards in refugee camps and groundwater sources are contaminated, it may lead to conflicts with the host country and community.

4. EcoSan Design for challenging environments

In 2010 I started to research sanitation in urban slums in Bangladesh. The conditions I found in Dhaka and Mymensingh were disastrous. As an industrial designer I asked "How may people relieve themselves with dignity, in safety and privacy?"; "How does a sanitation solution for those contexts need to be designed to improve people's hygiene and health?"; and "How can EcoSan become a feasible alternative?" The more openly phrased questions required systems thinking and the design of an ecosystem instead of a solely technological solution. Throughout the development process, I considered the context, culture, religion and political barriers. The German International Cooperation (GIZ) in Bangladesh supported and initiated the research in Bangladesh.

We invited people to join the design process for brainstorming, sketching and prototyping. We held group discussions and conducted interviews with slum dwellers, stakeholders and potential investors.

Figure 6: Design workshop with women in Mymensingh Bangladesh, 2011.

Many slum residents expressed their interest in a household toilet. This would allow them to avoid going out at night, share their toilet among fewer people, and, as a consequence, be more hygienic. The toilet should be easy to clean and visually aesthetic. Houses are small and space is limited, so a toilet needs to fit in the living environment. The strongest interest for private household sanitation came from those who spend most of their time at or near home: women, children, elderly, and disabled people.

A new toilet design alone would not solve the sanitation problem. A sanitation system and hygiene education is necessary to effectively reduce the spread of disease. During the product design research at Zurich University of the Arts (ZHdK) in 2013, I teamed up with the American start-up Sanivation to develop the ecological sanitation system in the peri-urban slum Karagita in Kenya. For four weeks, toilet prototypes were given to willing people who paid rental fees. We hired and trained people from the community to work within the sanitation service. To ensure excreta recycling we collaborated with an innovative group of makers, “The Lake Naivasha Environmental Disabled Group.” The group developed tools to make alternative fuel briquettes from charcoal and saw dust, and experimented with different mixtures.

4. The MoSan Toilet and Sanitation System

Given the circumstances of environmental, social and economic challenges in informal settlements and refugee camps — a sanitation solution needs to be intuitive to use, as well as modular, mobile and affordable. The **MoSan toilet** combines existing technologies, with design and functionality. Urine and feces are separated into removable containers within the toilet. Those containers have to be collected for transport and treatment off-site. The lightweight toilet can be carried and used by people at convenient and safe locations. The in-home use supports hygiene standards and provides security and privacy. In contrast to unhygienic public toilets, the appreciation for a private toilet is likely to be higher. Misuse and damage will happen less often. Users are responsible to find an adequate space to place and use the toilet, allowing for constant access. The convenience of better access and no waiting time can lead to regular eating and drinking habits and improve people's health. The toilet uses no water, electricity or chemicals and is easy to stack and assemble, durable, and long lasting. The elegant design allows low cost manufacturing.

Figure 7: Family in Kenya with the MoSan toilet and separate waste bin.
Figure 8: The MoSan toilet with feces bucket from metal.
Figure 9: The seat design separates urine and feces into removable containers.

The **sanitation service** ensures collection and treatment of excreta, offers hygiene education for users and creates job opportunities. In the Kenya case study of 2013, MoSan toilet containers were collected and replaced regularly by trained stuff. The toilet containers made from metal were placed on the Sanivation solar concentrator. After 6 hours, potential pathogens in excreta are deactivated by heat, and the feces are ready for recycling. The “Lake Naivasha Environmental Disabled Group” used wooden tools to mix feces with other waste products like sawdust, charcoal dust, organic waste or paper. The mix was pressed manually and dried in the sun for 4 days. Our analysis in 2014 showed that

the briquettes have a calorific value comparable to firewood and are an opportunity to meet the high demand for fuels in resource-scarce areas.

In parallel, urine was collected separately. From healthy people, urine is virtually free of pathogens. To lower health risks, we stored urine containers for 2 days in the sun. Urine contains the most nutrients excreted by the body and can therefore be applied as a liquid fertilizer in agriculture. Farmers in many developing countries successfully report improved growth of their crops watered with urine fertilizer.

Figure 10: Manual fuel briquette production from human feces and charcoal dust in Kenya 2013.
Figure 11: Briquettes dry in the sun for 4 days in Kenya 2013.
Figure 11/12: Corn crops without urine fertilization and watered with urine fertilizer in Kenya 2013.

Hygiene education should be central for all sanitation services. Hand washing is essential for health and hygiene. Especially in regions in Kenya with water scarcity, regular hand washing with soap is not practiced sufficiently. Campaigns to raise awareness at schools are essential to stop disease spreading.

One way to make sanitation solutions more feasible is the development of franchise businesses. Franchisers instruct manufacturers to produce sanitation hardware. The hardware is used by sanitation entrepreneurs to carry out a venture. The toilets can be

rented to customers for a monthly service fee. The venture creates a sanitation center, including trained collectors and technology for excreta treatment and recycling. By selling the recycling products to users or farmers, the venture makes a profit, ensuring continuity of the sanitation service. The start-up Sanergy is successfully applying this model in Nairobi.

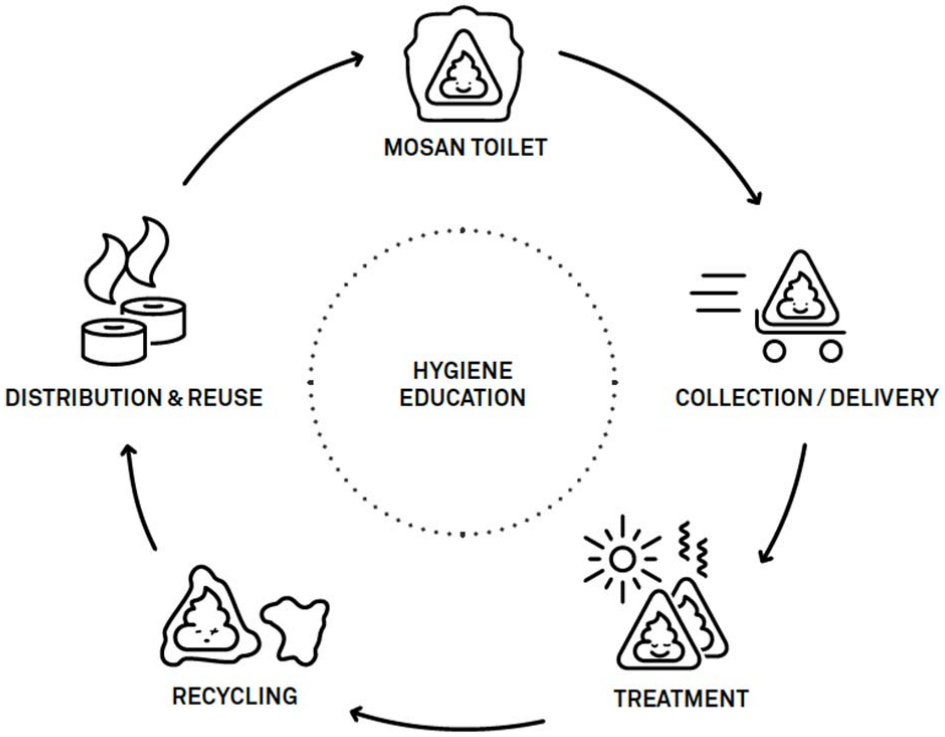

Figure 13: Illustration of the ecological sanitation system piloted in Naivasha, Kenya in 2013.

To make sanitation systems more sustainable, affected people need to be involved, e.g. as producers, suppliers, workers, distributors, and consumers, and are therefore the key to the success of the system. In this sense, they can be the innovators to the problem they face as a community. Participation encourages people's creativity to solve problems on their own and increases their acceptance of new concepts.

The design process offers powerful tools for social change. The human-centered design approach, collaborative and participatory design methods, prototyping, storytelling and behavior mapping are just a few examples. Designers may ask critical questions, "think outside the box", and find unconventional solutions. Applied within multi-stakeholder and inter-disciplinary settings, design unfolds its full potential and can become a catalyst for social change.

5. Conclusion

The containment of feces within the MoSan toilet, the safe collection of excreta containers by trained stuff, hygiene promotion through campaigning, and the hygienic excreta recycling are breaking the cycle of disease spreading. People stop defecating in the open and local water bodies are protected. Mortality from water-borne diseases is reduced. People's eating and drinking habits become healthier and the likeliness of girls dropping out of school at menstruation age is reduced. When they have a household toilet, women are no longer victims of rape and harassment when looking for a place to relieve themselves at night.

The recycling and reuse of human excreta allows the recovering of valuable nutrients for agriculture and can therefore meet the growing demand for fertilizers, necessary to feed the world population. Using alternative fuels from human excreta reduces the financial burden for households. Women and girls spend less or no time searching for firewood.

EcoSan is a promising solution for the sanitation crisis humanity is facing. To adapt EcoSan in different contexts new technologies and services are needed. Examples like the start-up Sanergy show that EcoSan services combined with container-based dry separation toilets are feasible in urban contexts. The MoSan toilet and sanitation system is the mobile answer for sanitation in challenging environments, areas with hard soil, prone to flooding or areas where the installation of permanent solutions is not possible. MoSan is user-friendly, rapidly deployable, low-cost, and stackable and does not need to be assembled. All those properties are enabling the promising ecological sanitation approach in refugee camps, disaster relief and challenging environments.

Acknowledgement

Initial research and development was supported by the German International Cooperation (GIZ). Dr. Alexander R. Jachnow initiated the research project in Bangladesh. The project was conducted within the studies of industrial design at the University of Applied Sciences in Magdeburg. Dr. Elisabeth von Münch and Christian Rieck (GIZ) as well as Prof. Ulrich Wohlgemuth acted as mentors. In Kenya the cooperation with Emily Woods from Sanivation (www.sanivation.com) enabled the design of the sanitation service. The service design was part of the Master of Arts in product design at Zurich university of the Arts (ZHdK). Prof. Michael Krohn and Herbert Pauser mentored the research.

The MoSan solution received the 1st BESTFORM award 2013 and the 1st Hans-Sauer Social Design Prize. MoSan is part of the innovate4climate program by Climate-KIC, the Creative HUB and CEWAS program. A current cooperation with the "design for scale" class at MIT - Massachusetts Institute of Technology provides concepts for series production of the MoSan toilet.

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