INTEGRATED APPROACH TOWARDS SANITATION
ISSUES IN THE RANN OF KUTCH
A Report

Submitted as a part of Sristi Summer School

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1. INTRODUCTION

1.1 Introduction to salt workers
Little Rann of Kutch, located in Gujarat is famous for Gudkhar (wild ass) and for salt fields. Little Rann of Kutch has area of about 3000 sq. km. 76.7% of India's total salt in India comes from Little Rann of Kutch, Kharaghoda and nearby places. (tnsaltcorp n.d.) Agariyas are the people who work in the Agar (Salt Pans) for their occupation. More than 70% of salt worker come from Kharaghoda and nearby villages. The families of Agariyas move to the Rann for extracting brine and cultivating salt which takes around 8-9 months. It starts from the month of September-October and ends in April-May. After May, Rann is submerged in the seawater in monsoon. Agariyas who are not employed at their village prefer to work on Agar for their livelihood. In Kutch, ground water is 10 times rich in terms of salt compared to seawater and TDS (Total Dissolved Solids) value is above 1200 ppm. Government gives 1000 litres of water per 20-25 days per family of 5-7 members. This water is mainly for drinking, cooking and therefore they face shortage of water. Due to the unavailability of toilets, the community practices open defecate in opens, mostly at night. In case of emergency, they even go during daytime by covering them with shawl or blanket along with few sticks to support the cover. At end of the season, Agariya sell salt and brine to brokers. (Bhagawati 2020).

1.2 Living of Agariyas
Agariyas move to Rann with their essentials including wood, water tank, household materials and food supplies. Agariyas after moving to Rann they make immediate hut in 3 days with the help of locally available materials. They reside near the salt pan where they going to extract salt and brine. For extracting salt, they make their
own equipment which needs to be heavy and able to pull. Amidst the harsh climatic conditions & unavailability of water, they use to cook traditionally by the means of wood which are carried by them when they go in the month of September. Now, some of the Agariya are eligible for LPG gas cylinder under Government’s scheme. They mainly consume chutney, pickles, cereals and pulses due to unavailability of vegetables.

Agariyas do not prefer toilet as there is not toilets and therefore, they defecate in open. Kutch is a plain land, so visibility is more and thus, they prefer to defecate in open at night because of social security. They go with a container of about 750ml water to wash themselves. Females specially prefer to go out at night to defecate therefore they control their bladder. This leads them to problems associated with bladder and their menstruation cycle as they compromise their health. Also, ladies drink less water to avoid going for urinating and deter their health.
1.3 Salt Process
Salt making starts after Monsoons in month of September-October. Salt extraction is a long process which requires around eight to nine months. Salt processing requires mainly sunlight and non-percolating land, which is fulfilled in Rann of Kutch. It is done when precipitation is nearly zero as rainfall can damage the entire salt crystal formation process. The Brine is extracted & poured to collection pond for sedimentation & then transferred to salt pans. The brine extracted has TDS of 1200 and above with rich content of salt and other chemical (mostly halides). The Agariyas lay out the water in the salt pans and allows it to settle. By the end of the process the crystals become geometric and bigger in size apt for further processing.

During September-October, shifting of machineries and finding of old wells or digging a new well manually. Brine water is extracted from the well and collected in collecting ponds. And in October to November, they transfer brine to salt pans to start crystallization. From November to March, they continuously take care of the salt crystals and convert big crystals to small with the help of Dantara. By March-April, salt is collected and ready for the shipment by means of truck. Even remaining brine water is sold as it is rich in chemicals. Locally brine water is known as “beaten”.
1.4. Mind-mapping the problems related to sanitation in the Rann of Kutch

Our group conducted a session to mind map the problems related to sanitation in the Rann of Kutch where different kinds of problems were identified. The problems were related to health, scarcity of various resources, social security and even problem of awareness and habits.
Figure 3: Mind map for the problems related to Sanitation problems at Rann of Kutch

Agariyas do not have access to toilets. Hence the community faces a host of challenges. Especially the females in the community drink less water to avoid urinating and they control till dark (when its safe to defecate in the open). This damages their bladder and leads to kidney disease. There is also lack of medical facilities as the area is isolated connected. However, NGO named SETU Charitable Trust provides medical facilities to an extent. Agariyas also faces heart disease because of hard laborious task. (Bhagawati 2020).
2. INTEGRATED APPROACH: WATER, TOILETS AND FECAL SLUDGE MANAGEMENT

Many aspects are important for toilet like water availability, odour, light source, social security, easy maintenance, structure of toilets, and faecal management. We categorized this in 3 major components: Water, toilets and fecal management.

2.1 Water Availability

As per the Kharaghoda resident, water is provided by Government in every 20-25 days. This water comes in the tanker and provides 1000 liters of water to a family with 7-8 members. This water is used for drinking, cooking, and washing purposes, and this water is stored in tanks. Although water is there in Kharaghoda but it is in form of salt water which has total dissolved solids (TDS) more than 1200ppm (Patel 2021). Water with such amounts of salt cannot be used for domestic purposes. According to Bureau of Indian Standards (BIS), upper limit of TDS should not exceed 500ppm. However, World Health Organization (WHO) recommends TDS level less than 300ppm. (Kent Co. n.d.)

Figure 4: A woman crosses the dry bed of a pond at Manoba village in Rapar taluka of Kutch district (Roja 2015)
It is difficult to manage water situation as the next round of tanker is after 20–25 days with uncertainty. And now from previous year, Government is giving contract to private companies for water supplies which are worse, according to the local (Patel 2021). They bath once in a month and women bath once in 2 months. Some of them are having small tanks which stores water for only ten days. (Khakhariya 2019) So, it is nearly impossible to use traditional toilets with flushes which consume nearly 7.5 liters of water/flush. (Which n.d.). Therefore, we need to come with a waterless toilets or minimal water usage toilets.

As water is scarce in Kutch, we cannot use conventional toilets. As of now, Agariyas prefer open defecation as it is maintenance-free, their habit in villages, minimal water usage and availability of vast land. Agariyas struggle to get cover for defecation, and therefore they prefer to go when it is dark. They go far from their huts, where visibility diminishes. Females go at night as visibility is diminished. They take a container of less than 1 litre (Bhagawati 2020)

Agariyas prefer the Indian toilet style squat position as faeces get dried in the presence of sunlight. Also, because faeces do not get contaminated. (Bhagawati 2020) maintenance-free, waterless, and odourless, near to
2.3 Fecal Sludge Management
While practicing open defecation in the desert, the feces get dried and eventually decompose. Here, there availability of land so there is no contamination and no such odor. (Bhagawati 2020) But Fecal Sludge Management is necessary when it comes to a fixed toilet. The question comes how to dispose the waste whether convert it in biogas or not. Fecal sludge management should be done considering feasibility, viability, cleanliness, odorless, storage capacity and process if any.
3.1. Water Availability

In arid areas like Rann of Kutch, the available water content is very low. Annual rainfall in this region is about 14 inches. The only source of water for is supply through tanks which according to them is irregular. They do not take baths for months due to low water availability. Less water content can also cause problems related with sanitation and proper hygiene. Drinking water availability is also limited. That is why if we can able to increase water availability in arid areas it will be boon for salt workers. Some available water source technologies:

3.1.1 Water from thin air
Metal–organic framework (MOF) is used as major component. This is basically a sponge-like compound that looks like sand to the naked eye, and which is extremely dense. Metal–organic framework that includes the element zirconium will capture water out of the air at night, store it, then release it during the daytime upon exposure to the heat of sunlight – no electricity needed. Other devices are available, but they work in foggy environment. Advantage: It works especially well in arid environments,
Low cost, no electricity required, can work in arid environment, Zeolite can also be used instead of MOF.

3.1.2 Seawater turns into Freshwater through Solar energy:

The working principle of the proposed technology is elementary: "Inspired by plants, which transport water from roots to leaves by capillarity and transpiration. The floating device can collect seawater using a low-cost porous material, thus avoiding expensive and cumbersome pumps. The collected seawater is then heated up by solar energy, which sustains the separation of salt from the evaporating water. This process can be facilitated by membranes inserted between contaminated and drinking water to avoid their mixing. The device is inexpensive and easy to install and repair. Disadvantage: Cannot be functional in arid environments.

3.1.3 Roof catchment:

Collects and stores rainwater from the rooftop, residential, commercial, and industrial buildings using steel or plastic tanks or concrete ground storage tank and other devices to meet the demand for adequate water for human consumption. Disadvantage: In the Rann of Kutch, annual rainfall is around 14 inches. Less amount of water can be stored and used in this way.
3.1.4. Virdas:

*Virdas* are shallow wells dug in low depressions called *jheels* (tanks). After rainwater infiltrates the soil, it gets stored at a level above the salty groundwater because of the difference in their density. A structure is built to reach down (about 1 m) to this upper layer of accumulated rainwater. Between these two layers of sweet and saline water, there exists a zone of brackish water. As freshwater is removed, the brackish water moves upwards and accumulates towards the bottom of the *virda*. 
3.1.1 Conclusion: Water Source
The water from thin air technology is very appropriate because of many reasons,
1. Works in arid environments
2. Low cost
3. Less maintenance
4. Optimization can be done.

3.2 Water-less Toilets Technologies
We now discuss innovative waterless sanitation technologies. The framework behind these technologies is that there are infrastructural inadequacies in sanitation in developing countries. Hence, it is impractical to expect that the people residing in these countries will be able to connect their homes to the not-existent-and-yet-to-be-built sewer and wastewater treatment plants. So how do we leapfrog and innovate beyond the socially accepted gold standard of sanitation? To achieve this, a water-less toilet should eradicate germs from human waste, recover valuable by-products like water and nutrition-rich fertilizer, operate off the grid (without any connection to a sewage system) and be affordable for people in the Rann of Kutch. The ultimate objective of these toilets would be to save lives.
We discuss some of these technologies below.

3.2.1 CalTech's Solar-Powered EcoSan toilet

Figure 10: EcoSan toilet in the Korba district of Chhattisgarh state. Source: WaterAid
This toilet is based on the solar-power technology developed by CalTech (Gupta, 2014). This toilet does not require water, electricity or plumbing and is suitable for water-scarce regions. The front of the toilet (which corresponds to the broader section of the toilet, see (figure 1) is used exclusively for urine, the middle portion collects faeces, and the end of the toilet is used for anal cleansing. The user can throw two handfuls of sawdust or ash after defecation to speed up the process of composting. Once the pit is filled with faeces, the toilet is closed and sealed, and within nine months, it turns to organic compost that can be used as a fertilizer in agriculture. While the first pit is sealed, the users can switch to the second pit. The urine and anal cleansing water undergo an electrochemical reaction that removes pathogens and turns them into clear and sterilized water. The water can then be reused for irrigation.

The creators also acknowledge that such technology is scalable only when the maintenance is easy. The group at Caltech is aware of such challenges and initially flew out to the different sites to fix minor recurring issues in their toilets. After that, they have devised a self-diagnosing maintenance system that uses inexpensive sensors to monitor the status. The sensors send an automated message to the local operators, who can then contact the team at CalTech. The team can then explain the solution on a video call and provide step-by-step pictorial instruction to repair the broken part. The technology was designed to anticipate such issues, and solutions are often simple; for example, a single screwdriver can repair every part.

3.2.2 Cranfield University’s Nano Membrane Toilet

Figure 11: The Nano Membrane Toilet displayed at the Reinvented Toilet Expo in Beijing. Source: (Drew, 2018)
Cranfield University's technology is a toilet bowl with a 'rotating ceiling flush'. Once the user is finished with their business, they close the lid, which drives further mechanism, hence eliminating the need for water to flush the waste. The toilet is also equipped with an odour barricading door that has been one of the major factors in enhancing the adoption of these toilets. The users' waste is collected in a holding tank with the liquid at the top and the solids at the bottom. The system converts the solid waste into small dry pellets that are fed into the in-built toilet combustor and converted into pathogen-free ash. This can be safely thrown away by the user. This combustion process warms the liquid waste, which is then passed through a nano membrane that removes pathogens and releases water that can be used for irrigation. The entire operation happens inside the tank, away from the sight of the people. Although the membranes need to be replaced once in three months, the servicing cost is low, around 5 cents (in US dollars) per user per day. (Drew, 2018).

3.2.3. Helbling’s HTClean Toilet

Figure 12: HTClean Toilet. Source: (ANSI Sanitation, 2019)
After the human waste enters the HTClean toilet, the user can choose the option for flushing from the black panel (see figure 3) depending on the need. The material is then moved through seven steps: the collection tank, the preheater, the reactor, the separator, the output tanks, the filter system and the flush water tank. After flushing, the combined solid and liquid waste is collected in the tank and fed into the preheated liquid chamber and heated to a temperature where it becomes as energy-efficient as possible. It then proceeds to the reactor and is heated to about 200 degrees Celsius. At this temperature, all the pathogens are killed, and the faecal biomass is transformed into charcoal. In the next step, another mechanical process separates the charcoal from the effluent. The users can then take out the solid output from the system and use it as an energy source. Finally, the remaining clear water is fed back into the flush-water tank, making the system independent from the fresh water supply.
3.2.4 Janicki Omni Processor

Figure 13: Janicki Omni Processor Source: (Cashman, 2020)

Figure 14: Janicki Omni Plant Source: (Cashman, 2020)
the Gates Foundation also funded the construction of the Omni Processor, a self-powered, smaller version of the wastewater treatment plant. This sewage system converts sewage into electricity, clean water and pathogen-free ash. When the sludge enters the system, it is boiled, separating the water vapour from the solids. Next, the dried sludge is fed into the fire and used to make high pressure, high-temperature steam. Next, the steam is sent to a steam engine that drives the generator to make electricity. This electricity is partially used to run the processor, and the remaining is delivered to the community. Finally, the separated water vapour in the boiling step undergoes a cleaning process to produce clean, drinkable water. Bill Gates promptly drank this water when he visited the plant, showing confidence in this marvellous engineering sanitation innovation. The plant is already successfully operational in Dakar, Senegal, serving around 100,000 customers without any additional power resources.

3.2.5 University of South Florida's NEW Generator treatment system

![Figure 15: USF's NEW Generator treatment system (Source: (USF, 2019))](image)

USF’s NEW Generator system stands for Nutrients, Energy and Water, which this generator recovers from human waste. When the liquid waste and solid waste enter
this system, they are processed as a single stream. The system uses a Nano-membrane filter (think of it as a much finer version of a coffee filter) that is lined up with faeces-digesting anaerobic bacteria (i.e., bacteria that does not live or grow in the presence of oxygen). These bacteria can filter water from human faeces. The recycled water can be used to run the system and for irrigation. It also generates nutrient-rich fertilizers in the process. This treatment system runs entirely on solar energy and can be easily attached to any existing toilet. (USF, 2019). Although all these solutions do not require electricity, are water-less, generate zero waste, but only EcoSan toilets have the additional characteristic of low cost. Hence, we recommend that we work further with the EcoSan toilets and leverage their technological innovation.

3.2.4 Conclusion: Water Source
The faecal management system and toilet go hand in hand. In our case we need to find we need to take care of odour, faeces, water availability and most important cost. Considering all the parameter we selected, Ecosan toilet because of following reasons:

1. Required less water
2. Low cost
3. Less maintenance
4. Can be modified as per requirement.

3.3. Faecal Sludge Management
There multiple ways to collect, process, dispose off the faecal sludge in India. Some of them are really old style like pit latrine were used. but as the urbanization increased the complexity has increased the concept of septic tank and sewage system started prevailing. Some of them are described in detail below (WHO, 2001).
3.3.1 Cartage
Cartage is the most basic form of excreta disposal—faeces are collected in a container and disposed of daily. An example is the bucket latrine, in which household wastes are collected in buckets under a hole in the floor of a specific room. Each day, the bucket is emptied into a larger container and the contents disposed of.

3.3.2 Pit latrine systems
In most pit latrine systems, faecal matter is stored in a pit and left to decompose. Unless specifically designed, pit latrines do not require periodic emptying; once a pit is full it is sealed and a new pit dug. If faecal matter is left to decompose in dry conditions for at least two years, the contents can be safely emptied manually and the pit reused.

3.3.3 Septic tanks
A septic tank is a form of on-site sanitation that provides the convenience of a sewerage system. It is usually linked to flush toilets and can receive domestic wastewater (or sullage). Since flush toilets tend to use large amounts of water, septic tanks are usually appropriate only for households with water piped into the home. The tank is offset from the house and linked to the toilet.

3.3.4 Aquaprvies
An aquaprvy is similar to a septic tank; it can be connected to flush toilets and take most household wastewater. It consists of a large tank with a water seal formed by a simple down pipe into the tank to prevent odour and fly problems. Its drawback is that water must be added each day to maintain the water seal, and this is often difficult to do unless water is piped into the home. The tank is connected to a soakaway to dispose of effluent. Unlike a septic tank, the aquaprvy tank is located directly below the house, but it, too, requires periodic emptying and must be accessible to a vacuum tanker. Aquaprvies are expensive and do not offer any real advantages over pour-flush latrines.

3.3.5 Sewerage systems
Sewerage systems are designed to collect excreta and domestic wastewater and transport them away from homes to a treatment and/or disposal point. All sewerage systems require water for flushing waste away. Conventional sewerage is a high-cost sanitation option; it is usually deep-laid and must be maintained by professional staff. Such a system is thus appropriate only where funds are available for operation and maintenance by trained staff. All sewerage systems should be linked to a treatment plant, as the raw faeces they carry represent a public health risk.

3.3.6 Conclusion: Faecal Management System
For faecal matter and toilet need to be upto the required. In our case we need to find we need to take care of cost, water availability and most important maintenance. Considering all the parameter we selected, pit latrine and Cartage because of following reasons:

1. No water require and ease of seperation
2. Low cost
3. Less maintenance
4. Can be modified as per requirement. And form a 3 hole system which separate area for water, urine and faecal disposal. These 3 different compartments are connected with different chamber.
4. Final Prototype/Design of the Sanitation System

For arid areas the major constraint is water availability. As water helps in diluting many of the component resent in fecal matter. One the important component is presence of Nitrogen contain in excetera which cause odour and create unwanted comfort. Compare to faecal, urine has higher content of nitrogen. It’s important to collect it separately and use it wisely or dispose off. For separation we used the idea mentioned in research paper (Fabiano, Danovaro, Olivari, & Misic, 1994). In which the researcher are trying to separate pseudo faece and faeces. The following figure depicts their representation.

In this process, samples of pseudo-faeces, faeces and water were taken and filtered through glass fibre filters (Whatman GF/C) in order to analyze lipid, protein, carbohydrate and nucleic acid content in faecal and suspended material. But we use it just to separate our faece matter and water present in it.

Then we need to add chamber which can decompose the faeces matter easily and without much of maintain. To decompose the faecal nature we need to add more of organic content, which will bacteria to multiple and speed up the decomposition process. Generally, there are 2 types of bacteria: 1) mesophilic bacteria which work in temperature range from $30^\circ C$ to $45^\circ C$, 2) thermophilic bacteria which work in temperature range from $45^\circ C$ to $80^\circ C$.

The organic content is increase to balance the concentration C:N ratio, which low in the case of faecal matter. For that we need to add more and more carbohydrates. To supply that we add cocopeat or coconut shell which are rich in carbohydrates. And saw dust which create a surface area for mixing of bacteria. faecal and cocopeat. Combining together we came up with following design.
This system consists of three drums which are connected which drain pipes another separated by a filter to segregate solid waste and liquid waste. The greywater drum collect all the water used in cooking, washing vegetable or hand and it reside at the same level of faecal drum. Further, the faecal collection chamber has 4 layer as shown in figure above. The liquid collection pan is connected with urine collection chamber. The urine chamber is at lower height compare to the tanks to create a gravity flow. And at regular interval the urine chamber is drained out by pumping it. And the faecal is turned into manure can easily collected in bags can sold after the salt production is finished.
5. CONCLUSION & FUTURE SCOPE

As a part of Sristi Summer School 2021, we managed to finalize the design for the low-cost sanitation solution for communities residing in the Rann of Kutch. We identified three major sanitation-related issues through a rigorous integrated approach: water availability, waterless toilet technologies, and faecal sludge management. We have identified low-cost solutions pre-existing solutions for each of the issues that are also suited for the arid regions.

To tackle water availability, we suggest generating water from the air; and for toilet, EcoSan toilet technology would be most suited. Our final design improves upon the EcoSan toilets and uses a novel faecal sludge management design. While the chambers of the EcoSan toilets separate urine from faeces, our novel design will percolate the urine from the faeces chamber in a controlled release manner. This will help in collecting the urine and faecal matter separation and as mentioned above it can disposed off.

In the future, we plan to take this project forward and construct a prototype of this toilet.
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