Final Design Report

LOW COST SANITATION FACILITY IN LITTLE RANN OF KUTCH

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May - June 2021

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Problem Statement

"A pair of black gum boots stands in the corner of Dhirubhai's temporary shack, his home for eight months in the Little Rann of Kutch. The shack built entirely of jute bags and plastic sheets and propped up by bamboo poles, houses nine members of his family. It is shaded a little by a babul tree from which hangs a rope swing.

Adjacent to the shack stretch the salt pans, beyond which lie miles and miles of barren, saline, cracked mudflats. These mudflats are intermittently broken by more salt pans, each with a solitary shack under a lone tree."

"A salt worker's hands and feet stiffen and at times water oozes out of our legs," "We receive 1,000 litres of water every 15 days," This scarce amount is just enough for drinking and cooking for her family of nine. Obviously, hygiene and sanitation are compromised. "We go every alternate day to Navagaon village, some 8 km away, to bathe."

The sun and salt also take a toll on their health. The searing blaze of the sun reflected by the salt pans causes early cataract and skin problems.

- The Hindu

The families of "Agariyas" move to the *Rann* for extracting brine and cultivating salt which takes around 8 months. As open defecation is prevalent, ladies hold up and control their bladder during daytime and cause damage to their health.

Primary Intended Beneficiaries

“Agariyas” (Salt-Workers) are the people who work in the Agar (Salt Pans) for their livelihood. In the little Rann of Kutch, 75% of the Agariyas come from the nearby village of Kharaghoda, a small town 40 kms from the Rann and 3 hours away from Ahmedabad.

Mission Statement

To address the problem of lack of good sanitation facilities for the Agariyas (salt workers) in the region of Rann of Kutch addressing several other issues faced by them.

Field Research Briefing

Introduction

The Little Rann of Kutch (LRK), a salt marsh in Gujarat, is a pristine, vast plain that stretches into the horizon. Sprawling over 3,570 sq. km, LRK is a unique landscape with characteristics of both wetlands as well as desert. This biodiversity of the landscape is due to seasonal rivers flowing through the area which goes on to meet the sea from the Gulf of Kutch.

The seasonal inflow of water during monsoon transforms LRK into a large, shallow wetland. In subsequent warmer months though, the floodwaters evaporate, gradually transforming it into a saline, dusty desert. These seasonal water dynamics makes LRK a highly productive landscape--both ecologically and economically.

This wetland is a source for one-third of India’s total inland salt production.

Problems Identified

1. Scarcity of suitable water for cleaning purposes

2. Inadequate potable water

3. Harsh climatic conditions

4. High diurnal range of temperature

5. Open defecation is a common practice.

6. Poverty and debts

7. Barefoot work culture (leads to callosities, corns and skin blisters).

8. Exposed electrical wires, open wells fatal for kids; also poisonous gases are present in wells- potential threats to health and safety of the Agariyas.

9. During the monsoon months of July- September, flooding results in water rising up to heights of around 5 feet.

Mind Map

Fig. 1. The mind map of overall problem

Decision Tree

Fig. 2. The decision tree to find out probable aspects for each and every problem

Problems Selected:

The entire problem has been categorized into three sections:

1. Desalination of the available brine to obtain water for drinking purposes/ Generation of clean water suitable for cleaning purposes.

2. Designing of the toilet system

3. Fecal waste management

This work mainly concentrates on the aspect of finding a solution for generating water suitable for cleaning purposes. Several methods for desalination of the available brine have also been looked into and their respective limitations have been pointed out.

DESIGN ITERATIONS

Prototype I:

Fig. 3. Failed Prototype I

EXPLANATION AND LIMITATIONS:

The water cone is a device that can be used to purify salt water (Ocean) and /or brackish water via Solar distillation. The material usually includes transparent plastics or thermo-formable polycarbonate. It is a conical, self-supporting and stackable unit fitted with a screw cap spout at the tip and an inward circular collecting trough at the base.

The mechanism requires pouring of salty/ brackish water into the pan. The watercone is then floated on the top. The black pan absorbs the sunlight and heats up the water to enable evaporation. The water that evaporates condenses in the form of droplets on the inner wall of the cone which then trickles down the inner wall into a circular shaped trough placed at the inner base of the cone. The cap at the tip of the cone is unscrewed and by turning the cone upside down, one can empty the potable water collected in the trough.

For our calculations, we have found out the measurements of the cone required to generate 50 L of water. The surface area of the cone required is found to be around 21.77 square meters which further yields that the slant height of the required cone as well as its base radius should be around 2.6 m. Thus, it would be extremely disadvantageous to build a cone with dimensions of base diameter being 5.2 m.

Prototype II:

Fig.4. Prototype II

EXPLANATION AND LIMITATIONS: The first idea was using sand filtration with a layer of charcoal and cloth in it. It is very commonly used in villages and the technology used is not complex as well. Before making a prototype out of it, the Pros and cons of the idea were studied and they are listed in the image. The major disadvantage of the idea was that the entire filter unit had to be made again (one time use) resulting in the second idea. As the sand in Little Rann of Kutch has high amounts of sodium benzoate as told by a native person from kharaghoda, the sand will not allow the water to percolate. Therefore this idea had to be dropped. The second idea was using a membrane like zeolite. There would be a container having zeolite as a filter and the pumped brine would be thrown on the membrane so that whatever pressure head the water has would be utilized by the water to travel through the membrane. The pros and cons are in the images. But Zeolite is very expensive and we wanted a low cost water generator. The related ideas are design changes that will try to cover certain cons and have a slight edge over the previous designs. The whole idea was rejected as there were no proper documents to support this claim. The prototype 3 was introduced to overcome the shortcomings of prototype 2.

Prototype III:

SUGGESTION: ATMOSPHERIC WATER GENERATOR

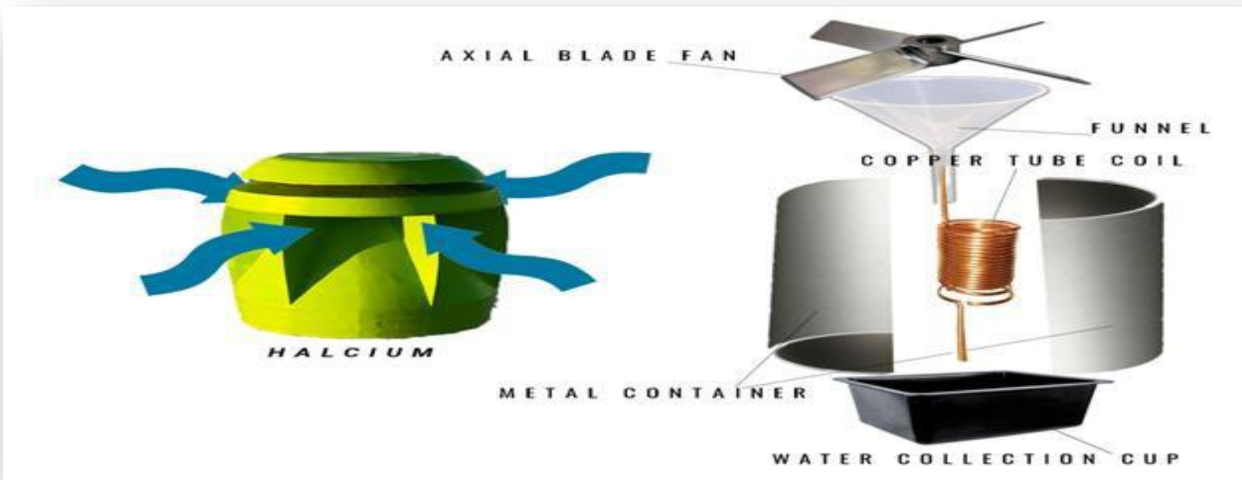

Fig. 5. Modified Ideation of Atmospheric Water Generator

Design improvements:

Fig. 6. Modificcations in the designs for proposed Prototype

FINAL DESIGN DESCRIPTION

- Existing Designs and its limitations:

From literature, it has been found that, among various methods, extracting water from atmospheric air is superior to mitigate the issue. Enough humidity and wind speed helps in concluding that, AWG* could be a good solution. Existing AWG has lower efficiency and higher cost. Moreover, existing AWG uses copper coils having larger pitch length and a fan. Instead of a fan, if a wind turbine could be installed at top and the shape of the coil could be changed into a vortex-spiral shape, then modified AWG will be more efficient. Likewise, several number AWG can be installed into the ground to mitigate the scarcity. The available AWG in the market is of high cost. Moreover, it draws more power and in that respect the production of water is very less. To find out the reason behind this, it has been observed that, existing AWG is using a normal fan of lower RPM and of higher cost. Moreover, we focus on the cooling coil, which also has less amount of turns, and pich distance is very high. From the literature, it is proved that, for better heat exchange and for better condensation, the high length should be kept minimum which results in more turns in the copper coil.

Motivation: After comprehensive observations, it was clear to us that, for better performance and more efficiency, there are two major portions in the design where we need to focus on. And for a very obvious reason, the fan and the cooling coil are coming into the picture. A high speed fan is needed which could draw more amount of atmospheric air and on the other hand, some copper cooling coil is required having lower pitch length and more turns. Moreover, the design should be made in such a way that it could create more pressure inside the copper coil. From literature it has been found that, if a pipe can be arranged in a vortex-spiral structure, in that case, it increases the flowrate of the water on the outer side and decreases the flow rate at the inner side. This results in a secondary flow rate of water. For the air stream also, the same kind of thing could happen and based on this, the copper coil's structure should be changed. Above all, the supply of electricity is also required. Keeping this factor in mind, if the work of a fan can be replaced by a wind turbine, in that case both the purposes can be solved. Wind turbine could generate electricity and on the other hand it could draw atmospheric air and deliver it to AWG although special modifications in the Wind Turbine are required.

Objectives:

- To design a WT, for AWG which could work in place of a fan. The blade of the WT needs special attention so that it could draw the atmospheric air and deliver it to the copper coil.
- The material for the blade of WT should be rust proof.
- There should be some mechanism for which at higher speed, (more than the cut off speed) the turbine will automatically stop and again it will start when it will go below the cut off speed.
- Designing a funnel which will increase the velocity of air and could create higher pressure before going through the copper coil.
- The copper coil needs a vortex-spiral shape which can do more heat exchange and consequently it could condense more air and production of water could increase at less time.

*AWG: Atmospheric Water Generator

Working: Air enters from all directions and as the area of cross section at inlet is decreased, it should travel more distance in one sec to conserve its mass. It means the velocity of air should increase at a narrower cross section. This has proven to increase the wind velocity by 33%*. The fan redirects the atmospheric air into the funnel followed by the copper tube coil. The air is compressed and its pressure and temperature increases. Now, we need to dissipate this heat for which the container would have to be wrapped by a wet cloth which would help absorb the rise in temperature of air due to compression and we would get condensed water droplets which is the purest form of water. Later, minerals like Ca and Mg could be added so as drinking distilled water could lead to deficiency in these minerals.

Challenges:

1) The main challenge is to increase the efficiency of the proposed device and get more potable water from the atmosphere only using renewable energy (WT in our case).

   All the existing AWGs require electricity to pump a liquid coolant in the copper tube around which condensed water droplets are produced. Moreover it increases maintenance cost and complexity, and won't be applicable in the context of the Agariyas.

2) Our system would make use of the humid and good wind speed conditions of the Rann of Kutch and could potentially help to produce a decent amount of potable water. We need to take advantage of the harsh climatic conditions of the night time, especially when the weather is very windy and the moisture in the air is more. If several AWG according to our proposed design can be installed then it could produce enough water for using it in the morning for sanitation purposes and other purposes also. Making that water drinkable by mineralising it is another challenge for us.

3) Though the work is under concept stage, few major calculations need to be done and the modifications in the design need to be performed. Above all, it is essential to visit that particular place where we want to install this AWG.

Without observing the ambience physically it is quite difficult to modify our design properly. However, from various literatures and expert comments, we are confident that the proposed product can solve the purposes regarding potable waters and electricity.

Future Work:

1. A CAD model to understand the mechanics and design aspects of the device. Performing Finite Element Analysis (FEA)for the device to withstand higher wind speeds without compromising structural integrity. Computational Fluid Dynamics (CFD) to understand the wind flow and design a better blade geometry to redirect the airflow more efficiently. If CFD is too computationally expensive, then on site testing with smoke to visualise airflow.

2. Fabrication of a working prototype and test it for the amount of water produced and further design improvements.

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