Warka Water Tower: An Innovative Method of Water Harvesting from Thin Air in Semi-Arid Regions

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Abstract: ***Semi-arid region is a region where the rainfall varies from 250 mm to 650 mm per year. Because of less rainfall, high evapo-transpiration, surface and ground water availability is very less in these regions. It leads to water scarcity and drought conditions. Conventional water harvesting structures are not suitable in these regions. Hence there is needed to go for alternative solution such as water harvesting from thin air. The aim of this research work is to find alternative method of water harvesting from thin air to overcome drinking water problems in semi-arid regions. The objective of this study is twofold, firstly to carryout comparative analysis of different water harvesting structures from thin air and secondly to carryout feasibility and cost analysis of Warka Water Tower in semi-arid region. In this research work, different water harvesting structures from thin air were studied and Warka Water Tower was found to be most economical and convenient because of its low initial cost, zero energy requirements and less maintenance cost and easy availability of construction material. The rate of discharge of a Warka Water Tower is 100 lit per day, however its efficiency can be increased with suitable conditions. Hence Warka water tower can be effectively used for drinking water purpose in semi-arid regions. In this study, feasibility analysis of Warka Water Tower was carried out and it was found that the structure is suitable at temperature 40 degree Celsius and relative humidity 50 -70 %. Cost analysis shows that the cost of a single warka tower is 33,000 rupees.***

Keywords: Semi-arid region, Warka Water Tower, water harvesting, drinking water supply

1. Introduction

Fresh water is available only 3% of total water. Less than 1% of the fresh water is accessible, in rivers, lakes, un underground reservoirs; the rest is suspended in the atmosphere or trapped in glaciers and the polar ice- caps. Water scarcity is difficulty in obtaining sources of fresh water for use during a period of time; it may result in further depletion and deterioration of available water resources. Water shortages may be caused by climate change, such as altered weather-patterns (including droughts), increased pollution, and increased human demand and overuse of water. water scarcity lead to about 20 to 50 % reduction in annual precipitation and surface runoff. Water scarcity lead due to very low amount of availability of surface water. Semi-arid climates are dominated by either grasses or shrubs because of water scarcity due to very low amount of availability of surface water. These regions are characterized by drying up of rivers, drying up of wetlands with losses of important habitats, heavy pollution of surface water and groundwater and depletion of aquifers. There is an urgent need to develop technological solutions that can provide enough water to serve rural which are normally isolated from conventional supply systems. Conventional water harvesting structures are not suitable in these regions because of low rainfall. Hence in semi arid region another source to get potable water from humidity available is thin air. The aim of this project work is to find out an alternative method of water harvesting from thin air in a semi arid region at less cost and greater efficiency to serve the rural community with the following objectives.

1. To carry out a comparative analysis of different methods of water harvesting from thin air.
2. To carry out feasibility and cost-benefit analysis of Warka Water Tower in semi arid region

2. Study Area

In this study the Marathwada Region which is a semiarid region located in Maharashtra state of India is selected as the study area because of the following reasons.

1. This area has been suffering from recurrent droughts because of the less rainfall (600 mm - 730 mm)
2. Drought caused by climate change is leading to reductions in the availability of fresh water supplies in some regions.
3. Temperature varies from 20 degrees (Night) to 38 degrees (Day) with a relatively humidity of 40-60%. The relative humidity exceeds to 85% in monsoon season. Hence there is a chance of harvesting the water from humid air in this region.

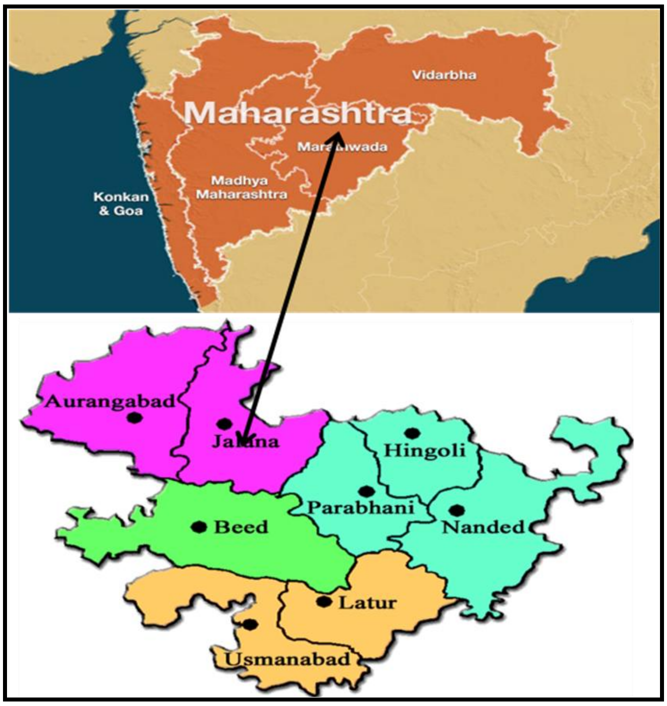

Figure 1: Location map of study area [7]

3. Methodology

The methodology adopted is shown in form of a flow chart below (Figure 2) and the detailed procedure of water harvesting from thin air is explained later.

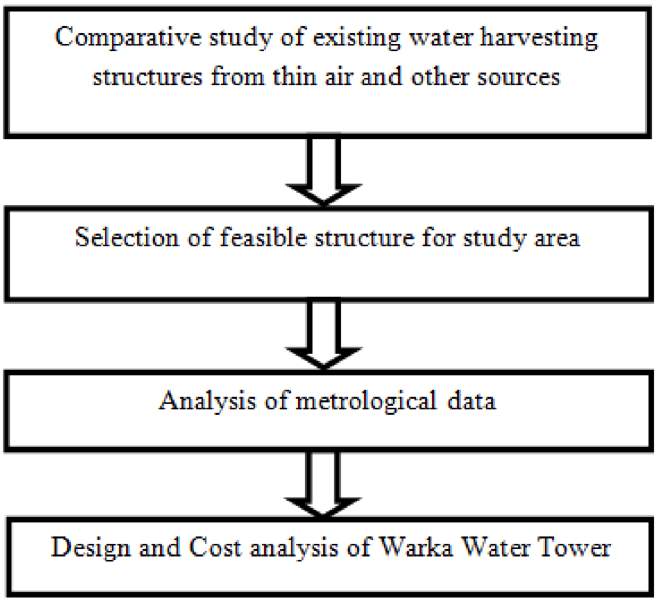

Figure 2: Methodology flow chart

Comparative study of existing water harvesting structure from thin air:

Different water harvesting techniques are found all over the world which is being implemented at different region in different countries as per suitable climatic conditions. Some of them are listed below.

a) Water maker: Water maker is a device, atmospheric water generator (AWG) which works on a unique technology called optimized dehumidification technique to extract and condense moisture in the air to produce healthy, purified drinking water. It is having an initial cost of Rs 4 lakhs and maintenance cost of Rs 3 per litre with energy requirement of 2.2-2.5 KW per day to run the device. It is suitable in condition where relative humidity varies from 50-80 % and temperature up to 40 degree Celsius. The rate of discharge is up to 110 lit per day.

b) Air well: An air well is a structure or device that collects water by promoting the condensation of moisture from air Design of airwells can be done in many ways, however the simple designs require no external energy source and have few moving parts. It is having initial cost of Rs 1.2 lakhs and maintenance cost of Rs 1.5 per litre with no energy required to run the device. It is suitable in conditions where relative humidity varies from 50-80 % and temperature is 40 degree Fahrenheit. Rate of discharge up to 110 litre per day.

c) Fog Collector: Fog collectors are nets slung between two poles. They are made of a polypropylene or polyethylene mesh which is especially efficient at capturing water droplets. When the fog rolls in the mesh, the tiny droplets of water cling to the mesh, and as more and more cluster together. Fog collectors are having initial cost of Rs 12 thousands and maintenance cost of Rs 1.5 per litre. It requires high altitude with fog condition and rate of discharge upto 400 litre per day, no external energy is required.

d) Skywell: Skywell, is pitching atmospheric water-generator systems, which extract water out of the air with its advanced water generators. The technology is comparatively simple, and works like a dehumidifier. Air is forced over a cooled coil, resulting in condensation of water. Each Skywell unit takes about 24 hours to generate 50-100 lit per day of water by consume about five to 8 kilowatt electricity per day. Its mechanical device cost is around 4 lakh rupees ($6300) and maintenance cost of Rs 5 per litre.

e) Warka Water Tower: Warka water tower is a vertical structure designed to collect / harvest potable water from the air. The basic concept behind this is when cool air pass through the mesh, mesh captures water, cool it and store in tank. It is suitable in condition where relative humidity varies from 50-70 % and temperature up to 40 degree celcius. No external energy is required to run this structure.

Table 1: Comparative study of different water harvesting structures from alternative sources

Characteristics	Water maker	Airwell	Fog harvesting	Skywell	Warka water tower
Initial cost	$6000	$2000	$200	$6000	$250
Suitable condition	Any where RH(50-80) TEMP(0-40 degree Celsius)	Any where RH(50-80) TEMP(<50 degree F)	High altitude with fog condition	Any where RH(50-70) TEMP(0-40 degree Celsius)	Any where RH (50-70) TEMP (0-40 degree Celsius)
Installation	Skill labour require to install and maintain it	No Skill labour require to install and maintain it	No skill labour is require	Skill labour require to install and maintain it	No skill labour is required
Principle	Device of dehumidification process	Structure and device is used for dehumidification process	Formation of water droplet	Device of dehumidification process	Formation of water droplet
Rate of discharge	110 lit/day	50-100 lit/day	100 gallon/day	50-100 lit/day	50-100 lit/day
Maintenance cost	$(0.2-0.3) per gallon	Less than $0.1 per gallon	Less than $0.1 per gallon	$0.3 per gallon	Less than $0.1 per gallon
Energy require to run	2.2-2.5kW /day	-	-	7-9 kW / day	-

Warka water tower is found to be most suitable from the comparative analysis of all the available water harvesting structures for our study area. A detailed description of the Warka water tower is explained here.

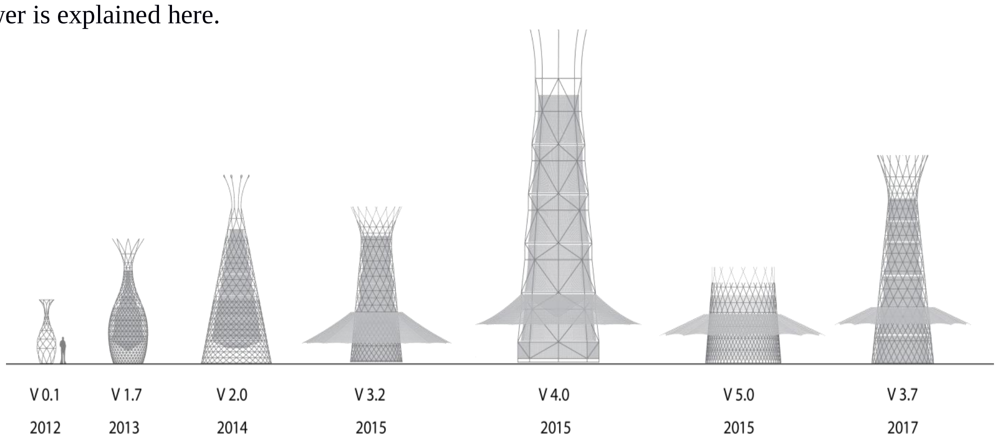

Figure 3: Structural revolution of Warka Water Tower [2]

The design and development activities of this structure have been mainly conducted at the Architecture and Vision labs, in Italy. A number of 12 prototypes have been constructed and WW has been assembled and constructed for test, demonstration, exhibition in several countries such as: Italy, France, Germany, Ethiopia, Brazil and Lebanon.

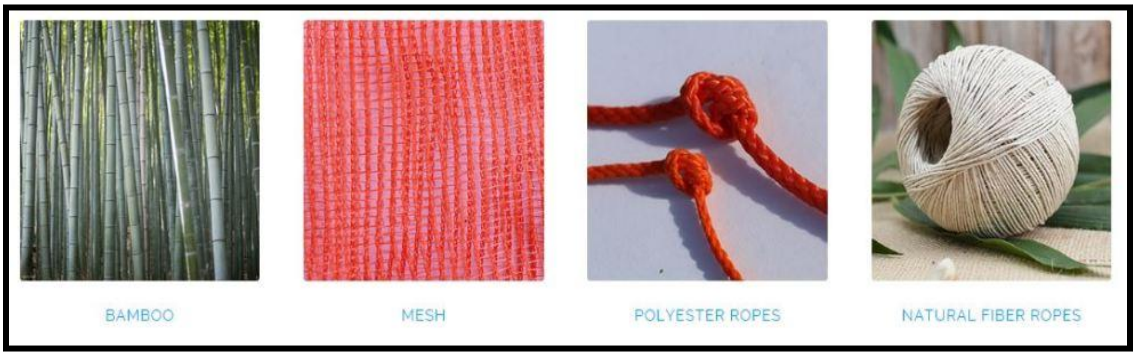

Figure 4: Materials of Warka Water Tower [1]

Warka Water Tower mainly uses local natural and biodegradable materials like bamboo, wiremesh, polyster ropes and natural fiber ropes (Figure 4). It is a temporary structure designed to not leave traces on the environment after removal and therefore doesn't require excavation or ground modification works for set-up. The Warka doesn't extract water from the ground. It can also be used for irrigation, reforestation and ecosystem regeneration apart from drinking water supply.

But this structure is works well only when the relative humidity of a region varies between 50-70 % and temperature up to 40 degree Celsius. Hence Meterological data viz. rainfall, temperature, cloud cover were collected from the IMD (Indian metrological department), Colaba from the year 1901 to 2001 for the feasibility analysis of the Warka Water Tower in the Marathwada region.

4. Results and Discussion

Analysis of Meteorological Data

From the analysis, it was observed that the average yearly temperature was 27.12 ^{o}C. It was also observed that 54 numbers of year received less than average temperature and 48 number of year equal and above the average yearly temperature out of total years under observation. From the average monthly wetday frequency analsyis, it was observed that the Jalna district had received maximum average wetday frequency in the month of July i.e. 8.39 days, and had received average minimum wetday frequency in the month of January i.e. 0.46 days out of total years under observation. From the annual average vapour pressure analysis, it was also observed that the maximum average vapour pressure was found in the year of 1996 i.e. 12.48 Kpa throughout the year. It was found that the average yearly vapour pressure was 10.985 Kpa. It was observed that 29 numbers of year received less than average vapour pressure and 73 number of year above the average yearly vapour pressure. From the above analysis it is clear that the temperature in the study area varies from 15.85 to 40.6 ^{o}C. Vapour pressure and cloud cover in the study area varies from 9.66 to 26.34 KPa and 0.46 to 8.39 days in months respectively. It was observed from the other sources that the Relative Humidity in the study area varies from 30 to 75%. (Source: Indian metrological department and world weather online). Hence warka water tower is feasible in this region.

Design of Warka water Tower

The warka water tower consists of four major parts such as stability structure, canopy's shade, Ropes and Mesh. (Fig. 5). The design considerations are done for a Warka Water Tower of height 9 meters which is the minimum height under which the WWT works well. The following dimensions are considered and calculated for a WWT of 9 m height.

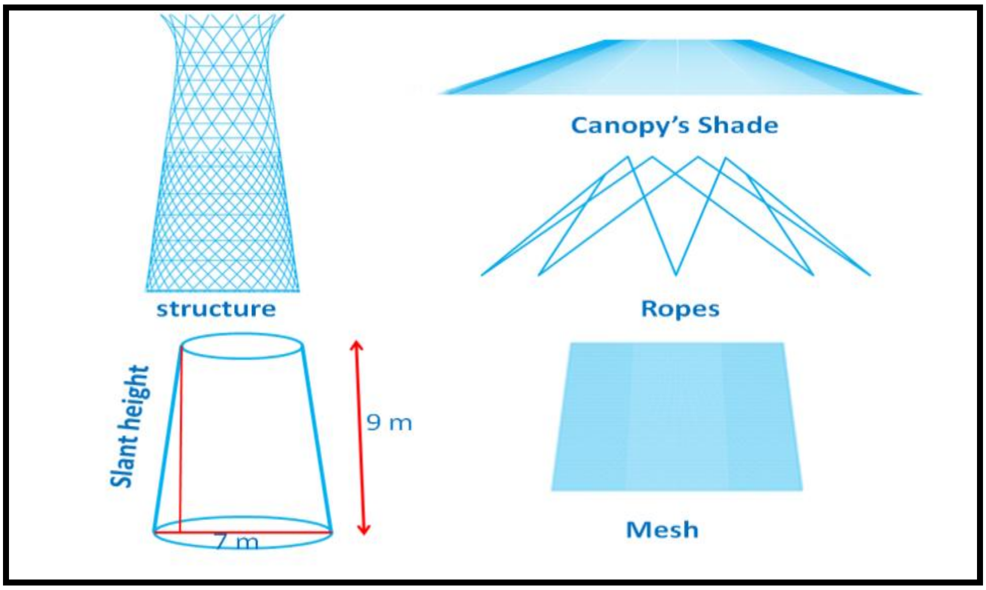

Figure 5: Parts of Warka Water Tower

Footprint diameter = (7,3) m
Diameter of canopy = 10 m
Slope of stability = 1 in 2.25
Slant height of tower = 9.85 m
Average perimeter of tower c/s = 15.71 m
Pitch height = 4.5 m (one spiral binding of splitter bamboos of complete one peripheral)
No. of spiral binding = 2
Length of each spiral binding = 16.34 m
Total length = 2 x 16.34 = 32.68 m
Perimeter of lower c/s = 22 m
Assuming space between two consecutive spiral = 0.5 m
No of spiral member required = 22/0.5 = 44 nos
Total length of spiral members = 32.68*44
Total length of spiral member = 1437.92 m = 4717.58 Ft
Ht of each bomboo = 5 ft having 6 fraction (spliters)

Cost Analysis of Warka water Tower

Considering a WWT of height 9 meters, total number of bamboo required = 200 nos, the cost of construction of a single WWT is summarized in table 1.

Table 1: Cost Analysis of a single Warka Water Tower

Main parts	Dimensions	Material of construction	Cost of materials In rupees
Funnel	5 m (Φ)		3000
Bamboo	200 of 5 fts height		20000
Mesh and ropes	30 sqm and 8 kg	Polymer mesh and natural fibres ropes	4000
Tank	1000 litre capacity	plastic	3000
Shade	60 sqm		3000
Total cost			**33,000**

5. Conclusion

This study aimed at finding a suitable water harvesting structure in a semiarid region from sources other than rainfall. Various water harvesting structures were studied and Warka Water Tower was found to be most economical and convenient because of its low initial cost, zero energy requirements, less maintenance cost and easy availability of construction material. The rate of discharge of a Warka Water Tower is 100 lit per day, however its efficiency can be increased with suitable conditions. Feasibility analysis of Warka Water Tower was carried out and it was found that the structure is suitable at temperature 40 degree Celsius and relative humidity 50 -70 %. The cost of a single Warka Water tower is calculated to be 33,000 rupees.

References

[1] Eswari R.A.K., "Warka Water Tower", International Journal of Advance Research, Ideas and Innovations in Technology, 2018; 4(4), 691-693.
[2] Warka Water Tower, available at http://www.warkawater.org/project/
[3] Fog Collector/Harvesting available at http://www.climatetechwiki.org/content/fog-harvesting
[4] Water maker abailable at http://watermakerindia.com/technology.php
[5] Skywell available at http://www.skywell.com/product/
[6] Airwell available at https://permies.com/t/airwell
[7] https://www.skymetweather.com/content/weather-news-and-analysis/why-marathwada-is-the-most-drought-affected-region