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Water issue and harvesting techniques for development in Nagaur district, Rajasthan

Pankaj Rawat
Delhi School of Economics, University of Delhi, Delhi, India

Abstract
Nagaur district of Rajasthan is severely affected form high fluoride concentration in ground water which leads to severe health issues. *Bankapatti* (banka-distorted, Patti-Belt) is a particular belt of Nagaur district where disability is commonality due to high fluoride concentrations in the ground water. The district experiences an arid to semi arid type of climatic conditions and characterized by undulated topography, moderately high degraded hills and sand dunes. Frequent monsoon failure resulting in widespread drought implies a deepening of the already severe water crisis. Fluoride contaminated groundwater and rainwater are the major source of water in district. In past, Nagaur district has over-exploited her groundwater without recharging the groundwater and creates a water famine. The food and water security of the Nagaur district is totally rely on the intensity of monsoon and ground water. The research attempts to discuss water related problems and possible feasible approaches of water conservation. Recharging of wells using latest water conservation and management techniques, rehabilitation of traditional water bodies systems, better planning of water use and proper education and awareness may aid present crisis.

Keywords: fluoride, bankapatti, groundwater, water crisis, water famine, water conservation, recharging groundwater

Introduction
Water Harvesting means capturing rain where it falls or capturing the run off village or town. It also measures to keep that water clean by not allowing polluting activities to take place in the catchment. These techniques can serve drinking water, water for irrigation and groundwater recharge. In general, water harvesting is the activity of direct collection of rainwater. The rainwater collected can be stored for direct use or can be recharged into the groundwater. Rain is the first form of water that we know in the hydrological cycle, hence is a primary source of water for us. In present times, we depend entirely on such secondary sources of water. In the process, it is forgotten that rain is the ultimate source that feeds all these secondary sources and remain ignorant of its value. Water harvesting means to understand the value of rain, and to make optimum use of the rainwater at the place where it falls. In Nagaur, the concentration of high fluoride in groundwater is due to natural as well as anthropogenic reasons like mining making it inappropriate for consumption. Nagaur district is an area where the effects of high fluoride concentration in ground water are very severe with results into the prevalence of diseases like dental, skeletal fluorosis, mental retardation, bronchitis, etc. Thus, an alternative source of water has to be adopted which brings forth the need of Rain water harvesting in Nagaur.

Statement of Problem
Fluoride consumed in excess amount may cause different types of health problems which affect metabolic activities of an individual. This can result into skeletal fluorosis, non uncerdyspepsia, polyurea (to urinate more frequent), polydispia (excessive thirst), muscle weakness, repeated abortions/still birth due to hampering of blood flow to foetus on account of hardening certification of blood vessels, oligosepermia (deficiency of spermatozoa in semen), low testosterone, discoloration of teeth enamel. The emergence of marble industry and hazardous, uncontrolled operations along with other factors resulted in cases of human impairments. The open mine sites release effluents into surface and ground water. These effluents contain high concentrations of toxic chemicals like Arsenic, cyanide and fluoride along with some less toxic minerals like copper and zinc. Even during mining and polishing of marbles, fluoride and marble dust are release which directly dumped into water. The problem of the area are low rainfall, high content of fluoride in ground water, high evapo-transpiration, moisture-scarcity, poor soil quality, less organic matter contents, poor moisture-holding capacity, limited number of rainy days and poor vegetative growth and lack of awareness and education.

***Source*:** By Researcher

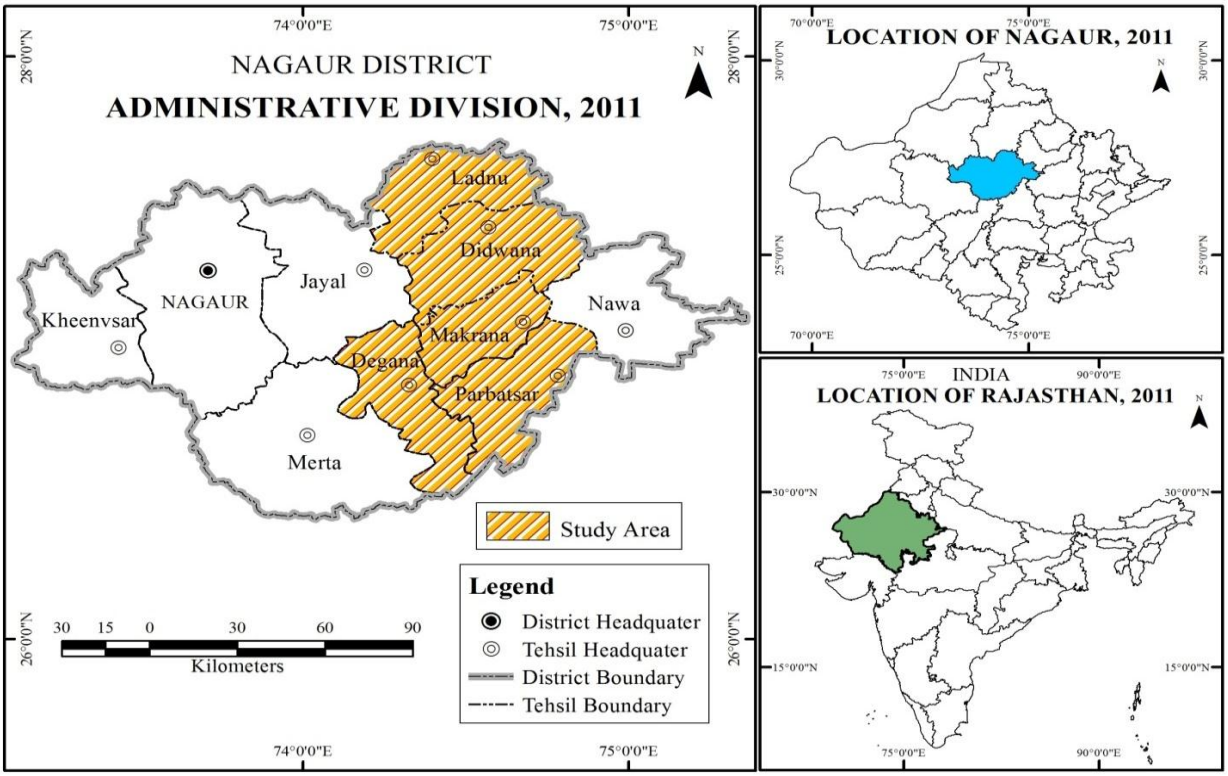
Fig 1: Marble Mining in Makrana, Nagaur

Objective of the research

The main objective of the study is to determine the water related problems in Nagaur districts and find out what could be the possible water conservation method for study area.

Study Area

Nagaur district is in central part of Rajasthan and covers an area of 17,718 km². District is located in extends between North latitudes 26°25' and 27°40" and East longitudes 73°10" and 75°15". It is bounded on north by Bikaner and Churu districts, on the east by Sikar and Jaipur districts, on the south by Ajmer, and Pali districts and on the west by Jodhpur districts. Its geographical spread is a unique combination of plain, hills, sand mounds and it is a part of the great Indian Thar Desert. According to census of India 2011, Nagaur district has a population of 3,307,743. Nagaur district has ten tehsils, in which Nawa tehsil has the highest number of villages (217) whereas Kheenvsar tehsil has lowest number of villages (92). Nagaur district has 1589 villages, out of them 1575 villages are inhabited and 14 villages are uninhabited. Nagaur district consists 80.7 percent rural and 19.3 percent urban population whereas the State percent of rural and urban population is 75.1 and 24.9 respectively. As the district lies in the desert area, the mean annual rainfall of the district is 41 cm and experiences 46ºC temperature in summers and 2ºC in winters. The high variation of temperatures in night and day also experienced in district. The economy of Nagaur district is mainly dependent on agriculture as 70.0 percent workers in the district are either cultivators or agricultural laborers. However the district percent of such workers is higher than the state average of 62.1 percent.



***Source*:** Prepared by Researcher

Fig 2: Study Area

Methodology and Database

The methodology of research is analytical and descriptive. The nature of data is in a form of publish and unpublished data. The primary data is collected with the help of observatory method, in-depth interview, group discussion and questionnaire to figure out the actual problem of the area. The random sampling technique used to collect data during the field survey in different villages of Didwana, Makrana, Ladnu, Degana and Parbarsar tehsils of Nagaur district. Different types of interaction were made with the local governing bodies i.e. Panchayat, women, local residents and persons suffering from fluoride related diseases. The secondary data is obtained from Indian Meteorological Department to study the patterns and occurrence of Rainfall and Drought. The use of secondary data is purely based on the purpose and theme of the research. The water samples from different sites are collected as primary data to understand the toxicity in groundwater. Primary data includes the total dissolved solid (TDS) and its analysis at the particular given temperature in different villages with the help of TDS meter. The data obtained during the survey was analyzed using both qualitative and quantitative forms. A triangulation of both quantitative and qualitative methods was used in order to give the research statistical and conceptual significance. The collected data is represented in the forms of table, charts and diagrams. Qualitatively, information gathered from the interviews, observations and key informants were summarized into statements and analyzed manually.

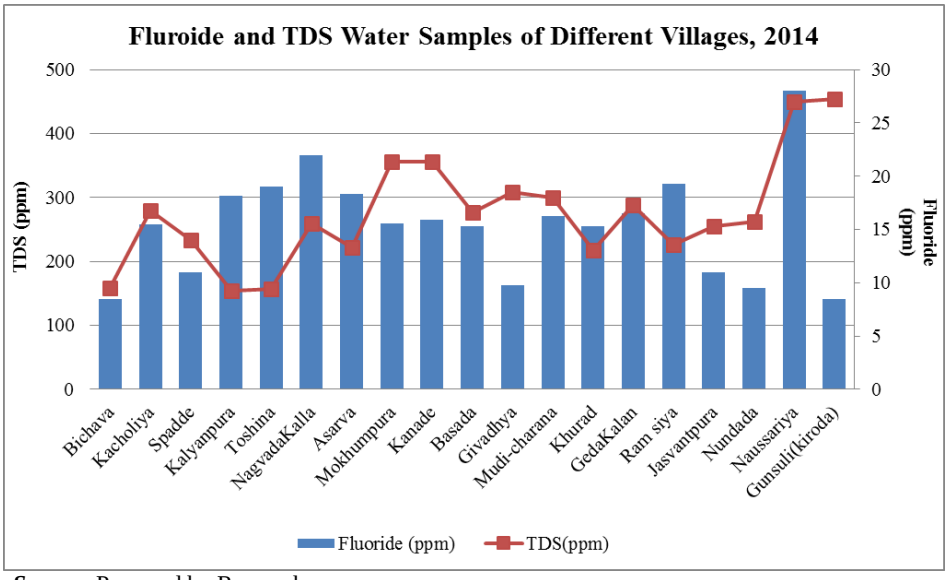
Result and Discussion

Water is one of nature's most important gift and essential to life. Nagaur receives less rainfall due to which groundwater is declining subsequently and salinity of water is increasing. Rainfall is a main source of surface water but the western Rajasthan lies in the arid and the rain shadow region because it receives less than 50 cm of rainfall for very short time period 2-3 months. The less availability of surface water puts immense pressure on groundwater. The groundwater level is decreasing day by day due to the over exploitation of it. Globally, fluoride in groundwater is known to contaminate the water sources. In surface waters, fluoride can occur naturally by the deposition of atmospheric derived particles and /or by fluoride-containing soils and rocks weathering and in ground water resources by leaching of rocks and soils. The problem of high fluoride content in drinking water has become a serious environmental issue in the field of water quality management and human health. Fluoride ions have dual significance in water supplies (Rana, 2015). Health is also in worse condition because of less water availability and poor quality of water due to high concentration of Fluoride and Nitrate. Due to the contamination of fluoride either bone is enlarged or become week consequent to which joint pain problem are quite common in this region.

Table 1: Fluoride toxicity in water sample of different villages

Village	Temperature(C)	TDS(ppm)	Fluoride (ppm)
Bichava	25ºC	158	8.50
Kacholiya	24.4ºC	280	15.50
Spadde	27ºC	233	11.00
Kalyanpura	32ºC	154	18.20
Toshina	32ºC	157	19.00
NagvadaKalla	29ºC	259	22.00
Asarva	27.9ºC	222	18.30
Mokhumpura	29ºC	356	15.60
Kanade	29ºC	356	15.90
Basada	31.6ºC	277	15.30
Givadhya	29.1ºC	308	9.80
Mudi-charana	26ºC	300	16.30
Khurad	21ºC	218	15.30
GedaKalan	30ºC	288	16.50
Ram siya	26.1ºC	226	19.30
Jasvantpura	27ºC	255	11.00
Nundada	24.2ºC	262	9.50
Naussariya	32ºC	450	28.00
Gunsuli(kiroda)	25.4ºC	454	8.50

***Source*:** Primary Survey, 2014



***Source*:** Prepared by Researcher

Fig 3: Water Samples

Causes of Water Problems

The cause of water problem in Nagaur district can be divided into two parts

Anthropogenic Problems

i) Mining activities

Mining occurs in the peripheral areas of Nagaur. It is a stretch consisting of parallel belts of mines can be observed within 2-3 kilometres. The depth of these mines ranges from 400-600 meters and it reaches or touches the groundwater. The mining areas are left as they are after the activities concluded. Thus further misbalancing is harming the ecosystem. After the mining activities are concluded the effluents released during the mining activities get discharged into surface and ground water. These effluents are believed to have high amount of toxic chemicals like Arsenic and cyanide along with some less toxic chemicals like copper and zinc. This release of effluent leads to increase in the acidity of the surface and ground water. Thus making it unfit for human consumption.

***Source*:** By Researcher

Fig 4: Visibility of Ground water due to Mining

***Source*:** By Researcher

Fig 5: Waste Dumps after Mining

ii) Waste dumping

During the cutting polishing of the marbles fluoride and marble dust is released and which are dumped into water which cause increase in fluoride and several toxic chemicals which make water unfit for human consumption.

iii) Over exploitation

Over exploitation of ground water table is cause of concern water from tube wells is a source used by locals which has led to decrease in ground water table up to 20-25 cm. The use of motors for the purpose of extraction has led to such decline.

***Source*:** By Researcher

Fig 6: Groundwater level from tube well

Physiographic Problem

i) Precipitation

Nagaur district is located in the rain shadow region due to the presence of Aravali hills which act as a cloud barrier and does not allow clouds to pass through them clouds which are at high altitude are able to reach Nagaur region and average annual precipitation of the region is 300-400 mm. The rainfall takes place from 10-15 days during a year in an irregular pattern this leads to water scarcity, ground water table does not get recharged or in case of less/ no rainfall it leads to adverse condition.

***Source*:** By Researcher

Fig 7: Aravalli hills creating rain shadow region for Nagaur District

ii) Temperature
Nagaur is located in Semi-Arid Region. Having average temperature in summer 40-45ºC and in winter 25-30ºC in daytime. In summer the rate of evaporation is very high thus leading to decreases in amount of water and soil moisture.

iii) Soil
Soil in Nagaur region is sandy which are finer in nature. Soil is porous due to the absence of clay due to which water cannot resist on the surface. Rocks in the soil profile have very high concentration of lime stones and sandstone (e.g. - Marble) which lad to high fluoride content in the soil. After percolation of water in these layers the water gets mixed with the element constituted by the rock leading to increase in amount of fluoride and salts in water. This in turn makes water unfit for human consumptions.

***Source*:** By Researcher

Fig 8: Sandy Soil for Agriculture

Topography
The topography/terrain of Nagaur is irregular and consisting plateaus as well as depressions. Water canals and water pipelines for human use cannot be constructed due to their high cost and irregular terrain.

Impact
The continuous degradation of surface and ground water, has led to serious consequences for the locals. The locals have experienced water problems ranging from health to economic activities.

iv) Economy
90% of the Nagaur village population is poor due to which they are not able to afford money to buy drought resisting seeds or HYV seeds and for higher education for their children. Due to poverty people are not able to build Pucca House so roof top rain water harvesting could not be implemented due to irregular rainfall. There is a higher possibility of crop failure and farmers face huge money loss. Loans are taken from village administration and farmers are unable to pay back the loans with high interest rates. Thus it results in loss of land.

Soil
Soil in Nagaur region is fine grained. It is good quality soil cultivation duly if potable water was available. Tubes well were installed on the fields, due to higher contamination of fluoride in soil get affected and farmer are unable to use land for cultivation for the next 10 years and suffers an economic loss.

Education
Most of the population of Nagaur is illiterate with women being the most uneducated. Woman are mainly engaged in household work are not allowed by the society to study or to do any kind of other activities. Due to lack of education people are unaware regarding the deteriorating water quality as people are uneducated they are not able to identify or counter these problem. As the quality of water is not good enough the local go too far off places to fetch potable water, thus reducing their time for education.

***Source*:** By Researcher

Fig 9: School in Makrana

Excess Fluoride: A Major Public Health Concern
Fluoride intake has negative effects in causing tooth enamel and skeletal fluorosis following prolonged exposure to high concentrations. Excessive fluoride intake usually occurs through the consumption of groundwater naturally rich in fluoride or crops that take up fluoride from high-fluoride irrigation water. In these areas, means should be sought to manage intakes by providing drinking-water with a moderate (i.e. safe) fluoride level or using alternative sources of water for irrigation. Although removal of excessive fluoride from

drinking-water may be difficult and expensive, low-cost solutions that can be applied at a local level should be developed. Acute high-level exposure to fluoride is rare and usually due to accidental contamination of drinking-water or due to fires or explosions. Moderate-level chronic exposure (above 1-1.5 mg/litre of water - the WHO guideline value for fluoride in water) is more common. People affected by fluorosis are often exposed to multiple sources of fluoride, such as in food, water, air (due to gaseous industrial waste). However, drinking water is typically the most significant source. A person's diet, general state of health as well as the body's ability to dispose of fluoride all affects how the exposure to fluoride manifests itself.

The toxic effects of high fluoride intake are due to the fact that it is a direct cellular poison, which binds calcium and interferes with the activity of proteolytic and glycolytic enzymes. Ingested fluoride reacts with gastric acid to produce hydrofluoric acid in the stomach. Thus, acute exposure to high concentrations of fluoride results in immediate effects: abdominal pain, excessive saliva, nausea and vomiting. Seizures and muscle spasms may also occur. Death due to respiratory paralysis is a possibility. The acute effects of inhalation of hydrogen fluoride are severe irritation of the respiratory tract, with coughing, choking and pulmonary oedema. Severe burns or prolonged visual defects may result from skin or eye contact. Inhalation or dermal exposure can be fatal. Repeated or prolonged exposure via inhalation of aluminium fluoride, primarily in occupational settings, may cause asthma. The main cause of respiratory disease is due to long term inhalation of high concentration of fluoride due to anthropogenic activities.

- Dental fluorosis is another major consequence of high fluoride intake which develops during tooth development. It is characterized by white patches on teeth which may result into stained and pitted teeth from reduced mineralization of enamel.
- Enamel /Dental fluorosis can develop only in children, as it results from intake of high levels of fluoride during the period of tooth development. It is characterized by the appearance of white areas in the enamel and in this form is considered an aesthetic issue. In the more severe form, reduced mineralization of the enamel results in stained and pitted teeth.
- In skeletal fluorosis, fluoride accumulates progressively in the bone over many years. Early symptoms include stiffness and pain in the joints. Crippling skeletal fluorosis is associated with osteosclerosis, calcification of tendons and ligaments, and bone deformities. There is an elevated risk of skeletal effects at fluoride intakes above 6 mg/day. These intake levels occur in many areas of the world because of naturally high fluoride levels in the groundwater.
- While the global prevalence of dental and skeletal fluorosis is not entirely clear, it is estimated that excessive fluoride concentrations in drinking-water have caused tens of millions of cases of dental and skeletal fluorosis worldwide over a range of years.

Plight of Banakapatti: Case Study

Most of the population in Nagaur Villages are facing various health disorder/issues due to unavailability of portable water. Fluoride accumulates in human body leading to curving of bones and joint pain. Jitu, a 9 year old boy in village Geda of Nagaur district has dreams in his eyes but is caught in the web of circumstances dimming his future. While boys of his age chirp around, the little kid is confined to the four walls of his home. Bearing stiffness and pain in his joints, he is one of the many suffering from 'Skeletal Fluorosis '. Jitu is a perfect depiction of the situation prevailing in Bankapatti where contaminated ground water has taken a toll on health of common people.

He isn't an exception, as Mathura Devi, a 64 year old woman from Asarva village is restricted from normal movements had enlarge joints due to regular intake of ground water. This is due to the fact that fluoride disturbs calcium absorption pathway which results into enlarged joints. These are all cases of abnormal morphology of skeleton, called Skeletal Fluorosis as it has resulted from high intake of fluoride i.e. above 6mg/day.

***Source*:** By Researcher

Fig 10: Enlarged joints of a woman

Ganga Ram, 45 year old man from same village suffering from curved/concave shaped legs owing to consumption of contaminated water from ages with the high amount of fluoride concentration

***Source*:** By Researcher

Fig 11: Concaved shaped leg of a man

Kannu Devi, 60 years old, who developed osteoporosis type1 disease on reaching age of 45 years when she started bending from waist. An explanation to this is that after menopause there is decrease in the level of hormones (oestrogen), iron, folic acids and vitamin B12 which are responsible for absorption of calcium in bones. So, there is also decrease in calcium absorption because of which many people witness bending of vertebral column.

***Source*:** By Researcher

Fig 12: shaped bent of a woman

Poornima Kumari a 18 year old girl had yellowish teeth which caused by Dentine fluorosis with the increase in level of fluorine there is decaying of enamel which cause discoloration and lead to falling of teeth. Parbhu, 68 years old from Toshina village had reportedly developed dental fluorosis during childhood which accelerated with continuous consumption of contaminated water for all through his life.

***Source*:** By Researcher

Fig 13: Dental fluorosis

Government Initiative

The RO water system is setup by government under the provision of National Rural Drinking Water Mission. The TDS level of these RO systems was recorded in between 25 PPM to 36 PPM which is the under the drinking water standards (Below 90 PPM water is permissible limit of drinking water). It was very surprising to see that RO systems set up by government in few villages haven't found any takers for a minimal price of water at 10L/1Rs even. It is still to be understood by people in Nagaur that Prevention is always better than cure, and many diseases can't even be cured, thus proving to be fatal lifelong.

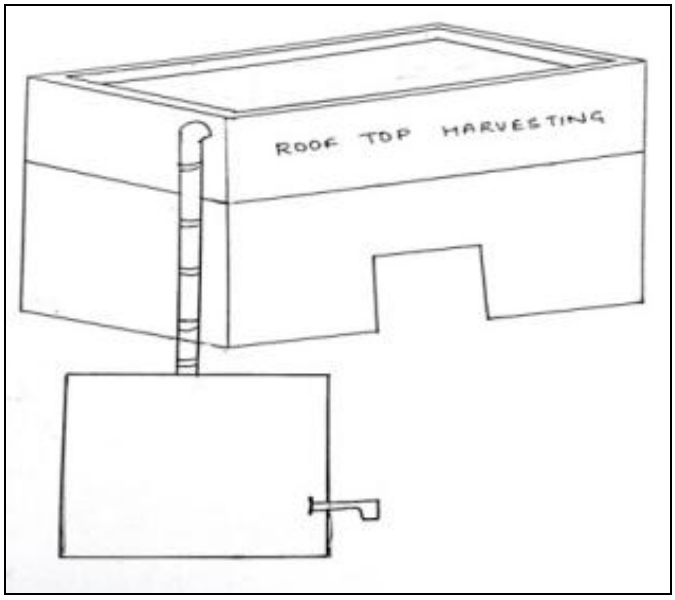
***Source*:** By Researcher

Fig 14: Government RO System

Water Harvesting Techniques: Remedy for Nagaur habitat

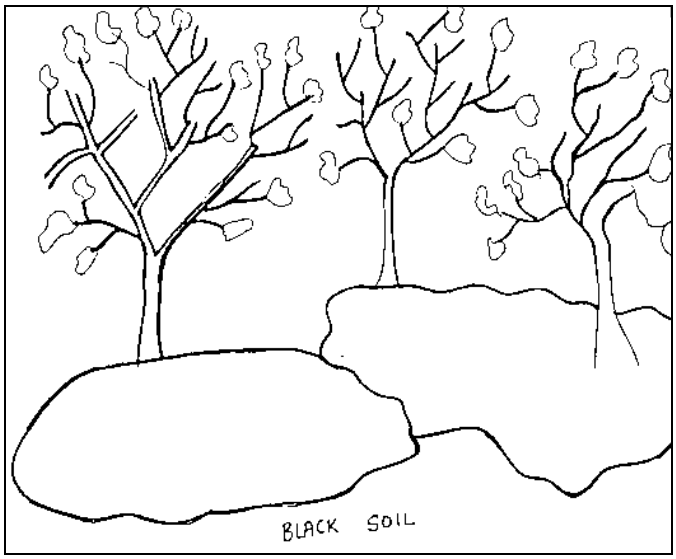
Water harvesting can play a major role for tackling different health hazard. Through the research, various water harvesting techniques have been suggested to solve various water related health problem. Umbrella, Inverted roof top, Roof top rain water harvesting techniques can be implemented on an individual basis but meagre economic conditions impose a barrier on their adoption. The only feasible solution is Community tank rain water harvesting technique which is also hindered by untouchability. On the other hand, lack of irrigation facilities have led to one cropping system. Therefore, curved road, khadin, jalabh, sand dune technique along with drip and sprinkler irrigation can be used to increase land productivity. The solely solution of major problem of the concerned area is water harvesting through different techniques which are mentioned below:-

i) Roof Top Rain Water Harvesting Technique:



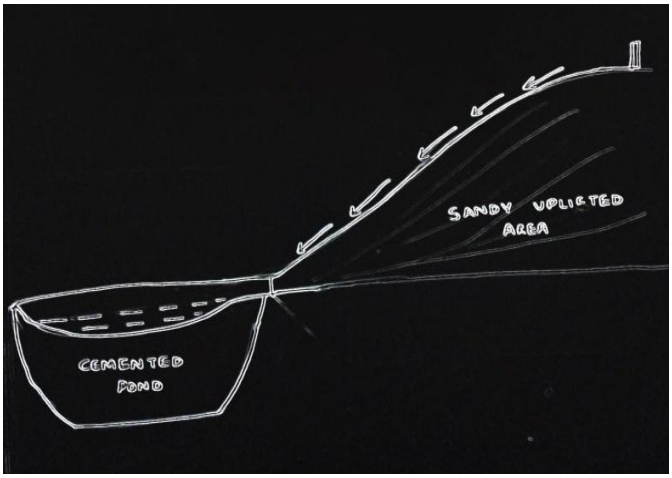
ii) Depression

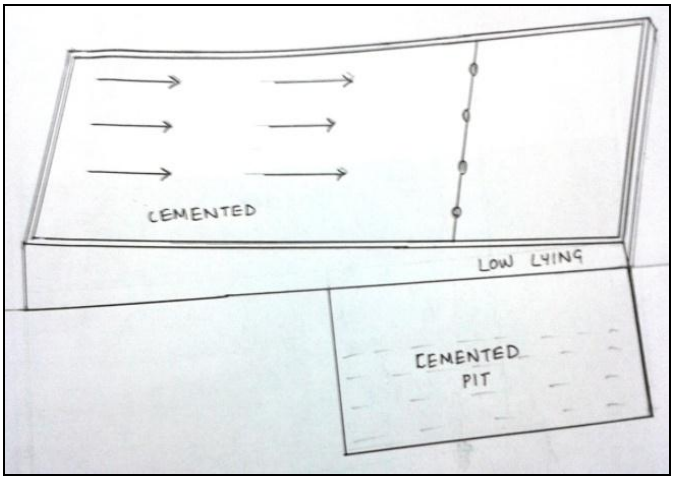
The depression is surrounded by slope. The rainwater is collected in a depression which resist on the surface due to the presence of black soil.



iii) Pit

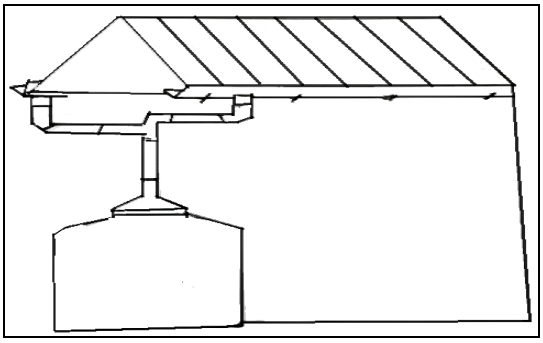
The pits are drug and the base of the pit is cemented for the purpose of collection of rain water. The pit can be used for irrigation/cultivation and drinking purpose. Barren land is cemented in such a way that water is collected at the central point in a storage tank in a circular shaped structure or water is collected in storage tank located at the end of rectangular shaped structure.





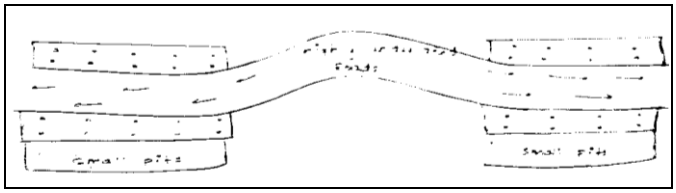
iv) Umbrella Technique

In this technique the roof top which is conical in nature, is covered with plastic so that the rainwater which falls over it slide down towards the edge and is collected in the tanks.



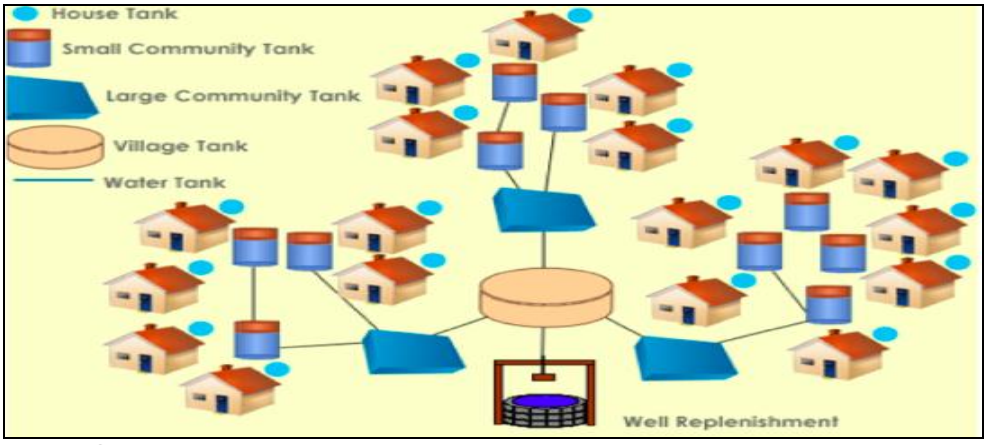
v) Curved Road Technique

The road is constructed in a curved shape. Water from the rain falls on these roads quickly descends towards both sides of the road and its collected in a canal like structure which then collected in a storage tank at the area which is easily accessible by the locals.



vi) Central Rain Water Harvesting Technique (Community Tanks)

The rainwater is harvested from the roof top to a smaller chamber which is connected to a main central pipeline. The central pipe lead to a main central chamber/ tank which has various inlets from different side coming from different houses. The main central tank will have a single outlet.

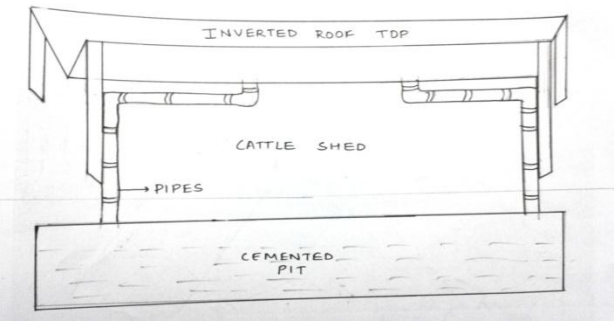


***Source*:** pinterest.com

Fig 15: Community tank

vii) Inverted Roof Top Water Harvesting Technique

Inverted Roof top rain water harvesting is the accumulation of rain water on the inverted roof top and that water goes through a pipeline, which is connected to a storage tank and water is collected and stored in water storage tank.

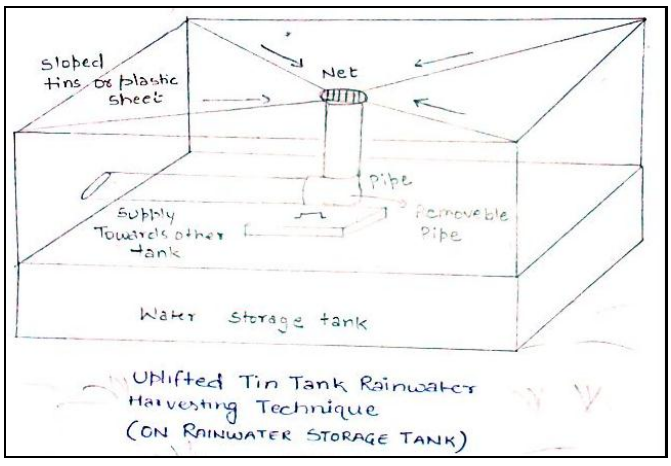


viii) Uplifted Rainwater Harvesting Technique

This technique is very appropriate for the rainwater harvesting system. In this application, we have to stand a sloped tin/plastic body over the water storage tank. Cover the tin body with plastic sheet so that rain water accumulates over the slope will fall down through a pipe, and flows down into the tank for the equality of the rain water, put a filtration net on the top of the pipe, so, that water flows down into the water storage tank pure. When the tank full, it will overflow. So, to save that overflowing water, use will put a removable pipe, connecting with the pipe, so that through that removable pipe, the water flows to the other or can be used for other purposes.

ix) Uplifted Tin Tank Rainwater Harvesting Technique

The technique is the second part (B) of the uplifted tin tank rainwater harvesting. In this technique, we can utilize the usual cemented tank by covering the tank with a fiber/tin /plastic in a sloping manner's. The fiber plastic can be used on the top of the tank and can also be used middle side of the tank so that the rainwater flows down through a pipe, which is connected with a community tank for the people.



Khadin/Johar

This ingenious construction harvests surface runoff water for use in agriculture. Its main feature is a 100-300m earthen embankment built across lower hill slopes lying below gravelly uplands. Sluices and spillways allow excess water to drain off. The Khadin system is based on the principle of harvesting rainwater on farmland and subsequent use of this water-saturated land for crop production.

***Source*:** By Researcher

Fig 16: Johar

Conclusion

Nagaur, a district in north-western part of Rajasthan is adversely affected by an epidemic like situation arising out of non-availability of potable water. Natural and anthropogenic reasons have contributed to contamination of ground water which now has contents of fluoride and other toxic chemicals. Ground water consumption hasn't seen a noticeable decline with generations leading to prevalence of diseases like Skeletal and Dental Fluorosis in a particular belt of district known as Bankapatti. In such conditions, rain water harvesting techniques as per se precipitation, structure, household need, economic viability can be applied to suffice for essential water needs of a family or for other purposes. The techniques proposed for Pukka house owners are Umbrella, inverted roof top, roof top water harvesting; feasible technique for Kuccha house owners is Community tank; for irrigation purposes curved road, Khadin, Jhalabh and Sand dune technique can be applied. Water is the prime cause of distress and the only hope for the people of Nagaur.

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