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RAINWATER HARVESTING: AN OPTION FOR DRYLAND AGRICULTURE AND POTABLE DRINKING WATER IN ARID AND SEMI-ARID IN MERTA BLOCK OF NAGAUR DISTRICT RAJASTHAN, INDIA

B. R. Rojh, Ravi Patel, Laxman Siyol, Bhakar Ram, Hakim, Jaina Ram, Pratap Ram
Department of Geology, Faculty of Science, Jai Narain Vyas University, Jodhpur
E-Mail-brownrojh89@gmail.com

ABSTRACT:

Rainwater Harvesting is the principle of collecting and using rainfall from a catchment surface. Due to the regular occurrence of draught in Rajasthan, the rainwater harvesting structures like Tanka, Anicut, Pond, Nadi, etc., are constructed by local peoples to fulfil their water needs. They are doing rainwater harvesting either for drinking or for agricultural purposes since time immemorial. In Rajasthan, Nagaur district is a part of the Thar Desert and has experienced issues of declining groundwater levels, high salinity, and fluoride and nitrate concentrations in form last few decades. The Nagaur district is divided into14 blocks (PanchayatSamitis), and one of them is Merta. Groundwater forms a major source of drinking water in the district as well as in the Merta area. Straight use of groundwater for industry, agriculture, city supply, and non-completion of surface water schemes is laying stress upon groundwater. The situation can be slowed down by launching massive rainwater harvesting and recharging programmers in the Nagaur district. Many methods are available for harvesting rainwater. The choice of a method depends upon the suitability of a particular site. Residents are constructing tanksin every house for the storage of drinking water. These tanks can be connected to the roof of houses to collect rainwater. JK White Cement Works has constructed artificial recharge structures (pits with bore well technology) near Dhanpa village, resulting in increased groundwater levels and quality improvement in the surrounding areas. Rainwater harvesting and artificial recharge methods are interlinked and dependable on one another.There are two main techniques of rainwater harvesting:

(a) Storage of rainwater on the surface for future use

(b) Direct recharge to groundwater

Rainwater harvesting can be admitted in urban areas by the collection of rooftop water for recharge and domestic purposes. This water can be collected in an underground water tank constructed within the house. It is fresh water and free from TDS and other pollutants. It is good for drinking and cooking purposes. In any rural area getting low to moderate rainfall during a single monsoon season, a sustained effort of water conservation of in situ rainfall is required. Other than collecting rainwater in underground tanks, the importance of rainwater harvesting lies in recharging aquifers by artificial methods. The artificial recharge of groundwater is the process by which the infiltration of surface water into the groundwater system is increased by modifying the natural movement of surface water by utilizing suitable construction techniques. There are different methods available for rainwater harvesting like Gully plugs, Bench Terracing, Contour trenching and bounding, rockfill dam, Check dam, Percolation tanks, and Subsurface dams. The main objectives of the artificial recharge of groundwater are to enhance the water table, decrease the dark zone, expand

the life of the aquifer, reduce runoff and soil erosion, to decrease the hazards of floods and get better soil fertility.

KEYWORDS : Groundwater management, Recharge structures, irrigation method Merta Block, Nagaur

INTRODUCTION:

The development of life on earth and human progress depends strongly on the availability and use of water, and globally, freshwater resources like groundwater contribute significantly in meeting the demands of domestic and agricultural wate. Over 55% of India's population, which is home to 15% of the global population, relies on groundwater for an array of different activities, such as irrigation, water for cattle, domestic consumption, and industrial uses.Rajasthan is the driest state of India, and Western Rajasthan is well known for its drought and Thar desert. As early as the third millennium BC, farmers in Baluchistan and Kachchh impounded rainwater and used it for irrigation dams (CGWB, UNESCO, 2000). The Thar Desert faces an acute water crisis due to deficit rainfall, high evapotranspiration, declining groundwater levels, and especially its poor chemical quality. In India, where rainfall patterns are highly variable, rainwater harvesting has been used for centuries. Applied to aquifer recharge, the principle is to store a fraction of the vast runoff volume generated during the monsoon, increasing its residence time and allowing it to percolate into depleted aquifers. It has received growing attention from governmental and civil institutions and was included in the central government policies on groundwater management in the 1990s.

The word"rainwater harvesting"(RWH) is used in a variety of contexts, and no one classification has been established (Ngigi, 2003). It can, however, be described as the collection and storage of excess seasonal runoff and its diversion for domestic and agricultural uses (Hatibu and Mahoo, 1999). Any technology that collects rainwater and makes it usable for home or agricultural uses is referred to as RWH (Liniger et al., 2006). A strategy for causing, gathering, storing, and preserving local surface runoff for agriculture in dry and semi-arid locations is known as rainwater harvesting, according to Nigigi (2003). It is regarded as the single most crucial method for raising agricultural output and offering a source of home water supply in places vulnerable to drought (Getaneh and Tsigae, 2013).This allows for the cultivation of crops twice or more a year and the option of supplemental watering during periods of early rain. Roofwater gathering, in-situ water harvesting, runoff harvesting, floodwater harvesting, and subsurface water harvesting are all types of rainwater collection (Finkle and Sergerros, 1995). Reliable water production and supply, efficient water use (increasing rainwater productivity), and less adverse influence on natural resources are the cornerstones of RWH sustainability (Pachpute et al., 2009). Rainwater harvesting systems are often divided into two categories: runoff-based systems (catchment and/or storage) and in-situ water conservation techniques, such as small basins, pits, and ridges (Awlachew et al., 2005).Usually, supplemental irrigation uses the storage system. Up until recently, Ethiopian storage plans were dominated by in-situ technologies, which increased soil penetration and water holding capacity. In-situ rainwater harvesting techniques (IRWHT), which maximise the advantages of rainfall where it falls, are widely used and have positive outcomes, particularly in semi-arid zones (Li et al., 2000; Tian et al., 2003; Li et al., 2006; Ito et al., 2007; Oloro et al., 2007; Rockström et al., 2009; Vohland and Barry, 2009).The well-known Banka Patti (banded skeleton), suffering from acute dental & skeleton fluorosis, is also situated in parts of the Nagaur district. In view of the deteriorating groundwater scenario. Merta region experiences not only surface water scarcity but also declining groundwater levels along with its poor quality due to high salinity and high fluoride and nitrate concentrations. Therefore, rainwater harvesting and artificial recharge are very good options for groundwater management in the Merta region of the Nagaur district, Rajasthan.

Study area and Physiography:

Rajasthan is a northern state in India, also known as the desert state of India, and has an area of 342,239 km^2, which is 10.4% of India's total geographical area. It is the largest state in India by area and ranked 7th in the population of the country. The majority (91%) of the population's drinking water is groundwater, and 66% of the aquifers in Rajasthan are overexploited

Geographic location:

The Nagaur district is part of the Rajasthan state and has been divided into14 blocks (Panchayat Samities), and one of them is Merta Block. Merta Block is located between 26°26'18"N and 26°51'00"N and 73° 41'45"E and 74°17′24″ E (Fig. 1). It covers 8% area of the Nagaur district. Groundwater forms a major source of drinking water in the district as well as in the Merta area. Straight use of groundwater for industry, agriculture, city supply, and non-completion of surface water schemes is laying stress upon groundwater. The situation can be slowed down by launching massive rainwater harvesting and recharging programs in the Nagaur district.

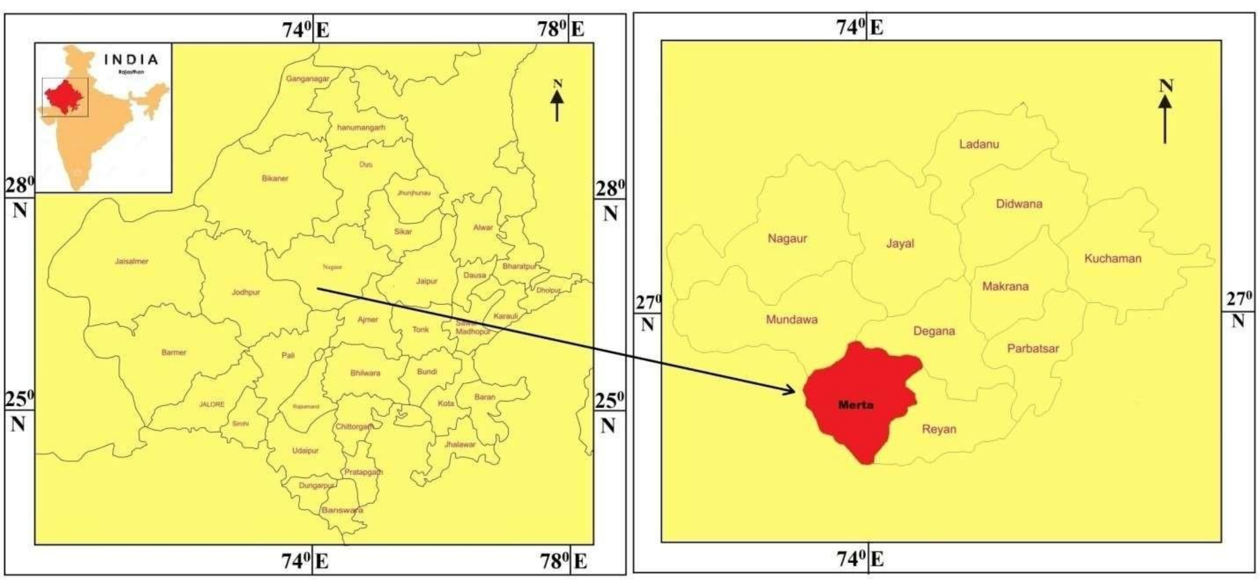

Figure 1-Location map of the study area, Merta region of the Nagaur district, Rajasthan.

Climate & Rainfall :

The district experiences an arid to a semi-arid type of climate. Both day and night temperatures increase gradually and reach their maximum values in May and June, respectively.

The temperature varies from 46 degrees in summer to 7 degrees in winter.The majority of the Mertablock is barren and lacks vegetation coverage, which indicates little water is present. The soil types are mostly sandy, loamy, saline, alkaline, and chalky (calcareous).
The mean annual rainfall is 363.1 mm. The atmosphere is generally dry except during the monsoon period. Humidity is the highest in August with mean daily relative humidity at 80%. The annual maximum potential evapotranspiration in the district is quite high, and it is the highest (255.1 mm) in May and the lowest (76.5 mm) in December.

GEOLOGY AND HYDROGEOLOGY:

The regional geology suggests that aquifers in this region comprise hard rocks of the Bhilwara Super Group, comprising granulitic gneisses, quartz mica schist, phyllite, and granite pegmatite intrusive (CGWB, 2013). The study area is a part of the Marwarsupergroup and comprises the Jodhpur Group, Bilara Group and Nagaur Group from older to younger, respectively. The presence of red sandstone and limestone found in these groups at varying depths, accompanied by weathered and fractured zones. In these aquifers, groundwater movement is controlled by the pore size, continuity, and interconnectivity of weathered and fractured parts. As the primary porosity is very poor in limestone and secondary porosity in weathered and fractured parts is important.Hydro geologically, the block can be classified into three formations, viz. consolidated formations, semi-consolidated formations, and unconsolidated formations.

Consolidated Formations:

Consolidated formations comprise limestone & sandstone of the MarwarSupergroup (Roy &Jakhar, 2002; Vyas et al., 2015, Anon 2013 a & 2013 b). Jodhpur sandstone mainly consists of medium to coarse-grained sand, cemented with silica and ferruginous matrix. The sandstone is intercalated with siltstone and shale. The sandstone is hard and compact, and forms a medium potential aquifer. Bilara limestone forms the most important and potential aquifer comprising limestone, dolomite, and shale. Dolomite/limestone is cavernous at places and susceptible to solution activity which gives rise to high discharge in wells and tube wells. Nagaur sandstone is coarse to fine-grained, loosely cemented with a gravelly basal part that acts as a good aquifer.

Unconsolidated Formation:

Quaternary alluvium is the potential aquifer which is comprised of unconsolidated to loosely consolidated fine to coarse-grained sand with intercalations of silt, clay, and ‘kankar’. Groundwater occurs under unconfined to semi-confined conditions in Quaternary alluvium. Its thickness is up to 200m.

RAINWATER HARVESTING STRUCTURE COMPONENTS :

Rainwater Harvesting is the principle of collecting and using rainfall from a catchment surface. As the regular occurrence of draught in Rajasthan, the rainwater harvesting structures like Tanka, Anicut, Pond, Nadi, etc., are constructed by local peoples to fulfil their water needs. They are doing rainwater harvesting either for drinking or agricultural purpose; therefore, Rainwater harvesting structures have three basic components:

1. Catchment area, i.e. the surface area utilized for capturing the rainwater.
2. Collection devices, like tanks or cisterns or percolation pits used for collecting or holding the water.
3. Conveyance system, i.e. the system of pipes or percolation pits through which water is transported from the catchment area to the collection device.

Rainwater harvesting system for the village community is designed in a locality where there is a scarcity of water. The annual rainfall in the Merta block is 511.6 mm per year. The water is supplied by the panchayat/local authority on alternate day. In the case of the summer season, the water is supplied by tankers therefore, it is proposed to conserve the rainwater to increase the groundwater level and also complete the water demand of the local people in future. It is proposed to conserve rainwater collected on top of every house, and a common rainwater harvesting system is designed for a group of 10 houses of the study area having an approximate area of 70 m^2 each.Therefore, two case study on rainwater harvesting of the study area has been discussed below.

CASE STUDY OF RAINWATER HARVESTING :

Rainwater Harvesting in the catchment surface is a good step towards increasing the groundwater level and meeting the demands of the local people in the study area. Due to the regular occurrence of draught in Rajasthan, the rainwater harvesting structures like Tanka, Anicut, Pond, Nadi, etc., are constructed by local peoples to fulfil their water needs. The following case studies have been chosen for rainwater harvesting and artificial recharge.

CASE STUDY:I

Rainwater harvesting system for annexure building of Govt. School, Chapari is being considered for study purposes (Fig. 2). The Government School, Chapari is located in the Merta Block Nagaur District region of Rajasthan State. The average annual rainfall of Nagaur town is around a range of 400 to 600 mm/year. The population of the city is more than lakh. Presently the water is supplied to the town by, Nagaur. Considering the capacity of the water treatment plant, the water is supplied to the town on an alternate day. The institute needs water about 350 m^3 per day. In the last few years, it has been observed that the groundwater level of the town has been depleted. It is essential to conserve rainwater not only in the city itself but also in areas surrounding Merta Block. No one can neglect the importance of rainwater harvesting. According it is proposed to collect roof water from at least ten hoses from each village. It is also proposed to collect rainwater from the roof of the Annex building of this institute. If this rooftop rain water harvesting scheme is implemented, all civil engineering students from this institute will have a role model. These students will see the system and in the future, they will be motivated to implement roof water harvesting systems elsewhere. The tentative estimate is as given below. Roof water harvesting is a system of collecting rainfall water from the roof of a building and storing it in some storage facilities for future use when there is a shortage of water (Haile and Merga, 2002).

Figure 2-A rooftop rainwater harvesting structure of Govt. school, ChapariMerta block.

CASE STUDY:II

JK White Cement Works has constructed artificial recharge structures (pits with borewell technology) near Dhanpa village, resulting in increased groundwater levels and quality improvement in the surrounding areas (Fig. 3 & 4). Utilization of Rainwater for well recharging, rainwater flowing in the farm is diverted to a water collecting tank of size 6 m x 6 m x 1.5 m near the well and a small filter pit of size 1.5 m x 1.5 m x 0.6m is made at the bottom of a large pit. Otherwise, suitable pit may be excavated depending on the availability of space near the well. The filter pit is filled with sand, pebbles larger than 20 mm and pebbles/boulders larger than 75mm pebbles is filled in three equal layers and connected to the well by 150 mm diameter PVC pipe and this pipe projects 0.5 to 1.0 m inside the well. The capacity of the water tank may be taken about 50 m^3. The percolation of water 400 to 1000 m^3 per year is possible through this structureMethods for increasing groundwater recharge include pumping surface water directly into an aquifer and/or enhancing infiltration by spreading water in infiltration basins (World Bank, 2006). There are two main techniques of rainwater harvesting, namely storage of runoff on the surface for future use and recharge to groundwater and shallow aquifer (MacDonald and Davies, 2000).Water harvesting can also have a positive impact on soil conservation, erosion prevention, groundwater replenishment and the restoration of ecosystems. Options for increasing groundwater recharge include constructing small dams or bunds, terracing, contour trenching, sub-surface dams and planting trees or planting vetiver grass (Gebremichael et al., 2005).

Run-off harvesting from a catchment using channels or diversion systems and storing it in a surface reservoirwater pans/ponds (Rockstrom, 2000) has shown that the yields and reliability of agricultural production can be significantly improved with water harvesting.

Figure 3-Rainwater harvesting and recharge structures.

Figure 4-A location suggested for artificial cum rainwater harvestingconstructed by JK White Cement Ltd. near village Dhanapain Merta Block of Nagaur district.

Other than these two case studies, there are many other rainwater harwesting stuctures have been constructed in the merta block of Nagaur district. In the lowest elevation part of the surroundiing hills a newly constructed artificial cum rainwater harvestingstructure near village Harsolav in Merta Block (Fig. 5). As well as an old rainwater harvesting structures and a Nadi has been constructed in village Bakaliyawas of Merta bolck at local scale (Fig. 6 & 7). There are many water harvesting structure made by farmers in study area to collect the rainfall water and further used for agriculture in non moonoon season. These types of stucures are very helpfulduring the rabicropes (Fig. 8 &9).

Figure 5- Newly constructed artificial cum rainwater harvestingstructure near village Harsolav in Merta Blockstructure near village Harsolav in Merta Block.

Figure 6- Old rainwater harvesting structure locally.

Figure 7- Old artificial recharge cum rainwater harvestingcalled Nadi/pond Lamba Jatan in Merta Blockstructure locally called Nadi near villageBakaliyawas inMerta Block.

Figure 8- Water harvesting structure made by farmers.

Figure 9- After storing rainwater, the farmer irrigates with the pipe method

PLAN OF OPERATION FOR RAIN WATER HARVESTING TANKS

During the rainy season, rainwater is collected in large storage tanks, which also help in reducing floods in some low-lying areas. Apart from this, it also helps in reducing soil erosion and contamination of surface water with pesticides and fertilizers from rainwater run-off, which results in cleaner lakes and ponds (Rockström, 2002). The main characteristic of floodwater harvesting is a turbulent channel of water flow harvested either by diversion or spreading within a channel bed/valley floor where the runoff is stored in the soil profile (Critchley and Siegert, 1991). Harvesting runoff water for supplemental irrigation is a risk-averting strategy, pre-empting situations where crops have to depend on rainfall whose variability is high both in distribution and amounts. By using underground spherical tanks in cascades and having a combined capacity of 60 m^3, seasonal water for supplemental irrigation for an area of about 400 m^2 is guaranteed (Mtisi and Nicol, 2013). Indirect benefits of RWH in terms of reduced incidence of downstream flood damage have been noted (Johnson et al., 2001; Gleick, 2002). Once these Rain Water Harvesting Tanks are constructed, the sluices should be kept open so that when it rains, the water will flow down to the existing minor irrigation tanks to fill them up to their full tank level in the monsoon. When the minor irrigation tanks are filled up the sluices of Rain Water Harvesting Tanks should be closed so that water can be stored in these Rain Water Harvesting Tanks. Then depending upon the number of fillings required (as per design) again, water can be released to lower existing minor irrigation tanks for their full utilization as per hydrological clearance given. Now close the sluices of Rain Water Harvesting Tanks and store water up to full tank level. If there are heavy rains again, the surplus water will automatically flow down through the surplus weir. Next year when the monsoon is late, some quantity of water from these Rain Water Harvesting Tank can be released through sluices to the existing minor irrigation tanks so that farmers can take up land preparation and sowing can be done in time. Even if the monsoon fails, the remaining water also can be released to downstream tanks so that the crops can be grown successfully. In a year when total rainfall is less than normal, these Rain Water Harvesting Tanks can be kept empty.Utilizing Roof Water to collect into the Storage Tanks Rainwater from the roof surface is drained through gutters into storage tanks. To prevent contamination and dust to flow into the storage tanks there is a provision of a hand-movable gutter connection which can be manually moved to divert the water out. The rooftop is used as the collection device. Guttering, generally made of PVC is used to transport the rainwater from the rooftop to the storage tanks. Storage tanks may be either above or below the ground and should be properly covered. In apartments, more than one storage tank can be used, and they can be interconnected through connecting pipes. The storage tanks should have provided an adequate enclosure to minimize contamination from human, animal, or other environmental contaminants. The end of the gutter, which connects to the storage tank, should be attached with a filter to prevent any contaminants from getting into the storage tank. It is also advisable to drain the first flow to get rid of the dust and contaminants from the rooftop.

CONCLUSION:

Water is an essential element of life. Everyone knows that if we do not harness available sources of water and use them judiciously with proper care, the problem of water scarcity is going to be serious. Irrespective of fast development in all fields of science, there can be no substitute for water. Hence, it is necessary to opt for various water harvesting measures. These are following conclusions have been made from this study:

- It is the responsibility of government organizations as well as individuals to harvest each drop of water falling on the earth's surface. For this, it is necessary that each person collect the raindrops falling on his roof, plot, and farm and recharges them underground.
- Two case studies of water harvesting for urban and rural areas have been considered in the present study. Similarly for other buildings, rooftop rainwater harvesting can be implemented. In fact, there is no village and habitation in India that cannot meet its basic drinking and cooking needs through rainwater harvesting techniques.
- These techniques of the artificial recharge of groundwater will helpful to enhance the water table, decrease the dark zone, expand the life of the aquifer, reduce runoff and soil erosion, decrease the hazards of floods and to get better soil fertility.
- An area of the Merta block has been chosen for very poor groundwater quality and the groundwater level decreasing with a high rate therefore, a newly low laying area has been suggested for rainwater harvesting as well as for artificial recharge for groundwater (Fig. 10).
- As per suggestions, a people awerenceprogrammes can be organized at a local scale to aware people for groundwater management as well as we can suggest to various methods of rainwater collection and how they will be beneficial for groundwater management.

- In further studies, we can generate three dimensional models for local aquifers to develop a groundwater management plan.

Figure 10- A location suggested for artificial cum rainwater harvesting structure

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