Rain Water Harvesting Plan in Chasnala Coal Mine, Dhanbad

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Abstract

Water is precious and fast becoming a scarce natural resource which is required to be conserved, augmented and harvested by applying suitable conventional as well as innovative techniques. Water harvesting is a technique of developing surface water resources that can be used in dry regions to provide water for livestock, for domestic use, and for agro forestry and small scale subsistence farming. Water harvesting systems may be defined as artificial methods whereby precipitation can be collected and stored until it is beneficially used. The system includes: 1) a catchment area, usually prepared in some manner to improve run off efficiency and 2) a storage facility for the harvested water, unless the water is to be immediately concentrated in the soil profile of a smaller area for growing drought-hardy plants. A water distribution scheme is also required for the systems devoted to subsistence farming for irrigation during dry periods. Mining activities disturb groundwater aquifers. Underground mining disturbs deep aquifers whereas opencast mining disturbs both shallow and deep aquifers. In order to extract coal, large quantity of water accumulated at the pit bottom is required to be pumped out to the surface. Therefore coal mining areas are always subjected to acute water crisis unless suitable care is taken to ensure the proper water supply and in this context, rain water harvesting is one of the most appropriate technology to conserve the water management in the study area. With these concepts in the background, the present study has been carried out in context with the Chasnalla Group of Mines, ISP, SAIL.

Keywords: Agro forestry, Water harvesting, Precipitation, Catchment, Groundwater Aquifers

I. INTRODUCTION

Rainwater harvesting is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. Rainwater harvesting can yield copious amounts of water [1]. For an average rainfall of 1,000 mm, approximately four million liters of rainwater can be collected in a year in an acre of land (4,047 m²), post-evaporation. As rainwater harvesting is neither energy-intensive nor labour-intensive, it can be a cost-effective alternative to other water-accruing methods, such as desalination of seawater and interlinking of rivers. One of the important advantages of rainwater harvesting is that it prevents intrusion of seawater into coastal regions. Rainwater harvesting is a technically feasible solution for overcoming the problem of water scarcity in cities. Water from rainfall infiltrates into an aquifer through an artificial recharge structure, thus recharging the aquifer [2]. The water is stored in the aquifer, from where it can be retrieved for future use. With the water table falling rapidly, and with concrete buildings, paved car parks, business complexes, and landfill dumps taking the place of water bodies. Rainwater Harvesting is the most reliable solution for augmenting groundwater level to attain self-sufficiency in public distribution of water in drought-prone areas [3]. In this context, rooftop rainwater harvesting can become a popular technique to improve the storage and recharge of water. Proper recharge of harvested water can augment the ground water storage and increase the ground water level. This will also partially meet the demand of drinking water [4]. It would also reduce the wastage of water due to surface runoff and has the potential to choke the storm drains [5]. Artificial Recharge is the best method of conserving rainwater, which will arrest the shrinking of water reserves. This can be motivated and implemented by consideration of the followings:

- Identify potential zones in this area and design and implement suitable, site-specific roof water and surface water harvesting structures to raise the ground water table. The activities would utilize geology, geophysics and hydrogeology as irreplaceable tools.
- Promulgate roof and surface water harvesting techniques through Community Rainwater Harvesting methods to produce significant first-hand remedies for water crisis in cities.
- Sustain the existing water supply schemes by artificial recharge
- Introduce water-harvesting structures on unpolluted rain water drains, open areas, parks and playgrounds.
- Use stagnant water for recharge purposes in relatively low-lying areas, store water during rainy days in appropriate locations, and construct suitable recharge structures in water-logging areas. This strategy will yield precious water for recharging aquifers.
- Introduce site-specific artificial recharge structures on wide roads, which become waterways during heavy downpour in the monsoon season.
- Convert dry tube wells and bore wells into recharge wells.
- Design projects for recycling and reuse of wastewater.
- Design projects for grey water treatment.
- Construct site-specific artificial recharge structures, like percolation pits, dug cum bore wells, mini artificial aquifer system, trench cum percolation pits, percolation ponds, recharge wells and sectorial recharge structures at technically strategic locations.
- Develop mass awareness programmes among the local people for consumptive usage of water and implementation of simple Rainwater Harvesting structures.
- Make roof water harvesting a people’s movement by educating the public through various means, like establishing rain centres, exhibiting surface models, case studies and attractive propagation of rainwater harvesting.

II. SITE DETAILS FOR RAIN WATER HARVESTING SCHEMES

Chasnalla Block lies in the South Eastern extremity of Jharia Coalfield (JCF) in the Dhanbad district of Jharkhand state. It covers an area of 4.5 Km². The area is roughly defined by north latitudes 23°38'25" and 23°40'00" and East longitudes 86°27'12" & 86°29'15". It is included in the survey of India Topo sheet no.73 1/6 and in Sheet No.8 of the geological map of JCF. Figure 1 shows the regional location of the area. This Block is located about 15 km from Jharia town and about 23 km from Dhanbad town. Dhanbad - Sindri Road passes through its northern boundary.

Coal Mine is one of the oldest and largest industries in India widely spread over several states. Coal Mine areas in general suffer for assured supply of drinking water and also water required for other purposes [6]. Compared to other industries, it generates large volume of waste water. Therefore particularly in context with the coal mining water harvesting is essential in order to have better restoration and replenishment of water [7]. Therefore all the office building and infrastructure at the site are to be provided with rain water harvesting structure [8].
III. RAIN WATER QUANTIFICATION

The unused areas besides quarry in the surface plan shows overburden dump area, mine site office and colony. The position of water is being discharged for sedimentation and distribution. The water harvesting structure (an unused quarry) site is approximately 600m length X 400m width X 3m depth. The volume of water harvesting structure will be 7,20,000 m$^3$ for storage.

IV. LAYOUT DESIGN FOR RAIN WATER HARVESTING STRUCTURES

Apron type water harvesting systems are used primarily for livestock, wildlife and domestic water supplies. The catchment area (apron) is treated to obtain a high run off efficiently, unless an existing impermeable surface is used. Gravel covered, asphalt impregnated fiberglass is a common treatment in the United States. The systems are designed for minimum maintenance and must be fenced. A storage tank with evaporation control is required with the necessary pipes and valves to conduct the water to drinking troughs or to households. The apron type system is the simplest to design. As a first approximation for the size of apron required, the following equation is helpful:

\[ A = 1.13 \frac{U}{p} \]

where:

- \( A \) = catchment area m$^2$
- \( U \) = annual water requirement litres
- \( P \) = average annual precipitation mm

The detailed schematic diagram of rain water harvesting is discussed below. More over the mine will have sufficiently large sump, which will help in recharging the ground water of the area. The residential colony will be provided with sewage treatment facility and recycled water will be used in reclamation of the site. The surface runoff (1,58,400 m$^3$) water will be discharged into nearby nalla during monsoon to maintain the average depth of quarry water. 83% of surface run off during monsoon will be stored in the quarry for recharging and conservation of water. After the monsoon this water may be pumped out in the harvested pits in low lying areas to recharge the ground water and the water scarcity in the lean period may be solved by appropriate treatment of this water. The rainwater harvesting can be done in the two phase. Firstly the existing schemes/structures have to be improved in order to arrest quantitatively and efficiently. Secondly the new structures can be made and joined for cumulative rainwater harvesting in the colony or abandoned areas. Following method has to be adopted for treating mine water given in the flow diagram, Figure 2.

![Flow Diagram of Treated Water for Reuse](image)

The mine water has to firstly pass through the bar screen chamber where all the extraneous matter gets trapped. It is then collected in the receiving sump where it is kept in a mixed condition by means of coarse air bubble diffusion. This mine water is then pumped to the Fluidised Aerobic Bed (FAB) Reactors wherein with the help of microbial activity the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of the mine water is reduced, this is an aerobic reaction. The excess bio-solids formed in the biological process are separated in the downstream Tube Settler Tank. The clear supernatant after disinfecting is passed through dual filter and activated carbon filter before being collected in the treated water tank. The sludge generated from the FAB is dried and the filtrate is collected and sent back to the equalization tank and the dried cakes are used as manure.
V. PROPOSED RAINWATER HARVESTING STRUCTURES

In the proposed colony quarters and other areas existed which can cumulatively used for the construction of proposed rain water harvesting structures. The average consumptions of mine water in the colony will be 100\(m^3\)/day. This reveals that the proposed structure constructed can hold minimum of this quantity. For these cumulative structures in the series either on roof top or on the ground can be made according to the available budgets. These structures may be as follows:

1) A percolation/absorption pit is a hand bore made in the soil with the help of an augur and filled up with pebbles and river sand on top. The depth of these pits will be anywhere between 4 and 8 meters depending on the nature of the soil. If the soil is clayey, the pit has to be dug to a depth till a reasonably sandy stratum is reached. The diameter of these pits will be 25 cm (10 inches). A square/circular collection chamber with silt arrester is provided at the top constructed in the open space at required intervals and the specification are as follows:
   - Size: 1m x 1m x 1.5m (depth)
   - Filled with broken bricks/pebbles
   - Suitable for sandy sub-soil area
   - One unit for 300 sq.ft area (approx.)

A borehole is to be drilled at the bottom of the percolation pit (Figure 3). Bore hole size may range from 150 - 300 mm diameter with 300-400 cm depth (approx.) filled with broken bricks which is suitable for clay area. Above structures are meant for area with small catchments like individual houses. RCC slab cover is optional with the top (1’) portion may be filled with sand. These wells are constructed using cement rings readily available in the market. The diameter of these rings range from 60 ft to 180 cm. The depth to which these wells are dug depends on the nature of the soil and the diameter depends on the number of roof top pipes that are likely to be connected to each one of these wells.

These wells are left unfilled and are covered with RCC slabs of suitable thickness to facilitate free pedestrian and vehicular movement on the ground. Rainwater from the terrace is diverted to the existing open well using PVC pipes through a filter chamber. The minimum size of the filter chamber is 2” x 2” x 2” filled with broken bricks in the bottom and sand on the top. The chamber may be covered with RCC slab.

![Fig. 3: Schematic Diagram of Percolation Well](image)

2) Rainwater Harvesting in Group Houses can be utilized for the open well if any, within the complex to divert the rainwater from the terrace into it. If not, a well is constructs for this purpose. The rainwater falling on the open space around the complex can be collected near the gate by providing a gutter with perforated lid. The collected water can be led through necessary piping arrangements into a recharge well of 1 meter diameter and 5 meter depth, Figure 3.

In colony areas, the roof top rain water can be conserved and used for recharge of ground water. This approach requires connecting the outlets pipe from roof top to divert the water to either existing well/tube wells/bore wells or specially designed wells/structures. The colony housing complexes or buildings have large roof area and can be utilized for harvesting the roof top
rain water to recharge aquifer in colony areas. The specific area can be constructed as roof top by an empirical formula given in the Table 1 which shows the availability of rain water through Roof Top Rain Water Harvesting. Economics of Rainwater Harvesting Structures

The proposed cumulatively rainwater harvesting structures to be constructed in the colony will also ensure the water availability and ground water recharge. The roof top can be modified for the rainwater harvest with slight modification with some investment. The per square meter modification cost comes Rs. 250 and the percolation tank made for this storage can be made by this unit cost of Rs. 5,000 only. A large storage tank can be made and connected with all the percolation pits/wells with the cost of Rs. 7.00 lacks which can hold rainwater harvested by roof top as well as excess water from the mine which is pumped out during operation.

The topography of the project area is rolling in nature and sloping towards quarry [9]. Keeping this in view the harvesting system has to be made through suggested water harvesting structure in the colony area by rooftop harvesting with slight modification with some investment.

### Table 1

<table>
<thead>
<tr>
<th>Roof top area (Sq.m)</th>
<th>Rain fall (mm)</th>
<th>HARVESTED WATER FROM ROOF TOP (Cum)</th>
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<tbody>
<tr>
<td>100</td>
<td>200</td>
<td>300</td>
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<tr>
<td>20</td>
<td>1.6</td>
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<td>320.0</td>
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</table>

The storage of water can be improved by modification suggested with economics. The other activities related with this, viz., plantation and garland drainage helps in the overall improvement in the availability of water received by this area. The second option has to be made through suggested water harvesting structure in the colony area by rooftop harvesting with slight modification and connected to percolation pit/wells and cumulatively connected to a big storage tank in the abandoned area [10].

### VI. CONCLUSIONS

Water harvesting offers a method of effectively developing the scarce water resources of arid regions. As contrasted to the development of groundwater, which is usually a finite water resource in arid zones, the method allows use of the renewable rainfall which occurs, even though in limited amounts, year in and year out. It is also a relatively inexpensive method of water supply that can be adapted to the resources and needs of the rural poor. It is necessarily small scale, and as such it can provide stability and improve the quality of life in small rural communities and that of small land holders who are several stages removed from the benefits of large scale development projects. Despite this, water harvesting is not a panacea. It involves some risk, dependent upon the vagaries of climate. New skills, though simple, are required, maintenance is a constant necessity, and good design is imperative [11].

There is no universally "best" system of water harvesting [12]. However, there will be some type of system that can be designed to best fit within the constraints of a given location. Each site has unique characteristics that will influence the design of the most optimum system. All factors, technical, social, physical and economic must be considered. During the past two decades, there have been many water harvesting systems constructed and evaluated at a number of different places in the world. Some of the systems have been outstanding successes, while others were complete failures. Some of the systems failed, despite extensive effort, because of poor design or the materials used. Other systems failed despite good design and proper materials because social factors were not integrated into the systems. These systems failed because of poor communication and lack of commitment by the local people.
both in planning and financing the projects. Unfortunately, one failure in a traditionally conservative social system, as are many rural societies in arid lands, can offset the effects of 10 successes. A successful system must be:

1) Technically sound, properly designed and maintained.
2) Economically feasible for the resources of the user.
3) Capable of being integrated into the social traditions and abilities of the users.

Much has been learned over the past two or three decades. Much more remains to be learned, but sufficient knowledge and experience has now accumulated to put into operation water harvesting projects throughout the arid lands of the world. Empirical information and documentation is needed from successes as well as failures on which to build a more exact technology.

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