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A Study on Ground Water Responses to Recharge through Rain Water Harvesting

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***Abstract* – The most valuable natural resource is water, but few people are aware of the limited freshwater availability, supply and importance especially in developing countries like India as well as countries endowed with lesser quantum of it. Ground water is critical to India's water, food and livelihood security and supports more than 55% of our irrigation requirements, 85% of domestic requirements in rural areas and over 50% of requirements in urban and industrial uses.**

Rain water harvesting is the collection of rain water from surfaces such as roofs in urban areas; the storage of rain water and the distribution of rain water for indoor or outdoor use. Rain water if stored conveniently will be an economical, safe and a sustainable source of water. However, in urban environments, the storage or the direct use of the water would be difficult mainly because of the constraints in storage and maintenance.

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INTRODUCTION

The use of rain water harvesting systems to capture rain water for direct domestic use can reduce the dependence on water supply and distribution systems in large urban centers. There will be less pressure on central water storage systems and can possibly reduce the need to increase the water storage infrastructure with the increasing population. The expenditure on water supply and supplementing with packaged water can be considerably reduced at local levels, so that the expenditure on purchase of water decline.

Therefore, rain water harvesting and recharge can have greater roles in water resources management in the context of increasing demands on existing freshwater resources. The use of rain water has a number of significant economic, social and environmental benefits that can be accomplished. The quality of rain water especially collected in places like urban environments are likely to be of low quality and may even contain pollutants or bacteria and viruses as dry deposition. However, if first flush devices or rain diverters flush off the first flow of water of a rainfall or storm event, this problem can be solved. The dirt, contaminants or bacteria on the roofs of buildings that has built up before the rain fall can be prevented from entering the storage tank.

Rain water may be harvested by collecting rain water that falls on the terrace of the buildings and in the open spaces around the buildings. This collected water can be diverted to the existing open or bore wells with suitable arrangements. Rain water can also be collected in the open spaces around the building and may be recharged into the ground by having percolation pits dug in small houses, recharge trenches for big houses and apartments and recharge wells for large buildings and industries.

ARTIFICIAL RECHARGE

Artificial recharge of groundwater is the process of adding water to an aquifer through human effort by different techniques for increasing the storage in addition to natural recharge. Rain water harvesting projects are variable, but usually involve storing surplus water in an aquifer for later use. Withdrawal of stored groundwater is commonly done through wells. It is a process by which the groundwater reservoir is augmented at the rate exceeding that under natural conditions of replenishment. Any man made structure or a facility that adds water to an aquifer can be considered to be an artificial recharge system. The artificial recharge techniques interrelate and integrate the source of water to groundwater reservoirs and are dependent on the hydro geological situation of the area. The artificial recharge and rain water harvesting is an environment friendly process that does not require much land and no displacement of population is required.

India has a large coast line and a good percentage of population is living along the coast. Saline sea water ingress is being observed in these areas due to large scale developments in the area which may have resulted in the deterioration of fresh groundwater aquifers. For example, in Chennai city, saline intrusion has been detected in northern coastal areas (UNEP 2009) and southern coastal zones.

The artificial recharge of groundwater aquifers requires adoption of different technologies under different ecological and hydro geological situations and similarly there is a need to develop separate technologies for recharge, specifically in urban areas. Aquifer storage and recovery is a special type of artificial recharge of groundwater that uses dual purpose of wells for both injecting water into the aquifer and recovering it later. Although artificial recharge is generally to increase the groundwater storage for later use, incidental activities such as excess irrigation, storm water disposal, canal leakage and leaking water pipes may also result in recharge. Artificial recharge always requires some form of man-made structures. Surface spreading techniques involve keeping water at the surface in areas where water can percolate down to a shallow, unconfined aquifer. Spreading basins, check dams in stream channels, furrows, trenches and ditches are common examples for artificial recharge, especially in places where land is not a constraint.

SCOPE OF STUDY

Increase in demand for water and also the dependence on the groundwater for the increased demand has led to the decline of water table. The surface water storage is finite in the city and dependent on success of monsoon rainfall. In the last two decades, in several parts of the city when open wells went dry, deep bore wells were drilled and the exploitation of groundwater increased further. The natural recharge to the groundwater has declined during this period, as the urbanization rendered more areas of the city impermeable. Hence, increasing recharge to the groundwater has become essential to sustain the existing groundwater supply.

Rain water harvesting is one good option available for augmenting groundwater recharge. The concept of rain water harvesting is tapping the rain water, where it falls. The component of natural groundwater recharge is generally less than 10% of rainfall in hard rock terrains. Rain water harvesting tries to increase this quantum of recharge by increasing the retention time of harvested water on land by constructing various structures so that increase in water table can be significant.

Realizing the importance of rain water harvesting for augmenting groundwater recharge, efforts on installing suitable rain water harvesting structures have been promoted by the agencies of the Government and academic institutions. In addition to the legal instruments proposed, the government used the media effectively and addressed the issue of providing rain water harvesting in existing buildings through several awareness campaigns and persistent efforts. Hence, the studies on Rainwater Harvesting and their evaluation has become very useful and important aspect in developing better groundwater management strategies for the city.

OBJECTIVES OF THE STUDY

The general objectives of the study are:

The specific objectives are

1. To analyze rain water harvesting and recharge program implemented to assess their effectiveness and role on groundwater resources.

2. To analyze changes in groundwater chemistry and quality.

REVIEW OF LITERATURE

A perusal of literature revealed that the area of rain water harvesting has captured the attention of the hydro geologists and groundwater engineers from across the world. The main focus of these studies is investigating the recharge process, its impact on the aquifer, changes in the pattern of recharge and also the changes in the quality of the groundwater.

The importance of artificial recharge has been recognized in India from the sixties onwards and continues to be an agenda of the water resources organizations of the State and the Central Governments.

Abdul-Aziz et al carried out a comprehensive evaluation of dams serving as a recharge source in the central region of Saudi Arabia. The data on the water levels in the reservoirs, meteorological parameters and observation wells located at suitable locations were collected at two recharge dam sites. The data were analyzed in a water budget approach to estimate efficiency of recharge. It was observed that as much as 82% to 92.45% of water stored in the two reservoirs was taken into the soil.

The transmission losses in surface water transport can influence the flood peaks and groundwater recharge. Standard procedures to estimate transmission losses are employed in this study and the parameters of the transmission-loss model are determined by calibration using measured inflow and outflow volumes from gauged ephemeral stream channel segments.

Frohlich et al (2004) carried out water balance studies for a densely populated rural region in China to assess the use of groundwater for drinking water purposes. It was observed that only a small portion of the annual precipitation and a fraction of basin retention becomes groundwater recharge. A technique to separate base flow from the time series of total discharge is described where transition curves have been determined to connect subsequent recession curves. The results have been verified by correlation with data from observation wells and with water balance calculations.

Kim et al (2001) studied the major factors affecting the urban water budget and quality of groundwater in

Seoul, South Korea. The factors include leakage from the municipal water-supply system and sewer systems, precipitation, infiltration, water level fluctuations of the Han River, the sub way pumping system and domestic pumping. The balance between groundwater recharge and discharge is near equilibrium. It was observed that the quality of groundwater and ability to control contaminant fluxes are impeded by sewage infiltration, abandoned landfills, waste dumps and abandoned wells in urban environments.

Kumar and Seethapathi (2002) assessed the natural groundwater recharge in upper Ganga canal command area. It was observed that the rate of aquifer recharge is one of the most difficult factors in the evaluation of groundwater resources management. The groundwater balance method was carried out season wise in the study for monsoon and non monsoon seasons. All the components of the groundwater balance equation were estimated using the hydrological and meteorological data. Based on the seasonal groundwater balance study, the authors have suggested an empirical relation for estimation of groundwater recharge from rainfall with reasonable accuracy.

The evaluation of the groundwater recharge continues to pose challenges in its estimation with the required accuracy for planning purposes continues today, in the context of rapid abstraction, land cover changes and the process of urbanization.

Hughes (2004) modified a popular rainfall – run off model used in African continent by adding two new components of recharge and groundwater discharge with a monthly time step. It was observed that the application of the revised model on two basins in southern Africa showed that the new components have a great deal of potential use, in that the new components have been able to simulate the groundwater base flow component of the total runoff more successfully and explicitly.

Martinez-Santos et al (2005) estimated a method to determine the artificial recharge capacity of the lime stone Crestatx aquifer in Majorca, Spain. A 3-D digital groundwater flow model was developed for the study area and calibrated to gain a better understanding of the aquifer dynamics and then to estimate its capacity for the artificial recharge. Tests were carried over a thirty year period. The results were analyzed by yearly input-output balances for the aquifer. The utility of the model developed was that the output suggests the implementation of the scheme might ensure a sustainable use of the aquifer in the future.

CONCLUSION

Increased dependence on groundwater needs improved understanding of aquifer management, recharge discharge issues, planning pumping rates and facing water quality problems associated with beneficial uses. The increased availability of computing power and modeling tools permit the mathematical representation of the groundwater environment with reasonable accuracy; to understand groundwater flow such that different scenarios of future abstractions and the role of artificial recharge program may be developed. Several authors suggest the use of reclaimed waste water in urban environments can also be gainfully used (Asano 2004, Shammas et al 2009, Lee 2010) in recharging the groundwater. However, we should obtain deeper understanding of the reclaimed waste water impact on the groundwater quality .

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