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Artificial Ground Water Recharge Techniques

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Abstract: Artificial groundwater recharge aims at increasing the groundwater storage by modifying the natural movement of surface water with the help of suitable structures. It is a well-planned human endeavour to increase the amount of groundwater available through structures designed to increase the natural recharge or percolation of surface water into the water table, resulting in an improvement in the amount of groundwater available for withdrawal. The main objective of this technology is to conserve and augment groundwater resources in various parts of India, which includes maintaining or diverting floodwaters, controlling saltwater intrusion, storing water to reduce pumping, and improving groundwater quality by merging with naturally occurring groundwater. In areas where artificial recharge of groundwater is required, a variety of methods can be used, including water spreading, recharge pits and wells, and many other alternatives. The choice of methods generally depends on topographic, geologic, and soil conditions, the quantity and quality of water available for recharge, and the technical and financial feasibility and social acceptability of the measure. This paper discusses various recharge methods and several issues related to artificial recharge of groundwater.
Keywords: Artificial Recharge, Water Spreading, Recharge Pits, Recharge Wells

I. INTRODUCTION

Groundwater recharge occurs by both natural and artificial means. Natural recharge occurs through the process of intrusion, where water percolates from the ground surface into the aquifer. However, due to rapid development and remarkable population growth in recent years, infiltration is decreasing day by day, so the area for natural groundwater recharge is also decreasing. Unlike natural recharge, artificial recharge uses water to artificially increase the water supply in the aquifer. Considering all factors, the calculation of the recharge rate is the most difficult factor to derive when determining groundwater resources. The calculation of groundwater recharge is usually dependent on the number of fluctuations and geometric variations. The increasing demand for water has led to the increasing importance of artificial recharge to improve groundwater supplies. Artificial recharge is a way to store water underground when there is a surplus of water to meet water demands during times of shortage.

II. METHODOLOGY

Artificial recharge is an action taken to raise the groundwater table to address the lack of groundwater recharge. Planning steps for an artificial recharge project include determining the recharge area, source availability, soil infiltration capacity, Hydrometrological, geologic, and geophysical conditions, etc.

Artificial recharge programs are typically conducted in three phases: -

1) Feasibility - This requires an assessment of the dynamics of groundwater flow and basin recharge. An important factor is the identification of basin compartmentalization or impermeable layers within the aquifer that impede aquifer recharge to the basin.
2) Design and operation of the sucker Based on the results of the feasibility analysis, a test program will be designed using existing facilities when possible. This work will include chemical and physical analysis.
3) Full-scale project implementation - The results of the test program will be used to recommend the final parameters of the full-scale program, including locations for additional wells or filtration ponds that may be a possible future option for source water acquisition, design of recharge management during regular operations, and required monitoring.

III. METHODS OF ARTIFICIAL RECHARGE

This system can be broadly divided into three major groups:

A. Direct Surface Methods

1) Channel Spreading

This involves the construction of small "L" shaped bundles within a river channel so that the water travels a longer distance, thus enhancing natural recharge. This method is useful when a small stream flows through a relatively wide valley. However, it is not useful when rivers are prone to flash floods and dams can be destroyed.

2) Ditch-and-furrow method

In areas with irregular topography, shallow ditches or furrows with apartment bottoms and close spacing provide maximum water contact area for recharge water from the headwater stream or channel. This technique requires less soil preparation than recharge basins and is less susceptible to siltation. Generally, three different trench and furrow systems are used.

a) Lateral trench pattern
b) Dendritic pattern
c) Contour pattern

The trench and furrow method is usually costly because it requires a high level of monitoring and maintenance.

3) Protection Dams/Nala Bund

These dams are constructed on small streams with gentle slopes and are possible in both hard rock and alluvium. The site selected for the retention dam should have sufficient thickness or permeable bed or weathered formation to allow recharge of the stored water within a short period of time. The water stored in these structures is usually confined to the stream channel and the height is usually less than 2 m (6 ft).

They are designed based on the width of the stream and excess runoff, with water pads provided at the lower end of the stream.

4) Percolation basins

These are the most widely used structures in India for recharging groundwater storage in both alluvial and hard rock formations. The effectiveness and feasibility of these structures is greater in hard rock formations where the rock is highly fractured and weathered. Infiltration basins are also constructed to recharge deeper aquifers where shallow or surficial formations are highly impermeable or clayey, requiring certain modifications.

5) Modification of village tanks as recharge structures

Existing village cisterns, which are often silted or damaged, can be converted as recharge structures. Generally, village cisterns are not required to have a "cut-off ditch" or weir. A village cistern can be converted to an enrichment structure by desilting its bed and establishing a COT at the upstream end of the tank. There are several such tanks that can be converted to enhance groundwater recharge.

6) Manhole wells

In both alluvial and hard-rock areas, there are thousands of dug wells that have either dried up or had their water levels dropped significantly.

These dug wells can be used as structures to recharge groundwater storage. Stormwater, tank water, and sewer water can be diverted into these structures to directly recharge the dried-up aquifer. In this way, soil moisture losses are reduced during the normal process of artificial recharge.

B. Direct Subsurface Method

1) Recharge Wells

These are the most efficient and cost-effective structures for direct recharge of the aquifer. They are constructed in areas where spring water is available either for some time or year-round. Recharge wells can be constructed in two different ways: vertical and lateral.

a) Vertical recharge wells - Vertical recharge wells can be provided with or without an injection well at the bottom of the well.
b) Lateral recharge shafts - Ideally suited for areas where the permeable sand horizon is within 3 m below the ground surface and continues to the water table - under unstressed conditions. Muddy water can be easily recharged. a 2 to 3 m wide and 2 to 3 m deep trench is excavated.

2) Enrichment pits

Enrichment pits are structures that overcome the difficulty of artificially recharging aquifers from surface water sources. Recharge pits are excavated to variable dimensions, deep enough to penetrate less permeable strata. The channel trench is a special case of an enrichment pit that is dug across a channel bed. An ideal location for channel trenches is the tributary of a stream, which is a dry patch.

3) Injection wells

These are structures that resemble a tube well but have the purpose of increasing the groundwater storage of a confined aquifer by pumping in treated surface water under pressure. Injection wells are advantageous when land is scarce. The choice of location for these facilities depends on the nature of the confined aquifer, the hydraulic gradient, and the location of the source of the excess surface water. It is always better to locate them closer to the source to save water pumping costs.

In alluvial areas, injection wells can be provided to recharge a single aquifer or multiple aquifers. An injection well with an opening against the aquifer to be recharged may be sufficient.

C. Indirect Methods

1) Induced recharge

This is an indirect method of artificial recharge that involves pumping from aquifers that are hydraulically connected to surface water to cause recharge of the aquifer. When the cone of depression intersects the recharge boundary of the river, a hydraulic connection is made with the surface source, which provides a portion of the pumping. These methods do not create an artificial aquifer, but simply convey surface water through an aquifer to the pump.

a) *Pumping wells:* The major advantage of this method is that under favourable hydrogeologic conditions, surface water quality generally improves as it passes through the aquifer before being discharged from the pumping wells.
b) *Collector wells:* Collector wells are constructed to extract very large volumes of water from riverbeds, lake-bottom deposits, or water-saturated areas. Because of the large flow rates and lower heads, these wells are economical, although the initial capital cost is higher compared to tube wells.
c) *Infiltration galleries:* In areas where the aquifer adjacent to the river is of limited thickness, horizontal wells may be more appropriate than vertical wells. Collector wells with horizontal laterals and infiltration galleries may receive higher induced recharge from the river collection wells.

2) Aquifer modification

These techniques modify the characteristics of the aquifer to increase its capacity to store and transmit water. Although these are yield enhancement techniques rather than artificial recharge structures, they are also considered artificial recharge structures because of the resulting increase in groundwater depletion in the aquifer.

a) *Borehole blasting:* These techniques are suitable for hard crystalline and consolidated strata.
b) *Hydrofracturing:* This technique is used to improve secondary porosity in hard rock strata.

IV. ADVANTAGES AND DISADVANTAGES OF ARTIFICIAL ENRICHMENT

Important advantages of artificial recharge are:

1) No large storage structures are needed to store water. The required structures are small and inexpensive.
2) Improvement in reliable yield of wells and hand pumps.
3) Negligible losses compared to losses from surface storage.
4) Improved water quality due to dilution of harmful chemicals.
5) No adverse impacts such as flooding of large areas and loss of crops.
6) No resettlement of local population.
7) Reduction in energy costs for water pumping, especially where the water table rises sharply 8- Utilization of excess surface runoff that would otherwise drain away.

There are a number of problems associated with the use of artificial recharge techniques. These include the drawbacks associated with aspects such as recharge efficiency, cost effectiveness, contamination risk due to injection of poor-quality recharge water, aquifer blockage, and lack of knowledge about the long-term effects of the recharge process. Therefore, the selection of a suitable site for artificial recharge in a given area should be carefully considered.

V. FUTURE SCOPE

Groundwater resources are limited and must be carefully protected from irrational use and pollution. Therefore, the protection of groundwater currently occupies one of the most important places in the system of planetary problems for the protection of the natural environment.

Most artificial recharge systems are simple and can be developed and maintained by the communities that directly benefit from them without relying on external guidance or constraints. The effectiveness of artificial enrichment under many physical and socioeconomic conditions has been little studied in depth, and its benefits are often anecdotal.

Artificial enrichment can support life in a wide range of physical and socioeconomic environments. Therefore, a well-rounded and well-informed view is needed. Groundwater management approaches that use artificial recharge techniques must first establish criteria that can help individuals, communities, governments, and nongovernmental organizations decide where artificial recharge is likely to make a meaningful contribution to solving water problems.

VI. OPERATION AND MAINTENANCE

Regular maintenance of the artificial recharge structure is essential because infiltration capacity is rapidly degraded by siltation, chemical precipitation, and accumulation of organic material. For injection and port wells, regular maintenance of the system consists of pumping or flushing with a slightly acidic solution to remove encrusted chemical precipitates and bacterial growth at the well pipe slots. Converting injection or interconnection wells to multipurpose wells can extend the time interval between one cleaning and the next, but in the case of spreading structures, except for underground dikes constructed with an overflow or outlet, annual desludging is required. Unfortunately, regular maintenance is often neglected because the structures were constructed as drought measures until a drought occurs when the structures must be restored. Maintenance of the structures is usually performed by several agencies and individuals.

VII. CONCLUSION

In the face of increasing water demand, water managers and planners must look extensively for ways to improve water management and increase water supplies. The Groundwater Recharge Committee concludes that artificial recharge can be an option as part of an integrated strategy to optimize overall water management and believes that with pretreatment, soil-aquifer treatment, and posttreatment appropriate to the source and site, water of impaired quality can be used as a source for artificial recharge of groundwater aquifers. Artificial recharge with impaired quality source water is a viable option when recharge is to control saltwater intrusion, reduce ground subsidence, maintain stream water tables, or for similar subsurface functions. It is particularly well suited for non-potable uses, such as landscape irrigation

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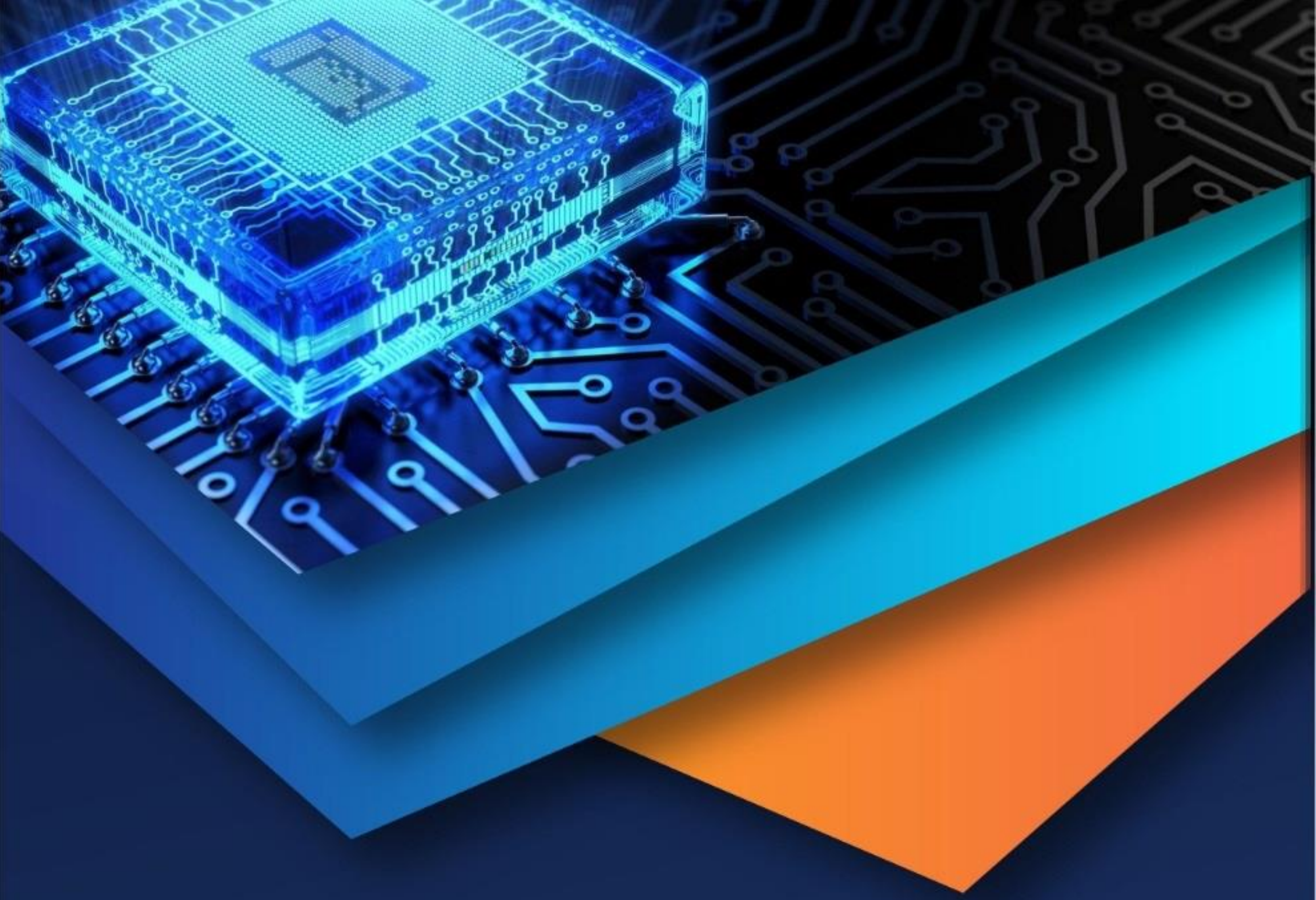

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