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"A REVIEW ON ARTIFICIAL GROUND WATER RECHARGE".

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ABSTRACT

In recent years the availability of water is low in low rainfall areas of the country so that people in those areas largely depend upon ground water for agriculture and domestic use. So that to improve the ground water situation it is necessary to recharge depleted ground water artificially. Artificial ground water recharge is the process by which water from above surface is added to the saturated zone of an aquifer either directly or indirectly. Due to over-exploitation of ground water decrease in the level of ground water so that increase level of saline water in costal areas. To avoid this some of the techniques like Spreading method, Recharge shafts, Injection wells, Induced recharge, improved Land and Watershed management are employed. Selection of particular method depends upon Hydro geological studies, Hydrological studies, Hydrometeoro-logical studies, Soil infiltration studies of area and chemical quality of water. This paper discusses issues related to artificial ground water recharge.

KEYWORDS : Artificial ground water recharge, Over-exploitation, watershed Management, Hydro meteorological studies.

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INTRODUCTION

Artificial recharge of ground water aims augmentation of ground water reservoir by modifying the natural movement of surface water by certain suitable techniques. The basic purpose of artificial ground water recharge is to restore supplies from aquifers depleted due to excessive ground water development. Aim of artificially ground water recharge is like,

1) To remove bacteriological and other impurities from sewage and waste water so that water can be re-use.
2) Storage of excess of surface water for future programs.
3) Improve quality of ground water.
4) To enhance the sustainable yield in areas where over-exploitation has depleted the aquifer.
5) Increasing the value of aquifers for water distribution in areas with many wells.
6) Discharging wastewater such as cooling water.
7) Reducing ground water salinity in agricultural areas.

Planning before artificial water recharge [2,13]

1) Identification of Area-

The artificial recharge of ground water is normally taken in following areas,

a) Areas where salinity ingress is taking place.
b) Area where amount of aquifer has been desaturated.
c) Areas where ground water levels are declining on regular basis.
d) Areas where availability of ground water is inadequate.

2) Scientific Studies

a) Hydro meteorological Studies

This study is carried out to determine rainfall pattern, evaporation losses and climate features. These can bring out the extent of evaporation losses in post mansoon period which would be helpful in designing the storage of particular capacity with a view to have minimum evaporation losses. Rainfall intensity and number of rain days are helpful in deciding the capacity and design of artificial recharge structures.

b) Hydrological Studies

Sources of water for Recharge

Before recharging of water it is necessary to determine the availability of adequate water for recharge. Following points are necessary to identify like,

a) Rainfall (Precipitation) over the demarcated area.
b) Canals for water storage for recharge.
c) Natural Streams from which water can be diverted for recharge without violating rights of other users.
d) Large roof areas from rainwater can be collected for recharge.

c) Soil Infiltration Studies

For spreading method in artificial water recharge, land and soil conditions which control the infiltration and downward percolation on the surface of the soil. The process in which water entering into a soil through the soil surface, called infiltration and The movement of water within the soil called percolation. Infiltration capacity of water depends upon soil type, moisture content, organic matter, season, air entrapment and formation of surface seals.

d) Hydrogeological Studies

This study is done to know the exact locations for water recharge and type of structures to be built for water recharge purpose.

1) Hydrogeological units demarcated or selected on the basis of their water bearing capacity at both shallow and deeper levels.
2) Depth of water level (Maximum, Minimum and Mean).

3) Amplitude of water level fluctuation.
4) Chemical quality of water.
5) Ground water potential.

e) Geophysical Studies

The application of geophysical methods is to bring out a comparative picture of the sub surface litho environment, surface manifestation of such structures and correlate them with the hydro geological setting.

The main purpose of applying this method for the selection of appropriate site for artificial recharge studies is mostly to help and assess the unknown sub surface hydrogeological conditions economically, adequately and unambiguously.

It can also identify fresh ground water interface, contaminated zone and the area prone to seawater intrusion.

f) Chemical quality of source water

Chemicals and salts

Before recharge water generally require some sort of treatment. At the time of infiltration, soil structure and biological phenomenon changes. So that chemical and bacteriological analysis of source water and ground water is essential.

Sediment Load

A major requirement for water to recharge is that should be silt free (un dissolved solid matter).

g) Prevention of Clogging of Soil pores

It is done to avoid clogging by,

1) Periodical removing of mud cake and scrapping of surface layer.
2) Installation of filter on the surface.
3) Addition of organic matters and chemicals on uppermost layer.
4) Cultivation of certain plant covers.

Influence of Artificial Recharge factors [1,13]

There is no possibility that all aquifers can be artificially recharged. The nature of the existing ground water, hydraulic characteristics of the aquifer, and the characteristics of the recharge water can have a major influence on the outcome of a recharge operation.

Hydrogeologic Factors

Artificial recharge depends on transmissivity and porosity values, and the uniformity of these parameters is very important. The receiving aquifer must be as homogeneous and isotropic as possible.

Geological Factors

Aquifer porocity is the main factors affecting recharge. Porosity should be as high as possible, and this factor depends on a uniformity coefficient: where the coefficient is small, porosity is high. Another factor is the hydraulic conductivity of an aquifer: when the hydraulic conductivity is high, recharge is very quick. The chemical equilibrium in the aquifer is very important.

Physical–Chemical Factors

The physical and chemical characteristics of groundwater and recharge water have a great effect on the results of artificial recharge. The chemical, physical, and biological compatibility of the two kinds of waters must be investigated, as these properties can greatly influence plugging of the aquifer and therefore the rate and duration of recharge.

1. Physical Characteristics

The main physical characteristics to consider are:

1) pH
2) Temperature
3) Electrical Conductivity
4) Total Dissolved Solids
5) Color and Odor

Temperature - affects water viscosity, as the two properties are inversely proportional. Since the hydraulic conductivity of the ground is inversely proportional to water viscosity, this means that water that is cold flows more slowly in the aquifer than warmer water. Moreover, if temperature decreases water density grows proportionally, leading to thermal stratification

of water in the aquifer. This stratification lead to the obstruction of pores and reduces water infiltration into the aquifer.

2. Chemical Characteristics

The main important parameters affecting artificial recharge are dissolved gas and dissolved salts.

Dissolved or suspended gas (air) has a double function—chemical and physical—inside the aquifer. The presence of small air bubbles inside the pores may cause blockage of the aquifer and reduce percolation into the unsaturated zone. Oxygen in the air causes redox reactions in the ground that can chemically precipitate compounds that block the aquifer, reducing water quality.

Oxidation can destroy pathogenic organisms, prevent the leaching of iron and manganese, and cause the precipitation of iron salts in groundwater.

The redox reactions raise the iron content of the water by increasing the solubility of the iron.

Criteria of Artificial Recharge [1]

1. Choice of Recharge Method

The choice of recharge method depends on various factors. Most important are *hydrogeological* variables:

1) Transmissivity
2) Storage Coefficient
3) Feed Flow

These are the main hydrodynamic parameters that regulate the efficacy of recharge. Other relevant conditions include the following:

a) Water available for recharge.
b) Appropriate physical–chemical properties of recharge water.
c) Availability of aquifers suitable for recharging.
d) Thickness and permeability of the unsaturated zone.
e) Land price and land-use regulations.

2. Treatment of Water for Recharge

An artificial groundwater recharge facility is economically viable if recharge is continuous and operations and maintenance costs are reasonable. The main costs are those associated with replacement of filtration systems. The bacterial quality of recharge water is more important in the case of surface recharge, because the filtration process in the unsaturated zone will remove bacteria.

Suspended solids (40–70%) and bacteria (25–75%) can be eliminated using settling tanks and filters (sand and gravel), which will eliminate approximately 20% of all suspended solids. When the suspended solids are colloids, it is necessary to remove them by flocculation or coagulation using suitable products such as aluminum sulfate and sodium aluminate. Activated carbon filters are mainly used to remove organic material, above all pesticides, herbicides, and other toxic organic compounds.

Removal of algae is another problem. Algae that are present in recharge water should be removed by filters, or they will grow in the recharge basin. Algae grow and die very quickly and the organic matter produced may generate unpleasant odors and consume much oxygen, producing an anaerobic environment. Algae also reduce carbon dioxide content, which leads to precipitation of calcium carbonate and the consequent plugging of the aquifer. It is possible to use chlorine, which is an algaecide, to oxidize part of the organic matter.

While recharge water is percolating through the unsaturated zone it loses oxygen and enriches itself with carbon dioxide. To reduce this effect, recharge water is often oxygenated before infiltration.

Method of Artificial Recharge [1,2,3,4,5,6,8,9,13]

1) Direct Surface Methods
a) Flooding
b) Basins or percolation tanks
c) Stream augmentation
d) Ditch and Furrow method

e) Over irrigation

2) Direct Sub-surface Methods
a) Injection Wells (Recharge Wells)
b) Recharge Pits and Shafts

3) Indirect Methods
a) Induced recharge from surface water source.
b) Aquifer modification

A) Direct Surface Methods[1,2,3,4,5,6,8,9,13]

a) Flooding

It is useful in the areas where a favorable hydro-geological situation exists for recharging the unconfined aquifer by spreading the surplus surface water from canals over large area for sufficiently long period so that it recharges the ground water body.

b) Ditches and Furrows

In the areas where irregular topography, flat bottomed and closely spaced ditches and furrows provide maximum water contact area for recharging water from canal. It requires less soil preparation than the recharge basin technique and less sensitive to silting.

Lateral Ditch Pattern

The water from stream is diverted to the canal from which smaller ditches are made at right angles. The rate of flow of water from feeder canal to ditches is controlled by valves. The furrow depth is kept according to topography and with the aim that maximum wetted surface is available and uniform velocity can be maintained.

Dendritic Pattern

The water from stream is diverted from the main canal to a series of small ditches sprfead in a dendriatic pattern.

c) Recharge Basins or Percolation Tanks

These are either excavated or enclosed by dykes or leaves. They are commonly built parallel to intermittent stream channels. In this method water contact area is quit high which typically ranges from 75% to 90% of the total recharge area. In this method efficient use of space is made and the shape of basins can be adjusted to suit the condition and available space.

d) Stream Augmentation

The natural drainage channel can be modified with a view to increase the infiltration by detaining stream flow and increasing the stream-bed area in contact with water. This method can be employed in areas having influent streams which are mostly located in piedmont regions.

e) Over irrigation (Surface irrigation)

It aims at increasing agricultural production by providing dependable watering of crops during gaps in monsoon and during non monsoon period. Whenever adequate drainage is assured and additional water source available it is mostly useful to give dual benefit of augmenting ground water resource.

B) Direct Sub Surface Methods[1,2,3,4,5,6,8,9,13]

a) Injection Wells

These are the use for the purpose of augmenting the ground water storage of a confined aquifer by “pumping in” treated surface water under pressure. The effectiveness of induction of water in injection well is determined by,

Pumping rate
Permeability of aquifer
Distance from stream
Natural ground water gradient

Type of Well

In alluvial areas injection well recharging a single aquifer or multiple aquifers can be constructed to normal gravel packed pumping well. An injection pipe with opening against the aquifer to be recharged may be sufficient. However, in case of number of

Permeable zones separated by impervious rocks, a properly designed injection well with inlet pipe against each aquifer to be recharged

need to be constructed. Injection wells are comparatively costlier and require specialized techniques of operation and maintenance to protect the recharge well from clogging.

b) Recharge Pits

These are the structures that overcome the difficulty of artificial recharge of phreatic aquifer from surface water source. Recharge pits are excavated of variable dimensions that are sufficiently deep to penetrate less permeable strata. A canal trench is a special case of recharge pit dug across a canal bed. An ideal site for a countour trench extending over long distances across the slope and following topographical countour. In case of hard rock terrain, a canal bed section crossing permeable strata of weathered fractured rock or the canal section coinciding with a prominent lineament or intersection of two lineaments, form ideal sites for canal trench.

c) Recharge Shafts

It is similar to Recharge pit but much smaller that pit in cross section. It is poorly permeable strata overlie the water table aquifer located deep below land surface, a shaft causes artificial recharge.

Main Advantages of these techniques are,

1) It does not require acquisition of large piece of land like percolation tanks.
2) There is no practically losses of water in the form of soil moisture and evaporation, which normally occur when the source water has to traverse the vadose zone.
3) Design and technology of recharge shaft is simple.
4) The recharge is fast. In highly permeable formation the recharge shaft are comparable to percolation tanks with no submergence and hence no land compensation to local farmers.

C) Indirect Methods[1,2,3,4,5,6,8,9,13]

a) Induced Recharge

It is an indirect method of artificial recharge involving pumping from aquifer hydraulically connected with surface water to induce recharge to the ground water reservoir.

In hardrock areas, the abandoned channels often provide good sites for induced recharge. The main advantage of this method is that under favorable hydro-geological situations, the quality of surface water generally improves due to its path through the aquifer materials before it is discharged from the pumping well.

Pumping wells

Induced recharge system is installed near perennial streams that are hydraulically connected to an aquifer through the permeable rock material of the stream channel. The outer edge of a bend in the stream is favourable for location of well site.

Collector Wells

For obtaining very large water supples from river bed, lake bed deposits or waterlogged areas, collector wells are constructed. The large discharge and lower lift heads make these wells economical even if initial capital cost is higher as compare to tube well.

Infiltration Gallery

These structure use for tapping groundwater reservoir below river bed strata. The gallery is horizontal perforated or porous structure with open joints, surrounded by a gravel filter envelope laid in permeable saturated strata having shallow water table and a perennial source of recharge. The collector well is more sophisticated and expensive but has higher capacities than the infiltration gallery.

b) Aquifer Modification

This technique modifies the aquifer characteristics to increase the capacity to store and transmit water. With such modifications, the aquifer, at least locally, becomes capable of receiving more natural as well as artificial recharge. Hence, in sense these techniques are artificial yield augmentation measures rather than artificial recharge measures.

Bore Blasting

These techniques are suited to hard crystalline and consolidated strata. Through hydro-geological investigation, suitable sites are fixed where the aquifer displays limited yield that dries in winter or in summer months. All the blast holes reach the depth of the aquifer required to be benefited, whether unconfined or confined.

Hydro-Fracturing

It is used to improve secondary porosity in hard rock strata. It is a process whereby hydraulic pressure is applied to an isolated zone of bore wells to initiate and propagate fractures and extend existing fractures. The water under high pressure break up the fissures cleans away clogging and leads to a better contact with adjacent water bearing strata. The yield of bore well is improved. In hydro fracturing, vertical fractures are initiated which inter connects aquifers at different levels in addition to extension of existing fractures.

Advantages of Artificial Recharge [1,2,7,10,11]

1) No large storage structures needed to store water. Structures required are small and cost-effective.
2) Enhance the dependable yield of wells and hand pumps.
3) Negligible losses as compared to losses in surface storage.
4) No adverse effects like inundation of large surface areas and loss of crops.
5) Improved water quality due to dilution of harmful chemicals and salts.
6) No displacement of local population required.
7) Reduction in cost of energy for lifting water.

Disadvantages of Artificial Recharge[1,2,7,10,11]

1) There is a potential for contamination of ground water from injected surface water especially from agricultural fields and road surfaces. In most cases surface water is not treated before injection.
2) Unless significantly volume of water is injected in an aquifer, ground water recharge may not be feasible.
3) Chances of groundwater contamination is high if landowners not drainage well adequately.
4) During the construction of water traps, disturbance of soil and vegetation cover may cause environmental damage to the project area.

Evaluation of Aquifer Recharge Area by Piezometric Map Analysis [1,14]

Aquifer recharge is affected by the amount of water that infiltrates the groundwater flow. Groundwater represents only one step in the hydrologic cycle; for this reason measurements of other components of the cycle may be useful in estimating the scale of water resources by calculating the *hydrologic balance*. The hydrologic balance supposes that the amount of water entering the aquifer is the same as that leaving it, less an amount that represents the water storage fluctuation:

I = ***O*** ± storage variation

Where ***I*** (income) is rainfall, recharge from surficial water, other aquifers, wells, or other sources; and ***O*** (outflow) is superficial streamwater, runoff, evapo-transpiration, surficial and underground drainage, catchments, springs, and other hydraulic elements.

The method depends on knowledge of every element of the water balance in a particular area, and on their quantification. In practice it is necessary to find all terms of the equation through direct measurements or estimation, leaving aquifer recharge (which is more difficult to obtain) as a value to calculate indirectly. Stoertz and Bradbury described a method for calculating the spatial distribution of water income and outflow, using as starting points a piezometric map and some estimates regarding hydraulic conductivity and the thickness of the aquifer. The application of a two- or three-dimensional mathematical model

as a basis for water balance model analysis is essential to the process.

SUMMERY

This Review article of Artificial ground water recharge discusses detailed study about its Need, Planning, Affecting factors of artificial ground water recharge, Criteria, Methods, Advantages and Disadvantages and Evaluation.

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