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Groundwater Recharge by Waste Water

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ABSTRACT

Water that seeps into an aquifer is known as recharge. Recharge comes from a variety of sources, including seepage from rain and snow melt, streams, and groundwater flow from other areas. Recharge occurs where permeable soil allows water to seep into the ground. Areas in which this occurs are called recharge areas. They may be small or quite large. A small recharge area may supply all the water to a large aquifer. Streams that recharge groundwater are called losing streams because they lose water to the surrounding soil or rock. Groundwater begins with precipitation that seeps into the ground. The amount of water that seeps into the ground will vary widely from place to place, depending on the slope of the land, amount and intensity of rainfall, and type of land surface. Porous, or permeable, land containing lots of sand or gravel will allow as much as 50 percent of precipitation to seep into the ground and become groundwater. In less permeable areas, as little as five percent may seep in. The rest becomes runoff or evaporates. Over half of the fresh water on Earth is stored as groundwater. As water seeps through permeable ground, it continues downward until it reaches a depth where water has filled all the porous areas in the soil or rock. This is known as the saturated zone. The top of the saturated zone is called the water table. The water table can rise or fall according to the season of the year and the amount of precipitation that occurs. The water table is typically higher in early spring and lower in late summer. The porous area between the land surface and the water table is known as the unsaturated zone.

I. INTRODUCTION

Water is the most essential fuel of life; clean and safe water for daily use is the basic need of human being. Even after decade of hard work and struggle by the govt. bodies & other organization to supply ample amount of potable water to each & every human being in every corner of the world, is not yet achieved. Increasing demand for water, particularly in arid and semi-arid regions of the world, has shown that the extended groundwater reservoirs formed by aquifers are invaluable for water supply and storage. Natural replenishment of this vast supply of groundwater is very slow. Therefore, exploiting groundwater at a rate greater than it can be replenished causes groundwater tables to decline and, if not corrected, eventually leads to mining of groundwater. Artificial recharge as a means to boost the natural supply of groundwater aquifers is becoming increasingly important in groundwater management. Groundwater can have a wide range of beneficial uses. For example, it can be used for irrigation of parks or agricultural land, industrial application, or to provide a potable water supply (i.e. one that is suitable for drinking).

Some factors to consider for Groundwater recharge are;

- Availability of waste water
- Quantity of source water available
- Quality of source water available
- Resultant water quality (after reactions with native water and aquifer materials)
- Clogging potential
- Underground storage space available
- Depth to underground storage space
- Transmission characteristics of the aquifer
- Applicable methods (injection or infiltration)
- Legal / institutional constraints
- Costs
- Cultural / social considerations

II.METHODOLOGY

2.1Ground Water

The part of the rainwater, which percolates through the earth’s surface, is known as groundwater. The percolation of the water depends upon the type of substrata. If the substratum is not pervious then the groundwater cannot be conserved as it percolates through the soil below. Groundwater is the major source of drinking water in both urban and rural India. Besides, it is an important source of water for the agricultural and the industrial sector. Water utilization projections for 2000 put the groundwater usage at about 50%. Being an important and integral part of the horological cycle, its availability depends on the rainfall and recharge conditions. The groundwater is stored in different depth zones.

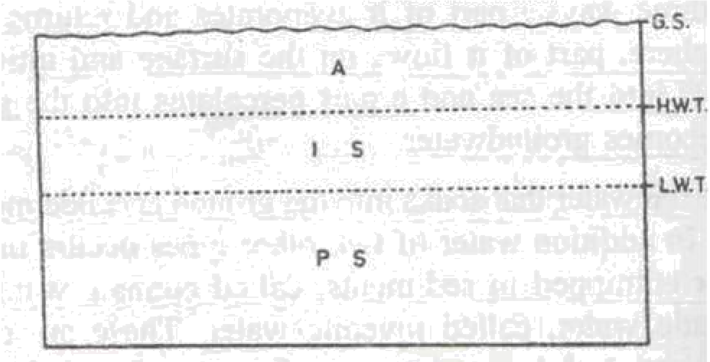


Fig :1 Groundwater Recharge

2.2 Depth Zones

In general there are three successive depth zones that may be recognized. They are as follows:-

2.2.1 Zone of Aeration or Zone of Non saturation

This is the uppermost of all the zones. Water is not stored in this zone but it percolates through it. Thus the zone of aeration does not store water, but allows passing the water through it. As it is not saturated, it is also called as zone of non-saturation.

2.2.2 Zone of intermittent saturation

The zone of intermittent saturation lies below the zone of aeration. The top of this zone is the water table. But the water table rises in the rainy season and sinks in summer season. This zone extends from the highest level reached by the water table after wet weather to the lowest level to which it falls in dry weather.

2.2.3 Zone of permanent saturation

This zone lies below the zone of intermittent saturation. The zone of permanent saturation extends downwards to the limit below which groundwater is not found. Below a certain depth, because of the above lying rocks there are no openings in rocks for water to occupy and groundwater cannot occur below this depth. This depth varies greatly according to local conditions, but it is usually at about 1000 m that the groundwater ceases to exist.

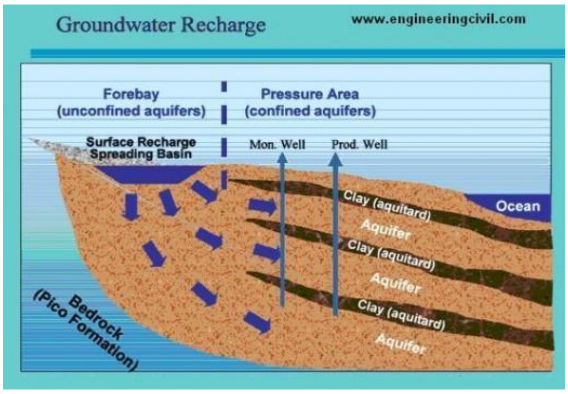


Fig.2 Depth Zones

A: Zone of aeration , IS : Zone of intermittent saturation, PS : Zone of permanent saturation.

2.3 Waste Water

Waste Water is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal waste water that contains a broad spectrum of contaminants resulting from the mixing of waste waters from different sources.

Sewage is correctly the subset of waste water that is contaminated with feces or urine, but is often used to mean any waste water. “Sewage” includes domestic, municipal, or industrial liquid waste products disposed of, usually via a pipe or sewer or similar structure, sometimes in a cesspool emptier. The physical infrastructure, including pipes, pumps, and screens, channels etc. used to convey sewage from its origin to the point of eventual treatment or disposal is termed sewerage.

2.4 Waste water treatment system

Waste water treatment consists of physical, chemical, and biological processes—either aerobic or anaerobic. The aerobic process is used most frequently. In the activated sludge process, air has to be forced into the liquid in a tank that is used to maintain aerobic microbial activity and to prevent odour. Additionally, temperature and pH must be maintained for the microbial activity. In a municipal system the flow moves as follows: from sanitary sewer to screening and grinding process, to primary clarification, to activated sludge or trickling filter, to secondary clarification, to chlorine treatment, and finally to a water body such as a river or stream. Waste water from the home enters a domestic or sanitary sewer —a system of pipes that collect the waste water. The waste is then transported to a waste water treatment plant. As it enters the plant, it flows through a bar screen, which strains out large materials. It then continues into a grit basin or chamber, where the water is slowed down enough to allow heavy or dense particles to settle out. These particles are then removed and taken to a landfill. The materials that do not settle out are ground up to prepare them to be digested by microorganisms in the treatment plant. The waste water then enters the primary clarifier, which allows materials to settle out

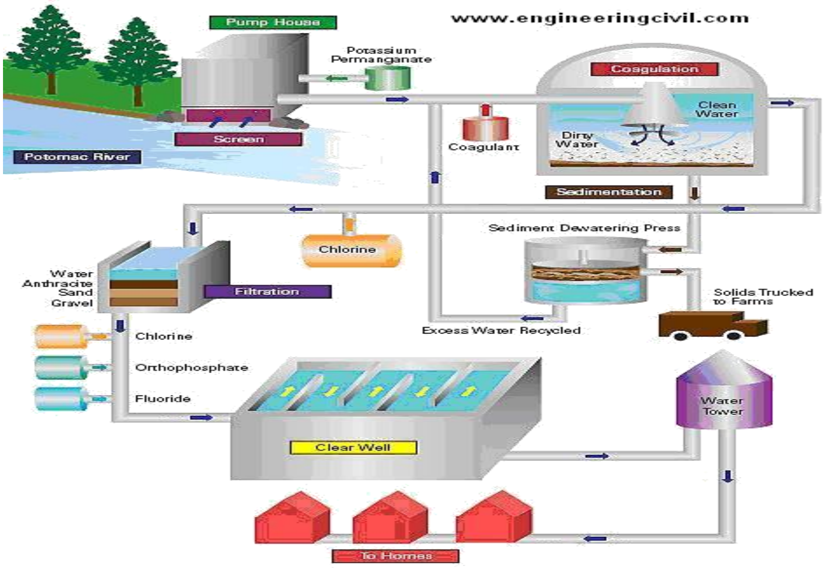
From the primary clarifier, the waste water enters activated sludge tanks or trickling filters. Trickling filters are large areas of biological decomposition consisting of rocks that host biological organisms on their surfaces. These organisms metabolize most of the suspended solids that did not settle in the primary clarifier. The build up on these rocks eventually sloughs off. The activated sludge tank is also used to remove waste from the waste water. In this process, water from the primary clarifier is pumped into an aeration tank and combined with a mixture rich in bacterial growth. Pure oxygen is pumped through, allowing the decomposition of the organic materials in the waste water. The remaining water is moved from the top of the tank, leaving sludge at the bottom. Water from the trickling filter moves to a secondary clarifier, which settles any remaining suspended solids. The solids are then pumped into a digester, while the effluent is chlorinated and released back into a water channel, river, or stream.

2.4.1 Aeration-The process of exposing large surface of water to atmospheric air is called Aeration. For removal of odours & gases, & to absorb more oxygen.

2.4.2 **Sedimentation-**It is process of removal of suspended particles of impurities by gravitational setting.

2.4.3 **Filtration-**It is process of removing particulate & bacterial impurities which could not be removed in earlier processes, from water by passing through a porous media.

2.4.4 **Disinfection of water-**It is process killing bacterial impurities & all pathogens.



2.5 Methods Of Groundwater Recharge

Groundwater recharge methods can be classified into two broad groups

2.5.1 Direct Recharge

1.Spreading method

This method involves surface spreading of water in basins that are excavated in the existing terrain. For effective artificial recharge highly permeable soils are suitable and maintenance of a layer of water over the highly permeable soils is necessary. When direct discharge is practiced the amount of water entering the aquifer depends on three factors – the infiltration rate, the percolation rate, and the capacity for horizontal water movement. In a homogenous aquifer the infiltration rate is equal to the percolation rate. At the surface of the aquifer however, clogging occurs by deposition of particles carried by water in suspension or in solution, by algal growth, colloidal swelling and soil dispersion, microbial activity act. Recharge by spreading basins is most effective where there are no impending layers between the land surface and the aquifer and where clear water is available for recharge; however, more turbid water can be tolerated than with well recharge. The common problem in recharging by surface spreading is clogging of the surface material by suspended sediment in the recharge water or by microbial growth. In coarse grained materials removal of fine suspended sediment is difficult. Playa Lakes or wet weather lake are depressions that collect water after rainfall or periods of snowmelt.

Playa lakes in Texas, New Mexico and Colorado have been used in artificial recharge projects Many Playa lakes have tight clay deposits that restrict leakage of water. Most of the water is lost by evaporation or by non-beneficial growth of vegetation in the lake. Heavy clay soils can be broken up and the lake bottom regarded for maximum recharge. In a demonstration project near Lubbock, Texas, playa lakes were modified by excavating concentration pits and using the excavated soil to raise the elevation of some of the previously flooded lands

2.Recharge Pits and Shafts

Conditions that permit surface spreading methods for artificial recharge are relatively rare. Often lenses of low permeability lie between the land surface and water table. In such situations artificial recharge systems such as pits and shafts could be effective penetrate the less permeable strata in order to access the dewatered aquifer. The rate of recharge has been found to increase as the side slopes of the pits increased Unfiltered runoff waters leave a thin film of sediment on the sides and bottom of the pits which require maintenance in order to sustain the high recharge rates. Shafts may be circular, rectangular, or of square cross-section and may be backfilled with porous material.

Excavation may terminate above the water table level or may be hydraulic connectors and extend below the water table. Recharge rates in both shafts and pits may decrease with time due to accumulation of fine grained materials and the plugging effect brought about by microbial activity .

3.Ditches

A ditch could be described as a long narrow trench, with its bottom width less than its depth. A ditch system can be designed to suit the topographic and geologic conditions that exist at a given site. A layout for a ditch and a flooding recharge project could include a series of ditches trending down the topographic slope. The ditches could terminate in a collection ditch designed to carry away the water that does not infiltrate in order to avoid ponding and to reduce the accumulation of fine material.

4.Recharge Wells

Recharge or injection wells are used to directly recharge water into deep water-bearing zones. Recharge wells could be cased through the material overlying the aquifer and if the earth materials are unconsolidated, a screen can be placed in the well in the zone of injection. In some cases, several recharge wells may be installed in the same bore hole. Recharge wells are a suitable only in areas where a thick impervious layer exists between the surface of the soil and the aquifer to be replenished. They are also advantageous where in areas where land is scarce. A relatively high rate of recharge can be attained by this method. Clogging of the well screen or aquifer may lead to excessive buildup of water levels in the recharge well. In ideal conditions a well will accept recharge water at least as readily as it will yield water by pumping. Factors that cause the build up of water levels in a recharge well to be greater than the corresponding draw down in a discharging well may include the following.

- Suspended sediment in the recharge water, including organic and inorganic matter.

- Entrained air in the recharge water.

- Microbial growth in the well.

- Chemical reactions between the recharge water and the native groundwater, the aquifer material, or both.
- Ionic reactions that result in dispersion of clay particles and swelling of colloids in a sand-and gravel aquifer.

- Iron precipitation.

- Biochemical changes in recharge water and the groundwater involving iron-reducing bacteria or sulfate-reducing organisms.

- Differences in temperature between recharge and aquifer water.

- Factors that cause the build up of water levels in a recharge well to be less than the corresponding draw down in a discharging well may include the following.

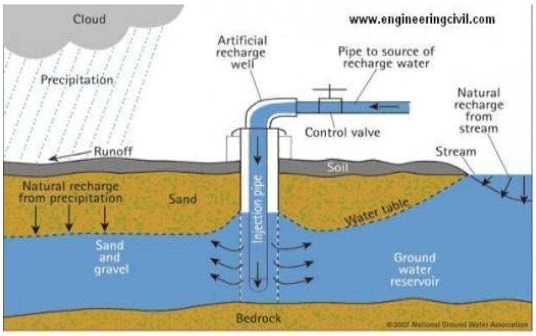


Fig no:5 Recharge Wells

3.6 Indirect Recharge

Enhanced Streambed Infiltration (Induced infiltration)

This method of induced recharge consists of setting a gallery or a line of wells parallel the bank of a river and at a short distance from it. Without the wells there would be unimpeded outflow of groundwater to the river. When small amounts of groundwater are withdrawn from the gallery parallel to the river, the amount of groundwater discharged into the river decreases. The water recovered by the gallery consists wholly of natural groundwater. Each groundwater withdrawal is accompanied by a draw down in the water table. For high recovery rates this draw down tends to lower the groundwater table at the shoreline below that at the river. Thus, surface water from the river will be induced to enter the aquifer and to flow into the gallery. In areas where the stream is separated from the aquifer by materials of low permeability, leakage from the stream may be so small that the system is not feasible

Conjunctive Well

A conjunctive well is one that is screened in both a shallow confined aquifer and a deeper artesian aquifer. Water is pumped from the deeper aquifer and if its potentiometric surface is lowered below the shallow water table, water from the shallow aquifer drains directly into the deeper aquifer. Water augmentation by conjunctive wells has the advantage of utilizing sediment-free groundwater which greatly reduces the damage of clogging well screens.

Other benefits are:

1. It reduces the amount of evapotranspiration water loss from the shallow water table.
2. Reduces flooding effects in some places. Environmental effects from the conjunctive well method must be carefully studied to assure that unwanted dewatering of wetlands or reduction of base flow will not occur. The possibility of coagulation due to mixing of chemically differ groundwater should also be investigated.

IV.ADVANTAGES AND DISADVANTAGES

4.1.Advantages

1. Artificial recharge has several potential advantages, namely:
2. The use of aquifers for storage and distribution of water and removal of contaminants by natural cleansing processes that occur as polluted rain and surface-water infiltrate the soil and percolate down through the various geological formations.
3. The technology is appropriate and generally well understood by both the technologists and the general population.
4. Very few special tools are needed to dig wells.
5. In rock formations with high structural integrity, few additional materials may be required (concrete, soft stone or coral rock blocks, metal rods etc.) to construct the wells.
6. Groundwater recharge stores water during the wet season for use in the dry season, when demand is the highest.
7. The quality of the aquifer water can be improved by recharging with high-quality.
8. Recharge can significantly increase the sustainable yield of an aquifer.
9. Recharge methods are environmentally attractive, particularly in arid regions.
10. Most aquifer recharge systems are easy to operate.
11. In many river basins, control of surface-water run-off to provide aquifer recharge reduces sedimentation problems.

4.2Disadvantages

1. In the absence of financial incentives, laws, or other regulations to encourage landowners to maintain drainage wells adequately, the wells may fall into disrepair and ultimately become sources of groundwater contamination.

2. There is a potential for contamination of the groundwater from injected surface-water run-off, especially

from agricultural fields and road surfaces. In most cases, the surface-water run-off is not pre-treated before injection.

3. Recharge can degrade the aquifer unless quality control of the injected water is adequate.

4. Unless significant volumes of water are injected in an aquifer, groundwater recharge may not be economically feasible.

5. The hydrogeology of an aquifer should be investigated and understood before any future full-scale recharge project is implemented. In karst terrain, dye-tracer studies can assist in acquiring this knowledge.

6. During the construction of water-traps, disturbance of soil and vegetation cover may cause environmental damage to the project area.

V.OPERATION AND MAINTENANCE

Periodic maintenance of groundwater recharge structures is essential because infiltration capacity is rapidly reduced because of silting, chemical precipitation, and accumulation of organic matter. In the case of injection wells and connector wells, periodic maintenance of the system consists of pumping and / or flushing with a mildly acidic solution to remove encrusting chemical precipitates and bacterial growths on the well tube slots. By converting the injection or connector wells into dual-purpose wells, the time interval between one cleansing and another can be extended, but, in the case of spreading structures, except for sub-surface dykes constructed with an overflow or outlet, annual de-silting is necessary. Unfortunately, because the structures are installed as a drought-relief measure, periodic maintenance is often neglected until a drought occurs, at which time the structures must be restored (the 5 to 7 year frequency of droughts, however, means that some maintenance does take place). Several agencies and individuals normally carry out structural maintenance.

VI.CONCLUSION

The present techniques are easy, cost-effective and sustainable in the long term. Many of these can be adopted by the individuals, rural and urban communities with locally available materials and manpower. Though ground water recharge scheme either naturally or artificially may not be the final answer, but they do call for the community effort and create the spirit of cooperation needed to subsequently manage sustain ably ground water as a community resource.

In general, the aim of groundwater recharge facilities is to augment groundwater resources. If the artificial recharge scheme is effective, a rise in groundwater level, or a reduction in the rate of the decline, should be observed. Baseflow from groundwater storage will ensure that surface water bodies flow for longer periods and, in some locations, seasonal streams may develop perennial flow. Wells and boreholes should be able to provide higher yields in previously lean months and the energy consumption for lifting water will reduce. If artificial recharge schemes contribute to groundwater availability, an increasing vegetative cover could be indicative of additional soil moisture which may result in a reduction in soil erosion and a general improvement in fauna and flora, e.g. influx of migratory birds, wildlife etc.

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