Artificial Recharge
to
Groundwater

Prepared By
K. Bijendra Pratap Rahi
Guest Faculty, Dept. Of Geology
Patna University, Patna

Recharge may be Natural or Artificial

- Natural Recharge ------- 1. Infiltration of Precipitation
  2. Seepage from Surface water

- **Artificial Recharge**

Artificial recharge may be defined as augmenting the natural movement of surface water into underground formations by some method of construction – by spreading method or by artificially changing the natural conditions.

The choice of particular method is governed by local topographic, geologic and soil conditions and the quantity of water to be recharged.

Concept of artificial recharge

Artificial recharge projects are designed to serve one or more of the following purposes

1. Maintain or augment the natural groundwater as an economic resource
2. Coordinate operation of surface and groundwater resources
3. Combat adverse conditions such as progressive lowering of groundwater levels, and saline water intrusion
4. Reduce or stop significant land subsidence
5. Provide a localized subsurface distribution system for established wells.

In most situations, artificial recharge projects not only serve as water-conservation mechanisms but also assist in overcoming problems associated with overdrafts.

Recharge methods

Direct Methods:

Water spreading methods:

Basin method
Stream channel method
Ditch and Furrow method
Flooding method
Irrigation method

- **Recharge Pit method**
- **Recharge Well method**

Indirect Methods

- **Induced recharge method**

Basin method: Water may be recharged by releasing it into basins formed by construction of dikes or levees or by excavation. Silt free water aids in preventing sealing of basins during submergence. Most basins require periodic maintenance to improve the infiltration.

Water from stream is led by a ditch into the upper most basin. As the first fills, it spills into the second and the process is repeated through the entire chain of basins.

Stream Channel method: Water spreading in a natural stream channel increase the time and area over which water is recharged from a naturally losing channel. Low check dams and dikes can be constructed. These structures are temporary. L-shaped finger levees in the stream, each of which impounds water.

Ditch and Furrow method: Water is distributed to a series of ditches, or furrows, that are shallow, flat bottomed and closely spaced to obtain maximum water contact area.

1. Contour: Where the ditch follows the ground contour
2. Tree shaped: Where the main canal successively branches into smaller canals and ditches
3. Lateral: Where a series of small ditches extend laterally from the main canal

Flooding method: In relatively flat topography, water may be diverted to spread evenly over a large area. It is desirable to form thin sheet of water over the land, which moves at a minimum velocity to avoid disturbing the soil. Compared with other spreading methods, flood spreading costs least for land preparation.

Irrigation method: The method does not require additional cost for land preparation because the distribution system is already installed. Even keeping irrigation canals full will contribute to recharge by seepage from the canals.

Pit Method: A pit excavated into a permeable formation serves as an ideal facility for groundwater recharge. In areas where shallow subsurface strata, such as hard pans and clay layers, restrict the downward passage of water, pits can effectively reach materials with higher infiltration rates.

Recharge well method: A recharge well may be defined as a well that admits water from the surface to fresh water aquifers. Recharge wells are different from the injection wells, which recharge brines and toxic industrial wastes to deep, saline water aquifers. If water is admitted into a well, a cone of recharge will be formed that is similar in shale but is the reverse a cone of depression surrounding pumping well.

Recharge rates seldom equal pumping rates. Pumping and recharge differ by more than a simple change of flow direction.

As water is pumped from a well, fine material present in the aquifer is carried through the coarser particles surrounding the well and into the well.

1) Any silt carried by water into the recharge well is filtered out and tends to clog the aquifer surrounding the well. 2) recharge water may carry large amounts of dissolved air, tending to reduce the permeability of the aquifer by air binding. 3) Recharge water may contain bacteria, which can form growths on the well screen and the surrounding formation, thereby reducing the effective flow area. 4) Chemical constituents (high sodium water) of the recharge water may differ sufficiently from the normal groundwater to cause undesirable chemical reactions.

Induced Recharge (Bank filtration):

Direct methods of artificial recharge involve the conveyance of surface water to some point where it enters the ground.

In induced recharge method, groundwater is withdrawing at a location adjacent to a river or lake so that lowering of the groundwater will induce water to enter the ground from the surface source. Wells located directly adjacent to and fed largely by surface water serve as means of artificial recharge.

Management of

Groundwater Resources

Intensive application of surface water in command areas of irrigation projects is creating water logging problems, and the increase of groundwater usage in agriculture, industry and domestic purposes is causing continuous depletion of water levels and quality problems.

Thus to protect aquifers to yield water continuously at economical cost, the management of water resources is essential.

The purpose of groundwater management in a basin is to develop the maximum possible groundwater to satisfy the requirements of all users within the basin.

Functions of groundwater management

a) Regulation of water consumption: Water consumption can be regulated either directly by allocation or indirectly by a fee or tax on consumption.

b) Augmentation of water supply: Artificial recharge, relocation of wells or importing water are the some of the methods used to increase the water supply.

c) Aquifer conservation: Certain protective measures should be taken to restore the aquifer against pollution and excessive withdrawals.

Equation of Hydrologic Equilibrium

To manage the groundwater basin, knowledge of the quantity of water that can be developed is a prerequisite.

In terms of hydrological cycle for a particular groundwater basin, a balance must exist between the quantity of water supplied to the basin and amount leaving the basin.

The equation of hydrologic equilibrium provides a Quantitative Statement of Balance. This balance is between water gains and losses in a certain basin during a specified period of time is known as the WATER BUDGET.

Hydrologic budget: It accounts for all surface and subsurface waters entering, leaving and storing within the groundwater basin.

Groundwater budget: It restricted to the balance of groundwater, whatever the sources might be.

Components of Water Balance Equation

Supply into the basin	Disposal from the basin	Method of estimation
1. Surface inflow	Surface out flow	Stream gauging – AWLR installations
2. Subsurface inflow	Subsurface outflow	Pumping tests and flownet analysis
3. Precipitation on the basin	Evaporation from soil & water	Rain gauge network Tanks and lysimeters Open-pan evaporation data
	Evapotranspiration data	Climatological data
4. Imported water & Sewage	Exported water & Sewage	Hydraulic methods
5. Decrease in surface storage	Increase in surface storage	Water levels in reservoirs, lakes etc.
6. Decrease in soil moisture storage	Increase in soil moisture storage	Soil sampling and soil moisture meters
7. Decrease in groundwater storage	Increase in groundwater storage	Specific yield and storage coefficient and water levels in observation wells.

If decrease in groundwater storage or surface storage occurs – Water supplies into the basin

Data Collection & Field Work:

1. Topographic Data: Contour maps and Aerial photographs
2. Geological Data: Surface and subsurface geologic mapping provides the frame work for the occurrence and movement of groundwater. Well logs, geophysical surveys and S & T values and quality of water information is necessary.

Alternative Basin Yields:

In managing a groundwater basin, one of the main goal is to evaluate the maximum annual groundwater yield of the basin that can be withdrawn without producing undesirable effects.

Safe Yield: "The quantity of water which can be withdrawn without depletion of the storage reserve".

The concept of the safe yield (sustained yield) has been modified by introducing two types of yields – 1) mining yield and 2) perennial yield.

Mining Yield: If groundwater is withdrawn at a rate exceeding the recharge, a mining yield exists. Continuous withdrawal of water resulting in a continuously depleted water supply.

Perennial Yield: The rate at which the water can be withdrawn perennially under specified operating conditions without producing an undesired results.

BASIN MANAGEMENT BY CONJUNCTIVE USE

In basins approaching full development of water resources, optimal beneficial use can be obtained by "conjunctive use", which involves the coordinated and planned operation of both surface water and groundwater resources.

The basic difference between the surface water development with its associated groundwater development and a conjunctive operation of surface water and groundwater resources is that the separate firm yields of the former can be replaced by the larger and more economic joint yields of the latter.

Management by conjunctive use *requires* physical facilities for water distribution, for artificial recharge and for pumping.

Groundwater reservoir can be developed by planned extraction of groundwater during periods of low precipitation, while subsequent replenishment can be made during periods of surplus surface supply. Such a coordinated operation of surface and groundwater supplies is possible, if there is sufficient groundwater storage and if the aquifers possess sufficient transmissibility to permit the movement of recharged water to the area of extraction.

The benefits accruing from the conjunctive use of water

1. A large subsurface storage at a relatively lower cost and safe against any risk of dam failure.
2. Provides water supply during a series of drought years while a surface storage can at the most tide over one such year
3. Efficient water use from spaced wells due to smaller surface distribution system than a canal irrigation scheme.
4. Water table can be controlled by pumping from wells and prevent water logging in canal irrigated areas and reduce land subsidence
5. Both water conservation and flood protection can be achieved simultaneously
6. A subsurface scheme can be developed in shorter period while it takes 10-15 years for the completion of a big surface water project
7. No evaporation and percolation losses, thus obviating (remove) the construction of expensive storm and seepage drains
8. In Project under conjunctive use of waters, tube well loads can be reduced by releasing surface water for irrigation during periods of peak power demand thus resulting in lower power costs.
9. Crop water requirements can be ensured right through the year using surface water during the monsoons and groundwater supplies when the surface water is not available
10. Groundwater and surface water can be mixed in proper proportions to obtain a desired water quality for irrigating certain crop types (particularly when the groundwater has a higher salt concentration)