Abstract—Managed aquifer recharge (MAR) is the method of intentionally recharging of depleted aquifers for subsequent recovery and for withdrawal at a later date, or to prevent saltwater or other pollutants from entering the aquifer. This review paper explains about the major advantages of MAR, technical methods to establish any MAR project schemes and the sources of water that can be recharged.

Keywords— Managed aquifer recharge, Ground water recharge, depletion of water table, Artificial ground water recharge

I. INTRODUCTION

Water as a precious natural resource is known as the elixir of life. Among the total water available on the earth surface, only 0.62% exists as groundwater and it is the basic resource that fulfills about 60% irrigation demands and 80% drinking water demands of India [9]. Though groundwater has played an important role in stabilizing Indian agriculture, its indiscriminate use, limited availability of monsoon and scarcity of surface water has resulted in fast depletion and degradation of this major natural resource. Construction of deep tube wells and other water extraction methods have also played a role in the over exploitation of ground water [7]. Water table is depleting at a faster rate in about 15% of India’s geographical area.

This situation has forced scientists and technicians to understand, plan, and manage augmentation of groundwater recharge artificially to control such fast depleting groundwater tables [8].

What is managed aquifer recharge?

Managed aquifer recharge (MAR) is the method of intentionally recharging of depleted aquifers for subsequent recovery and for withdrawal at a later date, or to prevent saltwater or other pollutants from entering the aquifer. Aquifer recharge activities can be classified as,

a. Unintentional - such as by deep seepage under irrigation or by leaks from water pipes and sewers.
b. Unmanaged - including water from drainage channels and sumps, leach out from septic tanks, usually for disposing unwanted water without thinking its reuse.
c. Managed - through mechanisms such as injection wells, and infiltration basins and galleries, storm water, surface water, treated water, and water from other aquifers can be used [4].

Importance and benefits of MAR

1. It reduces evaporation losses
2. Enhances groundwater quantity
3. Improves groundwater quality
4. Prevents salt water intrusion into coastal aquifers
5. Stabilizes groundwater levels where over-exploited
6. Can be applied where enough surface storage spaces are not available
7. Reduce soil erosion
8. Maintains natural flows in streams and rivers [6].

II. COMPONENTS OF MAR

Totally seven components are seen in all managed aquifer recharge projects for both confined and unconfined aquifer as shown in figures 1 and 2.
1.1 Confined Aquifer

Depending on the type of aquifer available for recharge, MAR projects will vary its nature. In confined aquifers, water is allowed to inject through a well.

![Figure 1: Components of MAR in Confined aquifer](image)

1.2 Unconfined Aquifer

Unconfined aquifers allow water to infiltrate through permeable soils, where recharge can be augmented by basins and galleries.

![Figure 2: Components of MAR in Unconfined aquifer](image)

III. METHODS OF MAR

A number of methods can be used to recharge water intentionally into aquifers with respect to different local conditions.

3.1 Direct surface methods

3.1.1 Infiltration ponds and basins: Allowing water to infiltrate to the aquifer by diverting surface flows. Area available for basins and infiltration rate controls the amount of water to be recharged [6].

3.1.2 Soil Aquifer Treatment (SAT): Treated sewage effluent is allowed to infiltrate through infiltration ponds in order to remove pathogens and nutrients. In this method both soil and aquifer considered as natural filters [5].

3.1.3 Recharge releases: Dams on ephemeral streams are used to retain flood water in the upstream, and slowly releases water into the streambed and then to infiltrate into underlying aquifers, thereby augmenting recharge [4].

3.1.4 Ditches and furrows: For obtaining maximum water contact area for recharge water, ditches and furrows should arrange closely in areas having irregular topography [1].
3.2 Direct subsurface methods
3.2.1 Recharge Wells: Abandoned bore wells or dug wells in alluvial soil or hard rock areas can be used as recharge wells by gravity flow, when enough source water is available. Diameter of the wells may range from 2 to 5m and depth will be up to 20m. Recharge water may be diverted through a filter media to avoid clogging of the well and guided through a pipe to the bottom of the well to eliminate the scoring of the well bottom [3].

a. Aquifer Storage and Recovery (ASR): This is the method of injecting water into a well for storage and recovery of the water from the same well. It is useful in aquifers with saline water, where storage is the primary consideration and water treatment is a lesser consideration.

b. Aquifer storage, transfer and recovery (ASTR): This is the method of injecting water into a well for storage, and recovery from another well. This is used to provide additional water treatment in the aquifer by giving extra residence time in the aquifer beyond that of a single well [4].

3.2.2 Injection wells: Injection wells are similar to recharge wells used for augmenting recharge of confined aquifer by pumping in water under pressure. Usually bore holes of 20 cm diameter should be inserted 2 to 3 m below water table. Proper filtration mechanism should be provided at the top. Effectiveness of injection wells depend on,

- Pumping rate
- Permeability of aquifer
- Natural ground water gradient
- Type of well

3.2.3 Recharge shafts: When a shallow aquifer is located below impermeable surface, this method can be adopted. Shaft should be 0.5 to 3m in diameter and depth should be within 10 to 15 m. The shaft should be drilled up to an impermeable stratum. For filtration of recharge water, gravel, pebble, coarse sand should be packed within the shaft. Up to 1 to 2 m in the top, brick work can be carried out for the stability of the shaft.

3.2.4 Recharge pits: This method can be adopted where permeable strata is present at shallow depth. Recharge pit of any cross-section is excavated generally 1- 2m wide and 2- 3m deep. The pit is filled with boulders, gravel and sand for filtration of source water [2].

3.2.5 Recharge trenches: In this, trenches of 0.5-1.0 m width, 1-1.5 m depth and 10- 20 m length can be constructed. Trenches should be filled with gravel and sand for cleaning of recharge water. This method can be used to recharge a shallow permeable aquifer.

3.3 Indirect methods
3.3.1 Aquifer modifications: This technique modifies the aquifer parameters to increase the capacity to store and transmit water. With such alterations, the aquifer becomes capable of achieving more natural as well as artificial recharge. Such techniques include,

a. Bore blasting
b. Hydro-fracturing

3.3.2 Induced recharge: It is also an indirect method of artificial recharge by pumping water from aquifer, which is hydraulically connected with any surface water sources to induce recharge to the ground water reservoir [10].

IV. SOURCES OF WATER CAN BE RECHARGED

Surface water, storm water and reclaimed water are the abundant sources of recharge. In order to assess the effectiveness of managed aquifer recharge in water quality aspect it is important to understand the baseline water quality, the impacts of anthropogenic activities and the geochemical processes involved like groundwater abstraction, irrigation, land use, agriculture and forestry, urbanization, liquid and solid waste disposal, salt water intrusion, chemical composition of the rocks etc.
4.1 Surface water: Surface water is the major source of recharge, if it not polluted or free from all suspended matters it can be directly diverted to the recharge structure. But polluted water from rivers and lakes should go through certain pretreatment process for purification prior to recharge.

4.2 Storm water runoff: Due to the variability in quality aspects of storm water runoff, greater care should be taken before executing the recharge process. Good quality water from rooftops can be directly diverted to dug wells or bore wells. If the contaminated water from industrial runoff, animal wastes, decaying vegetation, and chemicals applied to agricultural lands, septic tank seepage and litter etc. are used for direct recharge, in order to accommodate the soil infiltration effect, treatments like sand filtration is prescribed before recharge.

4.3 Potable water: In arid regions, especially in gulf countries, fresh water coming out of desalination plants is used to recharge aquifer. Due to the high quality of this treated water, chemical and physical properties of aquifer are not altered.

V. CONCLUSION

With respect to the population growth and over-exploitation of water resources, there is a need for adopting more sustainable groundwater management strategies. In this paper, detailed description on a promising groundwater management technique called MAR has been done. Even though the literature on MAR in India is abundant, there is an absence of a structured approach and implementation of this technique. A planned approach along with people’s participation is essential for the implementation and management for the success of every MAR projects. We have to harvest every droplets of water every possible places.

REFERENCES


