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M. Hellmer
Master degree in Geology, Imperial College London
London, Англия

# MANAGED AQUIFER RECHARGE

*Управление водоносными горизонтами*

**Аннотация:** автор в настоящей статье обращается к современной гидрогеологической технологии – управлению подпиткой водоносного горизонта, под которым сегодня понимается направленная инфильтрация собранной воды в недра в целях восстановления грунтовых вод или увеличения объема хранения. Рассмотрен опыт применения рассматриваемой технологии, ее премущества.

Managed aquifer recharge (MAR) is the directed infiltration of collected water into the subsurface for the purpose of groundwater remediation or increased storage. Typically, excess rainwater and/or surface water is channeled into ponds for diffuse infiltration, or pumped directly into an aquifer at depth. In practice, this can take on numerous configurations to meet water resources needs (Figure 1). Whatever the configuration, effective MAR sites should contain systems for capturing necessary quantities of water, pre-treatment, infiltration, recovery, post-treatment, and end use implementation [4].

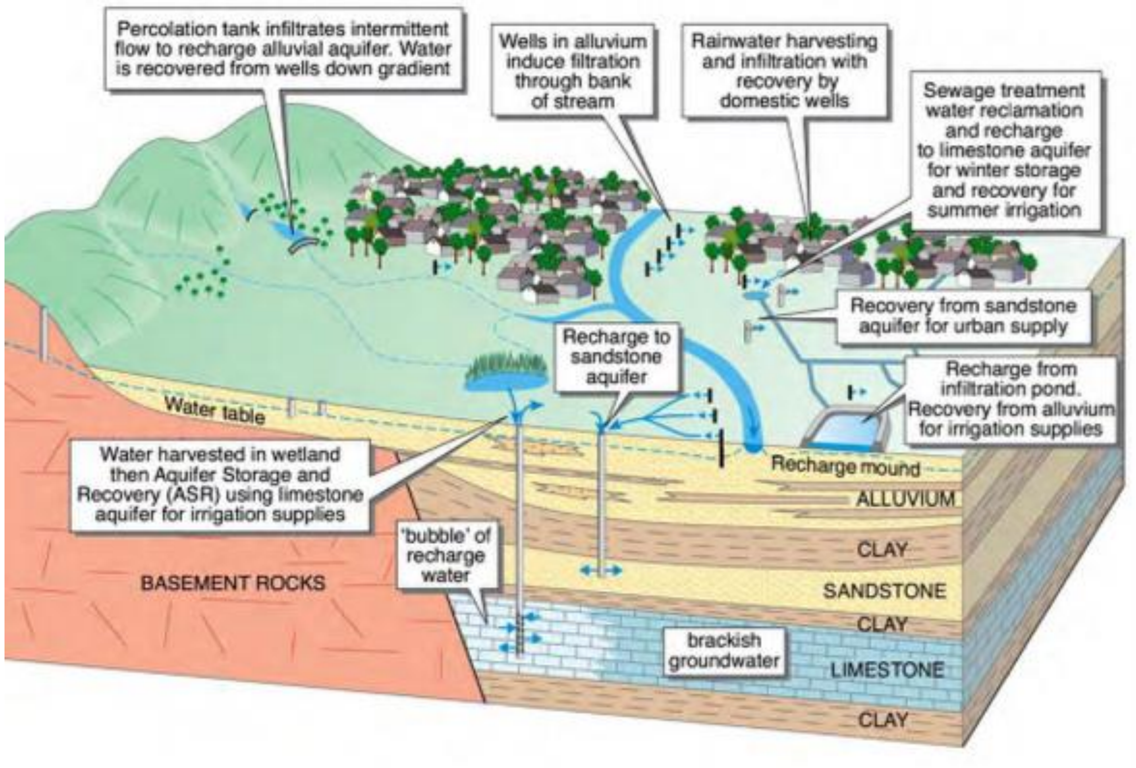


Figure 1. Visual representation of MAR systems.

Managed aquifer recharge has been used extensively in Australia for capturing and treating stormwater, soil and aquifer treatment, preventing saline intrusion, and maintaining groundwater levels. In the U.S. Southwest, MAR has been used to remediate groundwater quality and levels, as well as to prevent saline intrusion. In southern Bangladesh, MAR has been used to provide a reliable source of freshwater during the dry season [4, 5, 7].

Some advantages to using MAR include: high supply potential, low capital cost, high potential for passive pathogen removal, and low requirements for land use. Considerations of potential drawbacks in MAR implementation, however, can include: maintenance cost of injection, purification, and abstraction systems; losses due to interaction with potentially low-quality native groundwater; and constrained yields of infiltration/abstraction.

Considerations in planning whether or not MAR is applicable to meet water resources requirements should address all of these criteria: sufficient demand exists to warrant installation; an adequate source (e.g. seasonal rain, recharging pond); aquifer parameters are amenable to storage; a framework for collection, storage, and infiltration is logistically viable; and sufficient management of operations can be installed for monitoring and maintenance. Additional criteria should take into account socio-economic factors (e.g. social acceptance, population density of those in need of additional freshwater water storage) [4, 5, 7].

Factors affecting the long term stability and efficiency of ASR systems include: clogging through bioaccumulation, flocculation, or ion precipitation; ability to secure a stable supply of input; projecting demand growth; protection against contamination (e.g. hazardous chemical spill, saline intrusion); and ensuring proper management. Excessive pumping of these systems can lead to irreversible compression. Pretreatment of water prior to injection, and implementing daily flushing regimes are common approaches to reducing clogging [2].

The different mechanisms responsible for clogging wells during ASR operation can be separated into three categories: physical, biological, and chemical [1].

Physical clogging mechanisms are those typically associated with injecting water of high sediment load, compaction, gas entrainment, and sediment swelling. Unfiltered water injected into aquifers likely contains sediment loads of particle sizes larger than pore sizes. It is well documented that pre-treatment through filtration reduces clogging. In cases where entrained air within injection fluid penetrates the well casing and aquifer, air bubbles are capable of becoming entrained within pore space, thus presenting a blockage to flow. This mechanism is mitigated by proper well head designs that prevent negative pressure within the piping [3].

During injection, biological growth and accumulation associated with the interaction between the injected and ambient groundwater is a common technical issue. These can decrease permeability within the slotted section of the well bore. Stimulation of microbial growth during injection has the potential to increase injection pressures, or decrease injection rates. In the U.S., bioclogging in injection wells is mitigated by pretreatment (i.e. chlorination and ultraviolet radiation of injected water). Sultana and others postulate that bioclogging is minimal due to frequent backwashing of injection wells [7].

Chemical clogging during injection is a result of chemical reactions relating to the mixing of injected and ambient groundwater. Mineral precipitation of carbonates and metal ions (e.g. iron and manganese) occurs within pore space in the mixing zone resulting in reduced permeability. Trace metal concentrations in groundwater (e.g. copper) commonly act as catalysts, increasing rates of oxidation and precipitation [6].

Groundwater is characteristically depleted in dissolved oxygen, thus many chemical clogging mechanisms are triggered by shifts in redox conditions where the injected water mixes. The rate at which these chemical reactions occur is largely a function of injected water quality, ambient groundwater quality, aquifer mineralogy, and changes in temperature and pressure during ASR operation.

## References

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