LIFE Project Number

<LIFE +10 ENV/IT/000394/WARBO>

FINAL Report

Covering the project activities from 01/01/2012 to 31/12/2014

Reporting Date

<31/03/2015>

LIFE+ PROJECT NAME or Acronym

<WATER RE-BORN - Artificial Recharge: Innovative Technologies for the Sustainable Management of Water Resources>

Annex 51

Name of Deliverable:

Protocolli idrogeologici per la scelta delle aree di intervento,delle modalità di monitoraggio e della valutazione dell'efficacia della ricarica artificiale

Code of associated action: 2

Hydrogeological protocols for the selection of areas of intervention, methods of monitoring, and evaluating the effectiveness of artificial recharge

The artificial recharge to ground water aims at augmentation of ground water reservoir by modifying the natural movement of surface water utilizing suitable civil construction techniques. Artificial recharge techniques normally address to following issues

- To enhance the sustainable yield in areas where over-development has depleted the aquifer.
- Conservation and storage of excess surface water for future requirements, since these requirements often changes within a season or a period.
- To improve the quality of existing ground water through dilution.
- To remove bacteriological and other impurities from sewage and waste water so that water is suitable for re-use.

The basic purpose of artificial recharge of ground water is to restore supplies from aquifers depleted due to excessive ground water development.
The basic requirements for recharging the ground water reservoir are:
a) Availability water.
b) Identification of suitable hydrogeological environment and sites

Hydrogeological Aspects
Detailed knowledge of geological and hydrological features of the area is necessary for adequately selecting the site and the type of recharge structure. In particular, the features, parameters and data to be considered are: geological boundaries; hydraulic boundaries; inflow and outflow of waters; storage capacity; porosity; hydraulic conductivity; transmissivity; natural discharge of springs; water resources available for recharge; natural recharge; water balance; lithology; depth of the aquifer; and tectonic boundaries. The aquifers best suited for artificial recharge are those aquifers which absorb large quantities of water and do not release them too quickly. Theoretically this will imply that the vertical hydraulic conductivity is high, while the horizontal hydraulic conductivity is moderate. These two conditions are not often encountered in nature.

Identification Area
The artificial recharge projects are site specific and even the replication of the techniques from similar areas are to be based on the local hydrogeological and hydrological environments. The first step in planning the project is to demarcate the area of recharge. The project can be implemented systematically in case a hydrologic unit like watershed is taken for implementation. However, localised schemes are also taken to augment ground water reservoir. The artificial recharge of ground water is normally taken in following areas:
1. Areas where ground water levels are declining on regular basis.
2. Areas where substantial amount of aquifer has already been desaturated.
3. Areas where availability of ground water is inadequate in lean months.
4. Areas where salinity ingress is taking place.

In order to plan the artificial recharge schemes following studies are needed:

Hydrometeorological Studies
These are undertaken to decipher the rainfall pattern, evaporation losses and climatological features. The data on rainfall intensity, number of rain-days, etc. help in deciding the capacity and design of the artificial recharge structures.

Hydrological Studies

Before undertaking any artificial recharge project, it is a basic prerequisite to ascertain the availability of source water for the purpose of recharging the ground water reservoir. Four types of source water may be available for artificial recharge:

- Insitu precipitation on the watershed.
- Surface (canal) supplies from large reservoirs located within basin
- Treated municipal and industrial wastewaters.

'In situ' precipitation will be available almost at every location but may or may not be adequate to cause artificial recharge but the runoff going unutilised outside the watershed/ basin can be stored/ transmitted through simple recharge structures at appropriate locations. In addition none, one or both of the other two sources may be available in any of the situations, the following information will be required:

a) The quantity that may be diverted for artificial recharge.
b) The time for which the source water will be available.
c) The quality of source water and the pretreatment required.

Soil Infiltration Studies

In case of artificial recharge through water spreading methods, soil and land use conditions which control the rate of infiltration and downward percolation of the water applied on the surface of the soil assume special importance. Infiltration capacity depends on many factors such as soil type, moisture content, organic matter, vegetative cover, season, air entrapment, formation of surface seals or crusts etc. Of the soil characteristics affecting infiltration, non-capillary porosity is perhaps the most important.

Hydrogeological Studies

A correct understanding of hydrogeology of an area is of prime importance in successful implementation of any artificial recharge scheme. A desirable first step is to synthesize all the available data on hydrogeology from different agencies.

A detailed hydrogeological study besides the regional picture of hydrogeological set up available from previous studies is therefore imperative to know precisely the promising hydrogeological units for recharge and correctly decide on the location and type of structures to be constructed in field. The hydrogeological investigations required before implementation of an artificial recharge scheme are given below.

(1) Detailed Hydrogeological Mapping: the purpose of hydrogeological mapping is to present the following maps which facilitate in the analysis of the ground water regime and its suitability to artificial recharge schemes:

a) Map showing ground water contours to determine the form of the water table and the hydraulic connection of ground water with rivers, canals etc.
b) Map showing the depths to the water table are usually compiled for the periods of the maximum, minimum and mean annual position of water table.
c) Maps showing chemical quality of ground water in different aquifers

Aquifer Geometry

The data on the sub-surface hydrogeological units, their thickness and depth of occurrence, and to bring out the disposition and hydraulic properties of unconfined , semi-confined and confined aquifers in the area. For surface water spreading techniques the area of interest is generally restricted to shallow depths. The main stress is on knowing whether the surface rock types are sufficiently permeable or not to maintain high rate of infiltration during the artificial recharge.

Monitoring mechanism for artificial recharge projects

The monitoring of water levels and water quality is of prime importance in any scheme of artificial recharge of ground water. The monitoring data speaks for the efficacy of structures constructed for artificial recharge and greatly helps in taking effective measures for ground water management on scientific lines.

1) Water Level Monitoring

During the feasibility study stage the monitoring of surface water and ground water levels greatly help in identifying the method of artificial recharge. Net work of observation wells is used to study the ground water flow pattern and temporal changes in potentiometric head in the aquifer. The observation well net work during feasibility stage is generally of low well density but spread over a large area with the primary aim of defining the boundary zonation of the aquifer to be recharged and to know the hydraulic characteristics of the natural ground water system. After identification of the feasible groundwater structure the observation well net work is redefined in a smaller area with greater well density. The objective of monitoring system is to study the effect of artificial recharge on the natural ground water system. Depending on the method of artificial recharge and the hydrogeology of the area, the observation well net work has to be designed. The net work should contain observation wells (1) near the center of the recharge facility (2) a sufficient distance from the recharge facility to observe composite effects and (3) near the limit of hydrological boundaries. If the recharged aquifer is overlain by confining/semi-confining layer, piezometers should be installed to monitor the water levels of overlying and underlying aquifers which helps in the study of leakages etc. Where the surface water bodies are hydraulically connected with the ground water aquifer which is being recharged, it is advisable to monitor the water level profiles of both surface water and ground water.

The periodic monitoring of water levels can demarcate the zone of influence. Also the tracer technique are useful in demarcating the area of benefit.

2) Water Quality Monitoring

The monitoring of water quality during the implementation of artificial recharge schemes is essential to maintain the quality standards for specified uses of the augmented resource. In case of injection wells the composition of native water in the aquifer and the recharged water is important to prevent clogging of well and aquifer due to excessive precipitation of salts.

The data on the chemical quality of native water and the changes which take place during the artificial recharge schemes should be collected by regular sampling from observation well net work. Where treated wastewater is used for recharge a careful monitoring is required to detect and preclude any possibility of contamination through a network of monitoring wells. Thus, the type of water quality monitoring programme depends on the specific problem being studied i.e. changes in ground water quality, effect of soil salination, and prevention of any contamination etc. The samples to be collected will also depend on the purpose and are generally categorised into Indicative, Basic and Comprehensive. The indicative samples are collected at 1 to 4 months intervals and used to ascertain the presence of injected effluent. Basic samples are taken at monthly intervals for wells already influenced by recharge to determine the effect of recharge effluent on ground water quality and the purification provided by flow through the soil and aquifer system. Comprehensive samples are taken at intervals of 6 months to 1 year for observation wells and production wells to determine water quality with respect to specific standards for intended water use.

References

Committee on Sustainable Underground Storage of Recoverable Water, National Research Council (2008) - *Prospects for Managed Underground Storage of Recoverable Water*, The National Academies Press.

Central Ground Water Board (1994) - *Manual on artificial recharge.* (Technical series M; no. 3). New Delhi, India, Central Ground Water Board, Ministry of Water Resources.