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THE ARTIFICIAL RECHARGE PROJECTS IN ISRAEL FROM A REGIONAL HYDROGEOLOGICAL POINT OF VIEW

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SUMMARY

Artificial recharge of water in Israel is undertaken to compensate the groundwater basins for the deficit caused in dry years by overpumping from the aquifers and also to provide a long-term reserve stored for future years.

Artificial recharge into the aquifers is carried out with the aid of boreholes and spreading grounds and also by spreading storm runoff water over dune areas.

The amount of water recharged into the underground basins depends, on the one hand, on the winter surpluses in the Lake Kinneret basin, on the amount of storm runoff that can be intercepted, and on the demand for water, this latter depending on the intensity and distribution of rainfall over the different agricultural areas. On the other hand, the amount of water available for recharge is limited by the conveyance capacity of the National Carrier, the absorption capacity of the boreholes used for injection, and on the rate of infiltration through the spreading grounds. Most recharge operations are carried out in the winter months (from December to March). The amount of recharge in the months of April-May depends on the rainfall that takes place during the preceding months.

Israel utilizes at present about 925 million cubic meters of water annually from groundwater resources; about 58 per cent of the total amount of water consumed each year. The water is drawn from two main aquifers; the limestone and dolomite aquifer of Cenomenian-Turonian age, and the sandstone aquifer of Plio-Pleistocene age. Other aquifers of local importance are alluvial Neogene to Quaternary aquifers and Nubian sandstone aquifers in the southern part of Israel, and basaltic rocks of Neogene Quaternary age in north western Israel.

The limestone and dolomite rocks make up most of the mountainous anticlinorial backbone of Israel, the area where these aquifers are recharged. These rocks dip westward below a cover of chalks and marls of Senonian, Eocene and Neogene age. The waters flow down the dip toward the synclinal foothill regions and find their outlet as huge springs in structural highs, exposing aquiferous rocks.

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The eastern flanks of the central anticlinorium are down faulted towards the Jordan, Dead-Sea rift valley. The groundwater outlets here are typical fault-line springs.

The water in the limestone dolomite aquifers is thus found either under phreatic conditions in the mountainous areas, perched mainly on the aquiclude of clays and marls of Lower Cretaceous age, or under confined conditions in the lowlands where confinement is due to marls and chalks of Senonian to Paleo-Neogene age tens to hundreds of meters thick; the limestone dolomite aquifers are from one to eight hundred meters thick.

The sandstone aquifer underlies the Mediterranean coastal plains, it is composed mainly of calcareous sandstones and sands interfingered with clay and loam layers. These layers overlie a very thick sequence of clays and marls of Neogene age.

The sand and sandstone aquifer is phreatic in the eastern part of the coastal plain where it is recharged mainly by infiltration from precipitation on the area and floods from the mountains and by direct inflow from other aquifers. Towards the west the interfingered clay and loam layers cause the subdivision into confined and semi-confined aquifers. The water towards the sea is forming an interface with underlying saline sea water. This aquifer is about 50 meters thick on the eastern edge and 150 meters thick on the shoreline.

A sequence of a few hundred meters of basaltic rocks and fresh-water marls and limestones with perched aquifers in the jointed basalt gave rise to many medium to small size springs in the northwestern part of Israel. Wells drilled into the basalts gave a wide range of results, from highly productive to dry holes.

The schemes, Shigma and Nahale Menashe, which are based on storm runoff and percolation in sand dune areas, have been in operation a number of years and have recharged 7 to 8 MCM per year in the first case and 20 MCM per year in the second case. Rates of infiltration gradually fall off from 100 cm/day at the beginning of the recharge season to 7-15cm/day at its end. The process of recovery of spreading grounds includes dry periods and ploughing of the upper surface of the spreading grounds.

Other basins and large excavations in sandy and sandstone formations are used for infiltrating Lake Kinneret water and mixed water from the National Water Carrier. In these cases, infiltration rates are mostly higher and fall off at a lesser extent (from an initial rate of 100-300 cm/day to 20-130 cm/day at the end of the infiltration period). In a number of places it was necessary to treat the surface with a scraper and a cultivator in addition to the seasonal drying, in order to prevent additional impermeability of the soil surface and to preserve a reasonable infiltration capacity.

Percolation through the limestone layers in the two reservoirs built on intermittent streams reaches 25 and even 43 cm/day, immediately after floods, and drops to a few centimetres per day when the water level falls.

During the first year of the operation of the Dan Region Sewage Disposal and Reclamation Project, 10 MCM percolated into the groundwater, but it is still too early to evaluate the capacity and the operation of this important project.

Over 150 wells drilled in sand dune areas, in limestone and basalt, have been used since the early '60s for groundwater recharge. About 30 per cent of these wells serve exclusively for injection, whereas the others are operational wells, into which water is injected in the recharge season.

The average quantity of water which can be injected through one operational well drilled in a sandstone formation, exceeds 0.5 MCM for one winter season of four to five months. The rates of infiltration range mostly from 100 to 400 cu.m/hr. As a result of the severe clogging phenomena occuring in boreholes, the rate of absorption of injected water drops, as well as the specific infiltration rate (i.e. the rate of infiltration per metre of level rise in boreholes) after a single season by 20 to 80 per cent, varying with the characteristics of the well and the geological formation. It appears that the redevelopment of a well and continued pumping are the best means to restore the wells after it has become clogged. As a result numerous wells which had at first been designed as injection wells only, are now being exploited as dual-purpose wells, i.e. in the winter when surplus water exists, they serve for injection and in the summer which is the peak demand period, they are utilized for pumping. There is a marked dissimilarity in the absorption capacity of boreholes.

The infiltration capacity of wells drilled in limestone formations is much higher. The annual injected amount of water is on the average 1.5 MCM per season per well. A number of wells have absorbed larger quantities, up to 8 MCM per season per well, while the injection rates even exceed 2.000 cu.m/hr and clogging is almost undetected. Some wells located in basalt formation have also been used for injection.

A total of over 770 MCM of fresh water has been recharged in the country's different regions since the commissioning of the National Carrier, the maximum annual amount recharged reaching 148 MCM (in 1971). As stated, the quantities recharged are determined by fluctuations in the hydrological cycle, operational limitations in pumping from Lake Kinneret, and the absorption capacity of the injection boreholes and spreading grounds.