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THE WATER RESOURCES CENTER

Hydrology and Water Resources Engineering

Runoff Farms Unit

Desert Meteorology Unit

HYDROLOGY AND WATER RESOURCES ENGINEERING UNIT

An aquifer containing large amounts of brackish water (between 1000 and 1500 ppm Cl per liter) was found to exist in the Judean Group limestones below the central part of the Negev. A re-evaluation of the hydrogeological regime in the same aquifer in the northern part of the Negev showed that it has a potentially greater output (in the order of magnitude of 40 million cubic meters per year) then that estimated before by the wate authorities. Progress was also made in evaluating the potential of the saline-to-brackish water known to exist in the aquifers of Jurassic age (Arad Group). Research on the management of the aquifers containing fossil water in the Dead Sea region was also continued.

During the last year we established a hydrological monitoring network in the Ramon erosion cirque, to enable a better understanding of the hydrological and hydrogeochemical regime in an arid region. The interpretation of chemical and isotopical data from rainwater, springs and wells, enabled us to gain a better understanding of the salinization processes of water an soil in arid zones.

Progress has also been made in developing the possibilities for utiliz primary treated sewage for drip irrigation, and in the alternative uses of sewage water for aquatic agriculture or for biogas production. The unit participated in the construction of the new regional agricultural research farm near Ashalim. This farm has enabled the advancement of research on irrigation using brackish-to-saline water. The unit was also involved in the development of new methods for monitoring both nutritional environments in water culture and soil water tension. Progress was made with the introduction of prefabricated porous concrete pipes for drainage and irrigation, and with the use of irrigation "inserts" for the improved exploitation of water resources.

Within the framework of the agreement for Scientific Cooperation with ILRI, Wageningen, Holland, the construction of a rain simulator and soil laboratory was completed. This mutual research is an important step for t better use of water from microcatchments.

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Articles in Scientific Journals and Books

Issar, A.; The Rate of Flushing as a Major Factor in Deciding the Chemistry of Water in Fossil Aquifers in Southern Israel, 1980. Journal of Hydrology, Vol. 51 (1/3), pp. 285-296.

The sequence of rocks of Cretaceous and Pre-Cretaceous age in Israel and Sinai include in their composition thick carbonate and clastic aquifers containing water of different salinities. It is agreed by all the authors that have dealt with the geochemistry of the saline water in the subsurface of Israel that this water is of ancient marine origin. The difference in opinion is in regard to the time and concentration processes of the water, of these intrusions. This study, however, takes for granted that the deeply buried aquifers were saturated by formation water, and tries to explain what the processes were which caused the water salinity to become less and less concentrated. This can be avoided by examining the deepest known brines and finding out their special chemical characters. One can assume that these are the compositions of the formation water of marine origin of this region, before being diluted by meteoric water.

The history of the inflow, flushing, and mixture can be described as follows:

1) All aquifers were saturated by saline water or formation water.
2) The inflow of meteoric water into the aquifers saturated by the formation water was made possible only when an outlet was formed for the formation water to be pushed out.
3) The inflow occurred by a piston action which started mainly through the sandstone outcrops in central Sinai.
4) As the piston acted on all of the layers upwelling of saline water along major fault lines and unconformities could have occurred which caused mixture processes in spite of the piston action.

Ben Asher, J.; The Root Zone of Tomatoes under Trickle Irrigation, 1981. Agron. J. (in press).

Knowledge of the distribution of roots is required as input information nodels that describe the soil-plant-atmosphere continuum, and in order to ›rstand root response to environmental conditions. Measurements of root jth, weight, and surface area are among the direct methods used, while ;urements of water extraction and transport of tracers are indirect ıods for examining root systems. Root weight is probably the most common- ısed method. Its disadvantages are that many roots are lost during the washing process and that fine roots are neglected because of their small jht.

In this study root weight, cation exchange capacity (CEC) and the uptake tracer (Rb86) were used as criteria for determining root distribution of kle irrigated tomato plants (*Solanum Lycopersicum* h.). Most of the roots found to be close to the emitter. A linear correlation was found een root weight and the uptake of Rb86, but not identical to CEC. Thus as concluded that all three criteria emphasized the restricted distribu- of roots as well as their activity in the wetted volume of soil beneath emitter.

Oron, G. and Karmeli, D.; Solid Set Irrigation System Design Using Linear Programming, 1981. Water Resources Bulletin, <u>Vol. 17</u> (No. 4), pp. 565-570.

The search for the optimal irrigation is complex because the pipe flow tions allowing for pipe length and diameter are nonlinear. However, the mption that the pipe diameter is given for each pipe section for each uter calculation of the Linear Programming (LP) procedure, makes possible linearization of the design problem and allows the formulation of sets of tions for the use of LP. A case study in which LP is used to determine mal pipe diameters is presented for the solution of a solid set for a sprinkle system.

Boers, T., Ben-Asher, J., Oron, G. and Issar, A.; Micro-Catchment-Water Harvesting MCWH: I. Runoff Use Efficiency, 1981. Submitted to the International Institute for Land Reclamation and Improvement, Wageninge The Netherlands.

The use of micro-catchments (MC) to harvest runoff water is being teste and used in Israel, as well as in a number of other countries. A typical micro-catchment-water-harvesting (MCWH) system is where each MC consists of a contributing area (CA) and an infiltration basin (IB), in which a tree is planted. One MC supplies water for the consumptive use of a single tree. The objective of this study is to investigate the runoff use efficiency in MCWH, and to suggest a new approach to improve this efficiency.

Some suggestions for increasing runoff/storage are: rock clearing and vegetation removal; surface treatment by compacting the surface layer, application of wax treatment of soil cover; precision land leveling, or low the number of trees per ha; vertically inserting one or more perforated PVC pipes in the IB. This last appears to be the most effective.

Boers, T. and Ben-Asher, J.; Review of Rainwater Harvesting, 1981, Sub mitted to the International Institute for Land Reclamation and Improve ment, Wageningen, The Netherlands.

This paper reviews the state of the art of rainwater harvesting metho and gives a definition of water harvesting based on three characteristics: arid-semiarid climate, local water and small scale. Literature on the following elements of the definition is reviewed: runoff inducement - vegetation management, surface treatment, chemical treatment (salt, wax, asphalt); runoff collection - micro-catchment-water-harvesting (MCWH) and runoff-farming-water-harvesting (RFWH); storage and conservation. Definitions of MCWH and RFWH are given and design aspects are reviewed.

Ben Asher, Y., Oron, G. and Issar, A.; Technological Improvements in Microcatchment Water Harvesting, 1981. Hassadeh (in press, in Hebrew).

Microcatchment water harvesting methods are based on the idea that water from a relatively large area (about 250 sq.m.) can be collected onto a low-lying small square (about 2.5 sq. m.) in the center of which a tree is planted. According to local statistics, 60% of the rainfall events in the Negev Heights area cause runoff.

The data collected in the semicommercial almond grove planted at Wadi Mashash (25 km South of Beer Sheva) was close to the expected figures for the amounts of water which collected in each square of the grove (15 m^3 of water per rainy season per tree), and yet the yield and the physical form of the almond trees were very poor, owing to the high loss of water by evaporation and to poor perculation of the water into the root-zones.

Installing a very simple device - plastic "inserts" which will take the water directly into the root zones - can increase the efficiency of this kind of water harvesting method.

Flood in Wadi Mashash

Oron, G. and Walker, W.R.; Optimal Design and Operation of Permanent Irrigation Systems, 1981. Transaction, American Geophysical Union (in press).

There are potential advantages in utilizing pressurized solid-set irrigation systems as a means of improving productivity through better irrigation efficiency. For instance, operation is automatic and thus not dependent on manpower. In addition, automation conserves water and affords better control over the irrigation regime. There is, however, an inherent problem of increased investment costs as compared to non-solid-state systems. Most existing models used to solve irrigation optimization problems are restricted to formulations related to either a single pipe or to simple branched systems.

It has been recently suggested that since only a part of a field may be irrigated at a time, the design and operation should be based on partitioning the system into subunits. A subunit is an individually irrigated area consisting of a manifold and lateral system. One of the major problems with partioning an area into subunits is to find the optimal dimensions of the subunit. The optimization procedure involves a non-linear, mixed integer approach capable of achieving a variety of optimal solutions leading to significant conclusions with regard to the design and operation of the system.

Factors investigated include field geometry, the effect of the pressure head, consumptive use rates, a smaller flow rate in the pipe system, and outlet discharge. The objective function of the model described in this paper is to minimize the sum of the initial investment outlay of the distribution network components and the annual costs of operation (mainly energy) expressed as a present value.

Reports

Johnson, G., Ben-Asher, J., Oron, G. and Issar, A.; Water Harvesting in Arid Zones by Microcatchments, 1981. Final Report submitted to GIFRID. Sede Boqer, p. 17.

In many regions of the world there are extensive areas in which rainfall is substantially less than that required for normal dryland farming. For some countries these areas represent the sole remaining underdeveloped agricultural resource. Ironically, most of the limited precipitation which falls on these lands is wasted by evaporation and in uncontrollable flash floods. Water harvesting systems could supply water for many uses in these areas. This manual supplies technical assistants with the basic information required to introduce Micro-catchment schemes in their respective locations.

Micro-catchment water-harvesting technology for irrigation can supply the following advantages:

1) a higher percentage of runoff per unit than larger catchments;
2) low cost structures, easy to build and maintain;
3) requires negligible labor to operate;
4) saline soils will rapidly improve due to thorough leaching;
5) simplicity; the catchment surface is used for water transport, gravity for power and the soil profile beneath the plant for storage. Conveyance and storage losses are, thus, minimized.
6) marginal areas can be cultivated using only local water.

Oron, G., De-Malach, J. and Ben-Asher, J.; Application of Effluent in trickle Irrigation of Cotton in Loess Soil in the Beer Sheva Valley, 1981. Final Report for the period April 1980-March 1981, submitted to the Cotton Council. Sede Boqer, p. 47 (in Hebrew).

Agricultural productivity may be increased significantly by putting into use marginal waters such as storm water, saline water and reclaimed effluent. The use of marginal water in arid zone has significant importance for the welfare of people. The efficiency of water use can be increased by implementing improved irrigation technology. Applying the effluent through a trickle system is efficient in terms of water and energy saving.

However, the use of reclaimed effluent requires improved filtration to prevent emitter clogging.

Reservoir effluents from the Beer-Sheva wastewater treatment plant were experimented in a one year research project, conducted in a cotton field of the ESB branch. Various irrigation regimes using the flow rate emitters were examined and related to the effluent quality and emitter clogging along the laterals. It was found that it is possible to supply reclaimed effluent in quantities equivalent to 600 mm of rain with no clogging in the trickle irrigating system. The yield was highest under the following conditions: when the irrigating system was operated every two days; when the rate of supply was 2 liters/hour/emitter; when the laterals were positioned in every second row of cotton plants; and when the emitters along the rows were positioned one meter apart.

Karnieli, A. and Wolf, M.; Drainage of the Building Foundations in the "Model Neighborhood" in Dimona, 1981. Final report submitted to the Ministry of Housing, Beer-Sheva, Sede Boqer, p. 38 (in Hebrew).

The Model Neighborhood in Dimona was built and populated during 1971-77, after which a shallow perched water table formed below the foundations of the buildings, causing flooding in the underground shelters, shifting and damage to the foundations, and sometimes disintegration of the walls.

During the year 1980/81, a geological and geomorphological analysis was carried out, and the sources of the water defined. It was found that, in the past, rainfall had percolated into the ground in the Dimona area, and had then been carried by the River Awer toward the Dead Sea. This was now rendered impossible because of the destruction and blocking of underground streams as a consequence of the massive construction in the Model Neighborhood. In addition, considerable quantities of sewage water, as well as irrigation water from residents' private gardens, percolated into the ground in this area and collected under the buildings.

On the basis of the geological information collected in this area, it seems that the only solution to this situation is to drain the water out of the built-up area by pumping to a depth of almost 30 meters.

Boers, T., Micro-Catchment Water Harvesting: July-September Progress Report (No. 4), 1981. Report submitted to ILRI, Wageningen, Holland. Hydrology and Water Resources Engineering, Jacob Blaustein Institute for Desert Research, Sede Boqer, p. 29.

This quarterly report details the activization/completion of the Rain-
ll Simulator, the Planted Simulator, and the Gypsum Blocks. Also there
a report on the data collected to this date. All pistachio trees received
ter from a hose directly into the infiltration basins as described in
port no. 3. The infiltration process was measured and observed data
esented in graphs. Soil samples were taken for definition of the salinity
d saturation percentage.

Boers, T., Micro-Catchment Water Harvesting: January-March Progress Report (No. 2), 1981. Report submitted to ILRI, Wageningen, Holland. Hydrology and Water Resources Engineering, Jacob Blaustein Institute for Desert Research, Sede Boqer, p. 22.

This report gives a report on the preliminary layout of the micro-
atchment in the Planted Simulator and the Bare Soil Simulator, the preliminary
esign of the permanent Rainfall Simulator and the preliminary plan for the
n-site field office/soil and water laboratory. Also included are several
ppendices, papers and articles relevant to the project.

Boers, T.; Micro-Catchment Water Harvesting: April-June Progress Report (No. 3), 1981. Report submitted to ILRI, Wageningen, Holland. Hydrology and Water Resources Engineering, Jacob Blaustein Institute for Desert Research, Sede Boqer, p. 8.

This quarterly report concerns the finalization of the practical aspects
f the study; status reports on the field station, the Rainfall Simulator
nd the Planted Simulator. Pistachio trees were inspected with an expert
rom Kibbutz Sede Boqer and pollen from male trees from the Kibbutz were
sed for fertilization. During the winter season, Sede Boqer received
oughly 130 mm rainfall. In order to reach the total annual amount of 250
m the pistachio trees will receive additional irrigation water.

Wegter, M.; Report of Practical Work at the Jacob Blaustein Institute for Desert Research, 1981. Submitted to the Advanced College of Agriculture, Dronten, The Netherlands. Sede Boqer, p. 19.

This is a report of the work the author did while spending a half year at the Jacob Blaustein Institute for Desert Research. It includes a description of the Institute and its component works, and a report on three projects in which the author participated: Project Waterharvesting; diffuse resistance and water potential of the leaf; and Gypsum Blocks (porous blocks containing suitable electrodes and they can be used to determine the soil water potential for the range of pF 2.3 to pF 4).

Wegter, M.: Micro-Catchment-Water-Harvesting for Almond Production at the Experimental Farm Wadi Mashash, 1981. Report submitted to the Advanced College of Agriculture, Dronten, The Netherlands. Sede Boqer, p. 46.

Waterharvesting is a new word for a very old method, which has been used in arid and semi-arid regions of the world where water is scarce. This report deals with rain waterharvesting (RWH). RWH was practised as early as 4500 years B.C.E. by the people of Ur and later by the Nabateans in the Negev ca. 300 B.C.E. to 630 A.C.E. There are two different methods of RWH: Runoff-Farm-Water-Harvesting (RFWH) and Micro-Catchment-Water Harvesting (MCWH).

RFWH is a method to collect surface runoff from a catchment area using channels, dams, and diversion systems and to store it in a surface reservoir or in the rootzone of a farmed area for direct water consumptive use. MCWH is a method to collect surface runoff from a catchment area over a flow distance of less than 100 m to store it in the rootzone of an adjacent infiltration basin for water consumptive use. The purpose of this research was to study the relationship between rainfall on micro-catchments in Wadi Mashash, soil water content in the infiltration basins and agronomy data such as growth and yield of Almond trees.

Lectures Delivered at Conferences

Oron, G.; Management of on-Farm Agricultural Wastes for Energy and Food Recovery, 1981. Israeli/South African Symposium on Operations Research, CSIR Conference Centre, Pretoria, February 4-6.

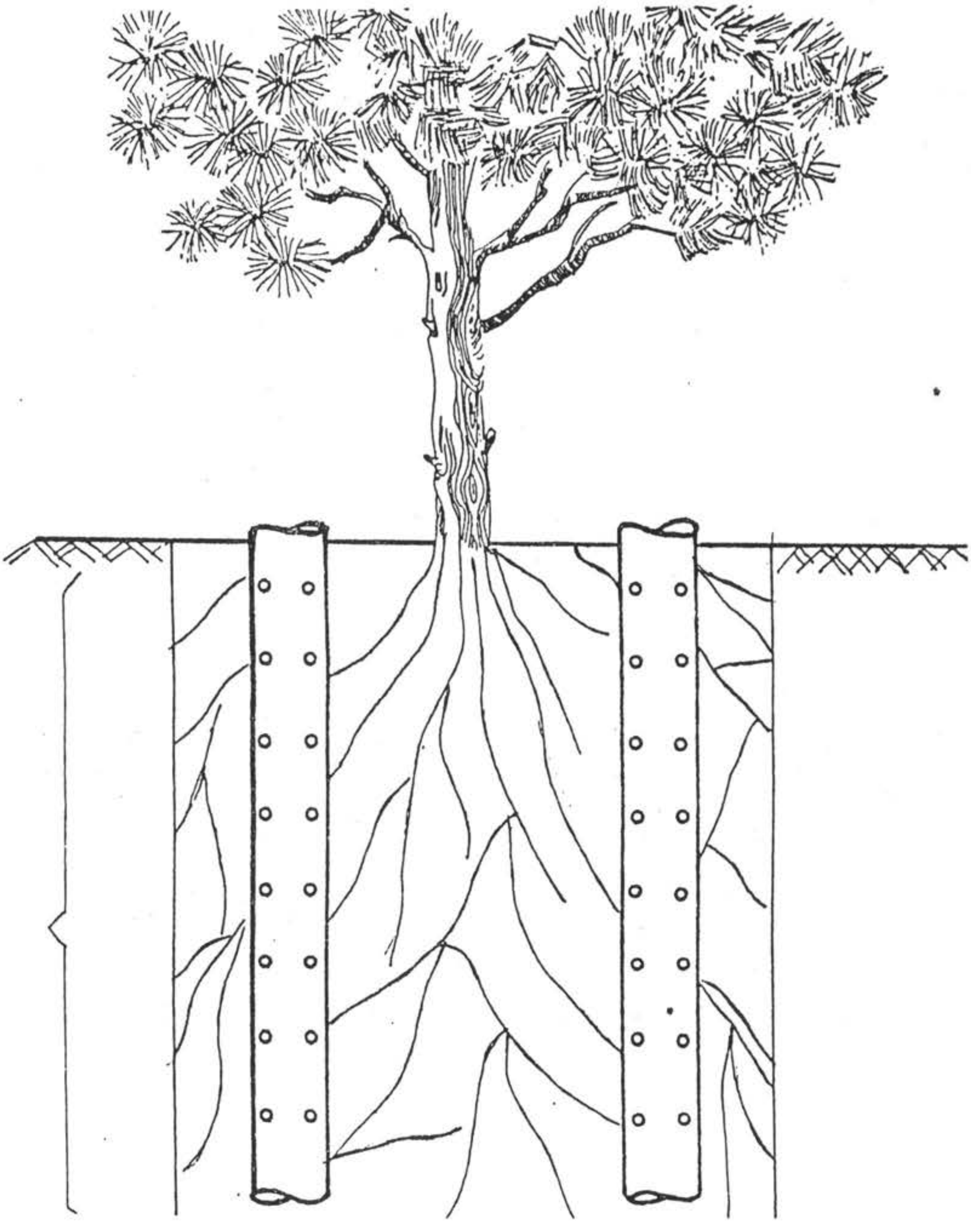
The increasing demands placed on finite supplies of energy and food make it imperative to find alternative, unconventional resources, to replace oil and animal proteins. Agricultural wastes, given proper treatment, prove to be a potentially exploitable resource. Integrated treatment of the family and farmyard wastes on the farm has environmental as well as economic advantages.

A promising technology for recycling agricultural wastes is through a two-stage process of anaerobic fermentation and algal biomass growth. In the first stage, methane gas is generated in digestors for immediate use on the farm, for machine operation, greenhouse and soil heating and cooking. In the secong stage, the digested sludge is used as a substrate in high rate oxidation ponds where algae are grown for use as a substitute protein in the manufacture of animal feed.

A management model was developed, providing guidelines for the optimal layout and performance of the proposed integrated system. A non-linear objective function is defined, which makes it possible to find the most economic management system, in terms of both energy and food (algae) production.

Zarmi, Y., Ben-Asher, J. and Greengard, T.; Overland Flow from a Steady Rainfall on an Infiltrating Microcatchment, 1981. Annual Meeting of the American Geophysical Union, November 10; Transactions, American Geophysical Union, Vol. 62, No. 45, H5-1-B-21.

A watershed of about 200 m^2 is used in many arid zones to provide the water use of a single tree. The objectives of this study were to develop and test a physical model to predict the hydrodynamic processes on a natural microcatchment of this size. Rainfall was applied uniformly over a catchment of 125 m^2 (loessial soil - fairly uniform grade of approximately 1%) at intensities of 60, 40, 20, 10 and 5 mm/hr. Analysis of all the hydrographs showed that the nature of the recession part was very similar for all intensities, appeared as parallel lines which decrease rapidly the moment the rain stops (lasting about the same time for all intensities - 10.4 ± 2.3 min). Using the least squares method to define the relationship between the outflow and depth of water layer, it was concluded that the best approximation is obtained when the velocity of water flow on the surface is assumed to be constant, independent of time or position along the catchment.



"Inserts"