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HISTORY OF TWO-WELL INDUSTRIAL WASTE-DISPOSAL SYSTEM

A 6-year study of a 2-well underground injection system (from 1964 to 1970) was conducted by Bureau of Mines engineers. Observations made from this survey include (1) selection of underground injection as the best solution to the waste-disposal problem, (2) origin and analyses of two separate waste streams, (3) surface equipment used for preinjection treatment of wastes, (4) well design and completion, (5) local and regional geology, (6) preinjections tests of the wells and laboratory tests of the disposal formation, and (7) the operating history of the 2 wells.

Major constituents of the wastes are propionic acid, phenol, butanol-1, butyraldehyde, and n-hexylamine. The adsorption characteristics of these compounds were determined in an autoclave under simulated reservoir conditions. The equilibrium amounts adsorbed and the effect of pH were determined as functions of concentration. The advance of the waste constituents is retarded by adsorption; thus, a zone develops at the advancing front which is completely depleted of waste constituents. This zone is shown to increase in depth as more of the formation is contacted by the injected fluid. These data are used to calculate the radius of migration of the waste constituents from the wellbore with respect to the total volume of waste injected, for planning waste-injection systems.

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ARTIFICIAL RECHARGE OF TREATED WASTE WATERS AND RAINFALL RUNOFF INTO DEEP SALINE AQUIFERS OF PENINSULA OF FLORIDA

Fast-growing population centers of the state of Florida, mainly in coastal beaches, have imposed large demands on the sources of fresh water. They also threaten to deteriorate the esthetic and recreational value of the area with their waste waters.

The largest of these population centers is on the southeastern end of the peninsula of Florida, commonly referred to as the Miami area. The second largest is on the central west coast of the peninsula in the Tampa-St. Petersburg area.

The Florida peninsula is underlain by several thousand feet of carbonate rock, with only minor amounts of clastic sediments. Cavernous limestone and dolomite aquifers at relatively shallow depths constitute the principal source of fresh water in the area. Deeper cavernous zones, separated from the freshwater zones by practically impermeable limestone and dolomite, are uniquely suited to receiving injected fluids.

Deep-well disposal of waste waters into deep saline aquifers, after secondary biologic treatment and disinfection, is feasible if (1) an aquifer exists that can accept treated waste waters without significant changes in its hydraulic and structural characteristics, and (2) if use of the water in that aquifer, adjacent ones, or from surficial sources is not impaired.

Two large disposal wells have been constructed for a private utility in the Miami area of southeast Florida. They are approximately 3,000 ft in depth and recharge an artesian aquifer having chloride concentrations near that of seawater (19,000 mg/l). The receiving aquifer is overlain by a thick aquiclude, by another aquifer (saline but of lower chloride concentration), and then by a thick, impervious section separating the highly mineralized waters from the shallow and fresh groundwater.

Three concentric steel casings, cemented at the proper depths, permit injection into the deeper aquifer with protection of the upper strata. Monitoring of the upper saline water-bearing stratum, where any possible leak from the deeper aquifer would normally be first detected, is performed through the annulus between the 2 inner well casings. An integrated water-quality aquisition system continuously monitors the injected waste and provides an alarm and pump shut down if established limitations are exceeded.

Operation of the first well for over a year has proved fully reliable, and economically advantageous. Eight similar disposal wells are being considered in the area.

On the basis of this experience, a new research program is being implemented to inject, store, and recover when needed, rainfall runoff into the deep saline aquifers of southern Florida.

A test-prototype well is presently being constructed within the city of St. Petersburg to determine (1) the characteristics of the deep underground formations; (2) the quality of the deep groundwaters; (3) the injection rate capacity and associated increase in pressure; (4) the ratio of the amount of fresh water that could be subsequently recovered to that injected; and (5) the quality of the recovered water.

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MOVEMENT AND ACCUMULATION OF SUSPENDED SEDIMENT DURING BASIN RECHARGE

The movement and accumulation of sediment suspended in water used for recharge were determined by radiotracer techniques and by examining thin sections of recharge basin material with a petrographic microscope. The purpose of the study was to determine suspended sediment accumulation and movement, loci of accumulation, and its effect on the recharge basin life.

The radiotracer study showed that 50% of the sediment suspended in the recharge water moved deeper than 33 cm when naturally occurring large pores were allowed to remain at the basin surface, but only 10% moved deeper than 2.5 cm when these pores were destroyed.

Horizontal and vertical thin sections were made from cores taken from the upper 30 cm of a recharge basin in which the large pores at the surface were destroyed, and that had recharged over 91 m of turbid water in 6 cycles. The nature of the sediment accumulations allowed identification in thin sections of the types, loci, and amounts. Three types of accumulations were observed: (1) flakelike structures on the upper 2.5 cm; (2) two horizontal sheetlike structures, 0.1 mm thick, between the depths of 5 to 8 cm and 8 to 12 cm, respectively; and (3) fillings in voids, mostly between 2.5 and 23 cm. The average pore volume lost between a depth of 2.5 and 5 cm was 1.5%, and below, 5 cm, less than 1%. The volume of accumulated sediment was 23% in the upper 2.5 cm, 5.5% between the depths of 2.5 and 5 cm, and less than 0.5% below 5 cm. These data agree with the data obtained from the radiotracer study.

Even though the material above 2.5 cm accumulated a large amount of sediment, porosity was maintained by freezing and thawing, and wetting and drying. Infiltration rates of the basin have not been noticeably reduced. The success of excavated basins for recharge of

turbid water should not be limited by the movement and accumulation of suspended sediment in the basin material.

HALL, CLINTON W.

U.S. ENVIRONMENTAL PROTECTION AGENCY POLICY ON SUBSURFACE EMPLACEMENT OF FLUIDS BY WELL INJECTION

The Federal Water Pollution Control Act Amendments of 1972 (public law 92–500) provide for comprehensive controls on surface water, but do not provide for specific regulatory control over subsurface water at the federal level. The only applicable regulatory provision of the act is for a federally approved state permit program which, among other things, requires a qualifying state authority to issue permits to control the disposal of pollutants into wells. Because of provisions in the new legislation requiring upgrading of the quality of discharges to both air and surface water, an increased assault on the quality of the nation's groundwater resources is anticipated. The EPA policy statement does not purport to have legal sanction, but rather puts the Agency on record as being opposed to the emplacement of materials by subsurface injection without strict controls and a clear demonstration that such emplacement will not interfere with present or potential use of the subsurface environment, contaminate groundwater resources, or otherwise damage the environment. The EPA policy does have some clout, however, in that it is designed to discourage the diversion of wastes treatable on the surface to the subsurface for the purpose of avoiding discharge permits or other provisions of P.L. 92–500, and most certainly will be used by the states in designing permit programs that will meet federal approval for the disposal of pollutants in wells.

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SUBSURFACE DISPOSAL OF LIQUID INDUSTRIAL WASTES IN ALABAMA

Five subsurface disposal wells have been drilled and completed in Alabama. These are: Stauffer Chemical Co., Mobile County; Ciba-Geigy, Inc. (2), Washington County; U.S. Steel Corp., Jefferson County; and Reichhold Chevmicals, Inc., Tuscaloosa County. The Geological Survey of Alabama has been involved directly in all 4 projects. The Survey served as a consultant to the Alabama Water Improvement Commission (the state agency responsible for protection of surface and groundwater in Alabama) on the Stauffer and Ciba-Geigy projects, and as consultant and supervisor on the U.S. Steel Corp. and Reichhold Chemicals, Inc., projects. The Environmental Protection Agency provided some funding on the research aspects of the Reichhold Chemicals, Inc., disposal well. These projects were undertaken as a research effort to insure that the responsible state agencies are fully cognizant of all aspects of this method of waste disposal.

At present, in Alabama, subsurface disposal is permissible for some types of wastes, if the well is properly designed and completed in an appropriate geologic environment, if conventional methods of waste treatment have been evaluated and proved to be inadequate, and provided an adequate monitoring system has been installed.

The Stauffer and Ciba-Geigy wells are in the Coastal Plain geologic province and the U.S. Steel and Reichhold Chemicals, Inc., wells are in Paleozoic sediments of the Warrior basin, The geology, drilling, completion, and testing techniques are presented as a basis for decision making for approval or rejection of the proposed deep-well disposal projects by a regulatory agency.

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ELECTRONIC DATA PROCESSING FOR DECISION MAKING IN SUBSURFACE INJECTION OF LIQUID WASTES

The West Virginia Geological Survey began a pilot study on subsurface industrial waste disposal in 1972 under a research grant from the U.S. Bureau of Mines. Electronic data processing (EDP) was chosen as the means of information assimilation and output. Data output includes maps showing freshwater and saltwater levels, oil and gas well locations, structure contours, isopachs, fracture pressure gradients, formation pressures, *etc.* A cost and effort determination has been made for each type of output, and leads to an overall evaluation of EDP for decision making in subsurface waste injection.

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EFFECTS OF WASTE PERCOLATION OF GROUNDWATER IN ALLUVIUM NEAR BARSTOW, CALIFORNIA

Barstow is 96 mi northeast of Los Angeles in the Mojave Desert region of southern California, adjacent to the normally dry Mojave River. Groundwater in alluvial fill is the only reliable source of water for the main water purveyors (the city of Barstow and the U.S. Marine Corps Supply Center). The alluvial aquifer near Barstow has been subjected to contamination from percolation of industrial and municipal sewage for nearly 60 years. The contamination has forced the abandonment of several domestic wells because of taste, odor, and foaming, and it threatens the well field serving the U.S. Marine Corps Supply Center. An intensive investigation was made to determine (1) the nature of groundwater degradation; (2) the areal and vertical extent of the degradation; (3) the rate and direction of movement of the degraded water; and (4) the effects of several proposed management practices designed to alleviate the problem.

A series of 53 observation wells was installed within the 10-sq-mi study area to supplement data from existing domestic and irrigation wells. Groundwater samples were analyzed for the usual chemical constituents plus arsenic, hexavalent and total chromium, dissolved organic carbon, detergents, ammonia, phosphates, and oil and grease. Concentration gradient for dissolved solids and several individual constituents were defined in 3 dimensions. The dispersive characteristics were investigated by use of a 2-well tracer-dilution test.

The chemical stratification found within the aquifer indicates that an old plume of degraded water (produced by percolation from sewage facilities near Barstow) occupies the lower part of the alluvial aquifer. Since 1910 this plume has moved down gradient about 4 mi. A more recent overlying plume of degraded water occurs near the downstream edge of the deeper plume. This recent plume is produced by effluent from sewage-treatment facilities installed in 1968. Detergent concentrations beneath this site reflect the current use of LAS-type detergents in contrast to the ABS types that are found in the deeper zones of degradation.