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The Problem of Non-Stationary Filtration of Water in Dynamically Interconnected Underground Porous Layers

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Abstract:

In this article, industrial waste dumps into deep subterranean pore layers the hydrogeological state of industrial wastewater discharge into underground layers and methods of its conservation are presented, as well as a review of global experience in water discharge.

Keywords: Reservoirs, industrial wastewater, layers, plowing into the subsoil

Introduction

Managing industrial wastewater, including various solutions, is a problem inherited from the twentieth century. Methods previously used and still in use, the main of which are the dumping of industrial wastewater into the environment - rivers, lakes, and seas, and the accumulation of wastewater in reservoirs, lead to environmental pollution and, ultimately, human impacts.

Addressing industrial waste, including the problem of collecting and storing liquid wastewater in one place, is becoming increasingly acute. Previously used and continuing methods: dumping and discharge into rivers, lakes and seas, wastewater collected above the ground, lead to environmental pollution and, as a result, have an impact on human health.

The experience of dumping industrial wastewater into deep underground layers has been studied in many developed foreign countries, such as the USA, Canada, Germany, Great Britain, France, Norway, Russia, Kazakhstan, Latin America, and the Persian Gulf.

At the 2003 international conference in Berkeley, USA, organized by the U.S. Environmental Protection Agency and the Ministry of Energy under the auspices of a number of scientific and commercial organizations, the problems of discharging liquid industrial wastewater and liquid and gaseous waste into deep underground layers were considered.

According to the conference, the United States is widely using waste management technology in this environment. This technology is known abroad as discharging industrial wastewater into deep reservoirs through drilling wells. The purpose of this is to discharge industrial wastewater through wells into low-permeability layers, which are trapped in clay rocks.

Based on the conference materials, the application of this environmental waste management technology, known abroad as Deep Well Injection, continues to expand in the United States. The disposal of industrial waste consists of their injection into deep layers of porous permeable rocks (reservoirs) separated from the surface by weakly permeable clay rocks through wells.

The second important direction is the discharge of industrial wastewater from empty wells of aging low-pressure oil fields, thereby increasing their productivity. Deposits in the Pacific coast of California, where 14% of U.S. oil is produced. The new territory is the northern state of Alaska, where 100 million tons of oil and refining industry are developed.

MATERIALS AND METHODS. The main oil and gas producing countries of the Middle and Near East are Iran, Saudi Arabia, Iraq, Kuwait, Qatar, and the small principalities of the Arabian Peninsula. These countries have over 70 major oil and gas fields.

Archaeological excavations in Iran have shown that oil was used here in the 4th century. BC. Particular attention to the oil and gas regions of the Middle East is attributed to the significant concentration of oil in certain areas, sometimes reaching 10 billion tons, with a high flow rate of wells - up to 1 million tons of oil per year.

The province on the southeastern slope of the Arabian Platform includes oil and gas fields in Syria, Iraq, Kuwait, Saudi Arabia, and Abu Dhabi (UAE). Oil is produced on land and in the Persian Gulf. Well rates for these countries are 1,000 tons per day. The presence of many important places (Gavar, Burgan, Safaniya, etc.) is characteristic. The largest of these is the Gawar oil field (Saudi Arabia), located 100 km from the coast.

RESULTS AND DISCUSSION. There are several oil and gas provinces on the African continent. The richest provinces are the Gulf of Guinea, the Sahara, and Libya.

One of the largest oil fields in the world, the Hassi-Mesaud oil field (Algeria), is located 690 km southeast of Algeria. Geological reserves of oil amount to 5 billion tons (800 million renewable tons). The locus is very soft, limited by fractured bracianticlin, which consists of Cambro-Ordovician rocks, which are directly covered by layers of salts containing Triassic salt.

The oil-bearing Cambrian deposits at a depth of 3000-3300 m contain four effective fractured and weather-beaten layers with an effective thickness of 80 m, in which there is a general gigantic oil reservoir at an altitude of 200 m beneath the water. Annual oil production is about 20 million tons.

The research can be applied in the design, construction, and operation of enterprises for the destruction of industrial liquid waste by driving it into deep layers of the earth.

Technical result:

- increasing the volume of storage in proportion to the volume of the considered layers of clay for the burial of liquid waste;
- increasing the reliability of liquid waste storage within the specified boundaries of the buried zone;
- rational use of the burial site's water resources.

The method involves utilizing layers of sand that are disposed of by discharging wastewater through wells. Low-permeability clay layers, including those classified as waterproofing, are created for the discharge of water-bearing waste through wells through forced filtration of the waste contained within them. Wastewater can be drained into one sandy layer and groundwater drained from the second, separated from the first by a layer of clay, and pumping stations are established around the reserve zone. It is possible to carry out hydraulic fracturing in the clay-clay layer, then pour the waste into an artificial sand layer formed as a result of hydraulic fracturing, etc. (Figure 1.1).

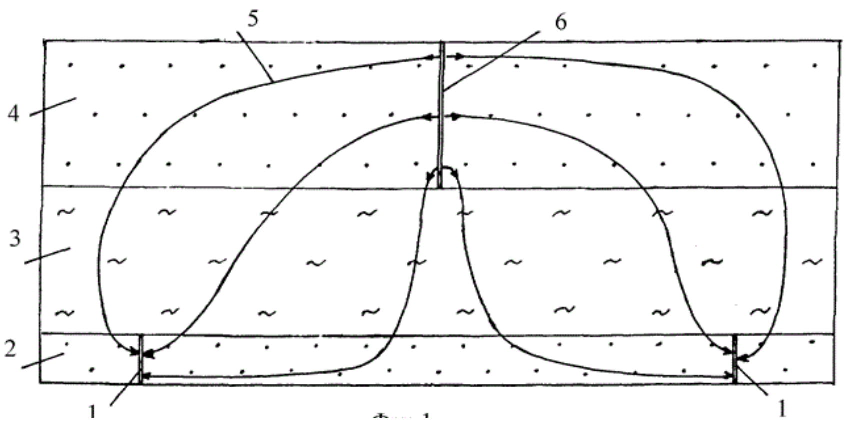

Fig.1.1. Artificial sand layer

The research relates to mining and can be used in the design, construction, and operation of deep storage facilities for industrial liquid waste (waste) in a layered underground environment, which is a slightly permeable variable layer of sandy and sandy-clay deposits with water-permeable and water-impermeable (mud-resistant) clay deposits.

Various methods for dumping liquid industrial waste underground are known. The most popular of them are:

- discharge of wastewater into deep reservoirs;
- burying waste in artificially created containers in water-tight clay and saline rocks (using mechanical rock digging, hydraulic fracturing, underground explosions, salt solution);
- burial in the loose rocks of the high-power ventilation zone due to the use of rock sorption capacity;
- burial of waste in mines (mines, mines);
- the use of certain types of wastewater in the irrigation system of oil reservoirs.

The common main drawback of these methods is the inefficient use of underground space for waste disposal. A method, which is the closest to the claimed one in terms of its technical nature and therefore accepted as a prototype, is also known, including the construction of injection wells with filters located in two different layers of permeable sandy-clay rocks in layered underground layers and the introduction of liquid waste into these layers.

Filling waste into several layers in a layered underground environment increases the efficiency of underground resource utilization, but not completely. Another drawback of this method is the placement of waste in permeable portions of the reservoir layers for many analogues, i.e., in portions characterized by high rates of natural groundwater movement.

Therefore, there is a risk of premature outflow of groundwater contaminated with waste to the surface or nearby groundwater intakes.

The purpose of the invention is to create a method that ensures the full utilization of underground space for the destruction of space debris in areas where natural migration processes occur with the least intensity.

The solution to this problem is provided by the method of dumping liquid waste into an underground reservoir, including the use of sandy and sandy-clay layers for the transport of waste through wells. For this purpose, in the utilization zone, the waste, consisting of two layers of sand with a three-tiered structure of the underground environment and a layer of clay separating them, is poured into one of the layers of sand, and groundwater is discharged from the other layer of sand, and pumping stations are directed to the edge of the waste zone.

In the solar zone, wastewater is discharged into two layers of sand with a five-tier structure consisting of three layers of underground media and two separate layers of clay, and groundwater is discharged from the middle layer of sand in this zone. When waste is introduced into one of the sandy layers of multi-layered underground layers, new injection wells are commissioned during disposal after the previous part of the waste distribution passes through the location of their filters. With a linear arrangement of injection wells separately sending waste into two layers of sand separated by a layer of clay, wells delivering waste to one of the layers of sand are located in the middle of the distances between wells delivering waste water to the other layer of sand.

CONCLUSION. When discharging wastewater into a water-permeable reservoir containing low-thickness and longness local clay layers, the filters of the discharge wells are located close to one of the permeable reservoir boundaries. It is advisable to add water-sand mixtures to the fracture site by pouring liquid waste into the newly formed sand layer, creating artificial permeable sand layers within them through hydraulic fracture.

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