

MEASUREMENT OF WATER REPLENISHMENT IN UNSATURATED SOIL AROUND HEAP LEACHING

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Abstract

The object of research is the soil around heap leaching sites, which are organized for copper extraction from oxidized copper ores. The project's goal is to implement an efficient and environmentally friendly technology for extracting copper from oxidized ores of the Kalmakyr deposit using heap leaching method with the application of **IT and ICT technologies**. The pilot project involved conducting experiments with observation of all chemical processes, including the mixing of water and sulfuric acid, calculated to maintain a normal natural environment while achieving effective results through experimentation. Experimental trials were carried out to find the most ideal conditions for chemical combination in the extraction of noble metals on an industrial scale.

The tables present the results of soil hydraulic conductivity around the heap leaching site.

Keywords

permeameter, bulb, oxidized copper ore, hydraulic conductivity, soil sorption capacity.

Introduction. Soil is a three-phase porous system, and understanding water movement within it provides important insights into its nature. Therefore, it is necessary to measure how much water is conducted through the soil, which directly affects its physical and chemical properties. Hydraulic conductivity refers to the rate at which water passes through soil or porous rock. If the hydraulic conductivity of soil is known, it is possible to gain an understanding of soil

properties such as soil compaction, clay type, total porosity, pore size distribution, pore geometry, and texture. If hydrological information about the soil is not taken into account, soil management planning will fail. Knowledge of hydraulic conductivity properties is also necessary for proper planning in the mining industry. However, determining the hydraulic conductivity of soil in laboratory conditions is not always accurate. For this purpose, the pedotransfer function (PTF) method is usually used to estimate the value of hydraulic conductivity. In this work, studies were conducted to determine the hydraulic conductivity around heap leaching [1-3].

Materials and research methods. A Guelph Permeameter was used to determine the rate of water infiltration into the soil. Soil and calibration augers were used to prepare and clean the pit.

Research results. The Guelph permeameter is a borehole permeameter with a constant head, operating on the Marriotte principle. The method involves measuring the steady-state rate of water replenishment in unsaturated soil from a cylindrical borehole, in which a constant water depth (head) is maintained [4-5].

A constant head level in the borehole is established and maintained at the level of the air tube bottom by adjusting the position of the air tube bottom, which is located in the center of the permeameter. When the water level in the reservoir drops, a vacuum is created in the air space above the water. The vacuum can only be released when air at atmospheric pressure, which enters the top of the air tube, bubbles out from the air intake tip and rises to the top of the reservoir. When the water level in the borehole begins to fall below the air intake tip, air bubbles emerge from the tip and rise into the reservoir's air space. Then, the vacuum is partially released, and water from the reservoir replenishes the water supply in the borehole. The size of the opening and the geometry of the air intake tip are designed to control the size of air bubbles to prevent fluctuations in the water level in the borehole.

When a constant water level is established in a drilled well in the soil, a "bulb" of saturated soil of certain dimensions forms relatively quickly (Figure 1). This "bulb" is very stable, and its shape depends on the soil type, well radius, and water pressure in the well.

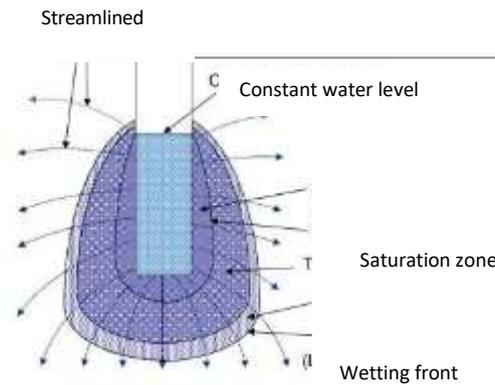


Fig.1. Saturated zone around the wellbore

Once the unique shape of the "bulb" is determined, the water flow from the well reaches a steady rate that can be measured. The rate of this constant water outflow, along with the well diameter and the water height in the well, can be used to accurately determine the saturated field conductivity, matrix flow potential, and soil sorption capacity [6-11].

The work was carried out around the Pilot Installation (PI), which includes heap leaching of copper from oxidized ores of the Kalmakyr deposit. Excavations were prepared to specific heights for the purpose of conducting permeameter tests at ten distinct locations.

Test pits were dug using soil and calibration augers (Augering Tool, Finishing Tool). A brush (Well Prep Brush) was used to remove the smeared layer that could block the natural flow of water from the well into the surrounding soil. The location of the test pits is shown in Figure 2.

Samples (200-400g) taken from 10 test pits were packaged and sent for analysis to South Korea and Canada.

Preparation for field tests of permeability under constant pressure requires drilling a homogeneous small-diameter test well in the soil where the permeometer test is being conducted. The diameter of the test pits was strictly maintained at 6 cm, and their depth ranged from 21 to 24 cm below the levels obtained after soil excavation during the digging of pits. A combined reservoir (valve up) was chosen for the experiments. To avoid turbulence and erosion in the well, as well as the potential pumping effect that could cause temporary well overflow, the air tube was slowly raised by 10 cm. Then, the water level was recorded and readings were taken every minute for 16 minutes. After 16 minutes, they switched to a two-minute time interval and continued for 30 minutes. The total duration of one experiment was 46 minutes.

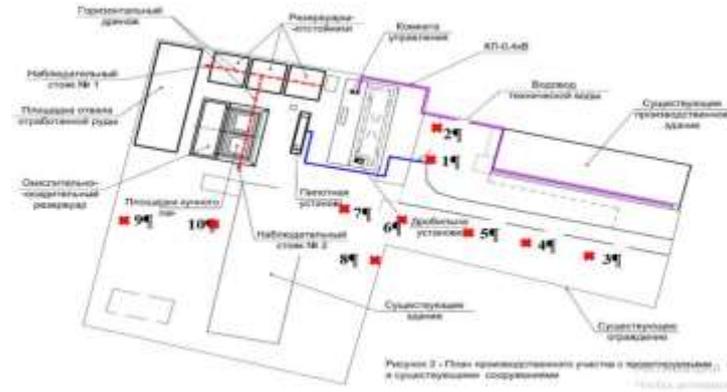


Fig.2. Location of test pits around the PS

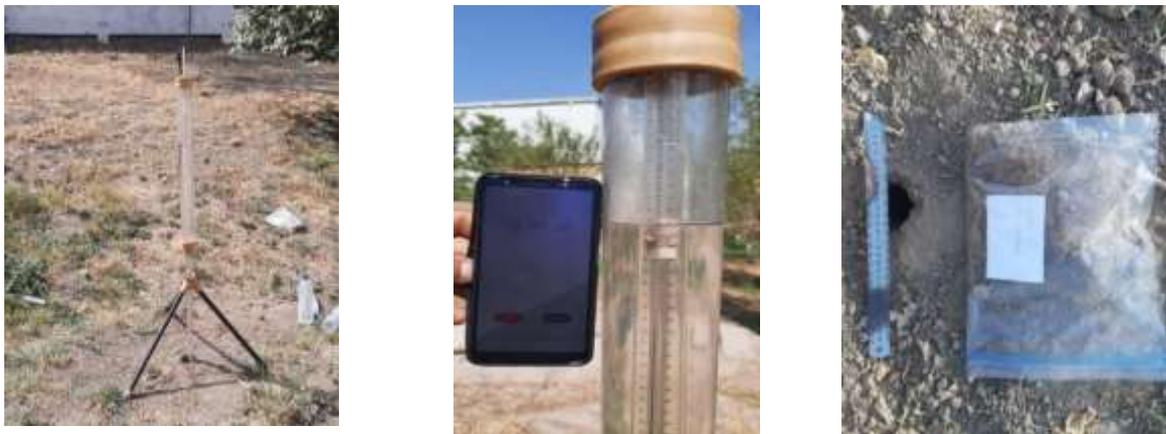


Fig.3. Measurement using Guelph permeameter
Below are the measurement results for point No.1.

Measurement results for point No.1									
Investigator:	Rasul Usenov				Date:	11.09.2021			
Location:	Pilot installation (Almalyk)				Test	1			
Pit depth:	22 cm				Radius:	6 cm			
Constant reservoirs used: 35.31									
Water level in the well:		10 cm							
Time	Δt (min)	Water in the pit h (cm)	Δh (cm)	Rate of seepage $\Delta h/\Delta t$	Time	Δt (min)	Water in the pit h (cm)	Δh (cm)	Rate of seepage $\Delta h/\Delta t$
		6.0			16	1	10.7	0.2	0.2
1	1	6.8	0.8	0.8	18	2	11.2	0.5	0.25
2	1	7.3	0.5	0.5	20	2	11.6	0.4	0.2
3	1	7.5	0.2	0.2	22	2	12.0	0.4	0.2
4	1	7.8	0.3	0.3	24	2	12.5	0.5	0.25
5	1	8.1	0.3	0.3	26	2	12.9	0.4	0.2

6	1	8.3	0.2	0.2	28	2	13.3	0.4	0.2
7	1	8.6	0.3	0.3	30	2	13.7	0.4	0.2
8	1	8.8	0.2	0.2	32	2	14.1	0.4	0.2
9	1	9.1	0.3	0.3	34	2	14.5	0.4	0.2
10	1	9.3	0.2	0.2	36	2	14.9	0.4	0.2
11	1	9.5	0.2	0.2	38	2	15.3	0.4	0.2
12	1	9.8	0.3	0.3	40	2	15.6	0.3	0.15
13	1	10.1	0.3	0.3	42	2	16.0	0.4	0.2
14	1	10.3	0.2	0.2	44	2	16.4	0.4	0.2
15	1	10.5	0.2	0.2	46	2	16.7	0.3	0.15

Conclusion. The results show that the rate of change ($\Delta h/\Delta t$) varies significantly from 0 to 2.

At the 8th test point, the water level in the reservoir did not change. After 11 minutes, the water level in the well was increased from 10 to 15 cm. However, the water level in the reservoir remained unchanged.

At the 3rd, 5th, and 9th test points, the water level in the reservoir varied from 1 to 2.

At the remaining test points 1, 2, 4, 6, 7, and 10, the water level in the reservoir ranges from 0.2 to 0.4.

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