Purification of borehole and domestic waters in rural conditions of Uzbekistan using filters and their hydraulic calculation

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Abstract. One of the main factors of human life is water, because more than 70% of the human body is water. In a situation where there is a shortage of fresh water around the world, there are increasing problems waiting to be solved, such as protection of water resources, effective use, and prevention of changes in their physical and chemical conditions. Environmental pollution also affects groundwater. Direct consumption of groundwater also has negative effects on the body in many cases. This article develops recommendations for specific amounts of groundwater treatment. Experimental tests were carried out and hydraulic calculations were carried out for the use of gravel and quartz sand, which are local raw materials, as filter load. The retention of organic and inorganic substances in a certain amount when water is passed through the filter load has been proven in experiments, and the results of the conducted research are presented in the article.

1 Introduction

Today, water consumption is divided into drinking water, technical water, fire fighting, irrigation, landscaping and other types. In water consumption, water treatment is mainly carried out depending on the purposes for which it is used [1, 2].

Groundwater is directly used as drinking water in various regions of our republic. Fresh underground water reserves are mainly concentrated in Tashkent (28.5%), Samarkand (13.7%), Surkhandarya (13.1%), Namangan (12.8%) and Andijan (12.3%) regions. Bukhara and Namangan regions are not provided with fresh underground water (0.3 percent), in the Republic of Karakalpakstan and Khorezm region, the reserves of fresh underground water are completely depleted.

Groundwater is water in liquid, solid (ice), vapor state located in the pore spaces of rock layers in the upper part of the earth's crust. Groundwater is a natural solution containing almost all known chemical elements. According to the total amount of substances dissolved in water, groundwater classified as is fresh - 1.0 g/l; **soup** - 1.0-10.0 g/l; salty - 10.0-50.0 g/l and brackish more than 50 g/l. According to the temperature, it is divided into

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underground waters that have cooled to 4 °C, cold 4-20 °C, warm 20-37 °C, hot 37-42 °C, boiling 42-100 °C and super-boiling above 100 °C [1, 2, 3, 4, 9, 11].

1. 2 Statement of issue

When using underground waters, their clarity, color and smell, taste, etc. must be taken into account. Excessive organic and inorganic substances in water have a negative effect on the human body. An excess of dry matter in water causes the activity of living cells in the human body to slowly deteriorate and cause premature aging. In water consumption, it is necessary to consume normal mineralized water. It is also not good to consume mineral water all the time, because the dissolved salts or other substances in it disrupt the balance between the salts in the body and accelerate or slow down the biochemical reactions in the gastrointestinal tract [1, 2, 3, 6, 8, 13].

It is recommended to pass groundwater through small filters before direct consumption. The filter serves to retain small organic and inorganic substances contained in underground water. Water purification from the filter depends on the filtration coefficient of the local raw materials in the filter. Water purification through filters is characterized by the filtration coefficient and speed [7, 15, 15].

2 Solution method

The experimental studies carried out to determine the filtration coefficient, filtration speed and water purification levels in the filtration process were carried out at the "Water filtration" device in the "HYDRAULIKA" laboratory of the "Engineering Communications and Systems" department of the Tashkent State Transport University (Fig. 1).

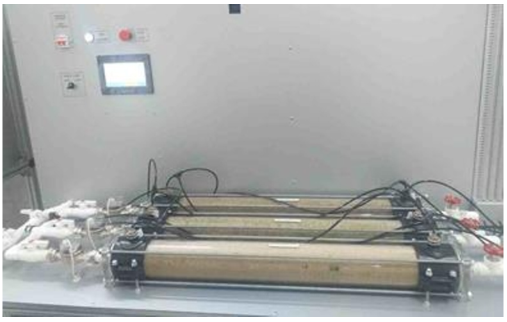

Fig 1. Overview of the experimental device.

The ability of soils to pass water through itself under the influence of hydrostatic pressure is called water absorption. The movement of water when the pore space of the soil is completely filled with water and when it is not filled is different. The process of movement of free (gravitational) water in a two-phase system (solid and liquid phases) is called filtration. This process is characterized by the filtration coefficient K_f (m/day). The process of movement of water in a three-phase system (solid, liquid and gaseous phases) has a diffusion nature. It is called wet permeability and is characterized by the coefficient of wet permeability K_n [5, 10, 14, 15].

According to Darcy's law, in the laminar movement of water in a soil completely saturated with water, the amount of water filtered per unit of time through this soil is directly proportional to the difference in water pressure ΔB that creates filtration, S is directly proportional to the area, and L is inversely proportional to the length of the filtration path:

$$Q = K_f S \frac{\Delta Б}{L} \quad (1)$$

Here, K_f is the filtration coefficient,

$$\frac{\Delta Б}{L} = J \quad (2)$$

is the hydraulic pressure gradient. The filtration rate w_f is defined as the flow rate of water per unit cross-sectional area of the stream.

$$w_f = \frac{Q}{S} = K_f J \quad (3)$$

The following follows from the law of linear filtration (3): the filtration coefficient Kf is the rate of water filtration when the pressure gradient is J=1. It is measured in K_f (m/day) [5, 12].

Using the results found in the experiment, the values of filtration coefficient, pressure gradient, water consumption, filter cross-sectional area, pressure lost in the layers of the filter product, hydraulic slope and filtration speed were found. The treatment levels of each filter load were determined by chemical analysis of the sampled waters [4, 10, 12, 15].

Dimensionless complexes and simplicities used as similarity criteria (to ensure geometric and dynamic similarity) are called independent dimensionless parameters. In addition to them, dependent (required) dimensionless parameters are used in hydromechanics [4, 10, 12, 15].

The filtration coefficient is considered as a dependent parameter in the process of experimental deviceization of filters.

$$k_n = k_m \quad (4)$$

According to Darcy's law, the filtration coefficient is the ratio of the filtration rate to the pressure gradient:

$$k_f = \frac{v_f}{i} \quad (5)$$

Napore gradient is defined as:

$$i = \frac{\Delta h_f}{l} \quad (6)$$

From the equality of filtration coefficients in the experimental device and in nature (k_n=k_m), the velocity scale is equal to:

$$\frac{v_n}{v_m} = 1, ie\ v_n = v_m \quad (7)$$

According to the results of research carried out in this field, the filtration coefficient of different soils varies widely. The values of filtration coefficients of soils in the literature studied by the author were summarized and presented in Table-1.

This article presents the experiments carried out on different fractions of gravel, which is a local raw material, whose fractions are 0.1-0.2 mm; It is 0.5-1 mm and 2-5 mm.

3 Results and samples

The laboratory device is designed for researching the hydraulic characteristics of filter soil layer models, which are made in the form of transparent cylindrical conductive pipes and are filled with soils of different permeability. Ports for pressure measurement were made along the edges of the soil sample, a pressure sensor (Figure 2) and a piezometric complex tube were simultaneously connected to each port.

Tank-Pressure generating tank, DD – pressure sensor, PD – pressure reducer, DT – temperature sensor, – filter, – pump, – connection point of piezometric complex pipes, Q – consumption meter, fraction 0.1-0.2 mm; fraction 0.5-1.0 mm and fraction 2.0-5.0 mm.

Table 1. Approximate values of soil filtration coefficients

Types of primers	Filtering coefficient K_f, m/day.
peat	0.01…4
soil	0.001…0.01
fine dusty soil	0.01…0.1
sandy soil	0.1…0.5
Sands:	
dusty	0.5…1.0
fine grain	1…5
medium grain	5…15
large grain	15…50
sand-gravel mixture	50…100
gravel	100…200

Procedure for preparing the device for operation:

1. Water is poured into the tank.

2. The device is connected to the network, machine login is enabled..

3. The device has two ways of transferring water to soil samples: through a pressure generating tank and a pressure reducer. To carry out laboratory work, one should choose one of these methods:

• taps 2, 4 are opened and tap 3 is closed to transfer water through the pressure tank;

• for water transfer through the pressure reducer, taps 2, 4 are closed and tap 3 is opened.

4. Then it is necessary to open the taps that pass the water through the sample of soil under investigation (5.1 and 6.1 for fraction 0.1-0.2 mm; 5.2 and 6.2 for fraction 0.5-1.0 mm; fraction 2.0-5.0 5.3 and 6.3 per mm).

5. The device is ready for operation. The pump is started using the switch connector on the front panel of the device.

Its physico-chemical composition was determined by studying underground water in the territory of the Republic in laboratory conditions. The indicators of natural groundwater are summarized in Table 2 below.

Table 2. Organic and inorganic substances in groundwater under natural conditions

Name	Blurry	Color	Dry residue	General hardness	Ca	Mn	SO_4	pH
Unity	mg/l	mg/l	mg/l	mg ekv/l	mg/l	mg/l	mg/l	mg/l
Value	2-2.5	25-30	1050	11	600	0,11	450	6-9

From the obtained values, it can be seen that underground water does not meet the standards of direct consumption, and has a significant negative impact on the human body.

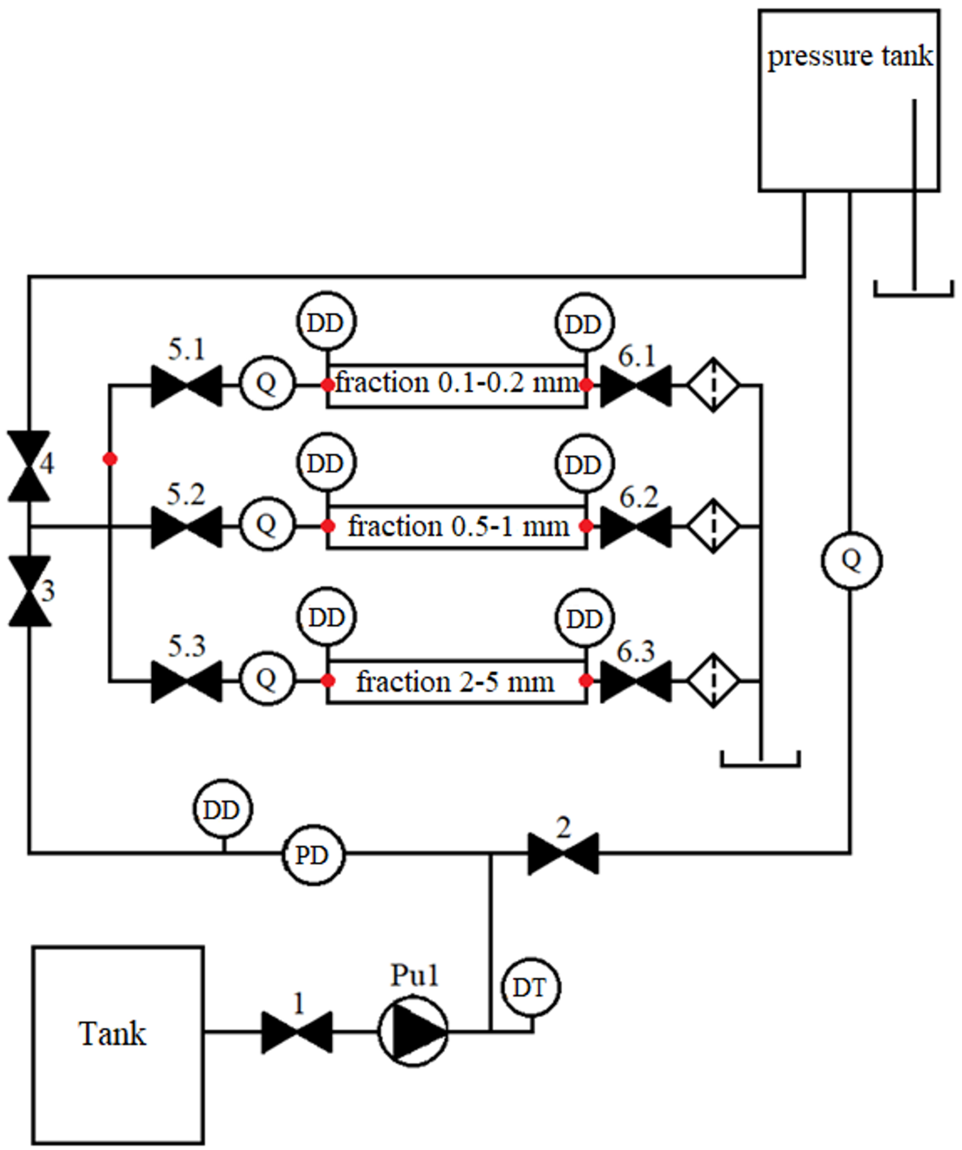

Fig. 2. Scheme of the device

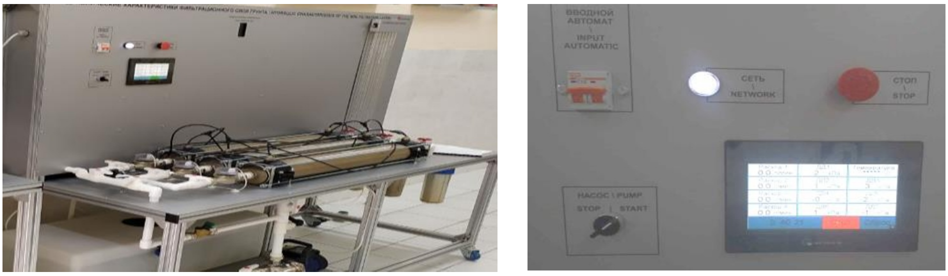

Fig 3. Control panel

During the experiment, groundwater was passed through a filter device made of local gravel with different fractions. As a result, it was found that the organic and inorganic substances contained in the water were significantly retained in the filter layers. When the content of the filtered water was re-analyzed in the laboratory, it was found that its content was lower than the standard requirement, and it is shown in Table 3.

Table 3. Organic and inorganic substances in filtered water

Name	Blurry	Color	Dry residue	General hardness	Ca	Mn	SO4	pH
Unity	mg/l	mg/l	mg/l	mg ekv/l	mg/l	mg/l	mg/l	mg/l
Value	1	20	700	7	400	0,11	450	6-9

4 Conclusions

The results of the laboratory showed that the parameters of underground water as drinking water do not meet the standard requirements. As a result of the conducted research, it was determined that the value of organic and inorganic substances is higher. Water purification with the help of the method we offer meets the requirements of the standard and differs from other methods in terms of economic efficiency. If there is an increase in organic substances in the composition of underground water due to the influence of the environment, it was determined that it can be cleaned by adding 5-10% activated carbon or bentonite to the filter load.

By changing the model coefficient "k", it is possible to create a filtering device for a different amount of water consumption. In this case, the specific groundwater flow and daily water consumption will be required. If the above two values are known, the values of the design parameters of the installed filters are derived using expressions 1-7.

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