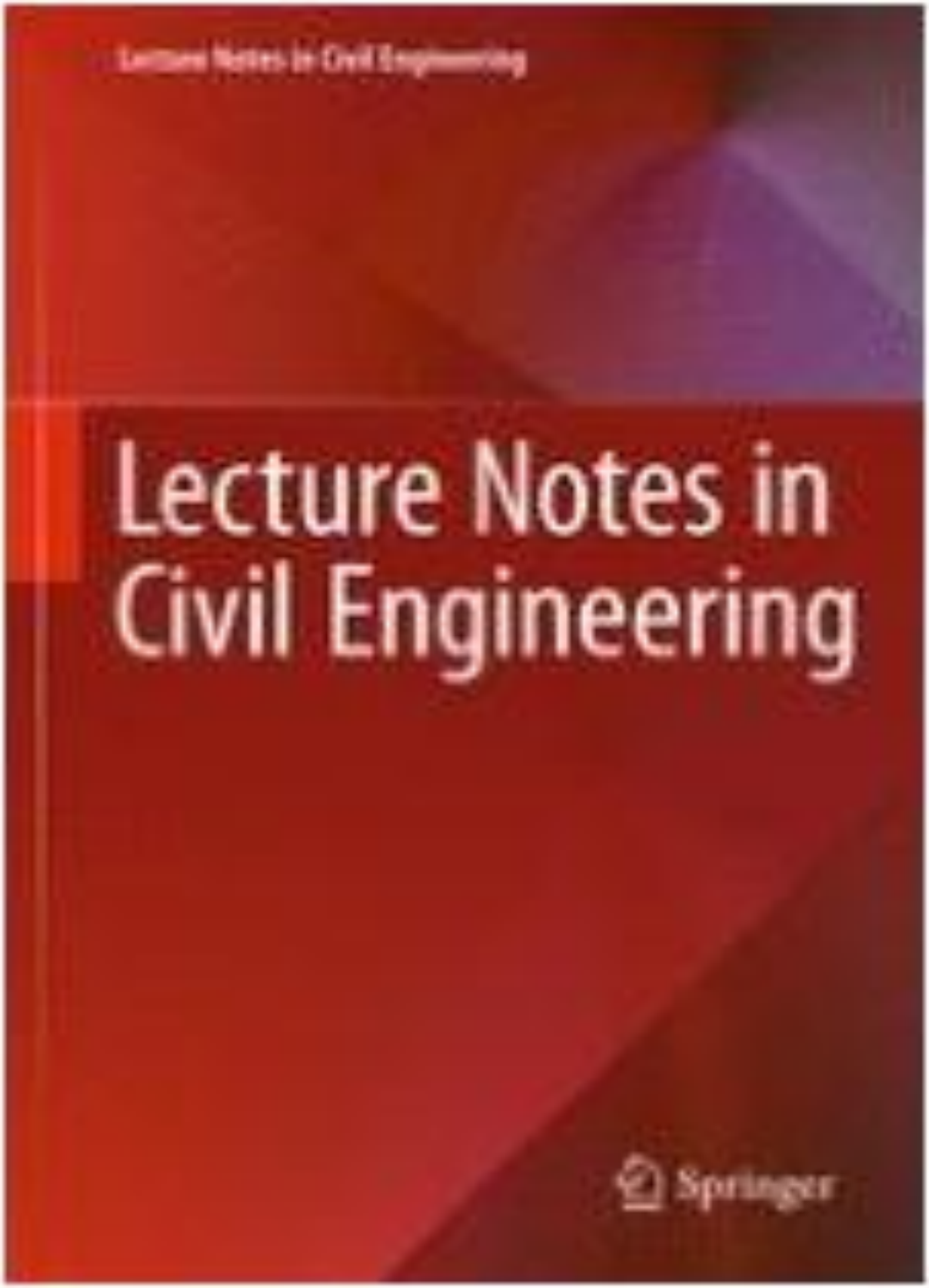
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Improved Surface Water Treatment Technology in the Kyrgyz Republic

T. Kh. Karimov, N. Baygazy kyzy, Zh. I. Osmonov, and M. T. Karimova

Abstract The paper considers the use of local quartz sand for cleaning the surface natural waters of drinking water supply. The Department of "Water Supply, Water Disposal and Hydro-technical construction" of the KG UCTA named after N. Isanov for two years conducted a study on the use of cheap local raw materials for the filter loading of fine water filters. Sand from Kyrgyz deposits was used as a loading.

The aim of the experiments was to consider the physical picture of the process of water clarification by filtration and the factors characterizing it, to study the features of the filter layers in terms of the loading height and depending on the grain diameter, as well as to determine the parameters of technological modeling for subsequent optimization of the process. The results obtained on the "short" columns were tested on a pilot plant, which is a conventional column with a full height of the filter load, calculated on the basis of technological modeling data. The operating conditions of the pilot plant generally corresponded to the operating conditions of the process simulation plant.

The task is to create a simple and affordable device for use in national conditions, in which it would be possible to use a filter load from a natural non-toxic material for the human body, which does not have high operational qualities, for a sufficiently long time to purify drinking water.

All technological schemes for the treatment of drinking water quality from surface sources using a rapid non-pressure filter are several times cheaper than similar schemes with filter loads from the Russian Federation.

Keywords Natural water · Surface sources · Filters · Filter loading · Local natural materials · Water clarification · Switchgear

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1 Introduction

Obtaining drinking water in sufficient quantity and of the required quality is a complex and urgent problem of a universal nature. To do this, it is necessary to make sure that all systems and structures for water treatment work in the appropriate norm and meet the requirements of the SNIP. In connection with the further development of the economy, the consumption of water for industrial, agricultural and household needs increases sharply. Therefore, the tasks of integrated and rational use of water resources and strengthening the fight against pollution of water supply sources are gaining more and more attention. Providing the population with water that meets specific sanitary and hygienic requirements is one of the main tasks of water supply. Water supply systems are a complex of engineering structures and devices designed to obtain water from natural sources, transport it and supply it to consumers under the necessary pressure, in the right volume and of the right quality [1, 2, 5, 8]. The paper analyzes the current state of surface water quality in Kyrgyzstan and the use of new non-traditional filters for water treatment. Water is the main vital natural resource in the entire globe, and it is the main carrier of infectious diseases and all kinds of chemical compounds in the human body. Drinking water in terms of quality indicators must meet the requirements of GOST 2874-82 "Drinking water". And the water used for the technological needs of industrial enterprises must meet the requirements of the technological processes produced in them. Natural waters in terms of their quality indicators in almost all cases (on a global scale), and in Kyrgyzstan, do not meet the above-mentioned requirements. Therefore, in the system of drinking and industrial water supply, engineering structures for water treatment are provided. Water treatment is carried out using a special technology [8]. In the technology of water treatment for drinking and industrial water supply in practice, the vast majority of cases use granular filters, which in SNIP 2.04.02-84 – "Water supply. Outdoor networks and structures" has a special section. In filters, the main working element is the filter loading filter material.

According to experts, 70–75% of the existing water supply networks are in poor condition, require restoration, repair and replacement, as most of this water supply system was built before 1970.

There are no funds to install additional and necessary equipment for water treatment and purchase reagents for existing water disinfection facilities.

To control the quality of drinking water in the water supply system in rural areas, only 10% of the staff work in many areas, which is a 75% reduction in employees.

Almost 90% of all drinking water supplied through centralized water supply networks, as well as most of the water for industrial use, is provided by underground water.

2 Research Methods

Studies of sand from local deposits in order to use it as a raw material base for the production of filter material were carried out by the Department of "Water Supply, Sanitation and Hydro-technical construction" of the KGB UCTA and were of a complex nature. They included a survey of deposits, taking samples from various sites, determining the most suitable quarries for development, analyzing and summarizing the results obtained.

On the territory of the Kyrgyz Republic, quartz sand deposits are widely known in the south of the republic in the areas of the Kok-Yangak, Sulyukta, and Markay coal deposits. And in the Chuysk region, quartz sand – Ivanovsky, Vasilievsky quarries in the Issyk-Ata district.

Studies of the parameters and properties of the filter material from quartz sand can be carried out on the basis of an integrated approach to the evaluation of filter materials according to the following program:

1) Determination of indicators and properties of quartz sand: physical and mechanical, chemical resistance, sanitary and toxicological;
2) Determination of the parameters of the granular layer: geometric structure, hydraulic characteristics, tangential stresses on the surface of the grains;
3) Determination of technological parameters of the filter layer: filtration speed, filter cycle duration, dirt capacity;
4) Conducting production tests of the filter material.

Tests and analyses were carried out in the laboratory of the Department "Water supply, Sanitation and Hydraulic Engineering" [1, 2, 8].

In this work, the main filter material is quartz sand. In the Kyrgyz Republic, quartz sand deposits are widely known: Ivanovsky, Vasilievsky quarries in the Chuysk region.

These studies were carried out in the laboratory of the department "WSSHE" KG UCTA. Water from the Ala-Archa River was taken for purification. The main filter loads are sand from the Ivanovsky and Vasilyevsky quarries and river sand. The experiment was performed on a model of a filter made in this laboratory (Fig. 1).

3 Research Results

In the laboratory unit, in the filter, three experiments were carried out, three cycles each. The sands of the Ivanovsky and Vasilyevsky deposits and the river sand of the Ala-Archa River were used, and crushed stone with a granulometric composition of 8–9 mm and 12–15 mm, respectively, was also used.

The experiments were carried out as follows.

Firstly, we prepare the investigated river water in a bowl. Then this prepared water is passed through a filter with the appropriate design of the filter layer.

Fig. 1 Rapid pressure-free filter with optimized drainage system

The first experiment – the main filter material was the sand of the Ivanovsky deposit, crushed stone, coarse sand. The design of the filter layer consists of:

- crushed stone (6–8 mm), $h = 12$ cm;
- coarse sand (4–6 mm), $h = 15$ cm;
- large crushed stone (12–13 mm), $h = 20$ cm;

$$H_{total} = 47\text{cm}.$$

We took 5 test tubes of the test water passed through the filter, every 2 min. at room temperature 18 °C.

On the device, the photoelectric concentration colorimeter KFEK-2, we check the water contained in each tube separately for turbidity, i.e. the concentration of the test water. The initial concentration remains constant, and the final concentration changes. After determining the turbidity on the device "pH-meter", we determine the acidity of the water in the test tube. The permissible acidity is normal in the range of pH = 7.5–9.0. At the end of the experiment, we determine the dry residue.

Based on the obtained data, we make the curves, determine the concentration and dry residue of the test water for each experiment separately. We set the sampling time (min) on the horizontal axis t, and the concentration of C (mg/l) of the solution on the vertical axis.

The results of the first experiment are shown in Fig. 2.

The second experiment - the sand of the Vasilyevsky deposit, crushed stone, coarse sand were used. The design of the filter layer consists of:

- crushed stone (6–8 mm), $h = 12$ cm;
- coarse sand (4–6 mm), $h = 15$ cm;
- large crushed stone (12–13 mm), $h = 20$ cm;

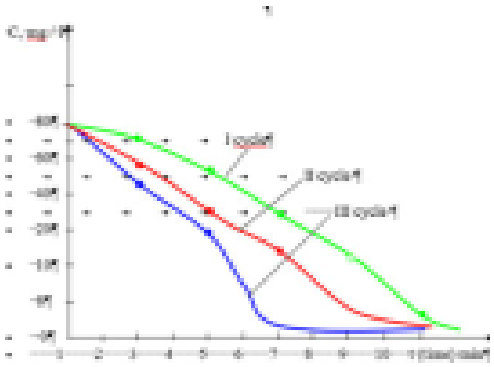

Fig. 2 I – Lightening curve on the sand of the Ivanovsky deposit

$$H_{total} = 47\text{cm}.$$

The results of the second experiment are shown in Fig. 2.

The third experiment - river sand of the Ala-Archa river, crushed stone, coarse sand were used. The design of the filter layer consists of:

- crushed stone (6–8 mm), $h = 12$ cm;
- coarse sand (4–6 mm), $h = 15$ cm;
- large crushed stone (12–13 mm), $h = 20$ cm;

$$H_{total} = 47\text{cm}.$$

Similarly, all the same operations are performed as in the first experiment, the graphs of the curves of the second and third experiments are made, respectively, in Fig. 2, 3, 4, 5.

Based on the results of the research, a simulation of the operation of a rapid filter with local loading of quartz sands from the Ivanovsky and Vasilevsky deposits of the Kyrgyz Republic was found (Table 1).

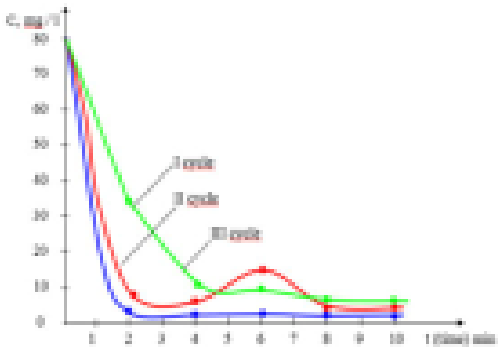

Fig. 3 II – Lightening curve on the sand of the Vasilevsky field

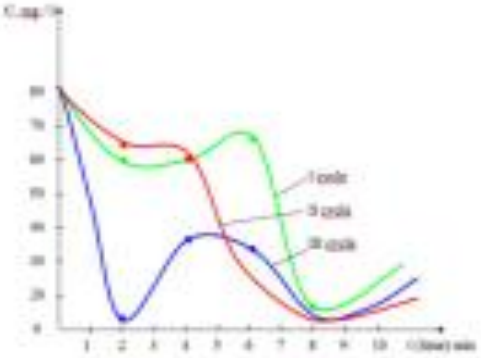

Fig. 4 III – Lightening curve on the sand of the Ala-Archa river

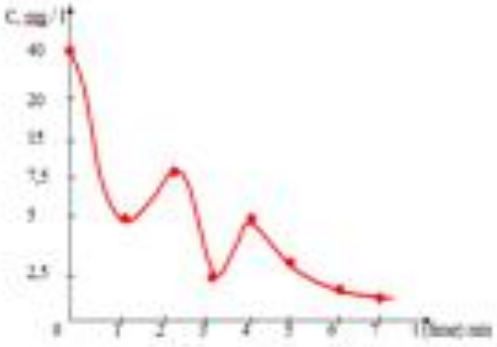

Fig. 5 Graph of water lightening in three filter cycles on quartz sand of the Ivanovsky field

The improvement of water supply and sanitation systems will create additional water resources.

As a result of the research, it was revealed that the duration of the filter cycle is doubled, and the water quality meets all the requirements of GOST and SES of the Kyrgyz Republic. For surface water treatment, a "Filter" is proposed that can purify up to 85% of water and up to 92% of suspended solids.

To solve the problem of preparing water of drinking quality, the technology of water purification from surface sources, which corresponds to GOST "Drinking water", is proposed.

4 Conclusion

Recently, the program of the Asian Development Bank and the World Bank for the supply of clean drinking water to rural settlements has been implemented. When designing water supply systems in these places, all design institutes of the Kyrgyz Republic use old standard projects developed in the 70 s and 80 s by design institutes of the USSR, which were designed without taking into account local conditions and on the raw materials of the Russian Federation. For example, rapid pressure-free filters were designed for the Volgograd and Astrakhan quartz sand, which has good

Table 1 Technological modeling according to the "fast filter" scheme Summary indicators

Filter cycles	C_0, mg/l	t_0, °C	Maximum hydraulic slope			Ultimate porosity			Maximum tangential stresses, Pa			Dirt capacity, kg/m^2				P_{up}, kPa	t_0, h
			1	2	3	1	2	3	1	2	3	1	2	3	total		
1	14.6	2.3	1.2	0.4	0.3	0.5	0.5	0.5	0.9	0.56	0.46	2.7	0.9	0.2	3.8	10.6	18
2	9.8	2.6	1.0	0.5	0.3	0.5	0.5	0.5	0.8	0.62	0.48	1.2	0.5	0.1	1.8	11.0	13
3	11.0	3.1	1.2	0.5	0.4	0.4	0.4	0.4	0.9	0.61	0.51	1.7	0.7	0.2	2.6	12.0	16
4	9.8	4.6	1.5	0.6	0.4	0.4	0.4	0.4	1.0	0.66	0.58	2.1	0.9	0.1	3.1	14.6	21
5	14.0	5.6	1.6	0.7	0.5	0.4	0.4	0.4	1.0	0.68	0.59	2.2	0.7	0.3	3.2	15.9	16
6	7.1	7.0	1.7	0.7	0.6	0.4	0.4	0.4	1.1	0.69	0.65	0.8	0.3	0.1	1.2	16.9	13
7	6.9	8.2	2.0	0.7	0.5	0.4	0.4	0.4	1.2	0.67	0.58	1.2	0.4	0.1	1.7	18.3	19
8	6.0	9.4	2.0	0.6	0.5	0.4	0.4	0.4	1.1	0.65	0.57	0.7	0.3	0.1	1.1	17.5	14
9	3.7	9.9	1.8	0.7	0.5	0.4	0.4	0.4	1.1	0.64	0.56	1.1	0.4	0.1	1.6	16.9	31
Average values			1.6	0.6	0.4	0.4	0.4	0.4	1.0	0.64	0.55	1.5	0.6	0.1	2.2	14.9	18

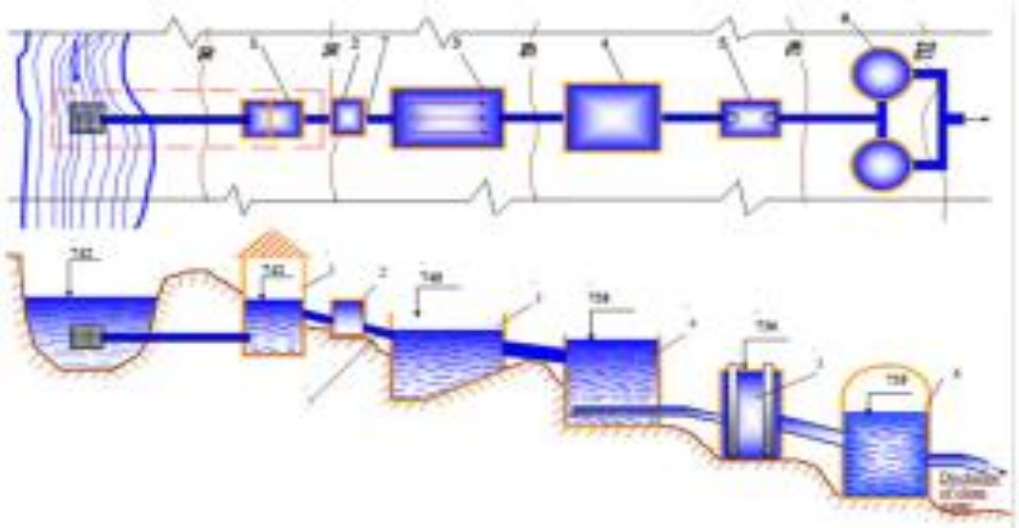

Fig. 6 1 – water intake; 2 – microhydroelectric power plant; 3 – sump; 4 – filter; 5 – decontamination device; 6 – clean water tank

sorption properties, or for the anthracite loading of Russian deposits. But despite this, design institutes develop schemes using these very loads, which lead to a multiple increase in the cost of drinking water for the rural population.

The Department of "Water Supply, Sanitation and Hydraulic Engineering" of KGUCTA for two years conducted a study on the use of cheap local raw materials for the filter loading of fine water filters. Sand from Kyrgyz deposits was used as a loading. As a result of the study, it turned out that the duration of the filter cycle is doubled; the water quality meets all the requirements of GOST "Drinking Water" and the Sanitary Code of the Kyrgyz Republic.

The proposed technological scheme for the preparation of drinking water quality from surface sources using a rapid non-pressure filter is several times cheaper than similar schemes with filter loads from the Russian Federation (Fig. 6).

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References

1. Ayukaev RI (1981) Production and application of local filter materials in municipal and industrial water supply. Express-Inform 3(6) 25 Moscow
2. Ayukaev RI, Vorobyev VA, Kivran VK, Koryakin VP (1976) Application of computers in the study of physical and structural properties of porous materials. KISI, Kuibyshev
3. Karimov TKh, Rakhmanbekov BR (2018) Monitoring of the Chu River and its main tributaries. Bull KGUCTA 61(3):109–114

4. Karimov TK, Karimova MT, Baigazy kyzy N, Maatkulova J, Abdykalykov AA (2019) Analysis of groundwater resources in the Kyrgyz Republic. J Environ Manage Tourism. vol. X, Fall 5(37): 984–990
5. Kastalsky AA, Mints DM (1982) Preparation of water for drinking and industrial water supply. Moscow (1982)
6. Korenev Yul (1980) Research of air washing of fast filters: Research in the field of water supply of LICI. Leningrad
7. Kurgaev EF (1972) Modeling of clarifiers and granular filters. Proc Inst Central Res Inst Transport 48:25–38
8. Mints DM, Shubert SA (1961) APU filters and Calculation of Filter Washing. MKH RSFSR, Moscow
9. Noskov MD, Zaytseva MS, Istomin AD, Lukashevich OD (2008) Mathematical modeling of the operation of fast filters. TSACE Bulletin 2:126–137
10. Petrov EG, Levitin SM (1985) Filter materials for non-reagent treatment of natural waters New research on networks and structures of water supply systems LISI, Leningrad