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Construction of vertical drainage wells using corrosion resistant materials

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Abstract. Vertical drainage wells in terms of construction technology and design do not differ from wells for irrigation. They are not deeper in-depth than irrigation wells and are generally 40-70 m. The main task of vertical drainage wells is land reclamation. They, depending on natural and economic conditions, serve on 5-120 hectares of area. In many areas, vertical drainage wells serve a dual purpose; land reclamation and irrigation of agricultural crops. Water intake wells, including vertical drainage wells, are characterized by a decrease in their flow rates during operation. To ensure the stable operation of the irrigation and drainage system, where water intake wells are operated, repair and restoration work is carried out on them, aimed at increasing flow rates. For the construction of vertical drainage wells in the Sirdarya river basin, steel pipes and filters are mainly used, which corrode in an aggressive environment. In the water intake zone of the well and the metal corrosion process, the colmatation process also occurs. All of them are the main reasons for the decline in well production rates. The carried out repair and restoration measures are aimed at destroying the structure of corrosion and clogging products. In practice, mechanical, physical, biological, and chemical methods are used to clean the filters of water intake wells. They all have their own technology and equipment. However, all these works do not exclude the repeatability of the process. Repetitive workover will come to ineffective, the stage of good concertation is approaching. It is known that polymeric materials do not corrode. They work steadily in aggressive environments. To prevent the corrosion process, polymeric-seam pipes were used as a filter frame and a casing for the construction of vertical drainage wells. Two pilot wells were built on the territory of the Chiyili district of the Kyzylorda region of the Republic of Kazakhstan. The wells were drilled with a rotary drilling unit with backwash. Pure water (irrigation) was used as drilling fluid. To form a gravel pack in the annular zone of the casing, gravel-sand material from the Jailma quarry was used. The material was brought by rail and road transport. Pipe sections were prepared on the surface of 10 meters. Steel rings were put on the pipe from both ends of each section; their connection in the barrel was made by electric welding. The results showed that in the initial period of operation, a decline process was observed. In further exploitation, the well flow rate stabilized. As a result of construction using pipes and filters made of polymer material, the effect was achieved in terms of water volume more than 3 times and in terms of service life 4.2 times compared to a metal filter well.

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1 Introduction

In the basin of the Sydarya River, in the zones of irrigated agriculture where vertical drainage wells have been built and operated, there is a shortage of crop yields associated with the socio-economic problems of the region. This is largely due to the work of vertical drainage wells and irrigation [1-3].

The purpose of our research is to identify the main shortcomings in the operation of water wells, analyze the technology for performing repair and restoration work, and develop recommendations for the technology of good construction using corrosion-resistant materials.

The object of this article is the territory of the Syrdarya river basin. The Syrdarya river flows on four states: Tajikistan, Kyrgyzstan, Uzbekistan, and Kazakhstan. It is formed at the confluence of the Naryn and Kara Darya rivers in the Fergana Valley. It flows into the northern part of the Aral Sea - "Small Sea". The river's length is 2,212 km, and the total length with the Naryn River is more than 3,000. The basin area is 150,100 km^2. The basin's territory can be conditionally divided into three zones: upper-Fergana valley, middle-Hungry steppe, and lower - Kyzylordy region of the Republic of Kazakhstan. For land reclamation and drainage of the territory of settlements, water intake wells of vertical drainage, wells for irrigation, watering of pastures, and others were used in all regions.

The productivity of land is influenced by many factors: such as soil fertility, water, air temperature and humidity, sunbeam, air flow rate, the level of implementation of agrotechnical measures, and others. The fertility of the land determines the mechanical, physical, biological properties of soils and nutrients [4-8]. In the process of assimilation of nutrients from the soil by the plant and mineral and organic fertilizers, water is involved. Therefore, in arid zones, as the territory of the considered region, water is supplied for irrigation in volumes of 500-10000 m3 / ha (9). At the same time, groundwater pumped out of vertical drainage wells and for irrigation has a significant share [10, 11]. However, the aging process in wells significantly affects their production rate [12, 13]. The operating experience shows that to ensure the system's stable operation, it is necessary to carry out repair and restoration work aimed at ensuring an increase in well flow rates.

2 Methods

On the topic, a review of sources based on archival and reporting materials of construction and operating organizations was carried out. On their basis, it was revealed that there is a need to improve the performance of the vertical drainage wells system. To determine the chemical composition of the water pumped out by vertical drainage wells, samples were taken in the field according to the SANIIRI method. Analyzes were performed in a chemical laboratory**.** The physicochemical properties of samples taken from the soil and the wells' depth during drilling were also determined in the chemical laboratory. Indicators of alkalinity and oxidation-reduction potential of water were determined in the field using special devices. To measure the wells' flow rates (flow rates), a cone flow meter PKR 219-100 was used, an electronic level meter was used to lower the static and dynamic water levels in the well.

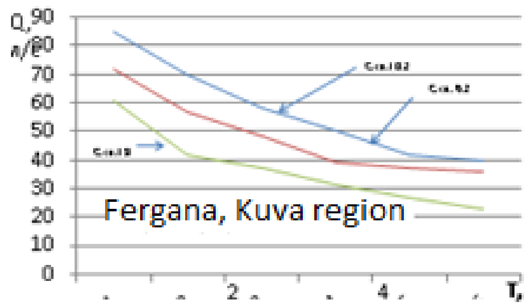
The data obtained were processed by statistical and graphic-analytical methods. Calculations are made to compare the performance indicators, which determine the economic efficiency of the work performed.

3 Results and Discussion

The positive aspects of using vertical drainage wells are as follows:
- rapid lowering of the groundwater level;
- a reliable technical means for groundwater management;
- a reliable tool for the stability of the crop;
- as an additional source in irrigation with a shortage of irrigation water.

Wells of vertical drainage by construction technology and design do not differ from wells for irrigation. They are not deeper than irrigation wells in terms of depth and are generally 40-70 m. In the Syrdarya river basin, they pump mainly saline water. They are designed and built to lower the level of groundwater, drain the territory of settlements, protect individual engineering structures, and desalinate the soils of irrigated agricultural areas.

Table 1. Some performance indicators of wells of the study object

<table>
<tr><th>Basin zones</th><th>Mineralization of pumped water, mg / l</th><th>Character of change in flow rates of vertical drainage wells</th></tr>
<tr><td>Upper (Fergana Valley)</td><td>0.3-3</td><td>
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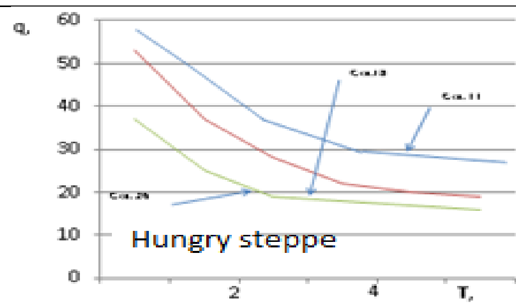
<tr><td>Middle (Hungry steppe, South Kazakhstan region)</td><td>0.5-7.5</td><td>
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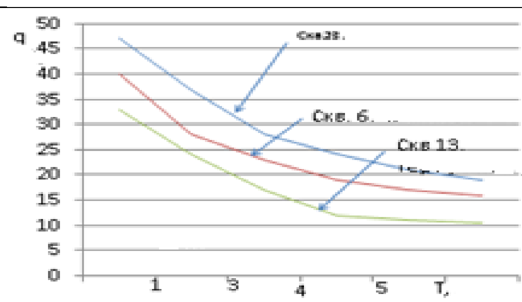
<tr><td>Lower (Kzilorda region)</td><td>1.5-30</td><td>
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The salinity of river and collector-drainage waters along with their course changes, that is, increases. This regularity is characteristic (except for individual local conditions) for groundwater as well. The performance of water wells is influenced by many factors, such as the geological and lithological condition of the area, the mode of operation, the materials used as a filter frame, the correctness of the construction technology, the operating mode, and others. Our studies over several years have shown that for the entire territory of the basin where water intake wells are operated, the process of decreasing production rates is characteristic (Table 1).

From the materials given in the table, it can be seen that water wells decrease their initial flow rates during operation. The main reasons are siltation of the good cavity with earth rocks, the process of clogging of water-insoluble salts in the water intake area, and corrosion of filter frames. This process is typical for other regions, too [14,15].

A decrease in well flow rates leads to an increase in electricity consumption for the specific pumping volume (Table 2), a deterioration in the reclamation state of drained lands, and a violation of planned water use. In the investigated object, water intake wells are equipped with submersible electric pumps of the ETsV type. According to our calculations, the wells, due to the decrease in production rates, operate with excessive electricity consumption.

Table 2. Electricity calculation results taking into account the degree of well production rate reduction

Pump name	Water consumption, m^3/hour	Pressure, m.	Pump type	Power, kWt	Relative energy consumption, m^3 / kW	Reduction of water consumption, times	Increase in energy, m^3 / kW
TsV 8-40-65	40	65	PEDV 11-180	11	3.64		
ETsV 8-40-165	40	165	PEDV 32-180	32	1.25		
1ETsV10-63-110	63	110	PEDV 32-219	32	1.97		7.31
ETsV10-120-0G	120	35	PEDV 22-219G	22	5.45		2.51
ETsV10-160-35G	160	65	PEDV 22-219G	22	7.27		3.96
							10.95
ETsV 10-160-65	160	65	PEDV 45-230	45	3.56		14.4
ETsV 12-160-65	160	100	AFP-273-45 / 2	45	3.56	2.01*	
ETsV12-160-100	160	140	PEDV 65-270	65	2.46		7.16
ETsV12-255-30G	255	30	2PEDV 32-219	32	7.97		7.16
ETsV 12-375-30	375	30	2PEDV 45-230	45	8.33		4.94
							16.01
							16.74

*Note: * -measurements and calculation determine value.*

We carried out a full-scale study to assess the performance of water intake wells operated in all zones of this basin. The results of the study showed that after the construction during the operation of vertical drainage wells, after a short time, the process of flow rate reduction begins (Table 1). The degree of reduction is 1.5-5 times; the average is 2.1 times. The measurement was carried out in over 100 wells. This indicates that the power consumption is doubled by the specific pumping volume.

Many researchers (V.M. Gavrilko, V.S. Alekseev, V.T. Grebennikov, A.I. Gurinovich, V.V. Ivashchechkin, G.A. Volokhovsky, V.G. Romanenko, E. M. Volnitskaya, R. A. Fatrakhmanov, H. I. Yakubov and others). The reduced well production rate can be restored by mechanical, physical, and chemical methods. Each method has the appropriate technology and equipment. After several repeated restorations of well flow rates, its further operation is considered not expedient. Experience shows that restorative work cannot provide a 100% recovery rate (Figure 1).

In this case, he switches to re-drilling the wells next to the old borehole to replace the filter cage and casing.

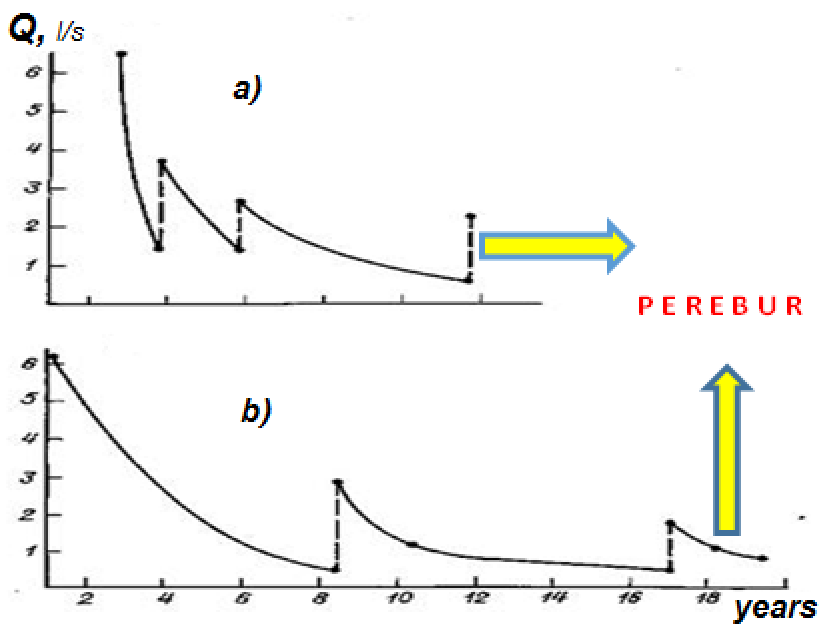

Fig. 1. Frequency of restoration work at the water supply well (Ulyanovsk water intake)

The essence of the mechanical method is that mechanical action by mechanical means is used to destroy the bridging agents during the process of work. In the implementation of the physical method, an impulse force acts on the bridging agent. They are formed by the use of a blowout, explosion, and others. When restoring the flow rate of a well by a chemical method, various chemical reagents are used (Fig. 2). They are used, taking into account the conditions of the well use.

In the conditions of the object under consideration, mechanical and physical methods were used to restore the flow rate of the vertical drainage well. As a mechanical method, an airlift is used to clean the wellbore from mechanical siltation. Special organizations are involved in this work. The physical cleaning method also showed good results. However, their introduction into production has not found wide application with the lack of the necessary equipment [16,17,18].

In the region under consideration, the population is growing. The specific irrigated area [19.20] and irrigation water are decreasing. These processes require an increase in the productivity of resources, partly of water and land.

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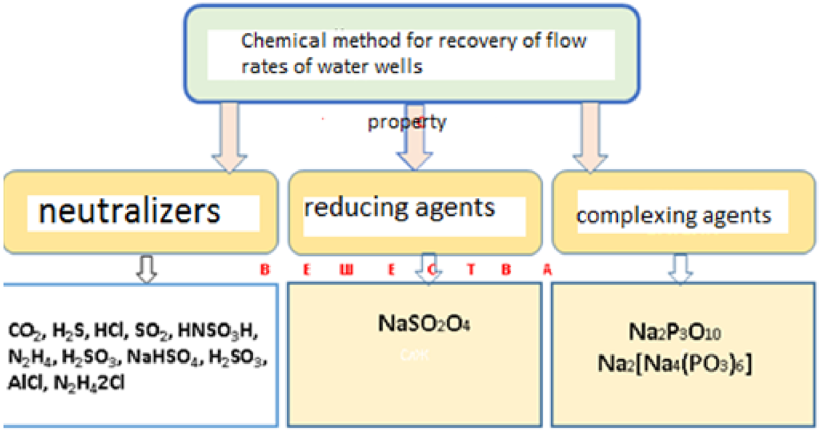

Fig. 2. Chemical reagents used when cleaning the filter of a water well from bridging agents

In this regard, it became necessary to develop and use non-metal pipes as a filter frame and casing during the construction of vertical drainage wells.

Spiral-seam polymeric metal pipes are widely used in water construction. However, there was no experience of using these pipes in vertical drainage wells. SANIIRI developed technical requirements and manufactured polymer-metal pipes of increased strength and reliability with a diameter of 300 to 400 mm and a wall thickness of 10-12 mm. The raw material is low-pressure and high-density polyethylene of grades 20308-0005, 20403-007 following GOST 16388-77. A wire mesh with square cells is used as reinforced material.

The first pilot well using polymer-metal pipes was built on the territory of the Chiyili district of the Kyzylorda region of the Republic of Kazakhstan to replace the old well (i.e., overdrilling). The new well was located 4 meters from the old one. The peculiarity of well operation in this region is characterized by high salinity of pumped water with a high content of iron ions, which significantly affects the formation of insoluble salts in the filter and the filter zone. Before the start of construction, the work site was prepared. It has a size of 50*10m.

A gravel and sand bed, pipes for drilling, a jig, pipes for a filter string, a drilling rig and the necessary drilling tools, a compressor, a carriage for the drilling crew were brought to the working site and placed in a strict, most convenient for work, gravel and sand packing.

A reservoir for water and drilling was prepared in advance. Before drilling, a 1.5 m high ground overpass was erected at the wellhead to maintain hydrostatic backpressure (maintaining the water level in the wellbore 2.5-3 m above the sub-pressure water level of the captured formation).

The drilling was carried out with a rotary drilling rig using the backwash method. Drilling diameter 1270 mm. A fundamental difference in the drilling technology is a large-diameter rotary-suction machine by means of fixing the borehole walls with clean water due to hydrostatic backpressure and creating high rates of flushing water to carry out cuttings destroyed in the bottom hole. During the drilling, while sinking the wellbore, there was a constant flow of clean water from the reservoir at a rate of 25-30 l / s, which provided a velocity in the wellbore of more than 2.0 l / s. This method provides the best conditions for forming a reliable gravel pack and maximizing the specific production rate.

The specific flow rate of the well built by this method in fine, fine, and medium-grained sandy aquifers, which is typical for this area, was 4.5-7 l / s. The results of the timing, carried out during drilling, showed that the time spent on technological processes of construction of wells with a diameter of 1270 mm with polymer-metal and metal pipes is the same. During drilling, samples were taken from the drilled soil from characteristic

depths. The captured aquifer is represented by gray fine-grained and medium-grained sands, characterized by the following indicators:
- bulk weight -1.67 g / cm3
- specific gravity -2.73 g / cm3
-effective diameter -0.06 mm
- average particle diameter -0.23mm
- the coefficient of heterogeneity of the rock -5.33

The granulometric composition of the soil is given in the table. After the completion of the drilling, the casing of the well began. Before casing, preparatory work was carried out to connect polymer-metal pipes. The connection method is electro-welded. The length of the filter frame is 20 m, the sump is 5 m. The perforation is perforated with a diameter of 5.8 mm. The perforation rate is 4.1% (Figure 3).

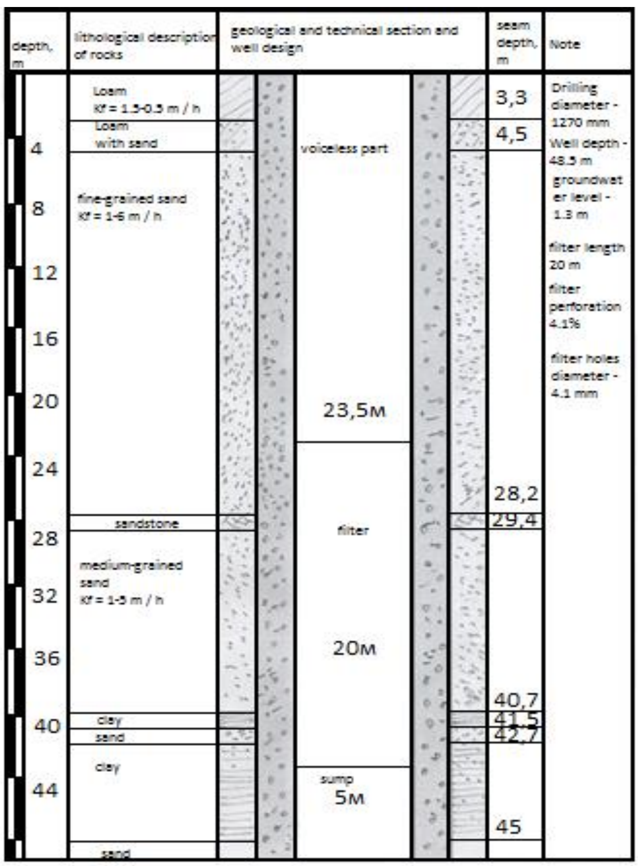

Fig. 3. Vertical section of the well

The practice of construction of high-rate vertical drainage wells has shown that backfilling of a properly selected sand and gravel mixture around the filter cage following the fractional composition of the soil of the aquifer is only the first stage of the formation of a stable filter, the second stage is construction pumping, which finally forms the filter

During the construction pumping period, small particles are removed from the backfill and the aquifer through the pores of the filter and the openings of the frame, and larger particles are deposited on its outer surface, forming a stable return filter. The captured formation is represented by fine-grained and medium-grained sands, construction pumping was started with a minimum flow rate. During the day, the water was clarified, and sand removal was

insignificant. Then we moved on to the next stage of the production rate (to a large decrease).
There was practically no sand removal, and the water cleared after 3.5 hours of pumping. Then, to get a large debit, we switched to the third decline. The water cleared in 5-6 hours; there was no sand removal. The total construction pumping time was 36 hours. The well flow rate during the pumping period is 45-50 l / s.

After joining the butt parts, the casing was lowered into the bottom hole using a crane, pipe by pipe. The casing depth was 48.5 m. Then they started backfilling the gravel-sand mixture of the Jilmen quarry into the annulus of the well. The gravel-sand mixture is characterized by the following parameters.

Table 3. Fractions of gravel-sand mixture

Diameter, mm	more 10	10-7	7-5	5-3	3-2	2-1	1-0.5	0.5-0.25	0.25-0.10
Content, in%	42.8	9.6	7.7	10	6.8	9.6	3.2	6	4.8

During pumping, water samples were taken for chemical analysis. The analysis showed that, in terms of the chemical composition of the pumped out water, it belongs to the sulfate and hydrocarbonate-sulfate type of salinization. The total salinity of the pumped-out water (the dry residue was 2.0 g / l with the content of sulfate ions 0.6 and chlorine 0.2 g / l. Then the well was equipped with pumping and power equipment.

The well flow rate was 60 l / s with a decrease of 10 m. The specific flow rate was 6 l / s * m. The decline in production rate was not noticeable (June-December). Whereas on a similar well built-in massif made of metal pipes, the flow rate decreased by 7-12%. It should be noted that the flow rate of the well (row 4 in Figure 4) has a stable character than other (row 1, row 2, row 3) wells in the Chili region.

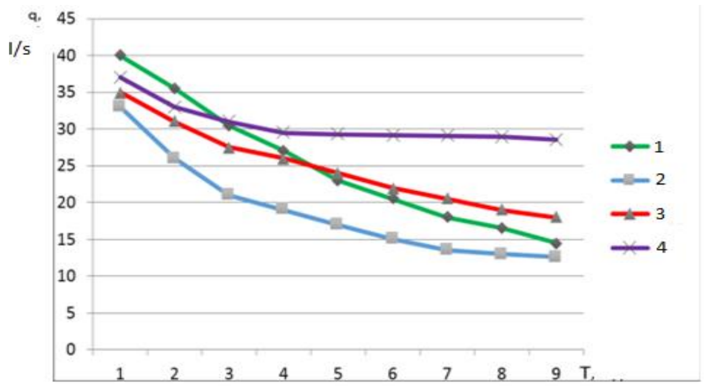

Fig. 4. Comparative well flow rate graph vertical drainage (row 1-well № 8, salinity 7.5 g/l, row 2-well № 21, salinity 2.6 g / l, row 3-well; № 13, salinity 1.6 g/l)

In this regard, we can talk about the high efficiency of the use of polymer-metal pipes, taking into account the solution of some technical issues, such as the mechanization of cutting holes and improving the design of butt joints.

4 Conclusions

It is advisable to design and build as well as to operate vertical drainage wells using filters and a casing made of polymer materials for land reclamation and irrigation purposes. For this, the grounds are:
- wells built using filters and casing. They operate at an almost stable rate (Fig. 4) than wells with a steel filter;
-polymer materials are 4-5 times cheaper than steel;
- design life of polymer materials 50 years, metal 12.

The research results show that all wells are characterized by the process of decreasing production rates in the initial period of their operation. This is due to the formation of a natural filter in the annulus. To improve this process, we consider it expedient to conduct scientific research.

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