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A METHOD OF INCREASING DRAINAGE FLOW TRANSPORTABILITY IN A DRAINAGE PIPELINE

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Abstract

The article delves into an examination of the factors influencing the conveyance of water flow in drainage pipes within irrigated regions. It also details research efforts aimed at augmenting the volume of water flow. The study's outcomes revealed that arranging drainage pipes in a sequential manner, with increasing diameters, can significantly amplify flow conveyance compared to conventional pipe setups. The findings underscore the potential for substantial enhancement in flow transportability by employing a series of drainage pipes with incrementally larger diameters. This approach capitalizes on the capacity of larger pipes to accommodate greater water flow, thereby minimizing the likelihood of blockages and obstructions.

Keywords: drainage pipe, ditch, flow transportability, sediments, water flow rate, flow capacity.

1. Introduction

In recent years, consistent reforms have been carried out on effective use of land and water resources, improvement of the water resources management system, modernization and development of water management facilities.

At the same time, due to global climate change, the growth of the population and economic sectors, and their demand for water is increasing year by year, the shortage of water resources is increasing year by year.

The average annual amount of water used was 51-53 billion cubic meters, including 97.2 percent from rivers and streams, 1.9 percent from collector networks, and 0.9 percent from underground, reducing by 20 percent compared to the allocated water intake limit.

In the republic, in 2020-2030, it is necessary to provide the population and all sectors of the economy with water, to improve the reclamation of irrigated lands, to widely introduce market principles and mechanisms and digital technologies to water management, and to ensure the reliable operation of water management facilities. Different reforms are being implemented by the government in order to ensure and improve the efficiency of land and water resource use[1].

In drainage networks, drainage flow transportability refers to the ability to efficiently transport water or other liquids through the pipe system. This is an important aspect of drainage design and is essential for long-term effective maintenance of drainage systems.

The main purpose of drainage network design is to collect excess water in the area, prevent waterlogging and potential damage to existing structures or landscapes. Good drainage ensures that water is efficiently removed from the area, reducing the risk of flooding or waterlogging.

Several factors affect the flow transportabilty of pipes in drainage systems, including pipe diameter, slope, material, and the presence of any local resistances. The diameter of the pipe determines the volume of water that the existing system can hold, larger diameter pipes have a higher flow capacity. The slope of the pipe also has a very significant effect on the flow rate, with steeper slopes allowing for faster flow.

The pipe material used in the design of drainage systems can also affect the flow transportability. Smooth and corrosion-resistant materials such as PVC (polyvinyl chloride) or HDPE (high-density polyethylene) differ from traditional pipes in that they reduce friction and minimize the accumulation of sediment, and promote better drainage flow.

Local resistance in the drainage pipe, for example, the accumulation of sediments, can significantly impede the movement of the flow. In order to ensure optimal drainage flow, it will be necessary to identify and remove any obstructions and constantly monitor through observation wells.

In an irrigated area, proper design and installation of drainage system pipeline is critical to achieving good drainage. When designing a drainage system, engineers and designers consider factors such as expected water volume, topography of the area, and required flow volume. Proper pipe dimensions, proper slope, and use of appropriate materials are essential to ensure optimal flow.

In conclusion, it can be said that the transportability of the flow in the drainage pipes is very important in preventing the swamping of the area caused by the inefficient use of water and the flood caused by a sharp increase in the volume of atmospheric precipitation, that is, in effectively removing

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excess water from the area. Various factors such as pipe diameter, slope, material, resistances or lack thereof play an important role in achieving optimum flow transportability.

Water balance equations in irrigated areas, the movement of underground seepage water, determination of the critical depth value, and researches conducted in such scientific areas as the basis of collector-storage types are carried out on the scale of the Commonwealth of Independent States. A.N.Kostyakov, S.F.Averyanov, A.P.Vavilov, L.Prozov V.A.Kovda, N.A.Besednov, K.Mirzajanov, V.A.Dukhovniy, H.Yakubov, H.A.Ahmedov, F.M.Rakhimbayev, F.A.Barayev, Sh.Kh.Rakhimov, B.S.Serikbayev, R.K.Ikramov, It was reflected in the work of MXXamidov, A.T.Salokhiddinov, A.G.Sherov, R.A.Murodov, A.Kh.Karimov, M.Y.Otakhonov and others, and certain positive results were achieved.

From the scientific research carried out in recent years at the world level, it can be analyzed that the flow transportability of drainage systems is affected by various factors, for example, the installation of pipes connected at a certain angle, the change of the flow direction, and hydraulic resistance. does [2,6]. In addition, drainage flow transportability is affected by the technical condition of the drainage system and the increase in hydraulic resistance along the drainage section [3]. In addition, the transportability of drainage pipe systems can decrease with the increase of flow velocity, and the change of flow direction at the points of connection of the drainage pipe significantly affects it in the drainage system [7]. In addition, the regional flow transportability of drainage systems is affected by factors such as contributing strength and sub-system resources and interregional flow potential [10]. It is very important that the drainage layers have good drainage properties, sufficient layer thickness and anti-clogging properties at the points where groundwater enters or joins the drainage pipe. Maintaining the design parameters of the drainage pipe system for many years of service life is important[5]. The hydraulic properties of drainage systems, including water carrying capacity and permeability, are very important for their efficiency [4]. In addition, the continuity of unsteady flow in soil movement can affect drainage efficiency, and pavement permeability plays an important role in evaluating drainage flow transportability [8,9].

Increasing water transportability in drainage pipeline system is important for several reasons:

An efficient drainage system: Water with good flowability moves through drainage pipes without obstruction or accumulation. This helps prevent or prevent clogging of the drainage pipe, allows water to flow efficiently, and prevents unexpected flooding or ponding in flood or irrigated areas.

Maintenance and cost savings: Good water flow permeability in the drainage pipe will reduce the cost of frequent maintenance and opening and reconstruction of drainage pipes. This, in turn, helps to minimize the accumulation of particles, sediment in the drain pipe that impede flow.

Extending the service life of pipes: If the water stream does not flow smoothly due to improper flow transportability, pressure changes and turbulence will occur, which will cause stress on the pipe walls, and over time, this stress can cause the pipe to fail. Optimizing the flow transportability helps to achieve a stable and controlled flow, reduces the stress on the pipes and extends their service life.

Optimum system performance: Effective flow transport allows drainage pipe systems to function optimally. This ensures that wastewater and rainwater reach the desired destination, i.e. collectors, efficiently. This results in improved overall system performance and functionality.

Pipe design, size, slope and regular maintenance play an important role in increasing the flow transportability. Proper design and installation of pipes, regular cleaning of sediments inside the drainage pipes and minimization of interruptions in the flow are the main factors to achieve smooth and portable flow through the drainage pipes.

One of the current challenges with drainage flow portability is the limited availability of mobile and user-friendly software tools for drainage flow analysis and visualization. Most existing software solutions are advanced and require high technical skills, while the lack of experts or practitioners involved in basic drainage flow analysis makes the process somewhat difficult.

In addition, there is a great need to improve the accuracy and reliability of drainage flow prediction. In some cases, existing models and algorithms used to study drainage flow do not adequately reflect the complex interactions and dynamics of water movement across different terrains and land uses. This leads to inaccurate forecasts and unreliable results, and affects decision-making processes related to drainage infrastructure planning and management.

At the same time, the issue of data privacy and security arises when sharing drainage flow data across different basin authorities or related systems. It is very important to ensure the protection of the drainage data related to a particular system or the personal data related to individuals or organizations, to maintain trust and to comply with the rules of confidentiality.

2. Materials and Methods

One potential solution to increase drainage flow transportability is to change the diameter of the drainage pipe along its length.(d_1=63 mm, d_2=90 mm, d_3=110 mm, l_1=150 m, l_2=100 m, l_3=50 m, Figure 1).

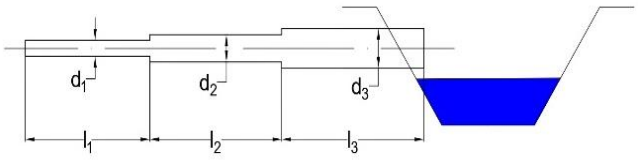


Figure 1. Drainage line with three different diameters.

Changing the diameter of the pipe helps to control the volume of flow passing through the movement section per unit of time, which allows controlling the passage of a certain volume of water and particles through this section. This reduces the risk of sediment accumulation along the length of the drainage pipe and as a result it causes to increase the Coefficient of Performance (the COP) of the drainage system.

A larger pipe diameter can also reduce flow velocity, which adversely affects particle transport in the flow. Also, a lower flow velocity increases the possibility of sediment settling and does not allow the particles in the flow to move together with it as a single body. In the case of a small pipe diameter, the opposite situation occurs, in this case, due to the increase in the flow velocity, high transportability can be achieved, but hydraulic elements that guarantee a steady flow cannot be achieved. Therefore, the optimal diameter of the drainage pipe, which ensures the transportation of particles in the water flow, should be chosen in such a way that, as a result, the movement of the water flow in this drainage pipe will cause the drainage system to work correctly and efficiently for many years and fully perform its function.

If the ditch networks are placed in the direction of the installation network and side by side, then the irrigation network must be equipped with a special coating against water wastage, or the ditch network is designed to be water-permeable only (closed and the drainage pipes are visible without holes). Hydraulic calculation of closed ditches, water flow rate of ditches (Q3), when the slope (i) and the pipe's roughness coefficient (n) are known, the diameter of the ditch pipe (d), the actual depth of the water in the ditch (h0) and actual speed values (Th 0) is to determine.

The characteristic value of water flow rate in drainage:

$$K = \frac{Q_3}{\sqrt{i}} \quad (1)$$

According to the graph in Figure 2, the diameter of the drainage pipe is determined from the relationship K=f (d), and it is the standard diameter dSt is brought to dSt through K=f (d) and S=f (d) from graphs of mutual functional dependence0 and S0 values are determined.

When the drainage pipeline is full of water, its transportability to carry particles in water flow rate (Qt)and the velocity of water in it (ϑt) will be as follows.

$$Q_t = K_0 \cdot \sqrt{i} \quad (2)$$

$$\vartheta t = S0 \cdot \sqrt{i} \quad (3)$$

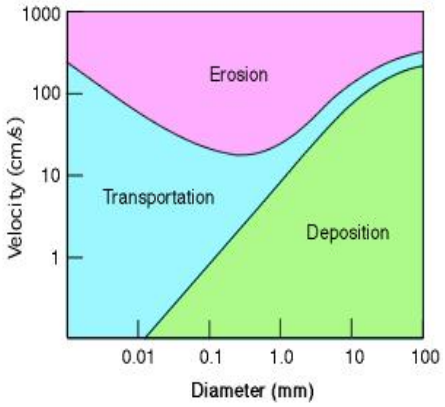


Figure 2. A graph of the relationship between the velocity and the diameter of the sediment - $\vartheta = f(d)$.

The real depth of water in drainage pipe (h_0) and the real velocity (Th_0) will be:

$$h_0 = \alpha \cdot dSt \quad (4)$$

$$\vartheta 0 = \beta \cdot \vartheta t \quad (5)$$

where: α and β are values $A = \frac{Q_z}{Q_t}$ is derived from data by value.

Table 1. A table for determining α and β by value

A	α	β	A	α	β
1,0	1,06	1,0	0,5	0,5	1,0
1,07	0,95	1,1	0,414	0,45	0,94
1,068	0,9	1,150	0,332	0,4	0,84
1,068	0,85	1,157	0,256	0,35	0,81
0,994	0,8	1,157	0,188	0,30	0,74
0,927	0,75	1,152	0,124	0,23	0,635
0,830	0,7	1,137	0,080	0,20	0,550
0,750	0,65	1,115	0,045	0,15	0,435
0,678	0,6	1,074	0,020	0,10	0,338
0,583	0,55	1,045	0,004	0,05	0,180

3. Results

In the design of closed ditches, it is important to evaluate the transportability of the flow. When evaluating the transportability of flow, it is necessary to take into account the flow velocity, hydraulic radius, sediment size. Nowadays, several formulas for determining the transportability of the flow have been recommended. The results of the theoretical research revealed that the formula recommended by A.M. Arifzhanov is suitable for determining the transportability in drainage pipe. Because this formula includes almost all the hydraulic elements of the flow:

$$S = \alpha \frac{\vartheta_{min}^{\ 3}}{g \cdot R \cdot W} \quad (6)$$

where: S-flow transportability, ϑ_{min} – minimum permissible velocity, g-free fall acceleration, hydraulic radius, W-hydraulic quantity in the equation:

$$\alpha = \left(\frac{d_0}{d_i}\right)^3 \quad (7)$$

where: d_0-optimal diameter, that is, the diameter of the sediment whose velocity is equal to the current velocity of water flow, di-the average diameter of the sediments in the flow.

In contrast to existing methods, α is a variable quantity in the equation, the value of which changes depending on the regime of motion and energy state of the particles in the flow. In the drainage pipe, as a result of similar processes, that is, as a result of the addition of seepage water from cultivated fields and underground to the water flow in the riverbed, the regime of motion and energy status of the flow changes. From the equation (3) given above, we can base the average velocity of the flow in the drainage pipe being designed.

$$\vartheta_{min} = \alpha_0 \sqrt[3]{S \cdot g \cdot R \cdot W} \quad (8)$$

where:

$$\alpha_0 = \frac{1}{\alpha}$$

Table 2. Calculated sediment transportability for three different diameters

63 mm		90 mm		110 mm	
W, m/s	**S, kg/m³**	**W, m/s**	**S, kg/m³**	**W, m/s**	**S, kg/m³**
0.0005	2.09	0.0005	3.5	0.0005	4.85
0.001	0.89	0.001	1.49	0.001	2.06
0.0015	0.53	0.0015	0.89	0.0015	1.24
0.002	0.37	0.002	0.62	0.002	0.87

From the relationship graph in Figure 3 illustrated by the results of Table 2, we can see that if 3 different diameter drainage pipelines are placed in series in order of increasing diameters, the increase of the sediment transportability S will be greater than that of a drainage pipeline with a constant diameter. it will be several times higher.

4. Discussion

However, changing the diameter requires re-updating the existing drainage infrastructure, such as adapting wells to the existing system or adjusting connections. In addition, changes in the volume of water flowing through the system will require

modification of open ditches downstream of the outlet pipe to handle existing flow events in the future.

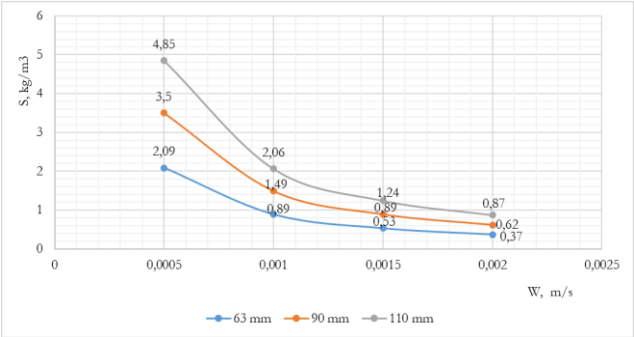


Figure 3. A graph of the relationship for pipes of three different diameters $S = f(W)$

Before making any changes, it is recommended that a thorough analysis and hydraulic modeling be conducted to assess the likely impact and feasibility of changing the pipe diameter. Factors such as available flow velocity, sediment characteristics, and overall capacity of the drainage system should be considered in this analysis.

5. Conclusions

To sum up, the essence of the method we recommend is that the drainage pipeline line is divided into 3 sections, taking into account the variability of the water flow rate in the drainage pipeline along the length of the drainage pipeline. At the beginning of the drainage line, a pipe with a diameter of 63 mm, a pipe of 90 mm in the middle and a pipe of 110 mm at the end are laid, that is, the rate of water flow at the beginning of the drainage pipe is less due to infiltration, and in the case of laying a drainage pipe with a small diameter, the velocity of the water flow increases relatively, as a result, the transportability increases and the risk of silting is reduced. Changing the diameter of the drain pipe can be a potential solution to increase the flow transportability of the drain. However, to ensure the effectiveness and sustainability of the drainage system, careful assessment of hydraulic and hydrological factors is essential before any changes are made.

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