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Calculation of the distribution of river sediments by the depth of the stream

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Abstract. This article presents an analysis of the calculation of the distribution of river flow in the irrigation system by depth of flow. These studies aim to understand the dynamics of river flows and the impact of irrigation, with researchers dedicating years to this endeavor . In the clarifiers, the larger and medium fractions of sediments should be retained in such quantities that they cannot be transported by the downstream channels. In this case, it is not allowed to re-cool the water in the clarifier, as this will cause the channels in the system to be washed and reduce the fine particles that will increase the productivity of the fields It is known that many scientific studies have been conducted on the depth of river flows. In this case, we will analyze the distribution of river sediments along the depth of the current, using the proposed formulas for calculation. Furthermore, research has demonstrated that the distribution of river flows by depth follows a linear pattern with increasing flow rate or a higher percentage of smaller fractions in suspended particle composition. This distribution characteristic has been observed in various related studies. The practical and scientific findings of these studies are exemplified through research conducted at the "Ekin-Tekin Pumping Station" in the Andijan region, serving as a significant case study in this field. We chose the "Ekin-Tekin pumping station,, located in the Andijan region, as the object of research, and calculated the distribution of turbidity of the river at this pumping station depending on the depth of the flow.

1 Introduction

Numerous scientific investigations have been conducted to model sediment movement in turbulent flows and assess their fractional and chemical composition. sprinklers in irrigation systems must ensure protection of the channels in the irrigation system from silting during their entire period of operation. These studies aim to understand the dynamics of river flows and the impact of irrigation, with researchers dedicating years to this endeavor . In the clarifiers, the larger and medium fractions of sediments should be retained in such quantities

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that they cannot be transported by the downstream channels. In this case, it is not allowed to re-cool the water in the clarifier, as this will cause the channels in the system to be washed and reduce the fine particles that will increase the productivity of the fields [1,2,3].

The type of strainer, the number of chambers and their main dimensions (working depth, width and length) are set based on a technical-economic comparison of options. The average speed of the flow in the cooler is within 0.2-0.4 m/sec. The clarifiers in irrigation systems are often installed by mechanical cleaning, but in favorable conditions the clarifier design should provide for hydraulic flushing of the turbidity [4,5,6].

The calculated turbidity of the flow at the entrance to the clarifier is determined based on the data of long-term monitoring at the catchment hydrogeological site or the data of the nearest hydrological station on the river. To determine the size of the clarifier, the calculated turbidity at the inlet and its fractional turbidity average are determined for the month with the maximum turbidity in a specific year of the multiyear period. The performance of selected sizes of clarifiers is tested for the specific year with the highest turbidity reading. The depth distribution of flow is found to be closely related to the granulometric composition of suspended particles [7,8,9].

Global research on river flow dynamics and control technologies for irrigation systems has produced significant findings. These include the development of numerical methods for solving multiphase flow equations (Massachusetts Institute of Technology, USA), studies focusing on hydraulic elements of channels and their correlations (G.L. Beichley Division of Research, Denver, USA), technologies for clearing irrigation channels of turbidity (Bureau of Reclamation, USA), and the development of empirical formulas for calculating river flow distributions (Technical University of Berlin, Germany). Additionally, numerical and experimental methods for calculating flow characteristics have been developed (Institute of Water Resources and Hydropower Research, China) [10,11,12,17,18,19,20].

Performance indicators of the "Ekin-tiki" pumping station: year of construction - 1970, water discharge capacity - 270 m^3/h, type of installed aggregates - 10-HMKX-2, water lifting height - 140 m, area covered with water - 950 hectares, maximum turbidity in water conductivity-0.925 kg/m^3 [13,14,18,19,20].

Furthermore, research has demonstrated that the distribution of river flows by depth follows a linear pattern with increasing flow rate or a higher percentage of smaller fractions in suspended particle composition. This distribution characteristic has been observed in various related studies. The practical and scientific findings of these studies are exemplified through research conducted at the "Ekin-Tekin Pumping Station" in the Andijan region, serving as a significant case study in this field [15, 16].

2 Materials and methods

The sedimentation properties of small-diameter particles in liquids with different viscosity coefficients were studied, and the sedimentation rate formula was determined depending on the particle diameter for different sedimentation regimes in this regard, we will try to find a solution based on the data of our pumping station, which is conducting scientific research.

So, it became clear from the analysis that in determining the parameters of the clarifier, it is necessary to express them taking into account the mode of movement of sediments and their shape. This shows that it is possible to base the parameters of the clarifier on the basis of the regime of sediment movement and the change of hydraulic size.

Table 1. Hydraulic characteristics of the thickener.

№	hk m	bk m	m	n	i	ω, m^2	χ, m	R, M	C	ϑ, m/s	Q, m^3/s

<table>
<tr><td>1</td><td>0</td><td rowspan="7">1.0</td><td rowspan="7">1.5</td><td rowspan="7">0.015</td><td rowspan="7">0.00185</td><td>0</td><td>4</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>2</td><td>1.25</td><td>2.87</td><td>5.5</td><td>0.52</td><td>59.8</td><td>0.08</td><td>0.22</td></tr>
<tr><td>3</td><td>1.5</td><td>4.87</td><td>6.4</td><td>0.76</td><td>63.7</td><td>0.1</td><td>0.487</td></tr>
<tr><td>4</td><td>1.75</td><td>6.34</td><td>7.3</td><td>0.86</td><td>65.01</td><td>0.11</td><td>0.7</td></tr>
<tr><td>5</td><td>2</td><td>8</td><td>8.2</td><td>0.97</td><td>66.8</td><td>1.2</td><td>0.96</td></tr>
<tr><td>6</td><td>2.25</td><td>9.84</td><td>9.1</td><td>1.08</td><td>67.5</td><td>0.13</td><td>1.27</td></tr>
<tr><td>7</td><td>2.5</td><td>11.87</td><td>10</td><td>1.187</td><td>68.58</td><td>0.14</td><td>1.7</td></tr>
</table>

Through numerous scientific studies, scientists have developed solutions for the distribution of river flows based on flow depth. To determine the distribution function, it is essential to examine and refine the molecular-kinetic theory using scientific principles, which is the primary solution. The movement of a particle in water is influenced by its weight relative to water, and its vertical displacement within the surrounding fluid depends on the difference between the vertical organization of the fluid and its free velocity:

$$V_s = u_y - w \tag{1}$$

The proposed formula has the following appearance:

$$S_y = S_0 * exp\left\{\frac{3* g*(p_t-p)}{2*p_t*u_i^2} * \left(\frac{d_i}{d_0}\right)^3 * (h-y)\right\} \tag{2}$$

With this formula, we will develop our formula that offers the following:

$$S = exp\left\{\frac{3* g*(p_t-p)}{2*p_t*u_i^2} * \left(\frac{d_i}{d_0}\right)^3 * H * (1-\eta)\right\} \tag{3}$$

During scientific research utilizing the proposed formula, numerous results were discovered by scientists, Table 1 below presents the composition of particles in the river flow under investigation, serving as a laboratory comparison. Based on this table, we welcome the fractional composition of the sediment in our scientific research object using labaratorical analysis.

Table 2. The fraction weight of turbidity in the stream.

Fraction weight [%]			
0.25	0.25-0.1	0.1-0.05	0.05-0.01

Utilizing formula (3) proposed above, we are conducting ongoing scientific research by performing laboratory analyses on our target object and comparing the results. The analytical parameters at the "Ekin-Tekin" pumping station under the Irrigation and Technical Bureau (ITB) of the Andijan region are as follows: the length of the water-carrying channel (designed to function as a sump) L_{uz}=600 m, width and depth B=3 m, water flow rate Q_{um}=1.2 m^3/s, velocity v=1.8 m/s, assumed constant. Furthermore, the turbidity levels at the inlet and outlet of the channel are determined based on laboratory tests, varying with changes in hydraulic radii and under invariant parameters.

Fig. 1. Laboratory processes

3 Results and discussion

Considering non-uniform design calculations, S_0=0.915 g/l, S_{ch}=0.15 g/l, and critical turbidity S_k=0.05 g/l are taken into account. Based on these parameters and scientific methodologies, we assess the status of Tinner parameters using Formula (3) and present the results in the table below.

Table 3. Fractional weight bearings

Fraction weight [%]			
0.25	**0.25-0.1**	**0.1-0.05**	**0.05-0.01**
d_i=0.45 d_0=0.001	d_i=0.35 d_0=0.001	d_i=0.17 d_0=0.001	d_i=0.12 d_0=0.001

As a result of these laboratory analyses, quantitative indicators based on the formula were obtained and Formula (3) conforms to the widely accepted principle regarding the distribution characteristics of suspended particles in a flow, enabling consideration of particle size. The distribution of suspended particles in terms of flow depth is influenced to some extent by their larger size, which contributes to the formation of sediment areas in rivers.

Acknowledging the stochastic and irregular nature of suspended sediment movement in flows, some researchers have applied probability theory methods to describe solid particle motion. By applying both Formula (4) and our proposed Formula (3), we anticipate achieving significant insights based on laboratory analyses.

These examples make it possible to study the hydraulic parameters of the turbidity in the flow of the" crop-free " pumping station, that is, its large size and fractional composition. Based on the provided information, it appears to be a fraction weight distribution table for different particle sizes in a sediment sample. The table lists the particle size ranges from 0.25 mm to 0.001 mm, with corresponding fractions of the total weight of sediment in each size range. The table also includes specific particle size values (d_i) for each size range, along with a reference value (d_0) of 0.001 for comparison. This kind of analysis is commonly used in sedimentology and sediment transport studies to understand the composition and characteristics of sediment samples. [21-26]

Based on the above data, an indicator of the amount of turbidity obtained from the inlet of the pumping station to the clarifier represents the distribution of the fractional composition of the particles in the stream by the length of the stream. Based on the work of this account, we will be able to form the following Epistle (Figure 1).

Table 4. Calculation of river flows by depth of flow (Calculation of the distribution of river flows by the depth of flow On the example of a "Ekin-tekin, pumping station)

№	η	d_i	d_0	u_{max}	u	G	p_t	P	H	S
1	0	0.25	0.1	1.8	0	9.81	2600	1000	3	1
2	0.2				1.377					0.42
3	0.4				1.544					0.2
4	0.6				1.652					0.1
5	0.8				1.229					0.05
6	1				1.8					0
№	η	d_i	d_0	u_{max}	u	G	p_t	ρ	H	S
1	0	0.15	0.1	1.8	0	9.81	2600	1000	3	1
2	0.2				1.377					0.48
3	0.4				1.544					0.26
4	0.6				1.652					0.15
5	0.8				1.229					0.06
6	1				1.8					0
№	η	d_i	d_0	u_{max}	u	G	p_t	ρ	H	S
1	0	0.08	0.05	1.8	0	9.81	2600	1000	3	1
2	0.2				1.377					0.53
3	0.4				1.544					0.31
4	0.6				1.652					0.19
5	0.8				1.229					0.08
6	1				1.8					0

When obtaining the required results, a qncha will conduct scientific research of scientists and comparative work on the circumstances of the research object, the result of our proposed Formula (3) will contain more accurate information about the process of sinking of river sediments along the length of the stream. Of course (4) the results illuminated using the formula are also comparable in comparative terms, which we will be able to see .

The Ulugnor pumping station of the Andijan region has a 1.8 km long clarifier with a 2-chamber water-carrying channel. The length of the kamaera is 2.5 km, the width at the surface is 10 m, the slope is i=0.0002. The total volume of the clarifier is 1846 m^3, the average speed of water is 0,4 m/sec. Cleaning is carried out in mechanical order and is cleaned and washed by simultaneous water transfer from 2 Chambers. A water-bearing channel (incinerator) is one in which the soil is laid in a hollow, simultaneously fulfilling the function of a incinerator, insoluble sediments in the water source sink here. The water-carrying channel is made of single-chamber, the length of the chamber is 2,5 km, the width on the surface is 10 m, the slope is 0.0002, the mark on the level is not lower than 290,5 m. Deposition of sediments (parts larger than 0,05 mm) with a water tyres of no greater than 0.4 m/s at the muddy hydraulic parameters of the channel and a maximum consumption of 7,500 m^3/s are provided.

Based on these parameters, the hydraulic parameters and fractional composition of fuzzy particles in the pump stasis flow are studied (Table 5).

Table 5. The process of distribution of sediments in the flow of the "Ulug'nor,, pumping station by the depth of the flow

Fraction weight [%]			
0.25	**0.25-0.1**	**0.1-0.05**	**0.05-0.01**
d_i=0.2 d_0=0.001	d_i=0.17 d_0=0.001	d_i=0.09 d_0=0.001	d_i=0.03 d_0=0.001

Based on the results noted above, the following table is created and the purpose is compared to the table discussed above, on these results, if the calculation is carried out in the formula we propose:

Table 6. Comparative results.

№	η	d_i	d_0	u_{max}	u	g	Pt	ρ	H	S
1	0	0.25	0.1	1.8	0	9.81	2600	1600	3	1
2	0.2				1.377					0.49
3	0.4				1.544					0.21
4	0.6				1.652					0.11
5	0.8				1.229					0.06
6	1				1.8					0
№	**η**	**d_i**	**d_0**	**u_{max}**	**u**	**g**	**Pt**	**ρ**	**H**	**S**
1	0	0.15	0.1	1.8	0	9.81	2600	1600	3	1
2	0.2				1.377					0.55
3	0.4				1.544					0.26
4	0.6				1.652					0.15
5	0.8				1.229					0.07
6	1				1.8					0

Upon analyzing the results, we observe a clear pattern in the sediment settling process in relation to flow depth, as evidenced by the data from the "Ekin-Tekin" pumping station. The turbidity processes within the flow indicate deficiencies in the operational system of the channel. For instance, the near-complete settling process, as indicated by the close approximation to 1, suggests that the current high turbidity levels at the pumping station necessitate the design of a new sediment trap. This is because the accumulation of muddy particles in the pump's intake chamber demonstrates the adverse impact of the pump unit on the functionality of the impellers.

4 Conclusion

The calculations presented above demonstrate the application of Formula (3) for determining the depth distribution of sediment in rivers. Moreover, similar calculations were performed for the average flow rate, turbidity, and depth distribution of muddy particles in suspended particle carriers in rivers. The quest for improved models that accurately represent the behavior of suspended particles in river flows remains a critical area of study in sediment movement research.

Additionally, the application of the molecular-kinetic theory has led to the development of a new equation for sediment distribution, which extends the theory of turbulent diffusion. This new equation provides a novel expression for the turbulent diffusion coefficient of particles, offering insights into sediment transport processes in riverbeds and irrigation canals and contributing to the economic efficiency of river management practices.

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