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Data Article

A comprehensive dataset for the evaluation of a horizontal tubular flocculator implemented for drinking water treatment

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A R T I C L E I N F O

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A B S T R A C T

This article presents a set of data obtained during the evaluation of a horizontal flow tubular flocculator for the provision of drinking water in developing communities. The HFTF is presented as an alternative technology to replace conventional flocculators, allowing high efficiency in the subsequent sedimentation and filtration processes. For obtaining the data, experimental tests were carried out using lengths of 68.4 m and 97.6 m for the HFTF, these lengths were combined with flow rates of 0.25, 0.5, 0.75, 1.0 and 2.0 L/s, as well as raw water turbidities of 10, 20, 50, 100 and 200 NTU. The data set generated from measurements and observations made during experimental field tests is detailed. The resulting data set covers the main parameters that determine the quality of drinking water, such as turbidity and colour, as well as flocculation efficiency data. The data from the ex-

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perimental system were compared with a conventional treatment plant that has a baffle flocculator. Likewise, data on the retention time and velocity gradient are presented that allowed the hydraulic characteristics of the HFTF are evaluated. This data set has significant potential for reuse in future research and development related to water treatment technologies in developing community settings. Detailed data has been collected on various operating conditions of the HFTF, such as different lengths, water flow rates and turbidity levels, as well as measurements of key parameters such as turbidity, colour, flocculation efficiency, retention time and velocity gradient, these Data could be used in future research and development related to water treatment technologies. Furthermore, a comparison of data from the experimental system with a conventional treatment plant provides useful insight into the relative performance of different water treatment technologies, which could be of interest to researchers, system designers and public policymakers in the field of drinking water supply in developing communities.

Specifications Table

Subject	Water Science and Technology
Specific subject area	Practical experimentation of a horizontal flow tubular flocculation device used in real situations to provide drinking water to developing communities
Type of data	Table, Graph, Figure, Filtered, Analyzed
Data collection	Data collected included measurement of turbidity and colour. Water samples were collected at three locations: (1) in the rectangular weir of the conventional Treatment Plant (CTP) (before coagulation); (2) at the outlet of the settler of the experimental system; and (3) at the outlet of the filters of the experimental system (Fig. 1). Simultaneously, two additional samples were taken: at the outlet of the CTP settler (2') and at the outlet of the CTP filters (3'). This allowed us to compare the effectiveness of turbidity and colour removal between the Horizontal Flow Tubular Flocculator (HFTF) of the experimental system and the horizontal hydraulic screen flocculator of the CTP.
Data source location	The data were collected at the "Bayas" Drinking Water Treatment Plant (PTAP), which is a conventional treatment plant with gravity operation, which includes the processes of coagulation, flocculation, sedimentation, rapid filtration and disinfection. The PTAP is located in a rural area of the city of Azogues, Ecuador, at 2797 m above sea level; at the coordinates 740,741 m E, 9,699,971 m S of zone 17M.
Data accessibility	Repository name: Data_Horizontal Flow Tubular Flocculator Data identification number: 10.17632/d7f678z5kz.1 Direct URL to data: https://data.mendeley.com/datasets/d7f678z5kz/1 [1]
Related research article	[2] García-Ávila, F.; Méndez-Heredia, A.; Trelles-Agurto, A.; Sánchez-Cordero, E.; Alfaro-Paredes, E.A.; Criollo-Illescas, F.; Tonon-Ordoñez, M.D.; Heredia-Cabrera, G. Experimental Evaluation of Tubular Flocculator Implemented in the Field for Drinking Water Supply: Application in the Developing World. *Water* 2023, *15*, 833. https://doi.org/10.3390/w15050833

1. Value of the Data

- The data provide detailed information about the performance of the horizontal tubular flocculator under real field conditions.
- The data allow the identification of specific challenges and optimization needs for improving water supply in developing communities.

- The data facilitate the comparison and validation of the effectiveness of this type of technology in different geographic and socioeconomic environments.
- The data can serve as a basis for future research and the development of solutions adapted to the local conditions of developing communities.
- Researchers can use the data to compare the performance of the horizontal flow tubular hydraulic flocculator with other conventional flocculators such as hydraulic seed flocculator or mechanical flocculator.
- The data could serve as a basis for the design and optimization of water supply systems in similar areas, thereby improving the quality of drinking water.

2. Background

The primary objective of the data set is to provide comprehensive and detailed quantitative information on the performance and effectiveness of a horizontal flow tubular flocculator (HFTF) in the provision of water for developing communities. The compilation of this data set arises in response to the prevailing need to address the challenges associated with the supply of drinking water in rural communities, especially in the face of growing concerns about climate change and anthropogenic effects on surface water quality. The study is oriented towards the evaluation of an innovative technology, the HFTF, as a viable and easy-to-implement alternative for water purification in these communities. The original motivation lies in the comparison of the efficiency of the HFTF versus the efficiency of a conventional baffle flocculator, in order to determine its suitability for application in rural environments [2].

3. Data Description

3.1. Retention Time Data in Horizontal Flow Tubular Hydraulic Flocculator

Data set [1] contains the Fig. 2 describing the actual and theoretical HFTF retention times for the two lengths analyzed (opju file: Retention time). In Fig. 2 you can identify the theoretical and real retention times for the different water flow rates and for the two lengths of the HFTF that were evaluated. These data are critical to understanding how flocculation efficiency can vary depending on retention time in the HFTF and how this factor can influence the overall performance of the water treatment system. Comparison between theoretical and actual retention times provides valuable information on the effectiveness of the HFTF design in terms of turbidity and colour removal, which is crucial to optimize operation and improve treated water quality [2].

3.2. Velocity Gradient Data in Horizontal Flow Tubular Flocculator

The data set [1] contains data on the theoretical velocity gradient (sheet: Theoretical velocity gradient) and data on the real velocity gradient (sheet: Real velocity gradient). In Tables 1 and 2, the theoretical and real velocity gradients can be identified for the different water flow rates and for the two lengths of the HFTF that were evaluated. The data set is essential to understanding how flow and agitation within the flocculator varies based on different configurations and operating conditions. Furthermore, it allows a direct comparison between theory and practice, which contributes significantly to the understanding of the hydraulic behavior of the system and the optimization of its design and operation. The raw data for the parameters collected are available in the repository DOI: 10.17632/d7f678z5kz.1 [1].

Table 1
Theoretical velocity gradient for the HFTF.

Length (m)	Flow (L/s)	Retention time (s)	Velocity (m/s)	Reynolds	Head loss in pipeline (m)	Head loss in accessories (m)	Total head loss (m)	Theoretical velocity gradient (s^{-1})
68.4	0.25	2218.17	0.03	2675.96	0.01	3.12E-03	0.01	6.15
	0.50	1109.08	0.06	5351.92	0.03	1.25E-02	0.04	16.81
	0.75	739.39	0.09	8027.88	0.05	2.25E-02	0.08	29.26
	1.00	554.54	0.12	10703.8	0.09	2.11E-02	0.11	41.13
	2.00	277.27	0.25	21407.7	0.33	6.45E-02	0.40	109.62
97.6	0.25	3160.00	0.03	2675.96	0.01	4.67E-03	0.01	6.20
	0.50	1580.00	0.06	5351.92	0.04	1.87E-02	0.05	16.96
	0.75	1053.33	0.09	8027.88	0.08	3.37E-02	0.11	29.50
	1.00	790.00	0.12	10703.8	0.13	3.15E-02	0.16	41.34
	2.00	395.00	0.25	21407.7	0.48	9.63E-02	0.57	110.12

Table 2
Real velocity gradient for the HFTF.

Length (m)	Flow (L/s)	Retention time (s)	Velocity (m/s)	Reynolds	Head loss in pipeline (m)	Head loss in accessories (m)	Total head loss (m)	Real velocity gradient (s-1)
68.4	0.25	1932.01	0.03	2676.21	0.01	3.12E-03	0.01	6.59
	0.50	1146.02	0.06	5352.13	0.03	1.25E-02	0.04	16.54
	0.75	859.80	0.09	8028.02	0.05	2.25E-02	0.08	27.14
	1.00	435.00	0.12	10,704.04	0.09	2.11E-02	0.11	46.44
	2.00	265.21	0.25	21,408.22	0.33	6.45E-02	0.40	112.09
97.6	0.25	3123.03	0.03	2676.17	0.01	4.67E-03	0.01	6.24
	0.5	1345.80	0.06	5352.14	0.04	1.87E-02	0.05	18.39
	0.75	966.60	0.09	8028.03	0.08	3.37E-02	0.11	30.80
	1.00	738.10	0.12	10,704.31	0.13	3.15E-02	0.16	42.78
	2.00	312.20	0.25	21,408.24	0.48	9.63E-02	0.57	123.67

3.3. Turbidity and Colour Removal Data

3.3.1. Turbidity and Colour at the Outlet of the Settler

The data set [1] contains data on the statistical parameters of turbidity and colour at the outlet of the settler of the experimental system for different flow rates and the two lengths of the HFTF (sheet: Sedimentator outlet). Table 3 describes the arithmetic mean, median, standard deviation (SD), minimum value and maximum value of the turbidity and residual colour obtained in the settler of the experimental system for the five flow rates tested in combination with the two lengths of the HFTF. These data could serve as a basis for future comparative analyzes between different treatment systems and process optimization in practical water treatment applications [3].

3.3.2. Turbidity and Colour at the Filter Outlet

The data set [1] contains data on the statistical parameters of turbidity and colour at the filter outlet of the experimental system for different flow rates and the two lengths of the HFTF (sheet: Filter outlet). Table 4 describes the arithmetic mean, median, standard deviation (SD), and the minimum and the maximum value of the turbidity and residual colour obtained in the filter of the experimental system for the five flow rates tested in combination with the two lengths of the HFTF. The data set is critical to understanding the system performance in terms of clarity of the treated water and effectiveness of the filtration process [3].

3.3.3. Turbidity and Colour Removal Efficiency in the Settler of the Experimental System and the Conventional Treatment Plant

The data set [1] contains data on the removal efficiency of turbidity and colour at the outlet of the settler of the experimental system for the different flow rates and the two lengths of the

Table 3
Statistical parameters of turbidity and colour at the outlet of the settler of the experimental system for different flow rates and the two lengths of the HFTF.

Flow (L/s)	Length HFTF 68.4 m									
	Turbidity (NTU)					Colour (Pt-Co)				
	Mean	Median	SD	Minimum	Maximum	Mean	Median	SD	Minimum	Maximum
0.25	7.78	8.15	3.68	3.76	12.00	73.40	76.00	37.92	31.00	113.00
0.50	7.11	7.92	4.25	2.97	13.10	67.00	75.00	37.08	28.00	116.00
0.75	7.88	5.98	3.46	4.95	13.40	72.90	57.00	29.37	45.00	116.00
1.00	7.08	6.82	2.29	4.40	10.30	68.00	66.00	25.35	39.00	105.00
2.00	23.05	22.00	14.88	6.81	43.75	148.35	145.00	68.24	67.00	248.00
Flow (L/s)	Length HFTF 97.6 m									
	Turbidity (NTU)					Colour (Pt-Co)				
	Mean	Median	SD	Minimum	Maximum	Mean	Median	SD	Minimum	Maximum
0.25	5.87	5.19	2.01	3.60	8.71	60.00	53.00	21.73	38.00	91.00
0.50	6.99	6.91	3.64	3.68	12.68	65.00	70.00	33.83	32.00	115.00
0.75	7.39	7.55	3.71	2.62	12.35	70.40	72.00	34.02	26.00	113.00
1.00	11.00	10.45	4.99	4.72	16.10	91.00	93.00	32.68	45.00	123.00
2.00	15.39	10.25	10.39	7.02	31.55	119.6	98.0	59.60	66.00	216.00

SD: Standard deviation.

Table 4
Statistical parameters of turbidity and colour at the filter outlet of the experimental system for different flow rates and the two lengths of the HFTF.

Flow (L/s)	Length HFTF 68.4 m									
	Turbidity (NTU)					Colour (Pt-Co)				
	Mean	Median	SD	Minimum	Maximum	Mean	Median	SD	Minimum	Maximum
0.25	0.21	0.16	0.16	0.11	0.49	0	0	0	0	0
0.50	0.32	0.32	0.12	0.20	0.51	0	0	0	0	0
0.75	0.41	0.47	0.14	0.24	0.53	0	0	0	0	0
1.00	0.34	0.31	0.10	0.22	0.48	0	0	0	0	0
2.00	0.56	0.56	0.12	0.39	0.73	1.00	1.00	0.71	0	2v
Flow (L/s)	Length HFTF 97.6 m									
	Turbidity (NTU)					Colour (Pt-Co)				
	Mean	Median	SD	Minimum	Maximum	Mean	Median	SD	Minimum	Maximum
0.25	0.24	0.22	0.07	0.17	0.36	0	0	0	0	0
0.50	0.29	0.27	0.09	0.20	0.44	0	0	0	0	0
0.75	0.35	0.37	0.12	0.19	0.51	0	0	0	0	0
1.00	0.39	0.43	0.12	0.24	0.53	0	0	0	0	0
2.00	0.63	0.68	0.13	0.45	0.76	1.00	1.00	0.71	0	2.00

SD: Standard deviation.

HFTF. Likewise, it contains data on the efficiency of removing turbidity and colour at the outlet of the settler of the conventional treatment plant (sheet: Removal efficiency_settler outlet). Table 5 shows the statistics of the turbidity and colour removal efficiency in the settler for both the experimental system and the conventional treatment plant. The arithmetic mean (Mean), the median (Me), the standard deviation (SD), as well as the minimum value (Min) and the maximum value (Max) of the removal efficiency are included, considering the two lengths of the HFTF. It provides a direct comparison between the effectiveness of the settlers in both systems.

Table 5
Turbidity and colour removal efficiency at the outlet of the settler of the experimental system for the different flow rates and the two lengths of the HFTF. Turbidity and colour removal efficiency at the outlet of the settler of the conventional treatment plant.

Flow (L/s)	HFTF L1: 68.4 m		HFTF L2: 97.6 m		Conventional treatment plant	
	Turbidity removal (%)	Colour removal (%)	Turbidity removal (%)	Colour removal (%)	Turbidity removal (%)	Colour removal (%)
0.25	59.62	64.13	39.34	47.50	79.80	81.40
0.25	80.54	74.17	85.51	80.35	92.12	88.44
0.25	84.80	78.13	90.33	86.65	96.47	94.89
0.25	89.83	81.53	93.27	87.86	97.12	95.04
0.25	93.66	88.33	95.73	91.73	97.81	96.24
0.50	70.20	71.43	56.32	61.45	82.37	84.53
0.50	84.88	77.62	83.99	78.53	85.04	78.43
0.50	85.03	79.89	82.85	75.09	94.86	92.05
0.50	91.60	85.00	92.41	86.82	97.05	94.43
0.50	94.55	90.50	94.60	91.26	98.06	96.77
0.75	59.59	60.87	43.87	38.46	80.23	76.72
0.75	79.73	75.18	76.83	71.48	91.58	90.07
0.75	77.80	69.70	93.61	91.13	95.66	94.92
0.75	94.05	89.77	91.67	85.01	96.54	94.50
0.75	94.15	90.73	93.67	88.36	98.07	96.67
1.00	37.72	36.84	53.29	59.80	84.04	86.44
1.00	64.84	55.37	50.24	26.90	85.08	80.45
1.00	91.37	89.28	87.68	83.77	97.92	98.78
1.00	91.82	86.50	85.32	80.11	96.98	94.58
1.00	95.00	89.87	93.55	91.28	98.08	96.81
2.00	22.79	21.18	38.68	41.59	72.53	71.72
2.00	28.00	15.15	57.08	44.37	85.36	80.29
2.00	58.96	56.97	85.42	80.24	96.19	94.24
2.00	74.90	71.97	83.89	79.85	97.71	95.65
2.00	80.73	80.18	86.10	82.76	98.33	97.28

3.3.4. Turbidity and Colour removal Efficiencies in the Filter of the Experimental System and the Conventional Treatment Plant

The data set [1] contains data on the removal efficiency of turbidity and colour at the outlet of the filter of the experimental system for the different flow rates and the two lengths of the HFTF. It also contains data on the removal efficiency of turbidity and colour at the outlet of the filter of the conventional treatment plant (sheet: Removal efficiency_filter outlet). Table 6 represents data on the arithmetic mean (Mean), median (Me), standard deviation (SD), minimum value (Min) and maximum value (Max) of the turbidity and colour removal efficiencies in the settler complemented with the two lengths of the tubular flocculator of the experimental system, and the data set about the efficiency of the settler from the conventional treatment plant is also presented. These data provide a comparative view of the turbidity and colour removal efficiency between the experimental system and the conventional water treatment process.

4. Experimental Design, Materials and Methods

4.1. Implementation of the Experimental Treatment System

The experimental treatment system intended for purification was designed for 1.0 L/s, it was made up of the HFTF, high-rate settler and rapid sand filters. The HFTF was built using 4 inch diameter PVC pipes, and two different lengths of the flocculator were used (68.4 m and 97.6 m). These two lengths were combined with five different raw water flow rates, which were 0.25, 0.5, 0.75, 1.0 and 2.0 L/s. Likewise, five turbidity ranges were considered: <10 NTU, 10-20 NTU, 21-

Tabla 6
Turbidity and colour removal efficiency at the outlet of the settler of the experimental system for the different flow rates and the two lengths of the HFTF. Turbidity and colour removal efficiency at the outlet of the settler of the conventional treatment plant.

Flow (L/s)	HFTF L1: 68.4 m		HFTF L2: 97.6 m		Conventional treatment plant	
	Turbidity removal (%)	Colour removal (%)	Turbidity removal (%)	Colour removal (%)	Turbidity removal (%)	Colour removal (%)
0.25	98.82	100.00	97.23	100.00	97.21	100.00
0.25	99.31	100.00	99.15	100.00	99.15	100.00
0.25	99.65	100.00	99.57	100.00	99.51	100.00
0.25	99.90	100.00	99.84	100.00	99.85	100.00
0.25	99.74	100.00	99.82	100.00	99.74	100.00
0.50	96.83	100.00	96.80	100.00	96.73	100.00
0.50	98.79	100.00	98.69	100.00	97.82	100.00
0.50	99.62	100.00	99.50	100.00	99.27	100.00
0.50	99.69	100.00	99.77	100.00	99.72	100.00
0.50	99.79	100.00	99.81	100.00	99.80	100.00
0.75	98.08	100.00	96.21	100.00	97.12	100.00
0.75	98.42	100.00	99.16	100.00	99.27	100.00
0.75	98.71	100.00	98.99	100.00	99.51	100.00
0.75	99.47	100.00	99.66	100.00	99.69	100.00
0.75	99.88	100.00	99.86	100.00	99.83	100.00
1.00	96.39	100.00	97.62	100.00	95.92	100.00
1.00	98.63	100.00	98.64	100.00	98.65	100.00
1.00	99.39	100.00	99.33	100.00	99.74	100.00
1.00	99.52	100.00	99.56	100.00	99.68	100.00
1.00	99.86	100.00	99.79	100.00	99.82	100.00
2.00	93.65	98.82	93.40	98.23	94.87	100.00
2.00	97.60	100.00	97.68	100.00	97.63	100.00
2.00	98.93	99.70	99.19	99.80	99.35	100.00
2.00	99.55	99.84	99.45	99.85	99.70	100.00
2.00	99.68	99.84	99.69	99.92	99.81	100.00

50 NTU, 51-100 NTU and >100 NTU. In total, 100 tests were carried out, which were duplicated and executed with natural raw water over one year.

4.2. Calculation of Retention Time and Velocity Gradient of HFTF

For calculating the theoretical retention time in the HFTF, Eqs. (1) and (2) were the five different flow rates were used. The volume of the HFTF was determined from the length and diameter of the pipe (Eq. (2)); in this case, the two lengths (68.4 m and 97.6 m) and the nominal diameter of the pipe of 110 mm were used [2].

$$t = \frac{V}{Q} \tag{1}$$

$$V = \pi \cdot r^2 \cdot L \tag{2}$$

where, Q is the inlet flow rate (m^3/s), V is the volume of the flocculator (m^3), r is the radius of the pipe (m), and L is the length of the flocculator (m).

The tracer technique was used for calculating the actual retention time of water in the HFTF accurately. It was achieved by administering instant doses of a solution of NaCl in water. The exact amount of salt required for the tests was determined based on the reactor volume (HFTF). The tracer was added at the inlet of the HFTF, the collection of samples for measuring the salt concentration (total dissolved solids TDS) was carried out at the outlet of the HFTF, that is, before the water enters the settler. The samples were taken every minute from the addition of the tracer, at the moment that an increase in TDS was detected, the sample collection time was reduced to 30 s for the flow rate of 2 L/s, and the interval sampling was every 15 s. Next, graphs of time vs SDT concentration were made with the data obtained. A TDS digital meter was used in the measurements. For the application of the tracer technique, the methodology was applied by Mastrocicco et al. [4].

According to De Oliveira and Teixeira [5], the velocity gradient can be calculated using Eq. (3). The velocity gradient and the theoretical and real retention period were determined using the tracer method. Water properties such as density and dynamic viscosity were taken into account considering the average water temperature during the experimental part.

$$G = \sqrt{\frac{\rho * g * h_f}{\mu * t}} \quad (3)$$

where, G is the velocity gradient (s^{-1}), h_f is the head loss (m), $\boldsymbol{\rho}$ is the density of water (kg/m^3), g is gravity (m/s^2), μ is the viscosity water dynamics (kg/m.s), and t is the retention time (s). For more details on this section, you can review the article https://doi.org/10.3390/w15050833

4.3. Sampling and Analysis of Parameters to Determine Efficiency

Turbidity and colour were established as the main parameters for determining the efficiency of the HFTF; For this purpose, a HACH model 2100 Q turbidimeter was used to measure turbidity and an HACH model DR/890 colourimeter for colour [6]. The points for collecting water samples for evaluating these parameters were the following: (1) in the rectangular weir of the conventional Treatment Plant (CTP) (before coagulation); (2) at the outlet of the settler of the experimental system; and (3) at the outlet of the filters of the experimental system (Fig. 1). Simultaneously, two additional samples were taken: at the outlet of the CTP settler (2') and the outlet of the CTP filters (3'). This allowed us to compare the effectiveness of turbidity and colour removal between the Horizontal Flow Tubular Flocculator (HFTF) of the experimental system and the horizontal hydraulic screen flocculator of the CTP.

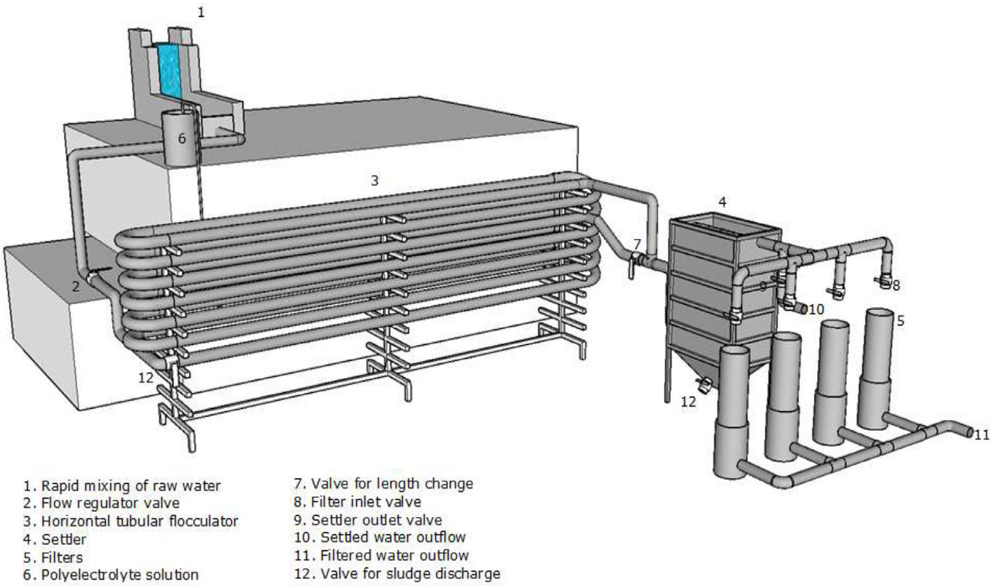

Fig. 1. Pilot system for the treatment of drinking water, this system includes a horizontal flow tubular flocculator.

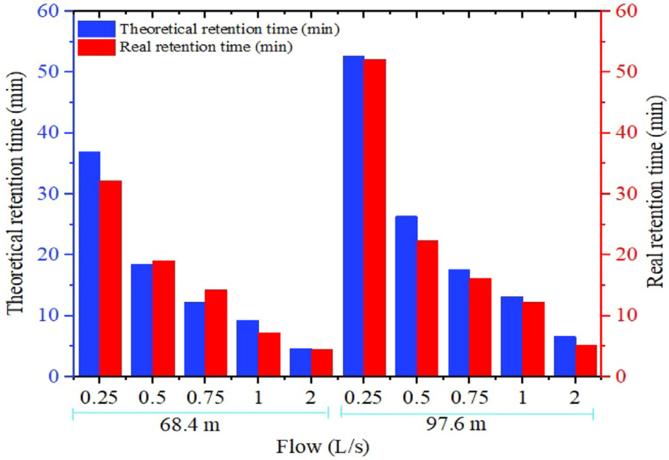

Fig. 2. Real and theoretical retention times of the HFTF for the two lengths analyzed.

For each test, the turbidity of raw water entering into the treatment plant was measured, then the dose of coagulant was calibrated, which was common for both the experimental treatment system and the conventional purification plant. At the same time, the flow rate was regulated of raw water upon entry. For each test, one of the five flow rates chosen was combined with a range of turbidity of the raw water and one of the two lengths of the HFTF.

4.4. Removal of Turbidity and Colour

The removal efficiency (RE) of each parameter (turbidity and colour) was determined using the following Eq. (4) [7,8]. In this equation, C_i represents the initial concentration of the parameter in the raw water that entered the plant and C_f is the final concentration of the parameter in the treated water that left the settler and filter.

$$RE = \frac{C_i - C_f}{C_i} \text{x } 100 \quad (4)$$

Limitations

Not relevant.

Ethics Statement

The authors affirm their comprehension of the ethical guidelines for data publication in Data in Brief and additionally assert that the data gathered excludes involvement with human subjects, animal experimentation, or information sourced from social media platforms.

Data Availability

Data_Horizontal Flow Tubular Flocculator (Original data) (Mendeley Data).

CRediT Author Statement

Fernando García-Avila: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft; **Alex Avilés-Añazco:** Formal analysis, Data curation, Writing – review & editing; **Ángel Méndez-Heredia:** Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing; **Alex Trelles-Agurto:** Conceptualization, Methodology, Writing – review & editing; **Lorgio Valdiviezo-Gonzales:** Conceptualization, Methodology, Investigation, Data curation; **César Zhindón-Arévalo:** Formal analysis, Writing – review & editing; **Emigdio Alfaro-Paredes:** Conceptualization, Methodology, Writing – review & editing.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dib.2024.110336.

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