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Scientific Paper

Evaluation of efficiency in using turbidity curtains to retain suspended solids carried out on a pilot scale

Avaliação da eficiência na utilização de cortinas de turbidez para retenção de sólidos suspensos realizada em escala piloto

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ABSTRACT

This study aims to stimulate debate on the behavior of geotextile blankets in retaining suspended solids and to offer subsidies for further research. By means of a simple and objective approach, the results of a pilot-scale experiment are presented, with the objective of suggesting the use of containment barriers as a simple and inexpensive technique for raw water pre-filtration. Due to the growing demand for treated water and a marked decrease in the quality of the water available for catchment, it becomes necessary to increase the dosage of chemicals used in the treatment. Consequently, this influences not only the costs but also the characteristics of the waste generated in the process, since the nature and quantity of the sludge depend, among other factors, on the turbidity and the dosage of coagulant chemicals. The experiment was carried out using an acrylic channel where two adequately spaced geotextile blanket barriers were positioned, with raw water from the Parshall flume being pumped into the channel and, after passing through the barriers, returned by gravity to the flume and then sent for treatment. The affluent flow was maintained at 3.5 L/min and the blankets used had a weight of 170.0 and 420.0 g/m^2, respectively. The results were not sufficient to conclude whether or not there is a relationship between the average raw water turbidity and the average turbidity reduction by the system. However, they show good chances of reducing sludge generation in water treatment plants receiving raw water pre-filtered by the proposed system, even with the average turbidity reduction considered low.

Keywords: spring water; geotextile blankets; water treatment.

RESUMO

Este estudo visa estimular o debate sobre o comportamento das mantas geotêxteis na retenção de sólidos em suspensão e oferecer subsídios para futuras pesquisas. Por meio de uma abordagem simples e objetiva, são apresentados os resultados de um experimento em escala piloto, com o objetivo de sugerir o uso de barreiras de contenção como uma técnica simples e barata para pré-filtração de água bruta. Devido à crescente demanda por água tratada e à acentuada diminuição da qualidade da água disponível para captação, torna-se necessário aumentar a dosagem dos produtos químicos utilizados no tratamento. Consequentemente, isso influencia não só os custos, mas também as características dos resíduos gerados no processo, uma vez que a natureza e a quantidade do lodo dependem, entre outros fatores, da turbidez e da dosagem dos produtos químicos coagulantes. O experimento foi realizado utilizando um canal de acrílico onde foram posicionadas duas barreiras de manta geotêxtil adequadamente espaçadas, sendo a água bruta da calha Parshall bombeada para dentro do canal e, após passar pelas barreiras, devolvida por gravidade à calha e então encaminhada para tratamento. A vazão afluente foi mantida em 3,5 L/min e as mantas utilizadas tinham gramatura de 170,0 e 420,0 g/m², respectivamente. Os resultados não foram suficientes para concluir se existe ou não relação entre a turbidez média da água bruta e a redução média da turbidez pelo sistema. Contudo, apresentam boas chances de redução da geração de lodo em estações de tratamento de água que recebem água bruta pré-filtrada pelo sistema proposto, mesmo com a redução média da turbidez considerada baixa.

Palavras-chave: água bruta; mantas geotêxteis; tratamento de água.

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INTRODUCTION

Water is an essential resource for life and of extreme importance for social development. When raw water is concerned, its quality is commonly characterized by the content of suspended solids, colloidal particles, natural organic matter, and other soluble compounds, mainly inorganic, which are present in different concentrations. Thus, whenever water is intended for human consumption, an appropriate treatment process is necessary to meet potability standards (HUANG; PAN, 2002).

During the production of drinking water, the coagulation and flocculation stages are generally used to eliminate turbidity caused by suspended solids and can be considered as one of the most important stages of the conventional treatment process (HUANG; PAN, 2002).

Aluminum sulfate, often used as a coagulant, has its application dosage determined by the characteristics of the suspended materials present in raw water, mainly by their concentrations (KAWAMURA, 2000). Considering the reduction in the quality of water sources and the growing demand for treated water, a proportional increase in the use of coagulants has become necessary.

It is worth mentioning that in the routine operation of Water Treatment Plants (WTPs) in Brazil, the definition of dosages is not always based on previous studies that enable the determination of effective values in order to avoid waste and excesses. This scenario can lead to issues affecting the efficiency of the treatment, such as the characteristics of generated residues. According to Ahmad, Ahmad and Alam (2016b), the nature and quantity of residues depend, among other factors, on the quality of raw water and the dosage of coagulant chemicals.

The so-called WTP sludge is composed of organic and inorganic matter in solid, liquid, and gaseous states, whose compositions depend on physical, chemical, and biological characteristics (BOURGEOIS; WALSH; GAGNON, 2004; BABATUNDE; ZHAO, 2007). This residue originates from suspended solids present in raw water, which are removed from the system by sedimentation and filtration, after the coagulation and flocculation stages, respectively (AHMAD; AHMAD; ALAM, 2016a).

Hence, there is a need to reduce the volume of suspended solids contained in raw water, directly affecting the reduction of sludge generation, which is the main residue of the process. In Brazil, discharging sludge directly into water bodies without previous treatment is a common practice, which constitutes a major environmental problem, especially because this water will supply other cities, in addition to animals and plantations along the way. In Brazil, as a general practice, this sludge is routinely disposed of directly into rivers, streams, or drainage systems, causing a significant environmental impact that compromises the quality of drinking water and the health of populations and animals relying on it. The growing concerns of environmental organizations have led to regulations restricting or prohibiting the discharge of this residue into the environment, including rivers, landfills, and soil (TEIXEIRA *et al*., 2011). Despite there being more than 7,500 complete cycle (or conventional) WTPs in Brazil and a legislation prohibiting it, the substantial release of sludge into waterways still persists (MONTEIRO *et al*., 2008).

The simple method of final disposal, although less expensive, is not adequate due to the possibility of contamination of water bodies and soil by the chemical products used in the treatment (AHMAD; AHMAD; ALAM, 2016a). In general, in Brazil, the most used coagulants are aluminum sulfate, ferric chloride, ferrous sulfate, and aluminum polychloride, which all return to rivers after coagulation, therefore causing environmental impacts.

In addition to the sludge generated, another factor that deserves attention and has the potential to be mitigated by reducing the suspended solids contained in the raw water is the cost associated with chemicals used in the treatment. Data from the Brazilian National Information System on Basic Sanitation (*Sistema Nacional de Informações sobre Saneamento* – SNIS) indicated that expenses with chemical products in 2017 reached approximately R$ 1.3 billion, accounting for 3.4% of total exploitation expenses (*despesas de exploração* – DEX), which corresponds to the costing values (SNIS, 2019).

The simplicity of the application process and the low maintenance needs corroborate the interest in developing the method presented in this study, as demonstrated during its use in the construction of the southern section of Rodoanel, one of the construction sites involving the highest volume of earthwork in Brazilian history (IPT, 2008). About 40.0 km of earthworks were carried out, with estimated cut and fill volumes of 30.0 and 22.0 million m^3, respectively (IPT, 2008).

One of the main structural measures used were the turbidity curtains which, according to researcher Dr. Sofia Julia, from the Institute of Technological Research (*Instituto de Pesquisas Tecnológicas* – IPT), proved to be very effective, as confirmed by the inspections carried out during flights over the reservoir after the rains, as can be seen in Figure 1.

This study aimed to demonstrate the efficiency of the method, corroborating several studies that ensure that one of the most relevant parameters for retention efficiency is the pore opening size of the blankets and that cake formation contributes significantly to particle retention (MOO-YOUNG; GAFFNEY; MO, 2002; KUTAY; AYDILEK, 2004; BOURGÈS-GASTAUD *et al*., 2014).

In this context, knowing the usefulness of geotextiles in the retention of suspended solids, in addition to the fact that their filtration capacity and performance are related to the characteristics of the blanket and the size of the sediment (QUARANTA; TOLIKONDA, 2011; LAMY *et al*., 2013; OLIVEIRA *et al*, 2018; OLIVEIRA *et al*, 2020), the present study aimed to evaluate the efficiency of turbidity curtains for the reduction of suspended solids in the raw water that feeds WTPs using a pilot-scale system.

Based on studies performed by Kutay and Aydilek (2004), Oliveira *et al.* (2018), and Oliveira *et al.* (2020), which indicated a higher efficiency when employing barrier systems in series, this study was developed using two turbidity curtains in sequence.

Source: IPT (2008).

Figure 1 – Non-woven geotextile turbidity curtain.

MATERIALS AND METHODS

To the best of our knowledge, no similar studies have been found in the literature, therefore, the experimental apparatus was created and tested by the authors in this study. Likewise, similar results were not found for comparison. However, although comparisons were not possible, the study is a reference for future projects aiming at the same purposes.

Materials

A centrifugal pump of 0.5 HP was used to pump raw water from the Parshall flume into the acrylic channel throughout the experiment. As it was a pilot-scale procedure, the experiment worked in a continuous flow supply for several days, operating 24 hours a day, unlike previous studies conducted by Oliveira *et al.* (2018) and Oliveira *et al.* (2020), which consisted of batch experiments running for a few hours.

In the literature and consequently in this experiment, turbidity curtains have some terminologies which can refer to the same structure, such as: geotextile curtains, geotextile barriers, geotextile blankets, and turbidity blankets.

The acrylic channel used had dimensions of 1.65 × 0.40 × 0.30 m, corresponding to useful length × useful width × height of the spillway, respectively, and a total useful volume of 198.0 L. The channel was allocated with a slope of 0.5% toward the outlet, containing incoming, outgoing, and overflow pipes to assist in flow control.

For each assay, two geotextile blanket barriers were used with an approximate distance of 0.50 m, placed inside the channel with the aid of an acrylic frame in order to fill the entire wet section, with an initial useful area of approximately 0.12 m^2 and reaching 0.16 m^2 at the end of the experiment. The channel and the arrangement of the barriers can be seen in Figure 2.

According to Oliveira *et al.* (2018), in a set of two or more barriers, the first one receives a greater contribution of sediments and has a higher value of retained mass when compared to the others. By establishing a successive sequence of grammages, the first barrier would provide sedimentation, while subsequent barriers, with higher grammages, would be responsible for sedimentation and retention.

The material used for the turbidity curtains was the continuous filament nonwoven needled geotextile type, with a grammage of 170 and 400 gm^{-2} (Table 1), as indicated by Oliveira et. al (2020), respectively.

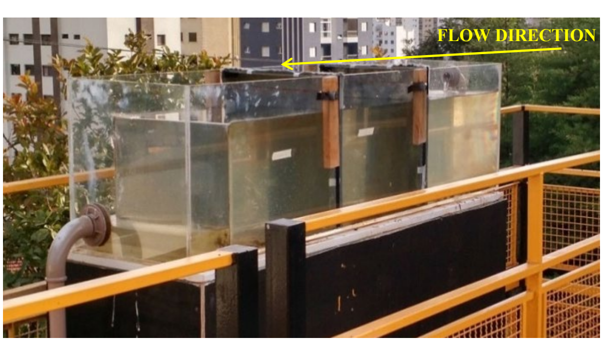

Figure 2 – Acrylic channel used in the experiment with the turbidity barriers installed.

Methods

The study was conducted in WTP-I, located in the municipality of Poços de Caldas, Minas Gerais (MG), whose nominal operating capacity is 200.0 Ls^{-1} and is supplied by two different sources, namely the Saturnino de Brito dam and Ribeirão da Serra.

Water is collected from Saturnino de Brito in the reservoir of the same name, whose drainage area has 26.34 km^2, the Ribeirão de Caldas basin, a reservoir which serves multiple purposes, including flood control.

Ribeirão da Serra is abstracted by run-of-river, with an approximate flow rate of 120.0 Ls^{-1} and conveyed by gravity, with only one railing at the water intake. This water capture has a flow rate of about 65.0 Ls^{-1}, is not regulated and is conveyed by gravity with only a railing.

Samples were collected in the Parshall flume and after each of the two curtains in the acrylic channel. The experiments were named in chronological order from experiment 1 to experiment 5, between 04/29/2019 and 05/07/2019 (experiment 1), 05/08/2019 and 06/03/2019 (experiment 2), 11/01/2019 and 12/16/2019 (experiment 3), 12/17/2019 and 01/04/2020 (experiment 4), and 01/13/2020 and 02/17/2020 (experiment 5).

The difference between the periods of the experiments occurred as a result of the saturation of the blankets, increased pressure drops, and technical problems that prevented their continuation. However, due to the considerable variation, the present study did not attempt to evaluate the fluctuations of the blanket use periods, but rather their efficiency.

Before starting each experiment, the channel was cleaned, the curtains were fixed on the acrylic supports and installed. According to Oliveira *et al.* (2020), system efficiency is higher for application rates below 50.0 $Lmin^{-1}$ m^2, therefore the attempt was to maintain the average continuous flow rate of 3.5 $Lmin^{-1}$, which corresponds to an application rate of 30.0 $Lmin^{-1}$ m^2.

The experiments were sometimes interrupted either by structural problems or due to saturation of the turbidity curtains.

It is worth noting that during each experiment all necessary precautions were taken and once the experiment was paused for maintenance on the pump, the channel was covered to avoid external interference. The activities were developed normally, and it was possible to keep a constant flow during the first four experiments. However, in the fifth experiment, the flow rate was not adjusted systematically as in the other experiments due to operational problems.

During the experiments, three samples were collected every two hours, according to the WTP routine, starting at 00:00 each day and continuing at every two-hour interval.

Samples were collected in raw water, after the first curtain and then after the second curtain. Turbidity measurement was carried out with a benchtop turbidimeter (Del Lab brand, model DLT-WV). Periodic calibrations were

Table 1 – Geotextile characteristics.

	Grammage	
Hydraulic properties	**170 g m^2**	**400 g m^2**
Permittivity (s^{-1})	2.00	0.80
Water flow (L min^{-1} m^{-2})	5,820.00	2,760.00
Normal permeability (cm s^{-1})	0.39	0.37
Apparent aperture (O_{95}) (mm)	0.21	0.15

performed with standard solutions < 10 NTU, 10 NTU, 100 NTU and 1,000 NTU, following the manufacturer's guidelines and in accordance with the scale used for the experiments.

The turbidity data were assessed in two different ways:

The first form of analysis was performed by separating the turbidity ranges (groups) and, from these groups, the frequencies of appearance of these turbidity ranges in the samples of raw water and water after the second curtain were evaluated. Based on these data, it was possible to analyze the variation of the samples with respect to each range, varying mainly for the lower turbidity groups.

The second form analyzed the average turbidity of raw water and after each barrier, evaluating the average reduction of turbidity and system efficiency. In this way, it was possible to analyze the behavior of the system under several aspects.

By means of methods correlating turbidity variables, total suspended solids, and water color, it is possible to estimate sludge production in a WTP. Hence, the model presented by Cornwell (1978) was used, according to Equation 1:

$$P = 3.5 * 10-3 * Tu0.66 \quad (1)$$

where P means production of solids (kg of dry matter.m^{-3} of treated raw water), and Tu is turbidity of raw water (NTU).

Therefore, the reduction of sludge generation in WTP-I was estimated, using the average turbidity of raw water and the reduced average turbidity as input data, after crossing the barriers. The maximum operating flow, *i.e.*, 200.0 Ls^{-1}, was considered.

RESULTS AND DISCUSSION

In order to better understand the experimental results, all data collected were divided into turbidity ranges (first form of analysis). Table 2 illustrates the ranges established in each experiment, as well as the percentage of data frequency for each of the turbidity ranges.

Concerning experiment 1, it could be noted that the established turbidity ranges were smaller than the others. This was because a maximum turbidity value of 29.8 NTU was observed, with only 4 collections presenting turbidity values higher than 25.0 NTU. For the other experiments, ranges varied between 0.0 and greater than 200.0 NTU.

An increase in the frequency of turbidity data below 10.0 NTU could be observed in all experiments, except in experiment 5, which showed no significant variation between the frequency ranges. The largest increase was found in experiment 1 (285.0%), whereas in experiments 2, 3, and 4 there was an increase of 176.0, 169.0, and 241.0%, respectively.

The lowest increase was obtained in experiment 5, in which no samples (raw and final) were reported with turbidity values below 10.0 NTU.

Another important point to be evaluated is the frequency reduction for the subsequent turbidity ranges, *i.e.*, the system was able to significantly reduce the turbidity of the larger ranges, especially the second one (10 – 50 NTU), while increasing the frequency in the smaller ranges, as reported by Oliveira *et al.* (2020). This difference would be expected due to Oliveira *et al.* (2020) work having been carried out on a laboratory scale and using water prepared in the laboratory with dry, crushed sediment, and with granulometric analysis carried out; therefore, it was expected that the performance of the blankets in a pilot project and with natural sediments would behave differently.

The behavior of sediment-prepared water and natural water from a real river basin with sediments can significantly differ (RIGGSBEE *et al.*, 2008), as well as the behavior of sediments in water bodies like a reservoir and rivers are very different (BELL, 1942; LOWE, 1979; TUNDU; TUMBARE; KILESHYE ONEMA, 2018). Sediment-prepared water is frequently employed in experimental and laboratory studies, as Oliveira *et al.* (2020) did, enabling a control over the composition and concentration of added sediments. This controlled approach allows for precise evaluation of parameters such as turbidity, sedimentation, and interactions between sediments and water. In contrast, water collected directly from a real river reflects the environmental conditions and natural variability of the river, including seasonal influences and potential pollutant sources. Consequently, such water may exhibit distinct characteristics in terms of turbidity, pH, and sediment composition.

Table 2 – Frequency of occurrence of values by turbidity range.

	Frequency		
	Turbidity Range (NTU)	raw Turbidity (%)	Final (%)
Experiment 1	≤ 10	21.5	61.3
	10 - 15	65.5	33.3
	15 - 20	5.3	1.1
	20 - 25	3.2	2.2
	≥ 25	4.3	2.2
Experiment 2	≤ 10	21.7	38.3
	10 - 50	71.9	56.2
	50 - 100	3.8	3.4
	100 - 150	0.4	0.4
	150 - 200	0.9	1.3
	≥ 200	1.3	0.4
Experiment 3	≤ 10	27.1	45.8
	10 - 50	66.6	48.5
	50 - 100	2.5	3.8
	100 - 150	2.2	1.1
	150 - 200	0.8	0.5
	≥ 200	0.8	0.3
Experiment 4	≤ 10	8.0	19.3
	10 - 50	72.2	61.5
	50 - 100	3.2	5.3
	100 - 150	5.3	4.8
	150 - 200	5.3	4.8
	≥ 200	5.9	4.3
Experiment 5	≤ 10	0.0	0.0
	10 - 50	36.2	39.1
	50 - 100	33.6	32.5
	100 - 150	15.4	15.1
	150 - 200	9.0	7.5
	≥ 200	5.8	5.8

As previously mentioned, experiment 5 demonstrated a different behavior from the others. This difference may be related to possible experimental errors or to climatic and sedimentological conditions. During the period of realization, the raw water inflow could not be monitored and regulated periodically, as in the other experiments. This may have caused an increase in the flow rate and consequently in the application rate, which would generate a lower efficiency of the system. However, because it was a very rainy period and the average turbidity of the raw water was very high, these data is presented so that future studies can evaluate the reasons for the discrepancy in relation to the other experiments.

In order to enhance discussion on the subject studied, the second way to analyze the data was by calculating the average turbidity of each experiment and correlating them to the average turbidity reduction, the average efficiency of the system, and the reduction of daily sludge generation.

Figure 3 shows that the increase in the average turbidity of the experiment is not related to the increase of the average reduction of turbidity, *i. e.*, the average reduction of turbidity is not necessarily greater for the experiments with higher average turbidity. Therefore, as can be seen in the graphic, the greatest average turbidity reduction occurred in experiment 4, which had the second highest average turbidity among the five experiments, with 37 NTU less than experiment 5.

As expected, due to the small variation of the average turbidity reduction between the experiments, from 2.0 to 4.4 NTU, experiment 1, with the lowest average turbidity observed in the period, was the one showing the highest efficiency values for the average turbidity, thus confirming the results obtained in the "first form of analysis", whose data frequency increased by 285.0% for the turbidity range below 10.0 NTU.

An important fact to highlight is that average turbidity of the raw water of experiments 1 and 2 presented low values, which is normal for the season of the year when they were performed. Experiment 3 was performed in a period after the beginning of the hydrological year and in theory a higher average turbidity was expected, however, as the rains at the end of 2019 in the study area were lower than expected in the study area, the average turbidity value obtained in experiment 3 was lower than in experiment 2. On the other hand, experiments 4 and 5, due to the period of the year in which they were performed, exhibited high average turbidity values.

In Figure 3, it can be noticed, again, that experiment 5 stands out from the others, especially regarding the efficiency of turbidity removal, which in experiments 1 to 4 remained fluctuating between approximately 10 and 15%. On the other hand, the efficiency in experiment 5 was reduced to 4.1%, an expected effect, as already mentioned, since the average turbidity reduction is independent of the average turbidity and there is little variation of the average turbidity reduction between the experiments; the higher the average turbidity, the lower the average efficiency of the system.

Concerning the use of two blankets operating in series, experiments 1, 2, and 4 showed similar behavior, with the first barrier being more efficient, while the second barrier showed greater efficiency in experiments 3 and 5, as shown in Table 3. Thus, it was not possible to conclude which barrier would be more efficient or if it is related to the average raw water turbidity of the period studied.

The calculation of sludge generation was based on turbidity, as presented in Equation 1. Table 4 shows that when estimating sludge reduction, values varied around 42.0 kg day^{-1} for a WTP of about 200.0 Ls^{-1} flow. For comparison and estimation purposes, a value of approximately 80 tons per year can be adopted for a WTP of 1.0 m^3 s^{-1}. This value is quite significant in the reduction of WTP residues, in addition to sediments, some metal associated with them as a result of the coagulant, which is usually produced from iron or aluminum.

In an attempt to find a logical relationship between the raw turbidity and the dosage of aluminum sulfate, some curves were plotted, but the results were not satisfactory. Hence, it was not possible to estimate the reduction in the dosage of coagulant generated by the decrease in inlet turbidity. This was mainly

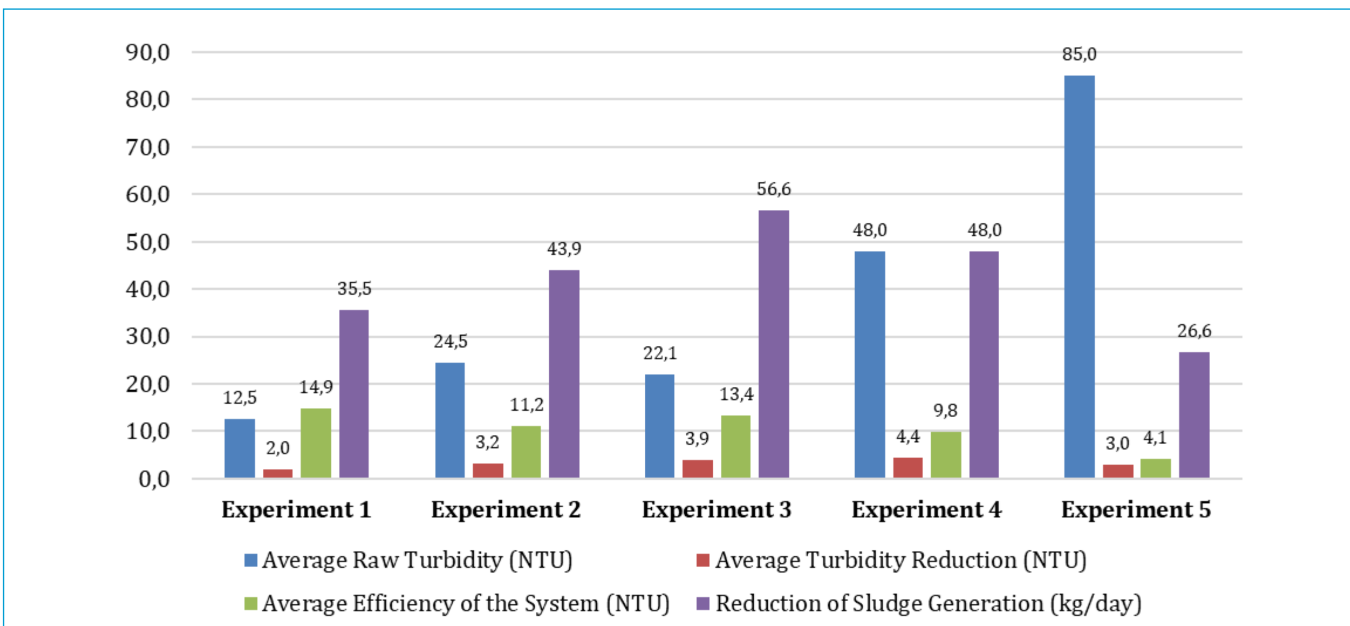

Figure 3 – Turbidity, efficiency, and sludge generation.

Table 3 – Removal efficiency of suspended solids from each barrier individually.

	Efficiency of each barrier individually									
	Experiment									
	1º		2º		3º		4º		5º	
	Turbidity (NTU)	Efficiency (%)	Turbidity (NTU)	Efficiency (%)	Turbidity (NTU)	Efficiency (%)	Turbidity (NTU)	Efficiency (%)	Turbidity (NTU)	Efficiency (%)
Average raw turbidity	12.53	---------	24.52	---------	22.08	---------	48.03	---------	85.04	---------
Average turbidity after 1st Barrier	11.23	10.38	22.73	7.30	20.05	9.19	45.31	5.66	83.95	1.28
Average turbidity after 2nd Barrier	10.50	6.50	21.33	6.16	18.15	9.48	43.63	3.71	82.05	2.26

Table 4 – Estimation of sludge generation.

	Estimation of sludge generation				
	Experiment				
	1	2	3	4	5
Sludge generation – raw water (kg/day)	333.69	477.95	443.12	687.41	1,133.83
Sludge generation – after the 2nd barrier (kg/day)	297.12	438.89	395.00	641.95	1,104.91
Sludge generation reduction (kg/day)	36.57	39.06	48.12	45.46	28.92
Sludge generation reduction (%)	10.96%	8.17%	10.86%	6.61%	2.55%

because in the WTP where the experiments were conducted there was not an ideal coagulant dosage made through Jar-Test experiments.

The quality of raw water and the treatment process are the key factors in determining coagulant dosage, as well as the quantity and quality of the resulting sludge. Consequently, any variations in water quality, whether due to seasonal changes or the introduction of turbidity curtains, can significantly impact both the quantity and quality of the generated sludge, ultimately affecting the cost of water treatment associated with coagulation-flocculation (KEELEY *et al.*, 2016; AHMAD; AHMAD; ALAM, 2016b; NAYERI; MOUSAVI, 2022).

It is worth mentioning that the proposed process will not generate hazardous waste or waste requiring specific treatment; disposal of the saturated blanket can be carried out in conventional landfills for inert materials.

CONCLUSION

Since this is an unprecedented pilot scale study, one may conclude that the experimental apparatus created presented satisfactory results, although the authors recommend greater control of the flow rate, as well as the analysis of the sediment quality for future experiments in order to further contribute to optimization and transition to full-scale.

According to the present data, it can be concluded that the use of non-woven blankets was efficient in reducing turbidity. Although the average reduction in turbidity has been considered low, between 2.0 and 4.4 NTU, the estimated reduction in the generation of sludge is considerable, since in the WTP where the study was carried out, it is expected that there would be a reduction in the generation of approximately 15 tons of waste during the year.

Regarding the use of two barriers in series, it is not possible to state that the higher the average turbidity, the more representative the second barrier becomes. However, it is understood that combined work increases the useful life of the system, as while the first barrier is responsible for sedimentation, the second barrier sediments and retains suspended solids.

In agreement with the efficiency of turbidity reduction, the estimated decrease in sludge generation also varied, being more effective for the periods with lower raw turbidity, as was the case of experiments 1, 2, and 3, whose estimated reduction was 11.10, 8.80, and 12.10%, respectively.

The lack of standardization in the coagulant and alkalinizer dosages as a function of turbidity prevented the development of a model that correlated turbidity reduction with a decrease in WTP input costs, however, it is expected that the data presented, and the performed approaches will contribute to future studies on the subject.

Full-scale experimental studies involving the application of these blankets are necessary, since the results of this investigation were promising.

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AUTHORS' CONTRIBUTIONS

Levighini, A.C.P.: Data Curation, Formal Analysis, Investigation, Writing – Original Draft, Software. Moura, R.B.: Data Curation, Formal Analysis, Validation, Visualization, Writing – Review & Editing. Tiezzi, R.O. Conceptualization, Formal Analysis, Funding Acquisition, Methodology, Project Administration, Supervision, Writing – Review & Editing and General Coordination.

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