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Evaluation of the Performance of Conventional Water Treatment and Direct filtration Treatment plant in the City of Tijucas/SC, Brazil

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Abstract
The demand for drinking water has grown rapidly around the world, but ironically, the continued degradation of water sources has reduced their availability, which is creating conflicts to serve all types of consumers. The scarcity of this resource has encouraged research that seeks theoptimization of the water treatment plant, but research that employs as net water production in performance evaluations is still restricted.Therefore, the objective of this study was to evaluate the performance of a conventional treatment system and a upflow direct filtration system, in real scale, considering the applicability of these technologies in relation to the water quality of the springs, the operational parameters of the treatment systems, such as the filter run and the backwash, and thenet water production.Analyses of the quality of raw and filtered water were performed, the durations of filter runs were calculated, andthe backwashed processes were evaluated, seeking to verify the possibility of obtaining an increase in net water production. The results showed that both systems studied have operational flaws in the backwashing processes,which do not prioritize water quality at the end of the filter run and disregard the duration limits, which puts at risk the health of consumers and increases the volume of water losses in the system. The treatment by upflow direct filtration obtained an average net water production of 93.38%, below the recommended level and the conventional level of 95.93%. In that event, the need for standardization of operational activities was identified, aiming at the adequacy of the criteria for closing the filter run and reducing the disposal of bottom sludged, in order to increase the net water production.
Keywords: Water Treatment Plant, Water Quality, Filter Run, Net water production.

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I. INTRODUCTION

With the increase in population and increased industrialization in recent decades, the availability of water has been insufficient to meet demand in many coastal regions of southern Brazil. It is estimated that about two-thirds of the world's population suffers from water scarcity for at least once a year[1].

On the other hand, urban development has produced contamination, generated by effluents from the urban population, rainflow and riverside occupation, which compromise the water quality of the springs[2], limiting its use and increasing the risks to human health by its consumption, which makes it a challenge for basic sanitation companies.

Such circumstances require the implementation of treatment systems with high levels of performance to allow the distribution of water under favorable potability conditions and increase the operational efficiency of treatment processes. Thus, the performance evaluation of water treatment units needs to consider, in addition to water quality, the net water production[3].

There are few studies aimed at evaluating the performance of treatment systems that include net water production as a parameter. Studies applied to coagulation processes are found in the literature, which use net water production as an indicator of the efficiency of the product used in the treatment, in view of the impact on the filter run[4, 5, 6].

Thus, the aim of this study was to evaluate the performance of a conventional treatment system (coagulation/flocculation/sedimentation/filtration/disinfection) and a upflow direct filtration system (coagulation/filtration/disinfection), on a real scale, considering the applicability of these technologies in relation to the water quality of the springs, operational parameters of the treatment systems, such as filter backwashing, water quality analysis, and net water production.

II. MATERIALS AND METHODS

The performance evaluation considered a treatment plant by Upflow direct filtration, with shallow spring uptake, with mean turbidity of 2.44 NTU and apparent color of 11.51 uH, and a conventional treatment system, whose surface spring has an average turbidity of 75.91 NTU and apparent color of 98.34 uH. The two systems are used for public supply of the municipality of Tijucas/SC.

Both constructive characteristics were evaluated, related to the composition of the filter units and basic design parameters, as well as operational characteristics of backwash and slode bottom discharges from both treatment systems.

2.1 Data collection

The data were obtained for the characterization of water from the water sources of the treatment systems, it was performed by means of daily analyses, every 2 hours of turbidity, apparent color and pH, in the period between July/2020 and December/2021, and thus, to evaluate the adequacy of the systems in relation to the quality of the raw water.

To allow the evaluation of the continuous degradation of the quality of the filtered water, in order to establish connection with the closure of the Filter run, water samples were collected in the filter units every 2 hours. The backwashing times of both treatment systems were also recorded, to allow the quantification of the length of the filter run of the units and to relate the turbidity of the water with the moments of startup of the backwash operation, seeking to identify the need for optimization of processes and ensure greater water production, without interfering in meeting the requirements of Brazilian legislation (Ordinance GM/MS No. 888/2021), where the turbidity of filtered water should be ≤ 0.5 NTU.

2.2 Determination of net water production

To evaluate the performance of potabilization technologies, the net water production(NP) of both systems was calculated by means of the adapted equation of, with data of water volume produced in the Filter run (UFRV), volume of water discarded in the backwashing of filters (UBWV), the bottom disposal volume of the flocculators and sedimentations tank (UFLV and UDCV) and the volume of water spent to empty the filters before the initial backwash (UFV), presented in equations 1, 2 and 3. Crittenden et al. (2012) None of the systems have sludge treatment, so there is no water recovery in disposals.

Equation 1: Determination of net water production in the water treatment system:

$$NP = [UFRV - (UBWV + UFLV + UDCV + UFV)]/ UFRV$$

Equation 2: Determination of the volume produced in the Filter run:

$$UFRV = Q_{WTP} * t_{OP}$$

Equation 3: Determination of the volume of water discarded in the backwash of the filters:

$$UBWV = Q_{bw} * t_{bw}$$

Q_{WTP} = Water treatment plant input flow (m³/h)
Q_{bw}= Backwash flow (m³/h)
T_{op} = Water treatment plant operating time (h)
t_{bw} = Total backwash time (h)

The UFLV and UDCV values were calculated by reducing the water level in the units during disposal. As in the upflow direct filtration system, the flocculation and sedimentation steps do not exist, the UFLV and UDCV parameters were nullified from equation 1 in the calculation of net water production of this system.

III. RESULT AND DISCUSSION

After the collection of water quality data and backwashing data during the period from July 2020 to December 2021, the following results were obtained.

3.1 Upflow Direct Filtration

This system consists of 6 fast filters, with a flow rate of 390 m³/h (108 L/s) and a mean filtration rate of 150 m³/m³.day (6.25 m/h). The filter bed consists of 5 sub-layers of sand of different particle sizes, with a total depth of 2 m, and 55 cm of support gravel.

The backwash operation is performed manually, with raw water and centrifugal pump use, at a flow rate of 561.60 m³/h, speed of 0.90 m/min. According to the operating manual of this treatment plant, the backwash process is carried out considering the following criteria:

i. Quality degradation - turbidity of filtered water close to 0.5 NTU or occurrence of solids breakthrough by medium filter;

ii. Increased head loss in filter units - visual evaluation only (increase in the water level of the filter load chamber);

iii. Level of drinking water reservoir - backwash started when the reservoir for water distribution is full.

The backwash procedure is, on average, 20 minutes per filter. After this period, the filter goes into production again, freeing up the ripening time (or recovery time).

3.1.1 Raw water quality of the Upflow direct filtration system

The raw water of the upflow direct filtration system presented relatively low physical-chemical parameters, due to the capture water coming from a well-protected slope spring (waterfall), which justifies the use of ascending upflow direct filtration technology. The parameters of turbidity, color and pH of the monitoring are the main parameters related to upflow direct filtration, although others are important as well (such as manganese iron, coliforms and algae), but are usually of low values in this spring. Thus, Table 1 shows the average results of turbidity, apparent color, and pH of the raw water of the upflow direct filtration system.

Table 1: Monthly average of physical-chemical parameters of the water of the Itinga River.

Collection month	Turbidity (NTU)	Apparent Color (uH)	ph
Jul/20	1,54	12,12	7,05
Aug/20	1,82	11,37	7,19
Sep/20	1,64	13,60	7,32
Oct/20	1,50	15,58	7,16
Nov/20	2,39	16,81	6,88
Dec/20	5,58	19,76	6,78
Jan/21	5,26	18,38	7,07
Feb/21	4,09	13,71	7,19
Mar/21	3,02	11,75	6,90
Apr/21	2,69	10,53	6,96
May 21	2,21	7,88	7,31
Jun/21	2,70	9,94	7,22
Jul/21	0,76	5,14	7,37
Aug/21	0,79	5,76	7,45
Sep/21	1,88	10,36	7,41
Oct/21	2,61	12,27	7,47
Nov/21	1,79	8,11	7,25
Dec/21	1,36	4,95	7,21
Total Average*	2,44	11,51	7,18
Total Standard Deviation*	7,75	11,27	0,32

*Values for daily samplings analyzed between July/2020 and December/2021.

The results of the spring analysis of the upflow direct filtration system indicate that sample values are well distributed around the mean, demonstrating a low homogeneity in the data during the evaluation period, possibly due to the climatic influence on water quality.

This fact is better perceived by the results obtained in the summer season (December to March), which reach higher averages of turbidity and apparent color compared to the other months. This season is known for torrential rains, which directly influence the values of suspended material onthe surface waters, due to the intake of particulate matter by surface runoff[7].

The results sampled for turbidity show a higher concentration of data below 10 NTU, and less than 5% of the data are above this value, which confirms the continuity of treatment by upflow direct filtration[8,9].

Regarding the apparent color parameter of raw water, although the monthly averages presented values below the tolerance limit determined in the literature to ensure the efficiency of treatment, when the frequency of the data was evaluated, we observed that approximately 15% of the values exceed the reference value of 20 uH[9] in 2020, and just over 5% in 2021.

The pH of the water of this spring remained stable, within the limits determined by Brazilian federal legislation (between 6.0 and 9.0)[10] in most samples in 2020 and in their entirety in 2021.

3.1.2 Quality of filtered water from upflow direct filtration system

The turbidity levels of filtered water over the research period resulted in 10% of the data sampled above the tolerance limit determined by Brazilian legislation (Figure 1), which infers in an irregularity, considering the requirement that at least 95% of the samples must have turbidity lower than 0.5 NTU.

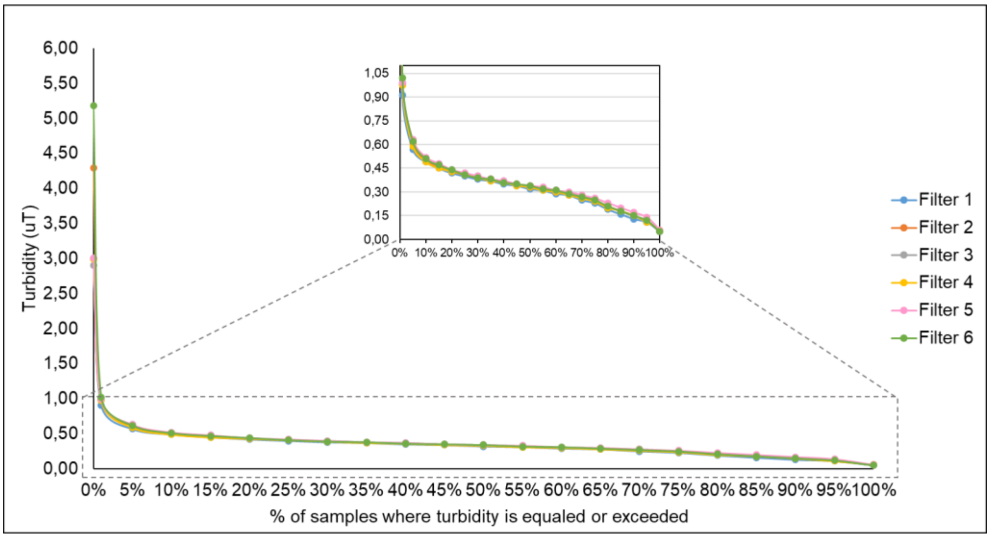

Figure 1: Exception permanence curve for turbidity analyses of filtered water in the 6 filters of the upflow direct filtration system.

This occurrence may be justified for three reasons:the first by preferential paths due to inadequate washing (low washing speed) of the filters, suffering greater influence with the increase in turbidity and color of raw water. The second by incorrect coagulant dosages in the various changes in raw water quality. Finally, by the way of operation, by the long wait to start the washing of the filters, because the washes are carried out only when the level of the reservoir is satisfactory. This last reason for the closure of the filter run, is justified by operators as a prevention of risk of dissupply of the city due to lack of pressure on the distribution network.

These operating conditions can reduce the efficiency of the chlorine disinfection step, especially in relation to protozoa. In addition, the presence of turbidity and color can confer flavor, odor and increase in THM index to water.

The upflow direct filtration treatment system was built 23 years ago, and the particle size characteristics and thickness of the existing filter material were not verified.

3.1.3 Evaluation of the backwash of theupflow direct filtration system

A study of 1471 backwashes were carried out to identify the relationship between the degradation of water quality throughout the filter run and its closure. The upflow direct filtration system, despite allowing greater control over the operation of the filters, and consequently, over the backwashing processes, because it consists of a manual process, it is still notorious the occurrence of breakthrough in the filter units, which is closely related to the increase of head loss in the filters, which here in the upflow direct filtration system is performed only visually. Due to the existence of this fragility in identifying the increase in head loss, the system had 20 breakthroughs, only in 2021.

What generate the alert in this system, is related to the occurrence of samples with high levels of turbidity without starting backwashing, because it considers as a criterion to end the filter run the water level of the reservoir. If it is not satisfactory for water distribution, the backwash is delayed until the reservoir reaches the desired level. This procedure may increase the risk of contamination with the increased likelihood of proliferation of microorganisms within the distribution network.

However, the highest concentration of turbidity data of filtered water before starting backwashing is below the tolerance limit (0.5 NTU), only 14-25% of the samples presented turbidity of filtered water ≥ 0.5 NTUbefore starting backwashing (figure 2), which would increase the filtration rate of the units and, consequently, increase water production in this system. These values also occur due to the level of the distribution reservoir, because the operators consider it appropriate to wash the filters, even with low water turbidity, to take advantage of the times of lower water consumption, and during the backwash, the flow of water sent to the reservoir is reduced.

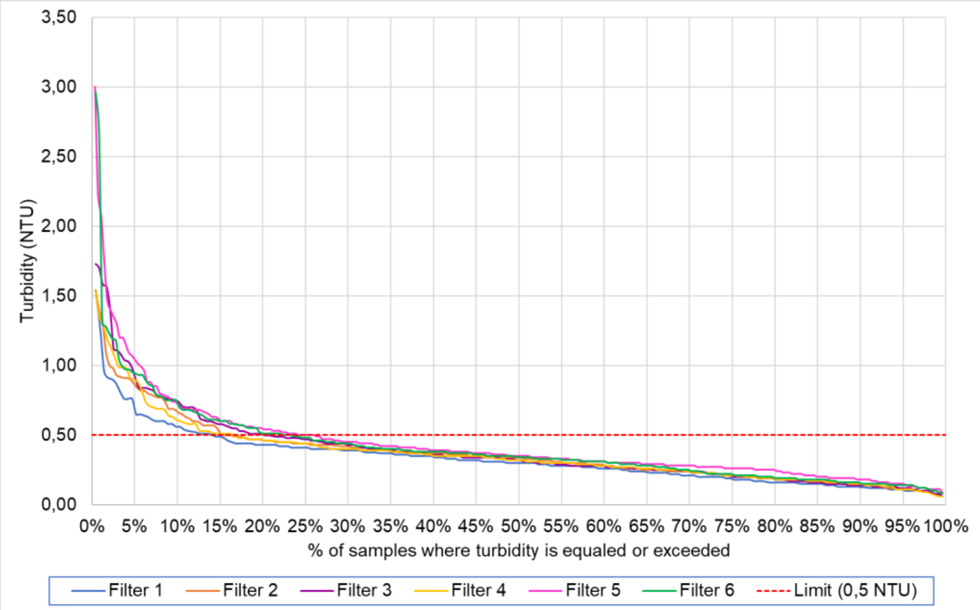

Figure 2: Turbidity of filtered water before starting backwashing in the upflow direct filtration system.

When the reservoir level is considered a criterion for the closure of the filter run, the backwashing process becomes disconnectioned in relation to the quality of the water destined for consumption, making the variation of turbidity irrelevant in determining the duration of the filter run.

3.1.4 Evaluation of the filter run of the upflow direct filtration system

A fragility was identified in the robustness of this system, in view of its inability to maintain water production in desirable quality conditions in situations of variations in the characteristics of raw water. Under adverse weather conditions, the water quality of the spring is changed and the length of the filter runs is strongly influenced. This is because on these occasions, higher coagulant dosages are applied to water, which causes faster clogging of filter units, since the upflow direct filtration system has limitations due to the lack of sedimentations tank[9].

Thus, in cases of waters with continuously high color and turbidity, the potabilization of water becomes unsatisfactory, besides causing the reduction of Filter run, as observed in this research (figure 3), where Filter run with less than 24 hours of duration occurred at some times (between 15 and 40% of the Filter run), interfering with the performance of the treatment plant. On the other hand, 31 to 45% of the Filter run had a very prolonged duration, above the limits recommended by the literature (maximum duration of 48 hours[11]).

These extremes allow us to affirm that the production of water in the upflow direct filtration system is strongly influenced by operational factors, requiring standardization of activities, so that the filter runs remain lasting between 24 and 48 hours. On the one hand, the possibility of prolonging Filter run is recognized, considering the quality of filtered water. However, care should be given to very long prolongation periods, which put at risk the effectiveness of the filtration process.

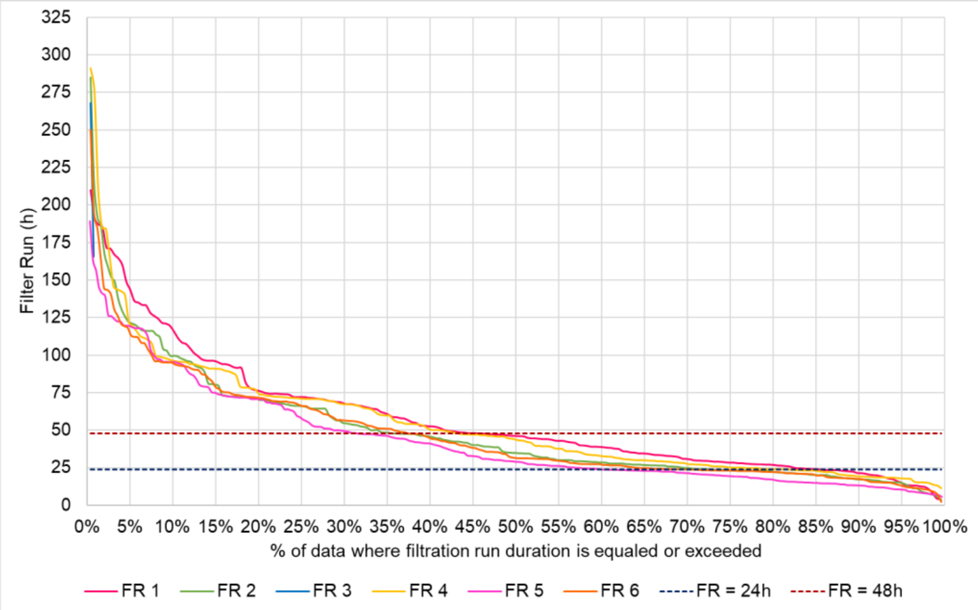

Figure 3: Expending permanence curve of the filter runs of the upflow direct filtration system.

3.1.5 Evaluation of the net water production of the upflow direct filtration system

The net water production of the upflow direct filtration system was performed month by month, in view of the perceived seasonal variations on water quality analyses, obtaining the following results:

Table 2: Spent volumes and monthly net water production of the upflow direct filtration system.

		Volumes Spent (m^3)		Net Water Production	
Month	**Total Monthly Production (m^3)**	**Backwashes (m^3)**	**Water within the filter Disposals (m^3)**	**Net water production (m^3)**	**Net water production (%)**
Jul/20	131.040,00	5.930,50	1.181,44	123.928,06	94,57%
Aug/20	290.160,00	7.783,78	1.550,64	280.825,58	96,78%
Sep/20	279.240,00	10.563,70	2.104,44	266.571,86	95,46%
Oct/20	290.160,00	13.528,94	2.695,16	273.935,90	94,41%
Nov/20	280.410,00	10.563,70	2.967,96	266.878,35	95,17%
Dec/20	278.460,00	20.015,42	3.987,36	254.457,22	91,38%
Jan/21	284.700,00	21.868,70	4.356,56	258.474,74	90,79%
Feb/21	262.080,00	19.830,10	3.950,44	238.299,46	90,93%
Mar/21	287.040,00	22.795,34	4.541,16	259.703,50	90,48%
Apr/21	279.630,00	13.343,62	2.658,24	263.628,14	94,28%
May 21	289.380,00	12.972,96	2.584,40	273.822,64	94,62%
Jun/21	276.120,00	15.567,55	3.101,28	257.451,17	93,24%
Jul/21	290.160,00	4.818,53	959,92	284.381,55	98,01%
Aug/21	290.160,00	8.339,76	1.661,40	280.158,84	96,55%
Sep/21	280.800,00	20.015,42	3.987,36	256.797,22	91,45%
Oct/21	285.480,00	27.984,53	5.574,92	251.920,55	88,24%
Nov/21	279.240,00	17.606,16	3.507,40	258.126,44	92,44%
Dec/21	290.160,00	19.088,78	3.802,76	267.268,46	92,11%
Average	**274.690,00**	**15.145,42**	**3.065,16**	**256.479,43**	**93,38%**

Therefore, the net water production in the upflow direct filtration system varies between 88.24% and 98.01%. It is notorious that the highest values of effective production correspond to the winter months. The average showed a value of 93.38%, which, although it seems a good performance, is below what the literature indicates, whose net water production should have a minimum value of 95%[12].

As this system does not have flocculation and sedimentation units, all discards are departing from the filtration processes, that is, the net water production in the upflow direct filtration system is significantly influenced by the amount of backwashing performed and all the disposal in occasions of solids breakthrough, as evidenced in October/2021, whose net water production presented the lowest value within the analysis period, when the volumes of backwashing and disposal of the water of the filters were precisely the highest. This again focuses on the need for adjustments in the backwash processes in order to reduce the volume of water disposal.

Another interfering factor refers to paralizations in the system, either for maintenance or for disruptions in the raw water pipeline, considering that these cause a reduction in water production and, consequently, lower net water production. Thus, indirectly, net water production is also linked to physical losses in adduction systems.

3.2 Conventional Water Treatment

This treatment system consists of 2 flocculators of 3 stirring chambers in series, 2 high rate sedimentations tank, 4 rapid filters of descending flow, followed by disinfection and fluoridation. It has an inlet flow rate of 108 m³/h and filtration rate of 200 m³/m².day. The filter bed consists of sand and anthracite coal, and the supports rolled pebbles.

The backwashing of the filters is automated, with a backwash ascensionspeed of 90 cm/min. The entire washing procedure takes place in a period of 7 minutes per filter. Bottom sludge disposals in sedimentations tank are carried out every 2 hours, lasting 20s. Weekly, in flocculators, sludge disposal also occurs for a time of 20s.

The filter run is closed only according to the criterion of increased head loss of the filters (measured by piezometers). The next filter run starts by freeing up the ripening time (or recovery time).

3.2.1 Quality of raw water of conventional system

The influence of seasonality on the quality of the raw water of the conventional system is remarkable. The period from December to March (summer season), characterized by the occurrence of convective rains, presents a significant increase in the indicator parameters of suspended and dissolved solids (table 3).

Table 2: Monthly average of physical-chemical parameters of the water of the Tijucas River.

Collection month	Turbidity (NTU)	Apparent color (uH)	ph
Jul/20	33,22	71,04	6,82
Aug/20	78,53	102,77	6,96
Sep/20	35,70	75,11	7,18
Oct/20	32,97	74,34	7,06
Nov/20	46,61	101,80	6,74
Dec/20	187,61	169,73	6,66
Jan/21	212,48	208,47	6,97
Feb/21	99,16	124,04	6,95
Mar/21	117,29	139,26	6,71
Apr/21	38,64	69,89	6,70
May 21	45,85	75,42	7,09
Jun/21	140,16	133,26	6,97
Jul/21	27,33	47,31	7,06
Aug/21	21,12	39,10	7,12
Sep/21	69,26	95,55	7,08
Oct/21	104,59	123,60	7,17
Nov/21	58,81	81,72	6,82
Dec/21	22,04	39,22	6,77
Total Average*	75,91	98,34	6,94
Total Standard Deviation*	116,82	72,79	0,24

*Values for daily samplings analyzed between July/2020 and December/2021.

The results sampled for turbidity showed great variability, however, just over 5% of the dataexceeded the value of 250 NTU, which assumes that this water could be treated by a conventional system without the need for complementary treatment units[14].

Theresults related to the apparent color also showed that the water of this spring is subject to treatment by the conventionalmodality[9], considering that less than 4% of the samples of the year 2020 presented values equal to or greater than 1000 uH and less than 2% in 2021. However, sporadically, due to heavy rains, treatment can be compromised, when the tendency is to increase the concentration of apparent color. The pH remainsbetween 6.0 and 9.0 in most samples.

3.2.2 Quality of filtered water from conventional system

Despite the water quality of the spring, which has a great oscillation in its parameters, when the results of filtered water are observed, this technology seems to efficiently remove the high levels of turbidity of the water of the Tijucas River, considering that the tolerance limit attributed by Brazilian legislation (0.5 NTU) is exceeded in only 1% of the sampled data (Figure 4). It is important to highlight that filter 4 remained inoperative from 10/01/2020 to 12/23/2020, which may have interfered with data observation in rainy .

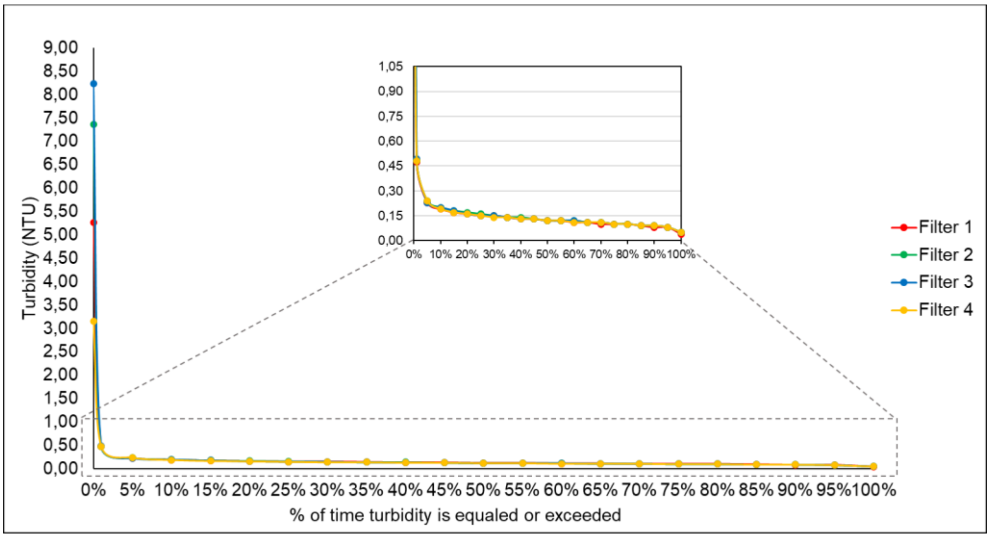

Figure 4: Exception permanence curve for turbidity analyses of filtered water of the conventional system.

With sudden changes in raw water quality, coagulant dosages need to be monitored and adjusted more frequently. Therefore, it is noticeable that the vulnerability of the conventional system is focused on the operation of the coagulation phase, considering that, despite the presence of flocculation and sedimentation units, turbidity peaks are still evidenced in filtered water that do not comply with the legislation. That is, the adjustment of coagulant in extreme episodes does not always occur in a timely manner to allow the period of contact and agitation necessary for the effective formation of flakes, causing part of the solids not to be removed before the filtration.

3.2.3 Evaluation of the backwashing of the conventional system

In the samples performed, it was noticed the existence of a gap in the data between the period of October and December, due to lack of records by the sanitation company. The data will be rescheduled from January 2021. Another interfering factor in the representativeness of the results is the paralyzing of Filter 4 for almost 3 months.

It is remarkable that in all filter units the backwashing process is not programmed according to the variation of the turbidity levels of filtered water, an operation also observed by other researchers in the water treatment units[15]. The backwash process is performed, mostly, when the turbidity is at levels below the required tolerance limit.

Because the only criterion for triggering theend of the filter run in this system is the increase ofthehead loss in the medium filter, the variability of the turbidity of the filtered water becomes indifferent. A small fraction of turbidity analyses performed before starting the backages (4 to 7%) presented results above the limit imposed by Brazilian legislation (≤ 0.5 NTU),according to figure 5.

It is possible to admit that the filter runs could be prolonged, in order to increase the net water production, considering that the quality of the water demonstrates stability, with values within the recommended most of the time.

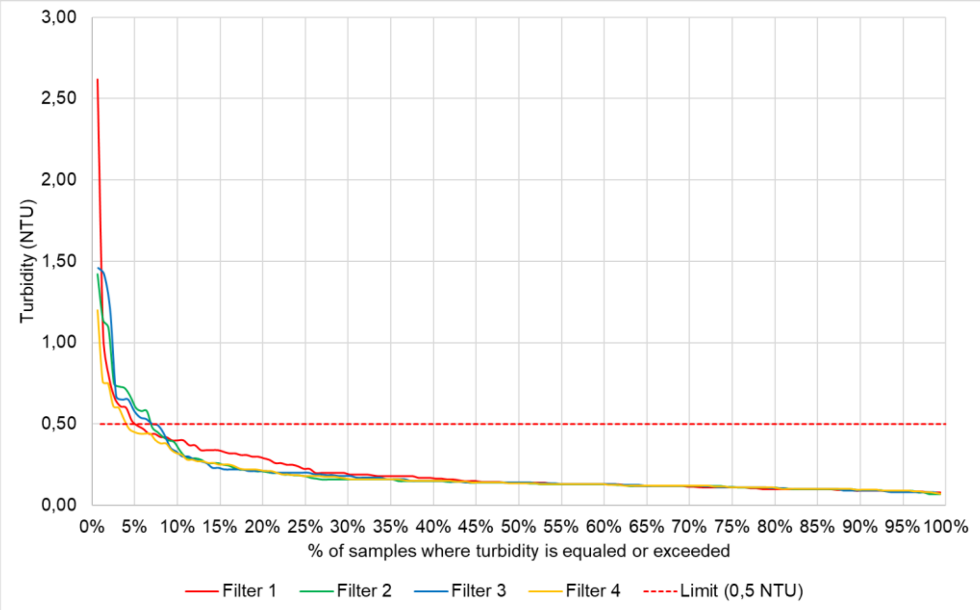

Figure 5: Turbidity of the filtered water before starting the backwashing in the conventional system.

Afterthe backwash, the production of water is affected, considering that the filter unit that receives the washing remains unproductive during this period. In addition, in this system, part of the water already produced is used in the backwash process. For municipalities that suffer from water distribution, as is the case of the study area, backwashing becomes the target of production losses.

Therefore, it is notorious that, although the conventional system assumes a greater rigor in the operation due to its automation and induces the projection of more efficient results, it ends up signaling the need to optimize the backwashing process when we start to consider the item of net water production in the performance of the units.

3.2.4 Evaluation of the filter run of the conventional system

The conventional system, due to its greater robustness and automation, brings the idea that its results present greater stability and allow greater reduction in the loss index through the increase of efficiency and reliability of thetechnology through its automation[9], which also allows a greater control of dosage of chemicals and, therefore, the increase in the length of the filter run. However, when evaluating the results obtained for the duration of the filter run of the conventional system, we identified both the occurrence of filter runsfar below the recommended value, as well as very extensive operations.

Although the conventional system is equipped with pretreatment, which should reduce the demand on the filter units and increase the filtration time, between 7 and 12% of the filter runs (figure 5) lasted below 10 h (between 3.88 and 9.88 h), which brings consequences under net water production, and very short filter runs can make the system uneconomical.

In the opposite situation, 48 to 65% of the Filter run were closed with more than 48 hours, filter 3 operated at a given time for more than 310 consecutive hours, which puts at risk the integrity of the filter bed, considering that prolonged periods of filtration can cause permanent clogging of the media grains[11].It is understood that the objective of a treatment plant is the production of water, however, it must be interconnected with the quality of the water produced and the guarantee of the operation of water treatment plant.

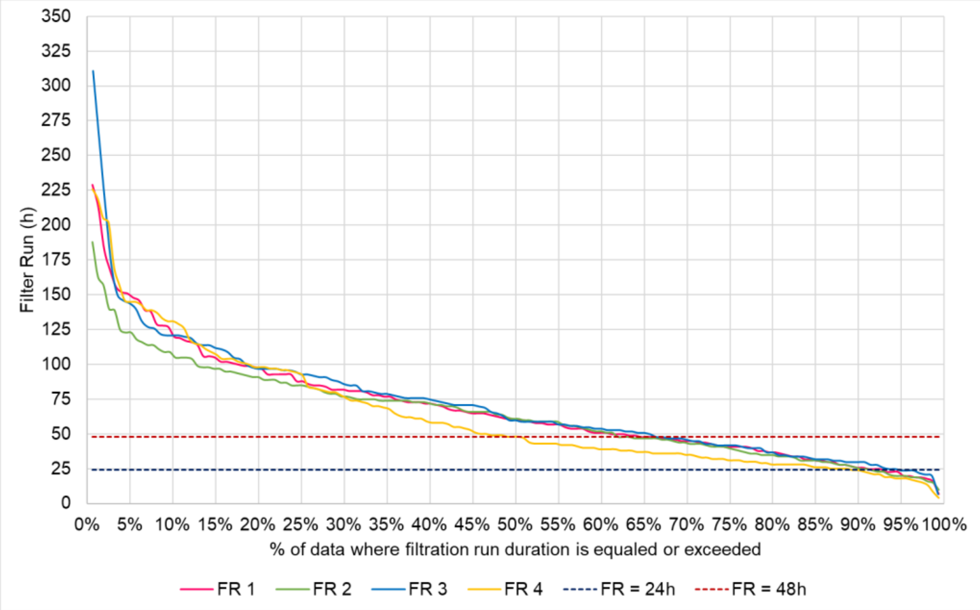

Figure 6: Permanence curve of the filter runs of the conventional system.

3.2.5 Evaluation of the net water production of the conventional system

The net water production was quantified considering the discards of the flocculatorsand sedimentations tank, in addition to the backwashing of the filters.Assludge disposals in sedimentations tank occur daily, every 2 hours, lost volumes end up presenting high monthly values (Table 3).

Table 3: Volumes spent and monthly net water production of the conventional system.

		Volumes Spent (m³)				Net Water Production	
Month	**Total Monthly Production (m³)**	**backwash (m³)**	**Flocculators Fund Disposal (m³)**	**Sedimentation tank Discards (m³)**	**Water within the filter Disposal (m³)**	**Net water production (m³)**	**Net water production (%)**
Jul/20	36.180,00	179,15	1,80	1.088,64	374,15	34.536,26	95,46%
Aug/20	79.056,00	481,85	4,50	2.410,56	1.006,33	75.152,76	95,06%
Sep/20	76.896,00	240,93	3,60	2.332,80	503,17	73.815,51	95,99%
Oct/20	-	-	-	-		-	-
Nov/20	-	-	-	-		-	-
Dec/20	-	-	-	-		-	-
Jan/21	79.056,00	166,80	3,60	2.410,56	348,35	76.126,70	96,29%
Feb/21	71.604,00	179,15	3,60	2.177,28	374,15	68.869,82	96,18%
Mar/21	78.408,00	185,33	4,50	2.410,56	387,05	75.420,56	96,19%
Apr/21	76.896,00	395,37	3,60	2.332,80	825,71	73.338,53	95,37%
May 21	80.352,00	438,61	4,50	2.410,56	916,02	76.582,31	95,31%
Jun/21	77.328,00	277,99	3,60	2.332,80	580,58	74.133,03	95,87%
Jul/21	79.812,00	277,99	3,60	2.410,56	580,58	76.539,27	95,90%
Aug/21	80.352,00	172,97	4,50	2.410,56	361,25	77.402,72	96,33%
Sep/21	77.112,00	191,51	3,60	2.332,80	399,95	74.184,14	96,20%
Oct/21	80.352,00	191,51	3,60	2.410,56	399,95	77.346,38	96,26%
Nov/21	77.328,00	179,15	4,50	2.332,80	374,15	74.437,40	96,26%
Dec/21	79.812,00	179,15	3,60	2.410,56	374,15	76.844,54	96,28%
Average	**75.369,60**	**249,16**	**3,78**	**2.280,96**	**520,37**	**72.315,33**	**95,93%**

It is noticeable that, even with the large discards, especially those related to sedimentations tank, the values of net water production in this system presented good results during the yearsstudied, with an average of approximately 96%, indicating an agreement with the minimum limit established in the literature of 95% effectiveness in water production net[12].

It is important to highlight the lack of records during the period from October to December 2020, these being the months of occurrence of greater fluctuations in water quality, which could cause greater need for backwashing of the filter units. This period still coincides with the time of higher water demand, requiring higher production. However, the stability of the net water production of treated water in the conventional system is seen, a fact that occurs due to the bottom disposal procedure of the flocculators and sedimentations tank occurring in a programmed and constant time (20s), which makes the volume lost in these procedures repetitive.

It would be of great importance to adjust the bottom sludge disposal range of the units, especially the sedimentations tank, to reduce the volume of water loss in these operations, which may be activated automatically, but without need.

IV. CONCLUSION

The water quality of the springs used in both treatment systems is strongly influenced by the climate. However, the water quality of the spring used in the filter run system (Itinga River) demonstrated favorable results for the application of this treatment technology, considering the turbidity of the water. For the apparent color, the system may present some fragility in the removal of this parameter in situations of more extreme climatic events. When evaluating the results of the turbidity analyses of the filtered water in this technology, water production net was verified for long periods with values above that indicated for post-filtration and pre-disinfection, mainly caused by the operating methodology.

The spring used in the conventional system (Tijucas River), on the other hand, presented low frequency of samples outside the standards, which indicates the continuity of water treatment by this technology. The quality of the filtered water showed satisfactory results. A lack of standardization was identified in both treatment plant, although conventional system has partial automation.

Water treatment plant by the upflow Direct filtration: The criterion adopted for the ending of the filter runs by the water level in the distribution reservoir makes it difficult to obtain filtered water with satisfactory quality. This same criterion caused the occurrence of filterruns with very short times, as well as filter runs with extremely long durations.

The netwater production was below the recommended (around 93.4 %), due to the high amount of backwashing and disposal in times of breakthrough of the solids, which may indicate the probable existence of preferential paths in the filter material. It was expected that the upflow Direct Filtration had higher net water production than conventional water treatment plant, but it was the other way around.

Nevertheless, it is interesting to continue the direct filtration system ascending by the low consumption of chemicals, however, changes in the way of operating are suggested: intermediate disposal to reduce the volume of water in the backwash; replace the filter material; and automate background disposals with backwash.

Conventional Water treatment plant: Operational failures were also evidenced in the conventional system, with the observation of both extensive and small filter runs, because the only criterion used to initiate the backwashing of filters is the head loss. That is, this treatment plantdisregards the degradation of water quality, and the duration of the filterruns. This demonstrates the need for adjustments of the filter run-ending criteria.

The net water production was higher than the previous system, around 96%, within the standard of the literature. However, it is recommended to conduct a study to decrease the frequency of sludge disposals from flocculators and sedimentations tank. All operational procedures directly influence the results of net water production and quality of the water produced and should be improved for better results in treatment plants.

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