D9 - Field evaluation of water consumption and drainage system performance when 6.8Lpf toilets were replaced by 4.8Lpf toilets

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Abstract

This paper aims to present the current results of the field phase of a Brazilian study of the performance evaluation of building water and drainage systems with 4.8Lpf toilets. The first results were presented at the CIBW062 Symposium 2016. The complete research aims to evaluate the performance of 4.8Lpf toilets and the performance of drainage systems when these toilets were installed. In this study, 2 phases were performed: a laboratory phase and a field phase. In the laboratory phase, 20 toilets were tested, and it was possible to verify that the reduction of flush volume could be a viable solution to reduce the consumption of potable water of the houses. In the field phase, the monitoring of the water consumption of the 10 houses and filming of the drainage system were conducted during 8 months, after 6.8Lpf toilets were replaced by 4.8Lpf toilets. Although problems were not reported in the performance of the toilets by the users, data monitoring revealed successive flushes in some houses, specifically in those in which there was not a reduction in water consumption. The results showed that not all models of toilets monitored have resulted in a reduction in water consumption. The average water consumption of all houses monitored remained constant after the replacement of the toilets. The reduction of the flush volume may have caused negative effects in the performance of the building drainage system, checked through 5 real-time videos, performed between August/2015 and April/2016. The real-time videos showed blockages in the horizontal pipes of the public sewage system. The deposit of solids may have occurred due to the reduction of the water consumption. Thus, it is not possible to conclude that the replacement of 6.8Lpf toilets by 4.8Lpf toilets has a major impact on water consumption nor positive effects on the performance of drainage systems in Brazil.

Keywords

Low flush toilet (4,8Lpf); water consumption; drainage system performance.

1 Introduction

The growing scarcity of natural resources required by the population, among them water, has reflected in an environmental crisis and encouraged the world population to reduce water consumption in buildings. Among the actions that can be taken to reduce water consumption in buildings, there are those that depend solely on the change of the habits of users and those that do not.

Actions to reduce water consumption that do not depend on the behavior or habits of users, but, rather, on the characteristics of the water supply system and that depend directly on the decisions that are taken by the professionals involved in the process of production of buildings, such as technological actions, are more effective in reducing water consumption in building. It is in the stages of design and execution of buildings that technology-based actions can be established that will determine the possibility of an efficient use of water throughout their lifespan (CBIC, 2016).

Using water efficiently means using only the amount of water required and sufficient for the expected performance of a given activity or equipment, without waste, without compromising the quality of the activity, and ensuring the health of users. At its limit, all the water supplied (measure) is used, in the smallest amount possible, to perform the aimed-at activities (CBIC, 2016).

The study introduced in this paper, which complements the paper presented at the CIBW062 Symposium 2016 (VALENCIO, I. P, GONÇALVES, O. M., 2016), was carried out to experimentally evaluate if the reduction of toilet water consumption (from 6.8 Lpf to 4.8 Lpf) will result in an effective reduction of water consumption for the users, without causing blockages and deposits of solids in the building drainage and sewage systems.

2 Reduction of toilet discharge water consumption

Even with the evolution of toilets, they are still accountable for most of the water consumption in residential buildings. However, the reduction of toilet water consumption requires an understanding of the characteristics of the discharge, to verify the effect on the performance of the building drainage system. Most countries such as Brazil use 6 Lpf toilets, but the discharge volume has followed a downward trend to 4.8 Lpf.

According Akiyama, Otsuka and Shigefuji (2013), several countries have regulations that limit the volume used in discharge. Some states in North America have introduced standards that limit the discharge volume to 4.8 Lpf, and the concept of this new limit has become a

worldwide trend. Toilets in Japan use a discharge volume of 4.8Lpf and 6.0Lpf, and 4 Lpf toilets have been used since 2011 (KOBAYASHI, N. and OTSUKA, M., 2012).

3 The drainline transport of solid waste in building

It is essential to avoid deposit of solids in the building drainage system, to prevent a reduction of the useful section over time, or so that larger solids are not agglomerated, causing abrasion on the inner walls of the pipes, thus damaging the flow and the pipes themselves. Since the flow varies over time, the analysis of the deposit of solids in building drainage systems is complex. Since the drainage flow is variable over time, water depth and speed also vary. At low contribution times, if the speed is low, the solid materials may deposit on the pipeline. Thus, the pipeline must be designed so that this does not occur, with sufficient flow speed to ensure a self-cleaning action. These conditions are usually critical at the beginning of the system, when the contribution flows are smaller.

Over the years, the volume of water used by sanitary appliances has reduced significantly. This caused projects of the drainage system to be analyzed differently, aiming to adapt the size of pipes to the new values of flow and volume of water (OLIVEIRA Jr., 2002). The reduction of sanitary appliance water consumption directly interferes in the performance of the drainage system, mainly in the capacity of transporting solids along the pipe.

The evaluation of the transport of solids in the building drainage systems depends on the interaction of water and solid factors (CHENG, C.L. et al., 2011). The adequate performance of the building drainage systems is essential in projects and, with a greater use of water saving equipment, the volume of water has been reduced to its limit, affecting the transport of solids and causing pipe blockages.

Motivated by these issues, the Plumbing Efficiency Research Coalition (PERC) created a research network on the reduction of water consumption in sanitary appliances and its implications on the performance of drainage systems.

In 2012, PERC published the first phase of the study “The Drainline Transport of Solid Waste in Buildings” (PERC, 2012). In this study, PERC verified the effects of the adoption of different variables, among them, a 1% and 2% slope angle of the piping system and discharge volumes of 3 Lpf, 4.8 Lpf and 6 Lpf. Problems of blockage with 3 Lpf discharges were reported, and it was verified that the performance of the 6 Lpf toilets may be better than those of 4.8 Lpf for the total cleaning of the drainage system.

This same study, also showed that a 3 Lpf toilet requires at least four times more discharges than a 6 Lpf toilet, to remove all the media from the building drainage system (simulated in a laboratory with a 41-meter pipe). This indicates that a new toilet with reduced volume may not be economical, since it needs more discharges to have the same performance of the current one.

Phase 2 of this study (PERC, 2015) analyzes the effects of two variables: 3.8 Lpf discharges and cross sections of the pipeline with a diameter of 75 mm. The results showed that the reduction of the discharge volume from 4.8 Lpf to 3.8 Lpf makes the system performance decrease considerably for the 1 % slope angle of the pipe. Regarding the cross section of the pipe, a decrease in diameter from 100 mm to 75 mm did not indicate improvement in system performance.

As a reduction of the total water consumption is only obtained when the operation of the toilet meets minimum performance requirements, established by the knowledge of the actual needs and local operating conditions, if reduced volume toilets cause obstruction, users will have to flush twice or more times and a reduction of water consumption will not take place.
To verify the impact that a reduction of the discharge volume causes in the performance of a toilet is also fundamental to verify the impact on the performance of the building system. It should be evaluated if this reduction can be sustained by the building drainage and sewage systems and if it will not provide blockages and obstructions, causing damages for the users.

4. Evaluation of the impact on the water supply and drainage systems due to the replacement of 6.8Lpf toilets for 4.8Lpf toilets

The replacement of a 6.8 Lpf toilet for a 4.8 Lpf toilet theoretically reduces water consumption by 2 L at each discharge. However, the reduction of the discharge volume should be associated to the performance of the toilet so that a reduction of the total water consumption may occur. If the toilet does not offer satisfactory performance for a user, he will flush once or twice - and the reduction will not occur.

The study introduced in this paper focused on the laboratory and field evaluation of the impact of replacement of 6.8 Lpf toilets for 4.8 Lpf toilets, in order to verify if an effective reduction of water consumption occurs for users, without causing blockage and deposits of solids in the pipeline of the building drainage and sewage systems.

4.1. Laboratory study

The laboratory study was divided into two phases called "Phase 1" and "Phase 2". The purpose of Phase 1 was to verify which toilets had potential conditions to offer adequate performance in the field, without causing inconvenience for the users. Phase 2 consisted in a prospective evaluation, which aimed to classify the toilets in relation to their capacity to transport solids along the pipeline of the building drainage system (Figure 1).

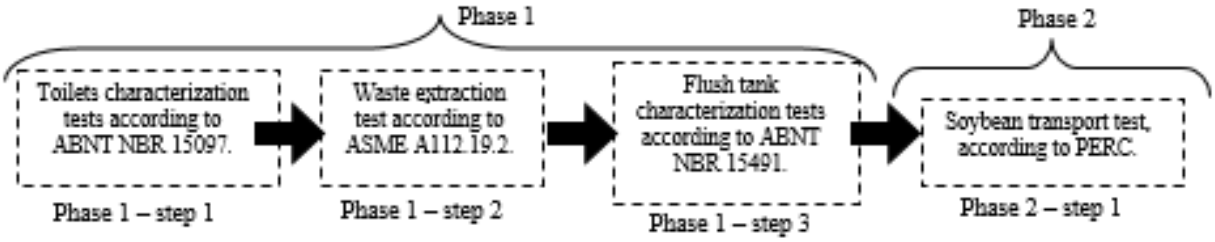

Figure 16 – Laboratory study – step by step

In all, twenty different models of 4.8 Lpf toilets were tested from different manufacturers. Among the toilets tested and currently sold in Brazilian market, some toilets were designed to operate with 4.8 Lpf and some were designed to operate with 6.8 Lpf but regulated to 4.8 Lpf. In the latter, a regulation of the flush tank was made so that it provided the volume of 4.8Lpf.

The results showed that most toilets are able to remove waste from the toilet itself, but they do not promote the cleaning of the building drainage system:

- With regard to the tests that verify the removal of the waste from the toilet itself (granule and ball test, mixed media test and spheres removal), nineteen toilets (95%) passed all the tests. Only one toilet failed in the mixed media removal test.
- One toilet (5%) did not restore the trap seal, and had a water trap seal height value after flushing up to 24% less than the minimum required to avoid the return of odors into the dwelling. Thus, it was deemed to have failed in the trap seal restoration test.
- One toilet (5%) did not affect proper cleaning of its interior and failed in the surface wash test.
- Four toilets (20%) failed in the solids transport test because they did not carry the polypropylene spheres along 10 meters of the pipeline, i.e., they did not provide sufficient discharge flow for the tested media to be transported along the pipe, which simulates the horizontal conductor, along the minimum distance of 10 meters. This indicates that a major problem found in reducing the discharge volume may be the removal of solids from the drainage system. The results of this requirement were up to 36% below the normative minimum limit.

Of the twenty toilets evaluated, thirteen (65%) passed all the requirements of NBR 15.097.

In the second step of Phase 1, the waste extraction test was performed to evaluate the removal of the media (seven specimens of soybean paste of 50g each and four balls of toilet paper, each ball consisting of six pieces of paper) from the toilet itself. Only five of the thirteen toilets (38%) evaluated passed in this requirement.

In the third step of Phase 1, the flush tank characterization tests were carried out in order to verify their performance. Only one (12.5%) failed due to leaking. Failure to comply with this requirement may result in users using unnecessary water. In these cases, the water from the flush tank may flow into the toilet, which is often imperceptible to users.

Non-compliance with the current Brazilian standard in 35% of the toilets evaluated reflects the need for product evolution. All toilets designed to operate with 6.8 Lpf, but regulated to 4.8 Lpf failed the laboratory tests. This proves that simply reducing the water level in the flush tank is not a viable solution to reduce toilet water consumption.

Thus, at the end of the Phase 1, five toilets were deemed to have passed in all tests of Brazilian standards ABNT NBR 15097 and ABNT NBR 15491 and in the waste extraction test, which represents 25% of the toilets evaluated. Note the difficulty of the products in meeting the current regulatory requirements.

After Phase 1, the soybean paste transport test was carried out to characterize the toilets and to find a relationship with their performance in the field.

In the soybean paste transport test, the amount of discharges required to remove all media from the 18-meter-long pipeline was measured. The toilets evaluated required two to six discharges to remove the soybean media along the 18-meter pipe.

4.2. Field study

The filed study was conducted to verify:

- How the toilets approved in the laboratory study behave in the field, that is, if they promote a reduction of water consumption, linked to the proper functioning of the product;
- The correlation of the results obtained in the field with the results of the laboratory tests;
- If there was an effective reduction of water consumption and, if this reduction implies impacts on public sewage and building drainage systems.

For such purposes, two steps were carried out: a monitoring of the toilet water consumption and real-time videos in the sewage system.

Firstly, the houses to be monitored were selected. The chosen houses consist of twelve houses (six houses on the ground floor and six on the first floor), according to Figure 17, with a frontal scheme of the units. Although the housing development has twelve houses, the residents of houses 9 and 23 did not allow monitoring. Therefore, the field study was conducted with ten houses.

The five toilets considered to have been approved in the laboratory study, were installed in the field. As the residents of ten houses accepted to participate in the study, each toilet was installed in two houses. As far as possible, the same model was installed on the floor unit and on the first floor, as shown in Figure 17.

Figure 17 – Scheme of the houses monitored

These houses were selected because of the critical characteristics that they have: beginning of sewage system and final low-slope pipe section, and without any extra contribution. These characteristics can be visualized in the scheme of Figure 18.

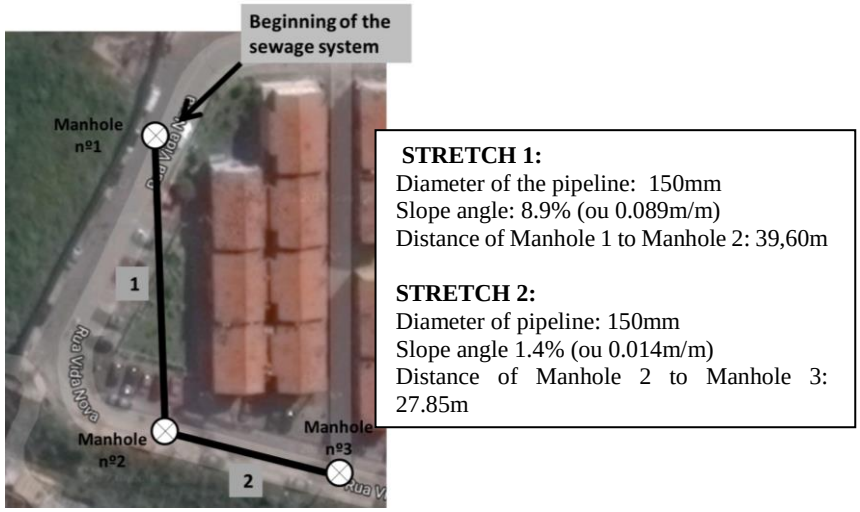

Figure 18 – Scheme of the sewage system monitored (top-view scheme)

A questionnaire was applied to characterize users and housing units. The questionnaire for user characterization has the function of identifying the number of inhabitants, age and habits. This questionnaire is important for future analysis of consumption data. The questionnaire characterizing the houses was carried out to assist in the planning of toilet replacement, in order to define the most appropriate model for each house.

The monitoring of 6.8 Lpf toilet water consumption was accomplished for a month. Then, the 6.8 Lpf toilet was replaced for a 4.8 Lpf toilet approved in the laboratory study. After the replacement, the monitoring of the toilet water consumption continued. During the monitoring, questionnaires to verify the satisfaction of the users with the product were applied, in order to

verify the need for a second discharge, the frequent occurrence of blockages or other usage problems.

The total water consumption was considered from the monthly water bills for each dwelling. Thus, it was possible to calculate the percentage of the consumption related to each toilet, and if the total water consumption in each house decreased with the change of the toilet.

4.2.1. Water consumption monitoring

With the monitoring equipment installed, on August 14, 2015, the monitoring of the initial water consumption with the toilets existing in the dwellings (all of them of 6.8 Lpf) began. This monitoring occurred for about 30 days. It was possible to observe that the total volume per discharge was close to 6.8L and no successive flushes were verified.

In this initial phase (before the replacement of toilets), with the number of inhabitants per dwelling obtained in the questionnaires and the daily toilet water consumption, it was shown that the general average toilet water consumption of all the monitored houses was 16.6 liters per inhabitant per day, as shown below.

Table 12 - Toilet water consumption per house, when the 6.8 Lpf toilets were considered

House	6,8Lpf toilet water consumption per day(L)	Total water consumption per house per day - last year's average (L)	Toilet water consumption/total water consumption	6,8Lpf toilet water consumption per day per inhabitant (L/person/day)	Number of inhabitants
3	35.0	92.3	37.90%	**17.5**	2
5	23.9	141.0	17.00%	**12.0**	2
7	37.9	220.5	17.20%	**126**	3
11	56.8	992.3 (*)	5.70%(*)	**15.2**	3.5
13	25.0	138.5	18.10%	**12.5**	2
15	103.9	430.8	24.10%	**20.8**	5
17	44.0	553.8	7.90%	**147**	3
19	45.9	441.0	10.40%	**115**	4
21	42.8	192.3	22.30%	**21.4**	2
25	81.1	425.6 (*)	19.10%(*)	**27.0**	3
Average	**49.5 L**	**276.3 L**	**19.4%**	**16.6**	-

(*) Leaking was verified in the hydraulic system (but not in the toilet). The leaking had not been completely solved by the end of the study. Thus, there values were not accounted for in the calculation of the average water consumption.

The replacement of the toilets for the 4.8 Lpf models occurred between days 15 and 17 of September of 2015.

The monitoring of the 4.8 Lpf toilets had two objectives: to evaluate the performance of the product - verified through questionnaires and the presence or absence of successive discharges - and to evaluate if a reduction in water consumption occurred.

Monitoring of the 4.8 Lpf toilet water consumption took place between September/15 and April/16. During the monitoring, it was verified that the total volume per discharge was close

to 4.8 L, indicating that no change was found, in the field, in the discharge volume obtained in the laboratory.

After the toilets were replaced, the general average of the toilet water consumption of all monitored houses was 17.6 liters per inhabitant per day, according to the table below.

Throughout the field study, questionnaires were carried out to verify users' satisfaction with the performance of the toilets. The users did not report problems related with the 4.8 Lpf toilets.

Considering all the houses monitored, it was verified that a reduction in the average toilet water consumption did not occur, which indicates that the users needed to give successive discharges when the 4.8 Lpf toilets were installed. There was a reduction in the toilet water consumption in only five of the ten houses monitored.
Although no problems were reported with the 4.8 Lpf toilets in the questionnaires carried out during the study, the analysis of the monitoring data indicates the presence of successive flushes in houses 11, 13, 15, 17, and 19.

Table 13 – Toilet water consumption per house, when the 4.8 Lpf toilets were installed

House	4,8Lpf toilet water consumption per day(L)	Total water consumption per house per day after the replacement (L)	Toilet water consumption/total water consumption	4,8Lpf toilet water consumption per day per inhabitant (L/person/day)	Number of inhabitants
3	22.7	60.0	37.8%	**11.4**	2
5	21.1	140.0	14.8%	**10.6**	2
7	25.4	263.3	9.6%	**8.5**	3
11	127.9	643.3(*)	19.9%(*)	**25.6**	5 (**)
13	36.9	130.0	28.4%	**18.5**	2
15	114.1	360.0	31.7%	**22.8**	5
17	58.5	596.7	9.8%	**19.5**	3
19	63.5	330.0	19.2%	**15.9**	4
21	33.2	130.0	25.5%	**16.6**	2 (***)
25	78.3	440.0(*)	17.8%(*)	**26.1**	3
Average	**58.2**	**251.6**	**22.1%**	**17.6**	**-**

(*) Leaking was verified in the hydraulic system (but not of the toilet). The leaking had not been not solved by the end of the study. Thus, these values were not considered in the calculation of the average water consumption. (**) an increase in the number of dwellers occurred during the monitoring. (***) This house often receives a visitor who remains there for long periods of time.

Fout! Verwijzingsbron niet gevonden. shows a comparison of the daily toilet water c onsumption per capita of each house. The positive values represent a reduction of water consumption and negative values, an increase in water consumption:

- Houses 3, 5, 7, and 21 showed a significant reduction in toilet water consumption.
- House 25 reduced 3% of consumption, which can be considered constant. However, in House 7, where the same 4.8 Lpf toilet model was installed, a 33% reduction in toilet water consumption was observed.
- Houses 11, 13, 15, 17, and 19 showed an increase in toilet water consumption.

- **Table 14 - Toilet water consumption per person**

Houses	toilet water consumption per day per inhabitant (L/person/day)		Difference in water consumption	
	6.8 Lpf toilets	4.8 Lpf toilets	(L/person/day)	(%)
House nº3 (toilet nº11)	17,5	11,4	**6,1**	**35%**
House nº5 (toilet nº11)	12,0	10,6	**1,4**	**12%**
House nº7 (toilet nº2)	12,6	8,5	**4,1**	**33%**
House nº11 (toilet nº13)	15,9	25,6	**-9,7**	**-61%**
House nº13 (toilet nº13)	12,5	18,5	**-6**	**-48%**
House nº15 (toilet nº15)	20,8	22,8	**-2**	**-10%**
House nº17 (toilet nº15)	14,7	19,5	**-4,8**	**-33%**
House nº19 (toilet nº20)	11,5	15,9	**-4,4**	**-38%**
House nº21 (toilet nº20)	21,4	16,6	**4,8**	**22%**
House nº25 (toilet nº2)	27,0	26,1	**0,9**	**3%**
Average	**16,6**	**17,6**	**-1,0**	**-8%**

Obs.: the house numbers have been paired according to the model of 4.8Lpf installed (see figure 2).

It is clear that in the houses where successive flushes were registered (Houses 11, 13, 15, 17, and 19), an increase in per capita of water consumption was observed in the toilets. This is because the reduction of water consumption is only obtained if users need a single flush; if the toilet has an obstruction or lack of adequate interior cleaning, users flush once or more times, and the water consumption will increase.

In the monitoring period, no direct relationship was found between the volume consumed by the toilet and the total water consumption of the dwelling. This fact can be explained by several leaks verified in the hydraulic system during the study. Although the average toilet water consumption was not reduced, the total average water consumption of the dwellings decreased by 24.7 liters per day.

4.2.2. Sewage system monitoring

During the field study, the sewage system was filmed in order to verify problems. The filming system was used to check for possible initial damage to the sewage system and to verify if any damage or clogging in the pipeline occurred after the installation of 4.8 Lpf toilets.

Five real-time videos of the sewage system were performed on 08/28/15, 11/19/15, 01/28/16, 03/03/16 and 04/11/16. Thus, the first real-time video was carried out before the replacement of the toilets and the following videos were carried out after the installation of the 4.8Lpf toilets.

On August 28, 2015, the pipeline was cleaned, avoiding that the dirt accumulated in the sewage system until that moment interfered in the results of the study.
The timeline of the real-time videos is detailed in Figure 19.

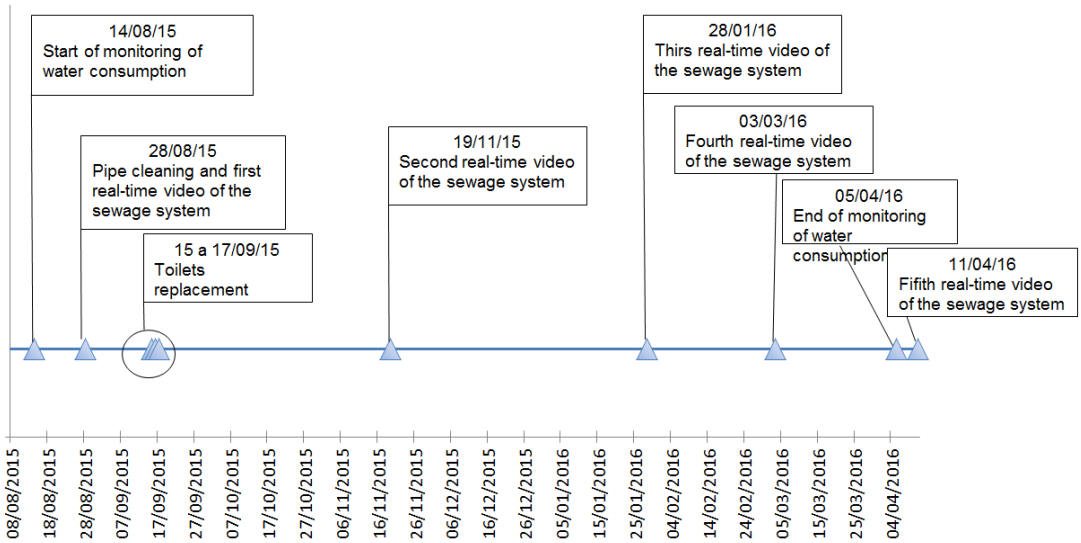

Figure 19 – Timeline of the real-time videos

During the eight months of field study, a progressive accumulation of solids in the pipeline of the sewage system was verified. Figure 20 summarizes the findings of these real-time videos.

Since the first filming after the installation of the 4.8 Lpf toilets (the 11/19/15 video), it has been possible to identify two points in the sewage system with obstructions. In the following videos, these points were kept with obstructions and new points with problems were observed as from March/16.

Another observation during the filming was a dark pipeline after certain points in the sewage system, indicating that the pipe was full a short time before the video. This can already be seen in the filming of 11/19/15, just at the beginning of the Pipe n.1, which is the beginning of the sewage system - and has a high slope angle (8.9%).

Figures 5, 6 and 7 show examples of damage verified during the real-time videos.

Figure 5 – Detail of the branch verified in the real-time video of 08/28/15

Figure 6 – Detail of Manhole 2, in the real-time video of 03/03/16

Figure 7 – Detail of obstruction noted in real-time video of 11/19/15

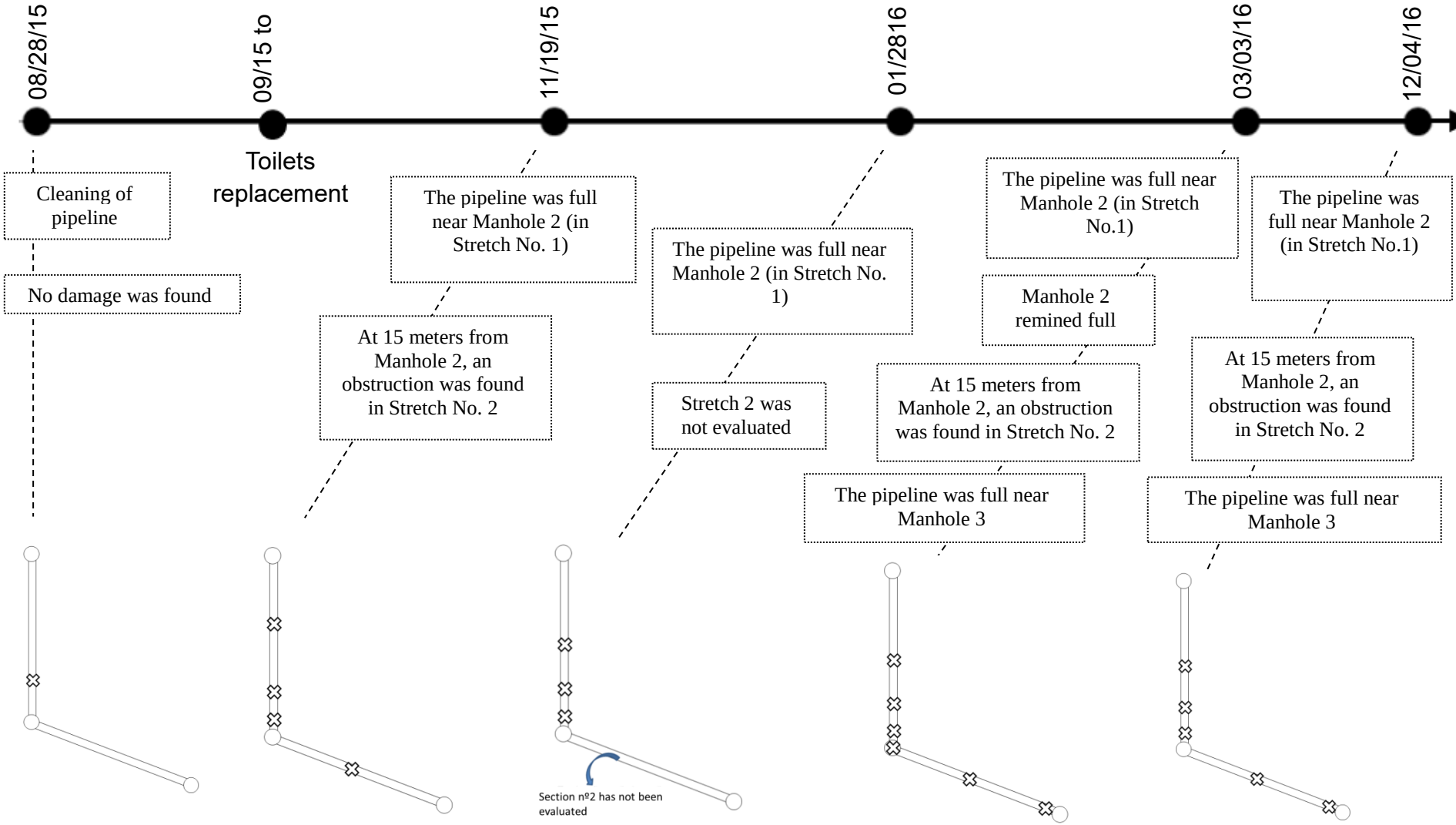

Figure 20 – Timeline with the results obtained in the real-time videos

The real-time videos showed deposit of solids in the pipes. From the second real-time video onwards, it was already possible to detect the accumulation of solids in the pipeline, which may have occurred due to the reduction of the total volume of water discharged in the system. The deposit of solids continued to be verified until the end of the study and each real-time video showed maintenance and/or increase of accumulation points. Therefore, it is possible to affirm that the replacement of the 6.8 Lpf toilets for 4.8 Lpf toilets can have an impact on the performance of the sewage system. Therefore, such a measure cannot be performed unrestrictedly. Figure 20 shows a timeline, with the results obtained in the real-time videos.

It was verified that, over time, the accumulation points increased, both in terms of quantity and in relation to magnitude, even with a high slope angle of 8.9% of the horizontal collector.

The comparison of the results of the field study with those of Phase 1 of the laboratory study, showed that the results of the tests offered in the current standards were similar among the toilets installed in the field, indicating that these tests are not sufficient to determine the performance of toilets in the field.

In the comparison of the field study results with Phase 2 of the laboratory study, it was found that those toilets that required three or less discharges to remove all media from the 18-meter pipeline in the soybean paste transport test, had good performance in the field, i.e., they did not offer problems for the users and led to a reduction of toilet water consumption.

Fout! Verwijzingsbron niet gevonden. shows a graphical comparison between the p erformance of the toilets in the field and the soybean paste transport test. The graphs show the results per house monitored.

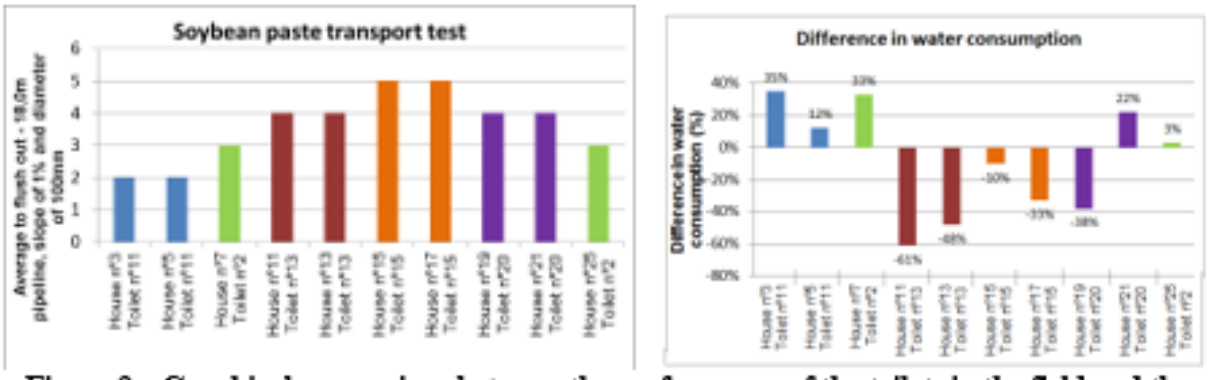

Figure 9 – Graphical comparison between the performance of the toilets in the field and the soybean paste transport test

In the case of the 4.8 Lpf toilet installed in House 3, there was a reduction in the toilet water consumption of 35%, when compared to the toilet that was installed before the replacement. This 4.8 Lpf toilet, installed in House 3, when tested in the laboratory (soybean paste transport test), required two flushes to remove all media from the pipeline. Therefore, one verifies that the toilet that required three discharges or less to remove the media from the pipe in the soybean paste transport test caused a reduction in water

consumption (with the exception of House 21, which, although the test result equaled four flushes, showed a reduction of water consumption).

This study needs to be expanded to confirm this correlation, since the sampling of toilets tested was small and one of the toilets, even with a result of four flushes in this laboratory test, showed a reduction of water consumption (House 21). And House 25, even with a good laboratory result, offered only a 3% reduction in toilet water consumption.

5 Conclusions

Current studies show that 4.8 Lpf toilets have the potential to meet the requirements of users and the system. That is why this study focused on the evaluation (laboratory and field evaluation) of the impact of replacement of 6.8 Lpf toilets for 4.8 Lpf toilets, in order to verify if an effective reduction of water consumption was offered to users, without causing blockage and deposits of solid in the pipeline of the building drainage and sewage systems.

Through the laboratory tests, one could verify that some toilets met the performance of the removal of waste from the toilet itself. This shows that some products have enough technology to work with reduced volume. However, 75% of the evaluated products did not meet the minimum requirements of the current standards. This reflects the need for toilet evolution.

Both toilets designed to work with 4.8 Lpf and toilets designed to work with 6.8 Lpf, but regulated to 4.8 Lpf were tested. All the latter failed in the laboratory tests. This proves that simply reducing the water level in the flush tank is not a viable solution to reduce toilet water consumption.

A major problem is related to the performance of the building drainage system – expressed through the solid transport test. Reducing the discharge water consumption without an in-depth study of the effect generated in the system can lead to deposits of solids in the pipeline, causing blockage. Only 80% of the toilets met this requirement.

In the field study, it was verified that different models of 4.8 Lpf toilets, all approved in laboratory study, offered different performance when installed in the field, ranging from reduction to increase of water consumption, in relation to 6.8 Lpf toilets. The toilets with better performance in the field, that is, those that led to a reduction of water consumption and did not offer problems to the users were the ones with better performance in the test of transport of soybean paste (those that required three discharges, or less, to remove the media from the pipe). This study must be broadened to confirm this correlation, because the sampling of toilets tested was small, but it is an indication that the soybean paste transport test is adequate to evaluate 4.8Lpf toilets.

During the field study, it was verified that, although the users did not report problems in the performance of the toilet, data monitoring revealed the presence of successive periodic flushes in some dwellings, specifically in those where there was an increase in water consumption after the replacement of the toilets. This observation points out the fact that the reduction of water consumption is not obtained simply by reducing toilet

water consumption, and that it is essential that the toilet meet the minimum operating requirements.

The average water consumption of the toilets (considering the average of all houses monitored) was not found to be reduced, which once more indicates that users had flush successively when the 4.8Lpf toilets were installed. A reduction in the toilet water consumption occurred in only five out of the ten houses monitored.

With the real-time video, deposits of solids were verified in the sewage system throughout the monitoring, after the toilets were replaced, even with the horizontal collector slope angle of 8.9% - which indicates that this measure cannot be adopted unrestrictedly.

The results indicated that a reduction of water consumption is only effective should facilities are planned together, i.e., if the water supply and drainage systems are planned taking into consideration the sanitary appliances that will be installed in dwellings, as well as the volume of water discharged by them.

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