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Study

Analysis and persistence of wet wipes in sewer systems

Client:

Gemeinschaft Steirischer Abwasserentsorger

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MIT UNTERSTÜTZUNG VOM

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Das Land Steiermark → Wasserwirtschaft

Saubermacher

Contents

1 Purpose

This study proposes to answer questions concerning wet wipes that are flushed into sewer systems from toilets and cause problems, for example in pumping stations upstream of water treatment plants. The questions are:

1. Is it possible to unambiguously demonstrate the problems caused by wet wipes in wastewater systems?
2. Is it possible to describe the problematic consistency of wet wipes?
3. What confirmed data on this issue can be established in this study?
4. How high are the estimated end-of-life costs for wastewater removal up to and including rake systems?
5. What remedial action can be recommended?

2 Introduction

The problem of wet wipes is known worldwide and has been described (e.g. Berger et al. 2017). However, the number of reliable publications is limited (e.g. Water UK 2017). Wet wipes lead to clogging of wastewater lifting pumps in pump works and treatment plants, more maintenance work in clarification tanks and clogging of digestion tanks (Figure 1).

Figure 1: Wet wipe clogging in a rake system (top right), clogging pumps (left) and other treatment plant systems (bottom right).

2.1 General

Wet wipes are increasingly used instead of toilet paper, for intimate care, for animal care, and as general or special cleaning cloths.

3 Material and methods

The study was preceded by numerous visits and discussions with parties involved with wet wipe issues:

- The client, the association of Styrian wastewater disposers
- Various wastewater associations, especially those of Mürzverband and Grazer Feld, the Graz Holding and the Mautern wastewater treatment plant
- Companies that are potential sources of wet wipe disposal into wastewater, namely farmers, nursing homes, hospitals
- Fibre producers, especially Lenzing AG, who are involved in the manufacturing process and representing the interests of wet wipe manufacturers
- Private individuals, who were asked about their personal wet wipe usage habits

Many parties and systems are involved in wet wipes from production to disposal. Figure 2 shows an overview of the areas covered in this study.

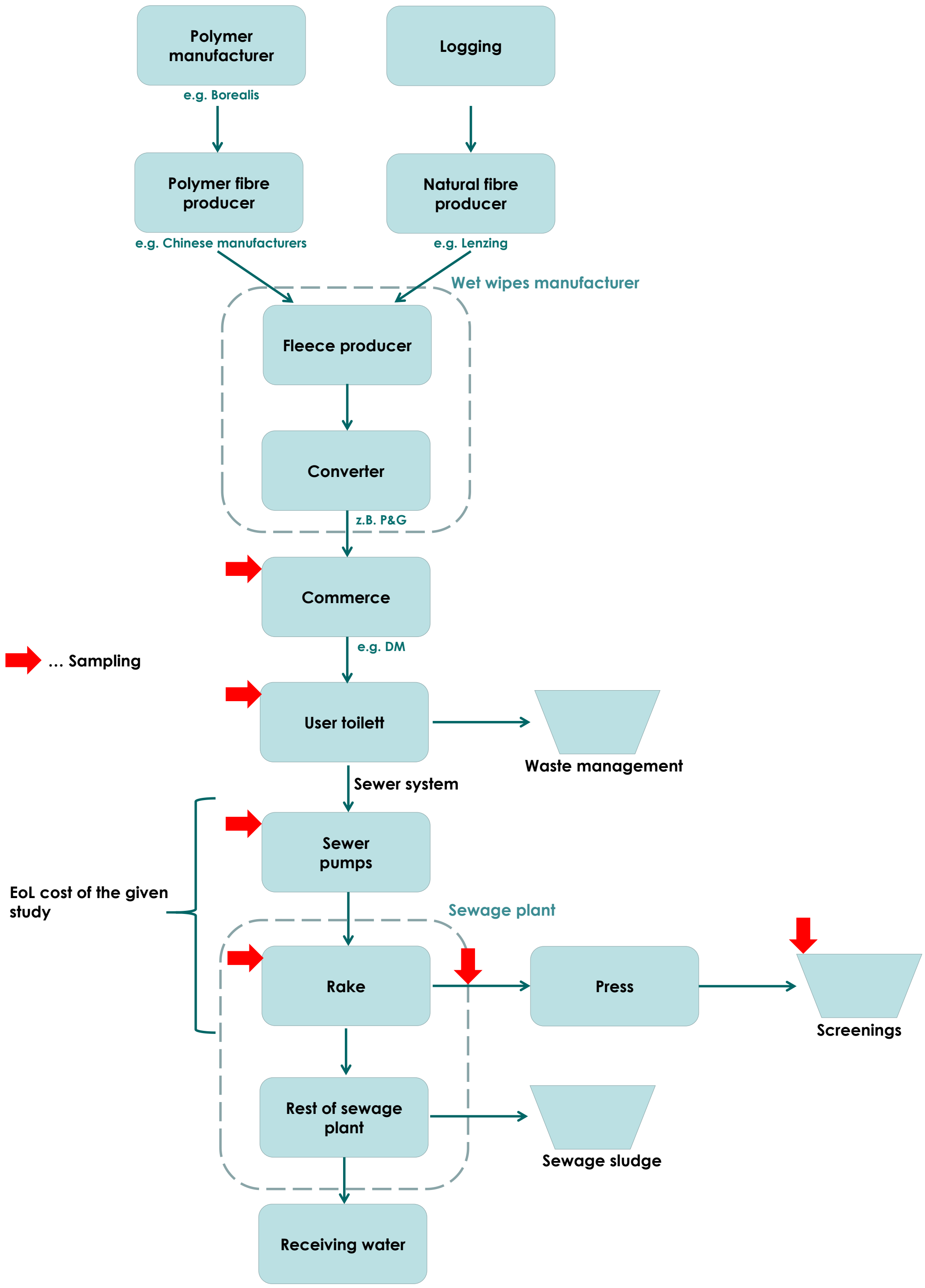

Figure 2: Wet wipes from production to disposal, from raw material to fleece manufacture to receiving water, with marking of sampling points and cost captures in this study.

3.1 Demonstration of problems caused by wet wipes

To demonstrate the issues around wet wipes, in Mürzzuschlag the floating layer of a pump station was sampled, in Kapfenberg the raked rake material of a treatment plant was picked through for wet wipes, and in St. Marein/M a clogged wastewater channel pump was opened and examined.

In a second step, the attempt was made to clog a Flygt brand 3.7 kW pump using actual wet wipes. To find out how many wet wipes are needed for this, the wastewater channel in Allerheiligen/M was opened and the wastewater applied directly to the pump. Two types of wet wipes were used. One was babylove brand baby wet wipes, as these have the highest artificial fibre content, and the other was Kerbel brand animal wet wipes made of mixed fibre.

The third step was the construction of a small test system to simulate a pumping station. The pump described was mounted in a water tank, wet wipes were added, and the number needed to clog the pump was counted (Figure 3).

Figure 3: Wet wipe pump clogging test setup

3.2 Consistency

Wet wipes in various categories (baby, toilet, cleaning wet wipes etc.) were purchased at several store chains in order to get a look at the different types on the market (Figure 4).

In addition to gathering general data like weight and dimensions, the lateral and transverse tear strength of wet wipes was tested both manually and using weights in a laboratory. The dry matter and water content of the wet wipes were measured. A slosh test was used to determine disintegration in water within 30 minutes. The composition of the carbon used in selected wet wipes was determined in the laboratory by the $C_{biogen/fossil}$ method, and that of the fibres in selected wet wipes by spectroscopy.

Figure 4: Some of the wet wipe brands tested

3.3 Data obtained

Sampling and sorting of the rake material was done three times each day for ten days in the three treatment plants Gössendorf, Kapfenberg and Mautern. The plants were chosen based on their size in population equivalent (PE), population structure of their catchment area, and access to uncompressed rake material. At 500,000 PE, Gössendorf represents a large plant serving an urban area. At 49,000 PE, Kapfenberg is medium-sized and serves a small town. The 4000 PE Mautern is small and serves a rural area.

From a total of 51 rake material samples, the **whole, undamaged wet wipes** were pulled manually and sorted into three categories, low, moderate and high tear force. The dry matter of the wet wipes and rake material was measured in order to determine the wet wipe content of the rake material.

The number of wet wipes and synthetic fibre wet wipes (WW) for Styria as a whole was extrapolated by first calculating the number picked per PE. Then all 511 treatment plants of PE >100 in Styria were sorted into three categories with the three sampled plants, based on their PE. The WW/(PE*a) in each group were then derived using the sum of PE in that group. Adding these three group values gave the weighted value for Styria.

The wet wipes pulled from the rake material were tear-tested manually on-site and sorted into low, moderate and high tear force.

3.4 End-of-life costs of disposal in wastewater up to the rake

Three treatment plant operators were surveyed in order to get an estimate of the end-of-life costs (EoL costs). The focus was on extra costs for pump cleaning, higher rake material quantity after switching to closer bar spacing, e.g. 6 to 2 mm, in order to avoid wet wipe issues downstream, and the amount of synthetic fibre wet wipes in the rake material. Maintenance costs for other parts of the treatment plants were not considered (Figure 2).

For the calculation of costs from switching to closer bar spacing, it was assumed that the amount of rake material would increase by around 75%, as was the case at the Grazer Feld plant from 2009 to 2010. The rake was changed in Kapfenberg in 2016, but was not yet changed in Gössendorf (6 mm spacing) or Mautern (4 mm spacing).

To determine the disposal costs of the synthetic fibre wet wipe content in the rake material, the material was calculated based on the sorting results in 2016 in Styria as described in the previous paragraph. The mean of Kapfenberg and Grazer Feld, 125 €/t, was taken as the cost of rake material disposal.

The sum of the three individual calculations gives the total added cost.

3.5 Remedial measures

Following literature and internet research, short surveys were carried out in a hospital, a nursing home, and 20 households.

4 Results

4.1 Demonstration of problems caused by wet wipes

The problems caused by wet wipes were evident in the pump station visits. At the Mürzzuschlag pump station a floating layer made up of wet wipes and other contaminants could be seen clearly (Figure 5). At the Kapfenberg pump station the plug of a clogged pump consisted almost exclusively of wet wipes, and possibly some textile scraps (Figure 6). The plugs were difficult to remove and required much effort. They could not be torn by hand. There is extensive photographic documentation of these issues.

Figure 5: View from above of the floating layer of a pump station in Mürzzuschlag

Figure 6: Disassembled pump with plug of wet wipes from a pump station in Kapfenberg

Applying original wet wipes to a pump intake shaft in St. Marein/M did not cause clogging. The pump briefly showed higher power consumption during intake of the wet wipes, but did not clog. Therefore, it was not possible to determine whether clogging can be caused by wet wipes alone, and how many wet wipes this requires. The role played by the sewer system also remained unclear, as did the issue of whether the plug begins to form upstream of the pump (for example, by getting caught at corners).

In water tank clogging tests, regular pumping interruptions simulating actual operation allowed wet wipes to settle in the pump and pipes, ultimately leading to plugs and clogging. This shows that synthetic fibre wet wipes tend to form plugs and can clog pumps. On average it took 125 synthetic fibre wet wipes to cause a clog. Mixed fibre wet wipes did not form plugs or create clogging, because they are torn into smaller pieces each time they pass through a pump.

4.2 Consistency

The table shows the prices, degradability and disposal information for the 19 wet wipes purchased (Table 1).

Table 1: 19 wet wipes studied (green: low tear strength, light red: moderate tear strength, red: high tear strength, NA: No information given on package).

Huggies	Baby WW	Müller	NA	Refuse bin	
Hakle	Toilet WW	Bipa	Water-soluble	Toilet	1.35 € / 42 pcs
Quality First	Toilet WW	Bipa	NA	Toilet	1.55 € / 60 pcs
Tempo	Toilet WW	Bipa	Water-soluble	Toilet	1.45 € / 42 pcs
Zewa	Toilet WW	Bipa	Biodegradable	Toilet	1.55 € / 55 pcs
Denk Mit	Toilet cleaning WW	DM	NA	Toilet	0.95 € / 15 pcs
Sagrotan	Toilet cleaning WW	DM	NA	Toilet	3.95 € / 60 pcs
Dettol	Disinfection WW	DM	NA	Toilet	2.85 € / 60 pcs
Kerbl	Animal WW	Lagerhaus	NA	NA	19.99 € / 1000 Stk
Beauty Baby	Baby WW	Müller	NA	Refuse bin	
wetties	Animal WW	Fressnapf	NA	Refuse bin	
babylove	Baby WW	DM	NA	Refuse bin	0.95 € / 30 pcs
Babywell	Baby WW	Bipa	NA	Refuse bin	0.95 € / 30 pcs
Pampers	Baby WW	DM	NA	Refuse bin	0.95 € / 12 pcs
Cif	Disinfection WW	DM	NA	Refuse bin	3.45 € / 60 pcs
Meister Proper	Disinfection WW	DM	NA	Refuse bin	2.69 € / 60 pcs
Jessa	Intimate care WW	DM	NA	Toilet	1.45 € / 20 pcs
bebe	Cleaning WW	Müller	NA	Refuse bin	2.99 € / 56 pcs
WC-Ente	Toilet cleaning WW	DM	NA	Refuse bin	3.45 € / 25 pcs

The water content (i.e. the amount that evaporates at 105 °C) and dry mass of the original wet wipes was between 52 and 70 % WC/WM and 30 to 48 % DM/WM (Table 2).

Table 2: Water content and dry mass of 12 original wet wipes

Brand	Type	Wet matter [g]	Dry matter	Water content %	Dry matter [%]
babylove	Baby WW	5,1	1,8	63,6	36,4
Babywell	Baby WW	5,9	1,8	68,6	31,4
Huggies	Baby WW	4,3	1,3	70,3	29,7
Pampers	Baby WW	3,2	1,2	54,9	45,1
Beauty Baby	Baby WW	4,3	1,3	69,0	31,0
bebe	Cleaning WW	4,4	1,3	70,8	29,2
Kerbl	Animal WW	2,1	1,0	52,2	47,8
wetties	Animal WW	4,8	1,3	72,4	27,6
Hakle	Toilet WW	4,4	1,3	64,0	36,0
Quality First	Toilet WW	4,7	1,4	69,6	30,4
Tempo	Toilet WW	4,7	1,4	70,1	29,9
Zewa	Toilet WW	4,3	1,3	69,3	30,7

The ash content of two low and two high tear strength wet wipes was a consistent <1 %.

The tear strength for all wet wipes differs across and along the fibre grain. It was higher along the grain, between 198 N/10 cm for the babylove brand and 18 N/10 cm for Hakle (Figure 7).

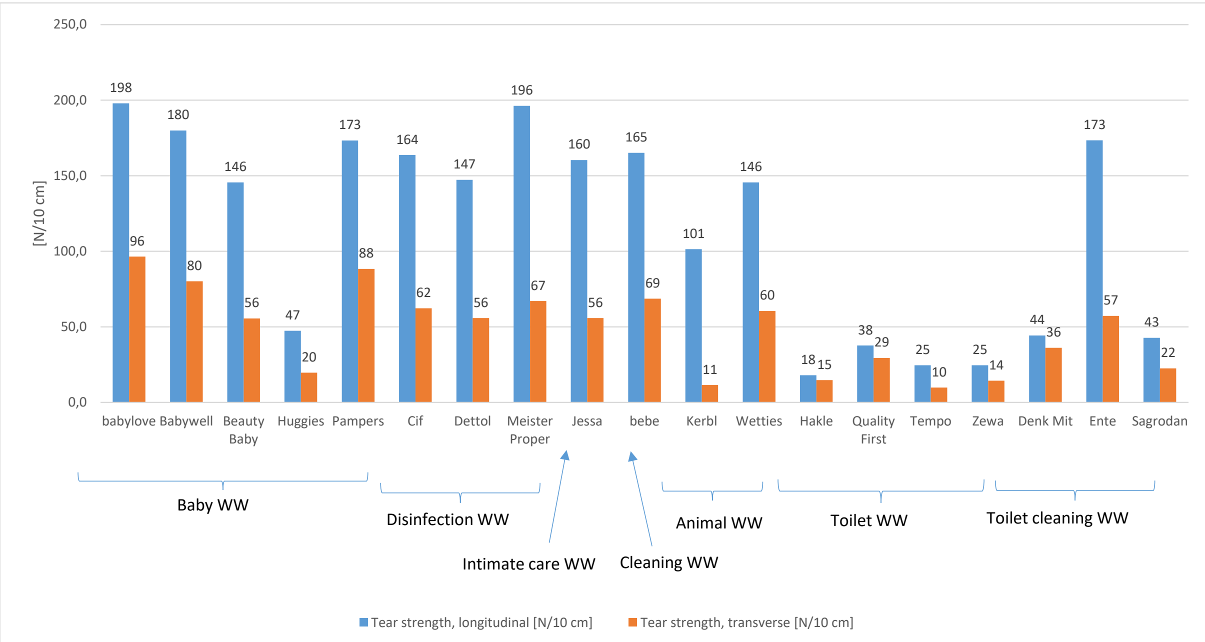

Figure 7: Comparison of tear strength of 19 original wet wipes along (blue) and across (orange) the grain.

Based on the tear tests, the wet wipes were placed in low, moderate, and high tear strength categories. These categories refer only to tear strength along the grain. The category delineations are as follows:

- High tear strength wet wipes: 151-200 N/10 cm
- Moderate tear strength wet wipes: 50-150 N/10 cm
- Low tear strength wet wipes: <50 N/10 cm.

All wet wipes marketed as toilet wet wipes are in the low tear strength range. Some toilet cleaning wet wipes are in the high tear strength range. Animal care wet wipes and Dettol and Beauty Baby brand wet wipes are in the moderate category. Among baby wet wipes, babylove had the highest tear strength. All other baby wet wipes except Huggies were also in the high tear strength category.

Fibre analysis showed that the low tear strength wet wipes are made of cellulose or viscose, the high tear strength ones of polyester and the moderate tear strength wet wipes a mix of natural and synthetic fibres.

The content of fossil and biogenic carbon in Hakle wet wipes was 96.7 % C_{biogen}, and in Zewa 97.7 % C_{biogen}. The content of fossil and biogenic carbon in Babywell wet wipes was 54.7 % C_{fossil} and in babylove 84.9 % C_{fossil}. It can easily be seen that C_{biogen} predominates in low tear strength wet wipes, and vice-versa in high tear strength wet wipes. Babywell wet wipes were an exception, as they were almost half C_{fossil} but still high tear strength.

In the slosh test, two of the eight brands tested disintegrated within an hour. These were Hakle and Zewa brand. Normal toilet paper also disintegrates. The synthetic fibre wet wipes tended to form a lot of foam but remained whole.

4.3 Data obtained

The most used wet wipes were pulled from uncompressed rake material in Gössendorf (urban area) at 90 WW/(PE*a). In the rake material from Kapfenberg (small town) it was 65 WW/(PE*a) and in Mautern (rural) it was lowest at 43 WW/(PE*a). Weighted by treatment plant size, the extrapolated consumption for Styria is 68 WW/(PE*a) (Figure 8).

The used wet wipes pulled from the samples were subjected to manual tear testing and sorted into three categories. The amount of synthetic fibre WW (high tear strength) is 16 % higher in rural areas (Mautern) than in small towns (Kapfenberg) and urban (Gössendorf), with 36 % and 37 % respectively. The amount of synthetic fibre WW in Styria was 31 % (Figure 9).

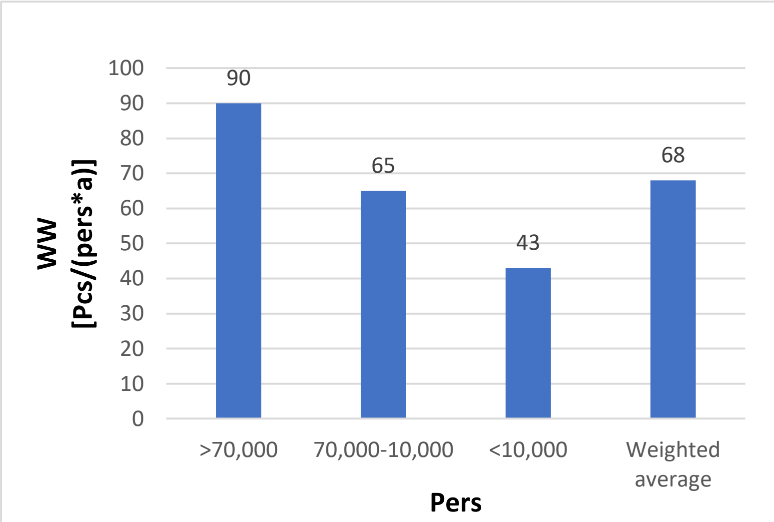

Figure 8: Comparison of the WW/(PE*a) of the three treatment plants examined, each representative of a PE size, and weighted average for Styria.

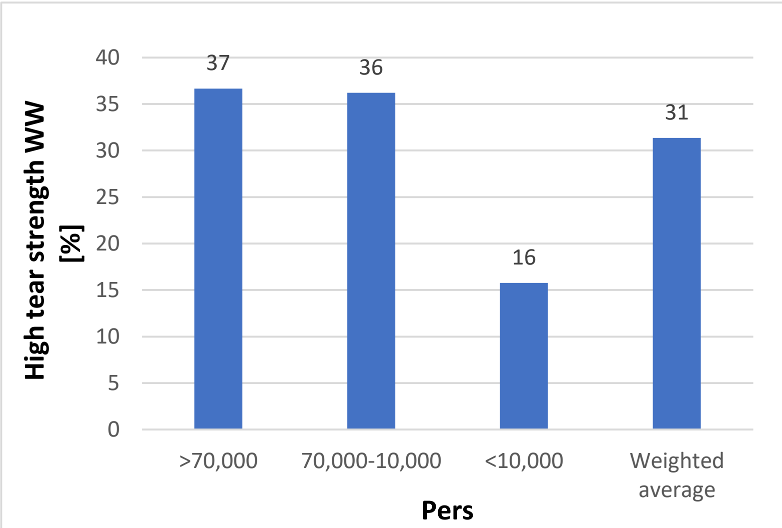

Figure 9: Comparison of the synthetic fibre WW percentage of all wet wipes pulled from the three treatment plants examined, each representative of a PE size, and weighted average for Styria.

4.4 End-of-life costs of disposal in wastewater up to the rake

The added costs for pump maintenance extrapolated for Styria were 3,146,769 €/a. The added costs for increased rake material due to the one-time switch to tighter bar spacing, extrapolated for Styria, are 394,909 €/a. The added costs due to synthetic fibre wet wipes in the rake material extrapolated for Styria are 29,608 €/a.

Thus, wet wipes cause added EoL costs for Styria of € 3,571,285 (Table 3).

The costs for pump maintenance were set at zero for Gössendorf, the largest (500,000 PE) Styrian treat plant, since its pumps experience no problems with wet wipes.

Table 3: Calculation of end-of-life costs from drainline to rake material

1. Added cost of pump maintenance (no added cost for 500,000 PE Gössendorf)

Place	Maintenance/ week	Week/a	Pump stations	Hours	Employees	Personnel costs	Pump truck 3rd party costs per h	Use of pump truck	Added cost	Pop.	PE-specific costs	PE comparable plants	Costs of pump maintenance
	[Number]	[Number]	[PS/a to clean]	[h]	[Number]	[€/(h*MA)]	[€/h]	[h]	[€/a]	[PE/plant]	[€/(PE*a)]	[PE/plant size ST]	[€/a]
GrazerFeld	5	52	***260***	6	2	38	120	2	***180.960***	120.000	*1,508*	280.000	***422.240***
Kapfenberg			**122**	2	2	38	120	2	***47.824***	49.000	*0,976*	1.025.000	***1.000.400***
Mautern	2	52	***104***	**3**	1	38	0	0	***11.856***	4.000	*2,964*	581.690	***1.724.129***
												∑	***3.146.769***

2. Added costs from more screen material through tighter bar spacing (Grazerfeld and Kapfenberg real, Gössendorf and Mautern fictitious)

Place	SM/a (100%)	Conversion SM/a (175%)	Δ SM	Disposal costs	Disposal costs	Pop.	PE-specific costs	PE comparable plants	Conversion costs
	[t/a]	[t/a]	[t/a]	[€/t]	[€/a]	[PE/plant]	[€/(PE*a)]	[PE/plant size ST]	[€/a]
Gössendorf	*565*	988,03	423	150	***63.516***	500.000	*0,127*	500.000	***63.516***
GrazerFeld	*159*	279	119	*150*	***17.917***	120.000	*0,149*	280.000	***41.807***
Kapfenberg	102	178,5	76,5	*150*	***11.475***	49.000	*0,234*	1.025.000	***240.038***
Mautern	*3*	5,3	2,3	*150*	***341***	4.000	*0,085*	581.690	***49.548***
								∑	***394.909***

3. Added costs through synthetic fibre WW in screen material less amount from tighter bar spacing

Place	Screen material 2017	Percent WW	WW	Percent synthetic fibre WW	Synthetic fibre WW	Costs for SM disposal	Costs for WW disposal	Pop.	PE-specific costs	PE comparable plants	Costs from synthetic fibre WW
	[t WM ww/a]	[% WMaa]	[t/a]	[%WM]	[t/a]	[€/t]	[€/a]	[PE/plant]	[€/(PE*a)]	[PE/plant size ST]	[€/a]
Gössendorf	*565*	19,8%	*112*	36,7%	*41,00*	*150*	***6.149***	500.000	*0,012*	780.000	***9.593***
Kapfenberg	*102*	16,3%	*17*	36,2%	*6,02*	*150*	***903***	49.000	*0,018*	1.025.000	***18.894***
Mautern	*3*	10,8%	*0,3*	15,8%	*0,05*	*150*	***8***	4.000	*0,002*	581.690	***1.120***
										∑	***29.608***

4. Total costs in Styria

Type	Costs
	[€/a]
Added cost of pump maintenance	*3.146.769*
Added cost from tighter bar spacing	*394.909*
Added costs through synthetic fibre WW in screen material	*29.608*
∑	***3.571.285***

On average, a wet wipe costs the consumer 5.3 euro cents. Costs for disposal in wastewater from toilet to disposal of the rake material are 13.7 euro cents each, or 259 % of the sale price (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

Table 4: Comparison of costs to purchase and dispose via wastewater per synthetic fibre WW

Consumption of synthetic fibre WW	Pop in Styria. 1 Jan. 2017	Added cost	Costs for disposal	Avg. retail price	Cost ratio
[Pcs/(pers*a)]	[Pers]	[€/a]	[€/pcs]	[€/pcs]	[%]
21	1.237.298	*3.571.285*	*0,137*	0,053	***259%***

4.5 Remedial measures

The wet wipes problem is known in AT, DE, GB, BE, CA and US (e.g. Seher 2016). The issue has gained the attention of critical satirists (New truTV 2018).

Consumer behaviour studies in the US show that few users dispose of wet wipes based on the information on the package (INDA-MEWEA 2015). Another study came to the same conclusion (Water UK 2017).

Market volume in 2016 for German wet wipe manufacturers was € 126 mln., with +8.5 % annual growth (Berger et al. 2017), in Europe in 2006 € 2.4 bln. and in the US in 2014 US$ 13 bln. (Dick 2016).

Most of the synthetic fibre for wet wipes is made by large Chinese companies. Cellulose fibre for wet wipes is made by Lenzing AG of Austria, Tangshan Sanyou Group of China and Aditya Birla Group of India (Igelsböck 2017a).

Typical wet wipes manufacturers (converters) are Nölken Hygiene Products GmbH, Albaad Deutschland GmbH, Kimberly-Clark Corporation and Procter & Gamble.

The industry associations EDANA in Europe (250 members) and INDA in the US represent the interests of all companies along the wet wipe production chain. EDANA and INDA have developed a multistage test for flushability (Figure 10) (Rahbaran 2016).

Standardisation activities are described in Germany and at the ISO level, but ISO standardisation group is at this time inactive and nothing is known about the group in Germany (Berger et al. 2017).

Figure 10: Flushability test of the EDANA/INDA industry associations

There have been research projects on wet wipes – the Berlin waterworks did the “Kuras” project (Berger et al. 2017), IAB Weimar developed a test procedure for wet wipes (Berger et al. 2017) and Water UK recently published a study (Water UK 2017). Water UK investigated samples from 54 plugs in Great Britain and concluded that much of the material was from non-flushable wipes. A series of recommendations calls for better and more truthful information on packaging. Manufacturers are called upon to take responsibility for disposal information in marketing and packaging information.

In a survey by the authors among acquaintances in 20 households, only 2 households said they dispose of wet wipes in the toilet with a frequency of 0.5 to 1 WW/(PE*d), while the others did not use wet wipes. A survey of two farmers, a hospital and a nursing home showed that none of them use wet wipes and do not dispose of such problem materials in the sewer.

A talk with a fibre manufacturer who is a member of the EDANA industry group and is involved in standardisation activity on wet wipes revealed that the manufacturer knew little of the problems wastewater utilities have with wet wipes (Igelsböck 2017b).

5 Discussion

The primary conclusion of this study is:

Synthetic fibre wet wipes do not belong in wastewater.

The tear strength of this type of wet wipe causes problems and therefore costs. In Styria, end-of-life costs for synthetic fibre WWs in wastewater systems to the treatment plant rakes is 3.6 mln. €/a.

The carelessness of manufacturers and distributors of industrial products is made clear by the wet wipe problem. At cost to society at large, products are marketed for a limited group (subset of the population) and the profits go into private hands, while the end-of-life costs are borne by the entire population.

5.1 Demonstration of problems caused by wet wipes

It was demonstrated the wet wipes are a problem for parts of wastewater disposal. However, distinctions must be made among low, moderate and high tear strength wet wipes. It was only possible for high tear strength wet wipes to show that they can cause stoppage of a standard 3.7 kW wastewater pump without other wastewater contents. Moderate tear strength wet wipes were pumpable even in high concentrations, albeit with a brief rise in the amount of power drawn by the pump. However, the fact that there are materials in wastewater that tend to form plugs makes it likely that these wet wipes also cause problems.

The first attempt to induce clogging of a standard wastewater pump in St. Marein/M failed, because, as was later realised, not enough wet wipes were used. In the second attempt in the water tank a higher concentration was used, and clogging was demonstrated unambiguously. It should be noted that this plug formation did not require other contaminants also known to be in wastewater, such as dental floss, tampons or hair.

No wet wipe problems are known at the largest Styrian wastewater plant, Gössendorf (500,000 PE). The drainline network there uses few pumps, and due to the high wastewater flow they are comparatively powerful. This is assumed to be the reason why synthetic fibre WWs can be pumped there.

5.2 Consistency

The description of the 19 original wet wipes proved simple and informative. Description of the used wet wipes from the treatment plants rakes was naturally more difficult.

Information on the packaging varies greatly and on at least some synthetic fibre WWs it is misleading, e.g. the Dettol and Jessa brands. Information on biodegradability is rare. Most brands give information on disposal, but not in accord with the results found.

The dimensions and dry matter content of the 19 wet wipe brands tested were described. A comparison of the dimensions of original and used wet wipes from a rake material sample showed that this criterion is not useful for determining the brands of used wet wipes. Indeed, it is no simple matter to identify used wet wipes. Measurement of the dry mass in original wet wipes showed that there is a substantial amount of volatile substances. This will probably cause additional burden on wastewater, but no further attention was given to them or their disposal.

Tear strength testing with a simple apparatus gave quantifiable results that agreed with the chemical composition and fibre analysis. We recommend using tear strength as a quality parameter for the flushability of wet wipes.

Chemical composition showed that in low tear strength wet wipes the carbon is mostly biogenic, in moderate tear strength wet wipes it is a mix of biogenic and fossil, and in high tear strength wet wipes it is largely from fossil sources. In connection with the examination of the fibres in selected wet wipes this showed clearly that high tear strength wet wipes consist of synthetic fibres like polyethylene while low tear strength wet wipes are of natural fibres like viscose.

Disintegration was tested in slosh tests which showed that the natural fibre wet wipes quickly disintegrate into small pieces, while moderate tear strength wet wipes with synthetic fibres remain whole. It is thus probable that all wet wipes with synthetic fibre content can contribute to plug formation in wastewater lines and treatment, and then be caught in rakes, causing an increase in the amount of rake material.

5.3 Data obtained

Sampling and sorting of used wet wipes from rake material requires great effort due to the hygienic issues, but it was possible to do it. It was necessary to convince treatment plant personnel to cooperate, since they had reservations concerning hygiene. Due to resource limitations, counter to the original plan only a few samples were taken from a small facility (Mautern). Small treatment plants, where there is uncompressed rake material that can be sampled, were available for sampling to a limited degree.

Extrapolation for all of Styria was done based on three treatment plant size groups. Obviously not all treatment plants could be sampled for this study. This method makes sense only under the premise that wet wipes enter wastewater as a function of population structure (urban, small town, rural). This was confirmed for the three plants chosen.

5.4 End-of-life costs of disposal in wastewater up to the rake

In Styria, end-of-life costs for synthetic fibre WWs in wastewater systems up to the treatment plant rakes are 3.6 mln. €/a. The costs for pump maintenance dominate. Costs for synthetic fibre wet wipe rake material and additional rake material due to reduction of bar spacing to protect the treatment plant, total 11 % of the overall costs, and so are of lesser importance.

With regard to the calculated number of synthetic fibre WWs in Styrian rake systems, the specific end-of-life costs for high tear strength wet wipes is 13.7 cents. The mean sale price is 5.3 cents. Thus, municipalities must pay >250 % of the purchase price for disposal.

The following assumptions were made:

- The costs for pump maintenance for the largest Styrian treatment plant, Gössendorf, were set at zero since there are not wet wipe problems there.
- The costs for moderate tear strength wet wipes were not captured. It is assumed that this would considerably add to the EoL costs.
- Costs for pump maintenance not related to wet wipe issues were not considered. It was assumed that these costs are very minor.

5.5 Remedial measures

Stakeholder research showed that the two interest groups in Europe and the US strongly support the sale of wet wipes. They are aware of the problems of synthetic fibre WWs in wastewater systems but the resulting remedial measures are limited to suggestions for putting information about disposal methods on packages (Rahbaran & Igelsböck 2017).

The wet wipes markets in Europe and the US are probably worth several billion € or $ in each case, and growing, so that more wet wipes in wastewater and waste systems can be expected. It can be assumed that this will also be the case for the proportion of synthetic fibre WWs, but that was not investigated for this study.

A survey of persons known to the authors showed that wet wipes are familiar as products, but toilet use is currently not as high as toilet paper, which corresponds to the calculated consumption of 68 WW/(PE*a) in Styria. Each household surveyed where wet wipes are disposed of in wastewater uses about 0.5-1 WW/(PE*d). The problems caused by synthetic fibre WWs in wastewater systems are largely unknown.

Stakeholder research is not solid literature research, and most of the information given in the literature list is grey literature. Nevertheless, the information gathered is reliable enough, and agrees with the interviews and studies described here.

Recommended measures:

1. Dialogue with wet wipes manufacturers is urgent, towards a reduction in the amount of synthetic fibre wet wipes and in order to get manufacturers to accept responsibility on multiple levels.

2. Standardisation efforts, of which there are signs, should be supported energetically in order to bring about a reduction or even partial prohibition of synthetic fibre wet wipes.
3. These study results should be widely publicised and made known to politicians, stakeholders and the public in talks and interviews, in order to raise awareness.
4. Tear strength as an indicator of flushability is recommended as an easily testable quality criterion.

Open questions:

The assumption made for the extrapolation, that wet wipes are used and/or flushed into wastewater in different amounts depending on the population structure of a region, needs to be confirmed on a broader basis.

A repeated study of synthetic fibre wet wipes in Styrian wastewater systems using the methodology described here would shed light on development over time. The authors recommend repeating it annually.

Problems from moderate tear strength wet wipes need to examined more closely.

A study of synthetic fibre wet wipes in household waste is recommended, in order to identify problems with this disposable product there as well.

In order to hold manufacturers responsible, it would be helpful if the brand or manufacturer of used synthetic fibre WWs could be identified. This study shows that such identification should be possible.

6 Summary

The questions in the Purpose description can be answered as follows:

1) Is it possible to unambiguously prove that problems are caused by wet wipes in wastewater systems?

Yes. Synthetic fibre wet wipes cause problems.

2) Is it possible to describe the problematic consistency of wet wipes?

Yes. Wet wipes can be divided into three groups. The tear strength shows whether a wet wipe contains synthetic fibres, and thus whether or not it is problematic.

3) What confirmed data on this issue can be established in this study?

About 125 synthetic fibre wet wipes lead to clogging of a typical small wastewater pump.

In Styria, extrapolation gives 68 WW/(PE*a) being disposed of in wastewater, whereof 31 % are synthetic fibre WWs.

4) How high are the estimated end-of-life costs for wastewater removal up to and including rake systems?

The end-of-life costs of synthetic fibre wet wipes are 3.6 mln. €/a or >250 % of the purchase price, calculated through to the rake material at the rake.

5) What remedial action can be recommended?

- Dialogue with wet wipes manufacturers is urgent, towards a reduction in the amount of synthetic fibre wet wipes and in order to get manufacturers to accept responsibility on multiple levels.
- Standardisation efforts, of which there are signs, should be supported energetically in order to bring about a reduction or even partial prohibition of synthetic fibre wet wipes.
- These study results should be widely publicised and made known to politicians, stakeholders and the public in talks and interviews, in order to raise awareness.
- Tear strength as an indicator of flushability is recommended as an easily testable quality criterion.

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