Inappropriate disposal of 'flushable' consumer products – reasons for concern

Darko Joksimovic, Anum Khan and Barry Orr

ABSTRACT

Inappropriate disposal of wipes and other products that are either explicitly labelled or assumed by the consumers to be flushable via toilets is increasingly being cited as the cause of a range of sewer systems issues. In the rapidly growing and diverse market for these consumer products, there are significant variations in consumer information provided by manufacturers, product composition and behaviour in different components of wastewater system. This paper summarizes the results of assessing the labelling, drainline clearance and disintegration testing of 101 consumer products, adopting the International Water Services Flushability Group flushability specifications. None of the products tested satisfy the product labelling Code of Practice, and all products other than bathroom tissue failed the disintegration test, including the 23 products that were labelled 'flushable'. The need for a global definition of a 'flushable' product exists and it is vital that it is brought into legislation in an effort to combat misconceptions around consumer products that may exist internationally.

Key words | consumer products, gross solids, sewer blockage

Darko Joksimovic (corresponding author)
Anum Khan
Department of Civil Engineering,
Ryerson University,
Toronto, Ontario,
Canada
E-mail: *darkoj@ryerson.ca*

Barry Orr
Environmental Applied Science and Management,
Ryerson University,
Toronto, Ontario,
Canada

INTRODUCTION

One of the reasons that is being increasingly cited as a potential cause for increased operational difficulties related to wastewater systems is the inappropriate disposal of wipes and other products that are either explicitly labelled or assumed by the consumers to be flushable. The physical characteristics and incomplete disintegration of these products are causing a wide range of issues: clogging of private drain lines and septic tanks; accumulation and interaction with fats, oil and grease leading to formation of fatbergs and sewer blockages; clogging and breakdown of equipment such as screens and pumps, which increases maintenance frequency and necessitates costly equipment upgrades; sewer overflows; and potential emission of plastic materials into the environment. The number of products labelled 'flushable' has been increasing, and now includes various baby wipes, household wipes and cosmetic wipes, cloths, diaper liners and facial tissues, etc. The 'flushable' wipes industry alone has nearly doubled in the 2013–2018 period (Smithers Pira 2018), with indications for this growth trend to continue into the future. With this in mind, the problems associated with the presence of 'flushable' products in sewer systems are likely to worsen if measures that span a broad variety of stakeholders, from manufacturers to consumers and sewer system managers, are not taken.

The journey of these manufactured products, however, starts at store shelves, where package labelling influences both consumers' decision to buy them and their choice of disposal methods. Over the last two years, the Association of the Nonwoven Fabrics Industry (INDA) and the European Disposables and Nonwovens Association (EDANA) have published a labelling Code of Practice (CoP) (INDA & EDANA 2018). The intent of the CoP is to direct manufacturers to make it evident on product packaging not to flush products that could be problematic for wastewater systems but have the potential to be flushed down the toilet by consumers. Additionally, it was designed to direct manufacturers to clearly indicate the appropriate disposal method of the product on its packaging, including a Do Not Flush (DNF) symbol for products that do not meet the flushability criteria. The CoP provides on-pack

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labelling criteria for manufacturers, which includes the location, colour, size and wording. More than a year after the issuance of the CoP, the importance of compliance with the voluntary CoP was again emphasized in a memo to manufacturers (EDANA 2018). However, as the CoP is entirely a voluntary measure, it is unclear to what degree it is being adopted by the manufacturers of products that are potentially disposed in toilets.

The definition and behaviour of 'flushable' consumer products is being addressed by the manufacturers and their associations, sewer managers and operators, and the research community. In-sewer testing was conducted in Vancouver, WA, that observed minor changes in dyed wipes retrieved after travelling in a sewer for more than a kilometre (Thompson 2013). Several organizations have issued testing guidance aimed at defining the flushability of products. These include the guidance from the manufacturer's associations (INDA & EDANA 2017) and, more recently, national (e.g. UK Water Industry 2019) and international (International Water Services Flushability Group, IWSFG 2018a) testing specifications. Although there are some similarities in certain parts of the testing (e.g. drain clearance), the tests specified in these documents vary significantly with regards to other criteria (e.g. product disintegration). Therefore, a product that is deemed 'flushable' on any one set of testing criteria may or may not achieve the same designation based on a different test. Investigations into the behaviour of wipes, including the physical and numerical modelling of wipes in flowing water, have been carried out by Karadagli *et al.* (2009) and Karadagli *et al.* (2012). The transport of gross solids in sewers has received less attention compared to sewer sediment transport (Murali *et al.* 2019), although some modelling approaches do exist (e.g. Littlewood & Butler 2003; Spence *et al.* 2016). McDermott *et al.* (2019) present a comprehensive review of studies on the transport of solids in low flow sewers, identifying gross solids/misuse as the most commonly reported blockage factor and stressing the need for continued research in this area. Overall, there is a lack of agreement on the testing protocol, combined with an incomplete scientific understanding on the behaviour of products that consumers dispose via toilets.

In addition to testing the flushability of individual products, several studies investigated their presence and contribution to blockages in various parts of the sewer system. A forensic study of materials collected from a wastewater treatment plant influent, serving a combined system in New York City (Fuss & O'Neill 2016), provided a snapshot composition. The results indicated that 62% of the wipes materials were baby wipes, and that wipes labelled as flushable constituted only 2% of wipes recovered, in addition to various other trash materials. In the Water UK study (Drinkwater & Moy 2017), the blockage materials from sewers, pumps and treatment plant inlet works were collected and analyzed. The results indicated that 75–95% of materials were non-flushable wipes, concluding that wipes being flushed constitute a serious problem and recommending a range of actions related to the composition of wipes, clarity of labelling and public education and awareness. A year-long study of wastewater sampling in Germany (Mitchell *et al.* 2017) found significant variations in captured material composition between 12 samples, with paper (45%) and textiles (33%) being the largest fraction of captured solids, and concluded that wet wipes are definitely a relevant category. Spence *et al.* (2016) reported a large diurnal variation in the composition of gross sewer solids, as well as the importance of population characteristics in contributing areas, with low income and ageing areas having the largest contribution of wet wipes. In addition to the overall number of studies being low, their repeatability is lacking and they vary significantly in terms of their objectives, classification of materials found in wastewater and sampling protocols, which in some cases included very small quantities of materials. It is also noted that no accurate estimates of the portion of wipes sold as flushable appear to be available.

The objective of research presented in this paper is to investigate a large number of consumer products that could potentially be flushed down the toilets, assessing: (1) the packaging adherence to the industry association packaging guidance (CoP), (2) drainline clearance characteristics and (3) disintegration behaviour. The aim of the project was to provide a broad overview of the lifecycle of a general consumer product, beginning with its life on a store shelf to its end in wastewater collection systems. A smaller subset of the products were also tested for product composition. Broader goals of the ongoing project are to raise public awareness on the products that may be misleadingly labelled as 'flushable', and add to the developing international research on flushability to facilitate evidence-based dialogue between sewer systems managers and consumer product manufacturers.

METHODS

The project started with a purchase of a variety of products to include toilet tissue, facial tissue, moist wipes labelled flushable and 'Do Not Flush', toddler wipes, baby wipes, and some other items that have been labelled flushable,

such as toilet cleaning brushes, dog waste bags and diaper liners. The selection of products was intended to be representative of consumer products found across local stores in Ontario, Canada or available online, and may vary considerably in different geographic regions. The majority of the 101 products tested in this project were manufactured in the USA (61), followed by China (17), Canada (12) and other countries (Germany, Ireland, Israel, Italy, Korea, Thailand and the UK). Using the industry CoP, each of the 101 products tested during this project were systematically examined for adherence to package labelling guidance.

The testing in this project followed the IWSFG PAS 3: 2018 Disintegration Test Methods – Slosh Box (IWSFG 2018b). In the testing, the two criteria – toilet and drainline clearance and disintegration–required two fundamental steps: preconditioning and agitation. These fundamental steps were performed for each of the products tested. A complete test for each product required five samples. A physical model consisting of a toilet (6/4.1 L) and a private drain connection was set up in the Water Resources laboratory in the Department of Civil Engineering at Ryerson University, Toronto. The preconditioning step consisted of flushing a product sample down the toilet and allowing it to remain at the end of the drainline in a catch basket for a 30-minute period. However, if the product sample did not clear the drainline in the first flush, additional flushes were subsequently used at 5-minute intervals until the product reached the downstream end of the drain, for a maximum of six flushes. The purpose of this fundamental step was to enable the hydraulic forces and interaction between the water and product to rinse the sample of its lotions. The drainline used in the project was 20 metres long and consisted of 75 mm and 100 mm PVC pipes with two 90-degree elbow fittings, laid at 1% slope.

Once the preconditioning step was complete, the sample was transferred from the catch basket to the slosh box. With the sample inside, the slosh box was continuously tilted at $11^\circ \pm 0.50^\circ$ on either side for a 30-minute period for each product sample. The agitation step was performed using a slosh box with specified parameters (IWSFG 2018b). Parameters such as the tilt angle and rotations per minute of the oscillating motor were calibrated accordingly. The variables considered in the design of the slosh box, such as Reynold's number of 20,000 and 4 litres of water at $15\,^\circ C \pm 1\,^\circ C$, were designed to be closely representative of conditions in existing municipal wastewater collection systems, as per IWSFG (2018b). Finally, a test report detailed the variables and constraints used for calculations as specified in IWSFG (2018b). Twenty of the 101 products were selected for further testing of fibre composition. The fibre composition analysis was carried out in accordance with the Technical Association for the Pulp, Paper and Converting Industry (TAPPI)/ American National Standards Institute (ANSI) Test Method T 401, Fibre Analysis of Paper and Paperboard (TAPPI 2018). This TAPPI/ANSI Test was completed through the SGS Test Method carried out by a third-party laboratory (SGS-IPS Testing in Appleton, WI, USA).

RESULTS AND DISCUSSION

Product labelling

Figure 1 shows the number of products tested in each of the ten categories displayed. Cleansing wipes represent the largest proportion of products tested, and almost half of the products tested within this category are labelled as 'flushable'. Examination of the product labelling showed that they were either labelled 'Flushable' or (1) had text that indicates 'do not flush', (2) provided the DNF symbol, (3) provided both the DNF symbol and test that indicated 'do not flush' or (4) had no disposal instructions.

As evident from the results of evaluating the product packaging adherence to the CoP, presented in Table 1, specific categories like baby wipes, cleansing wipes and diaper liners required that all their products display a DNF symbol. However, none of the products tested adhered to the criteria for package labelling in the CoP, including those that were required to display the symbol. The results indicate that there is a great deal of inconsistency with package labelling as there are varying percentage compositions that display a DNF symbol. Some product categories, such as cleansing cloths, dog waste bags, facial tissues and paper towels displayed a DNF symbol even though the criteria do not specify that such is required. Other categories like diaper liners, where 100% of the products are required to display a DNF symbol, showed that none of the products displayed a DNF symbol.

A key visual observation made during the evaluation of product adherence to package labelling was that although 19 products displayed a DNF symbol, the symbol failed the stated criteria because of several reasons. These reasons may have included the following:

- DNF symbol appears on plastic wrapper that is designed for removal prior to product usage, in which case the DNF symbol is not visible to user after wrapper has been discarded.
- DNF symbol is either too small or hidden.

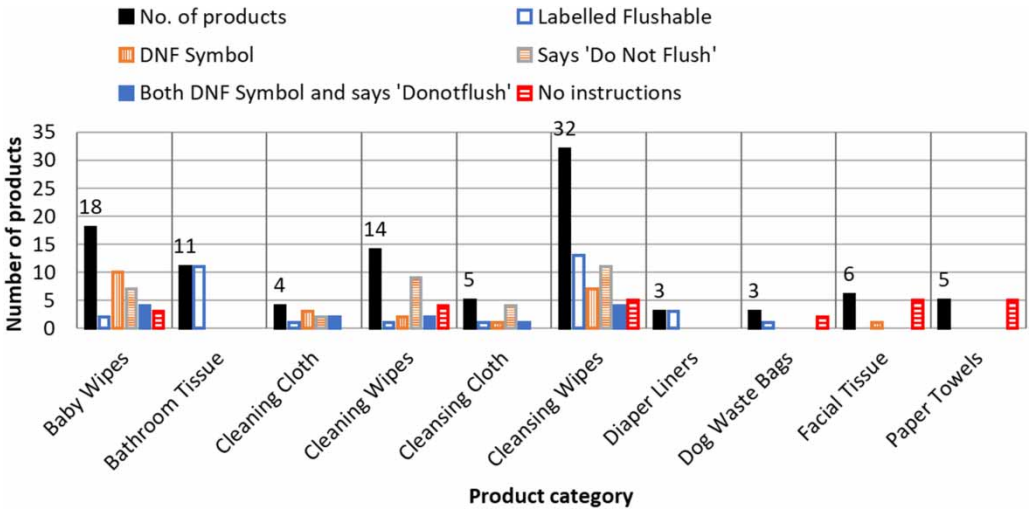

Figure 1 | Overview and labelling summary of products tested within each category.

- DNF symbol is displayed under the product fold.
- Symbol displayed is not the universal DNF symbol.

Drainline clearance

As per the procedure in the PAS 3 (IWSFG 2018b), product samples were required to clear the drainline within a 30-minute period. Some products were conveyed out of the drainline within the allotted time while others remained inside the drainline. Products that did not clear the drainline within one flush were flushed subsequently every 5-minutes until they cleared the drainline, for a maximum of six flushes within 30-minutes. Heavier products, such as those within the product categories of baby wipes, cleaning cloths, cleaning wipes, cleansing cloths, cleansing wipes, diaper liners and paper towels, often required multiple flushes to clear the line. Figure 2 depicts the average number of flushes per product category based on five tests. Note that there are small variations, with 81 products achieving the same results for each flush, and the remaining 20 products having a standard deviation of less than 0.5 flushes. Cleaning cloth flushing results indicate about four flushes on average as the maximum and bathroom tissue showing just below two flushes on average as the minimum between the ten product categories tested. Products with a slightly lower mass, such as those within the product categories of bathroom tissue, dog waste bags and facial tissues, often cleared the drainline in one to two flushes. Products that required another flush or two would normally flow past the two

Table 1 | Product adherence to package labelling[a]

Product category	% of products that require a DNF symbol	% of products that display a DNF symbol	% of products that meet DNF symbol criteria
Baby wipes	100	56	0
Bathroom tissue	n/a	0	n/a
Cleaning cloths	25	75	0
Cleaning wipes	86	15	0
Cleansing cloths	n/a	20	n/a
Cleansing wipes	100	26	0
Diaper liners	100	0	0
Dog waste bags	n/a	0	n/a
Facial tissue	n/a	17	n/a
Paper towel	n/a	0	n/a

[a]n/a indicates that, based on the CoP, product category does not require a DNF symbol or is out of scope (used for comparison only).

Figure 2 | Average number of flushes per product category.

elbow fittings and stop quarter of the way through the drainline at about 5 metres.

Product disintegration

Results of product disintegration testing, shown in Table 2, indicate that only 17 out of the 101 products tested showed some visible evidence of disintegration. From these 17 products, 11 products fully disintegrated. However, all 11 of these products were from the bathroom tissue category. Other products, such as cleansing cloths, cleansing wipes, facial tissues and paper towels partially disintegrated, whereas products from the categories of baby wipes, cleaning cloths, cleaning wipes, diaper liners and dog waste bags did not show any evidence of disintegration.

It is to be noted that between the five test repetitions for each product, the products showed little to no variability between sequential tests. If a product was deemed a FAIL, then neither of the five test repetitions showed successful disintegration.

Table 2 | Summary of product disintegration testing results

Product category	Partially disintegrated	Fully disintegrated
Baby wipes	0 of 18	0 of 18
Bathroom tissues	11 of 11	11 of 11
Cleaning cloths	0 of 4	0 of 4
Cleaning wipes	0 of 14	0 of 14
Cleansing cloths	1 of 5	0 of 5
Cleansing wipes	1 of 32	0 of 32
Diaper liners	0 of 3	0 of 3
Dog waste bags	0 of 3	0 of 3
Facial tissues	3 of 6	0 of 6
Paper towels	1 of 5	0 of 5

Although a total of 23 out of 101 products tested are labelled 'flushable', only two products partially disintegrate, and none of these 23 products fully disintegrate. Bathroom tissue is not included in this count of 23 consumer products. It should be noted that bathroom tissue here is assumed as 'flushable' by the public and is therefore used as a comparison to show that it fully disintegrates. Moreover, from the 101 products assessed for flushability, 90 (out of 101) products were deemed as FAIL according to the PAS 3 (IWSFG 2018b) because the specification states that at least 95% or more of the material must pass through a specified sieve to be classified as a PASS.

Product composition

The composition of 20 products, selected to cover all categories and determined using TAPPI/ANSI Test Method T 401, is shown in Table 3. The most prevalent fibre type amongst the products evaluated was softwood. The dominant regenerated cellulose material amongst the consumer products evaluated was rayon, whereas the recessive material used was lyocell. From additional research, an estimation of 20–35% composition of polypropylene was made for products no. 6 and no. 11. Overall, 75% of the consumer products evaluated for fibre composition in this project contained at least one type of man-made material – synthetic or regenerated cellulosic material. Seven products out of the 20 tested contained some form of plastic fibres in significant quantities, and these products do not pass the IWSFG (2018b) Criterion One (Safety in the Environment and Composition of Materials), which specifies a product to be acceptable if the percentage by weight of the synthetic fibre is less than 1%.

CONCLUSIONS

A number of public education campaigns have been developed over the years to ensure that nothing other than urine, faecal matter and paper enters the sewer systems. However, the results of these activities are not entirely clear because many municipalities are continuing to report increases in blockages and citing wipes as one of contributors. At the same time, the number of consumer products in the form of wipes continues to increase.

The current guidance on flushability of consumer products requires major improvements to provide clarity and ensure appropriate disposal, which may be compromised even within household laterals. As evidenced by the results

Table 3 | Fibre composition of select product samples

	% Fibre type						
	Natural			Man-made			
				Regenerated		Synthetics	
Product no.	Softwood	Hardwood	Cotton	Lyocell	Rayon	Polyester	Polypropylene
1 Baby wipe (flush)	70.5	1.1		28.4			
2 Baby wipe (flush)	75.8	0.3		23.9			
3 Baby wipe (DNF)			24		20.8	55.2	
4 Baby wipe (DNF)					34	35.5	
5 Baby wipe (DNF)					64.5	35.5	
6 Baby wipe (DNF)							$20–35_{estimate}$
7 Baby wipe (DNF)					29	71	
8 Bathroom tissue	41.6	58.4					
9 Cleansing wipe (DNF)				100			
10 Cleansing cloth (flush)	99	1					
11 Cleansing wipe (DNF)							$20–35_{estimate}$
12 Cleansing wipe (flush)	61.8	0.4			37.8		
13 Cleansing cloth (flush)	73.6	0.1		12.4	14		
14 Cleansing cloth (flush)	59.1	0.2			40.8		
15 Cleansing cloth (flush)	70.7	1.4		27.8			
16 Denture wipe (DNF)					87.2		12.8
17 Diaper liner (flush)					100		
18 Diaper liner (flush)	100						
19 Facial tissue (DNF)	30.1	69.9					
20 Paper towel	62.7	37.3					
Total count of product tested containing fibre type	11	10	1	5	9	4	1[a]

[a]Estimates are not included in the total count.

of this study, the development of the voluntary CoP has not resulted in coherent and consistent labelling being provided to the consumer regarding the disposal of products contained in the package. The consumer advice being advocated by municipalities and sewer systems operators to only flush human waste and paper down the toilet is confirmed to be the only correct guidance by this study. In addition, there are current initiatives to regulate the labelling of 'flushable' products (e.g. California Bill AB-1672 Solid Waste: flushable products) and to conduct official investigations of the current flushability claims of manufacturers (e.g. #FlushMeNot Petition in Canada). The need for a global definition of a 'flushable' product exists and it is vital that it is brought into legislation in an effort to combat misconceptions around consumer products that may exist internationally.

A large number of products may remain intact in the sewer systems, failing to disintegrate and potentially causing blockages and other issues described earlier. The use of the word 'flushable' indicates that a product is safe for wastewater collection systems. However, based on the results presented in this report, it is evident that none of the products other than bathroom tissue are 'flushable'. Therefore, eliminating the use of the word 'flushable' from consumer products can help to reduce, if not eliminate, the presence of these products in wastewater collection systems, treatment plants and the natural environment.

Work orders completed by crews responding to sewer blockages often contain valuable information on the potential causes, and these should be collected and processed to gain further insight. In the longer term, a methodology needs to be developed to collect the information on

blockage causes in a more systematic and easy way to better understand this issue and to aid in developing effective control measures.

The current study should be expanded to include the testing of products sold in other jurisdictions, as well as other consumer products such as feminine hygiene products, kitty litter and dental floss. The consumer products that are of interest here undergo changes in terms of the manufacturing process and materials used, and these should be accounted for through closer communication with manufacturers and possible re-testing. Finally, emission of a significant portion of products to the environment (e.g. through sewer overflows) will result in discharge of not only natural fibres common to toilet tissues but also synthetic materials.

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