City of Vancouver
Study of the Treatability of gDiaper™ Disposable Diapers and their Impact on Sewer and Wastewater Systems

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Introduction

Like many other communities, the City of Vancouver (COV or the City) has had difficulties with rag material clogging pumps in its sewage collection system. This rag material also chokes equipment at its two water reclamation facilities (WRF); Westside (WS) and Marine Park (MP). This incompatible rag/solid material adversely impacts the collection system and efficiency of the treatment process and drives up maintenance and repair costs. The recent introduction of what are advertised as "flushable disposable diapers" has the potential to significantly increase the amount of incompatible rag/solid material which must be handled by the City's wastewater management infrastructure. This rag/solid material could impact the quality of wastewater effluent discharged to the Columbia River. These concerns within the Department of Public Works prompted further investigation into the gDiaper product[1].

The gDiaper is composed of an outer pant made of rag material that is intended to be re-used, and a disposable insert that is intended to be flushable. The disposable insert is composed of three primary elements: 1) a semi-permeable outer liner made of viscose rayon[2], 2) engineered cellulose fluff filler material, and 3) sodium polyacrylate crystals (PAC) which act as the primary absorbent. The City's Wastewater Engineering Team (WET) conducted a periodical and literature search, solicited information through Water Environment Federation networking resources, and contacted the manufacturer and the City of Portland

[1] "gDiapers" is the name given to an Australian product, "Weenees", for marketing purposes in North America. Thus analyses performed in Australia will refer to the product as a Weenee while analyses performed in North America will refer to the product as a gDiaper. Both terms will be used in this paper in an effort to accurately relate analytical results as they were originally obtained and reported.

[2] Viscose rayon is defined by the U.S. Trade Commission as "manmade textile fibers and filaments composed of regenerated cellulose" (4).

Bureau of Environmental Services for relevant information[3]. COV found three instances of research or analysis, all of which were supplied by the manufacturer of gDiapers: one Australian study examining the degradability of Weenees in commercial septic systems (9), one BOD_5/COD analysis[4] (1), and one "flushability" test (2). Note that the BOD_5/COD analysis and the flushability test were commissioned by the manufacturer.

While these sources provide some valuable information, they do not fully address the behavior of gDiaper disposables across the spectrum of mechanical and biochemical systems typical of a municipal sewage collection and treatment system. Within the collection system, the City is interested in the potential impact of the gDiaper disposable materials on mechanical equipment which may affect sewage flow. At the water reclamation facility, the City is interested in how the gDiaper component materials would impact pumps and other mechanical devices. Settleability and degradability of these materials in a highly aerobic environment with an entirely different biochemical composition and a much shorter residence time than that which is used in anaerobic septic systems are also of key importance to the City.

In order to better understand the potential impact of this new product to the City's wastewater stream, the City WET performed an additional literature search for information on the biodegradability of gDiaper component materials. The potential volume of new material to be treated or removed based on local demographic data was calculated and a controlled study involving laboratory and field investigations was conducted.

Laboratory Analysis Methodology

gDiaper Decomposition Analysis

M.A. Line, University of Tasmania – Weenee pads and "commercially-available plastic nappies"[5] were placed in three different environments: soil, earthworm compost, and a commercial septic tank designed for multi-family housing. The

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[3] The City of Portland was contacted because gDiapers' manufacturer indicates in their advertising that this city conducted a review of their product. The Wastewater Group at Portland BES was unaware of any such review and could not provide any information on gDiapers. The manufacturer was also unable to refer COV to any specific report or individual in Portland who might have been involved in this review.

[4] BOD_5 provides a measure of treatability of a substance in a municipal wastewater facility. COD is a measure of the total amount of organic material in a substance. COD is generally higher than BOD_5 because a certain amount of organic material will exist in a form that is not readily metabolized by microorganisms. A high BOD_5 and BOD_5/COD ratio indicates that a wastewater is readily degradable by microbes under aerobic conditions. Likewise, a wastewater with low BOD_5 and low BOD_5/COD ratio will not be degraded at a municipal wastewater treatment facility and will pass through to either the biosolids or the receiving waters into which the facility discharges.

[5] Brand information for the plastic nappies used in this study is not provided by the author.

pads and diapers were removed at irregular intervals for a dry-weight determination, from which a degradation rate was calculated. The experiment also evaluated the toxicity of sodium polyacrylate based on earthworm health and soil microfauna health. The parameters used to evaluate earthworm health were not reported. The parameters used to evaluate microbial health were agar plate colony density, plate colony size, and plate species diversity.

BOD_5 and COD Analyses

Allison Laboratories - These analyses were done in March of 2004 in accordance with "Standard Methods for the Examination of Water & Wastewater, 17th edition or Analysis of Raw, Potable & Waste waters"[6]. The details of the specific analytical tools employed within the broader methods referenced, such as seed source and seed control, are unknown as this was simply a commissioned chemical analysis and not a directed study. The dilution used in analysis was one "Medium Size Weenie Pad" (equivalent to 1 medium gDiaper liner pad) in 10 liters of tap water (approximately equivalent to the volume of 1.5 standard flushes). Three different mixtures were tested: the tap water as a blank, the mixture of the pad and water, and the supernatant remaining after the pad was allowed to settle for an unknown period of time.

Physical Property Analyses

COV - The City performed two 30-minute settleability tests on the cellulose fluff material from the disposable gDiaper liner pad using a 1 liter Imhoff cone filled with typical WRF influent. The tests were done with ¼ cup and ½ cup of fluff[7]. One medium gDiaper Liner pad contains approximately 2 cups of filler material. The mixture of fluff and influent was allowed to stand for 30 minutes, after which time the level of settling was recorded and observations were made about the interaction between the fluff and the influent. The City also performed a simple observational experiment with the disposable gDiaper liner pad material and clean tap water. The cellulose/PAC filler material from a small liner pad was placed into a 5-liter vessel and water was added in 250 ml increments. The interaction was observed and recorded.

NSF Engineering & Research Services - NSF Engineering & Research Services, as commissioned by Down to Earth Designs Inc., prepared a report in May of 2005 which examined the ability of the gDiaper disposable liner pad to pass through typical North American domestic plumbing systems. Because the content of the NSF report has been restricted to the internal use of Down to Earth Designs Inc. by NSF, the methodology is not detailed in this report. Note that within the NSF

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[6] The analyst cites these two references as equivalent alternatives but does not specify which was the primary method followed.

[7] The liner pad filler is designed with very small PAC crystals embedded in the compressed cellulose fluff. Thus a complete segregation of these two dry materials is not achievable and it is expected that a small amount of PAC was still present in the settleability test.

report, it is clearly stated that the report is neither an endorsement nor a certification of the gDiaper product.

Field Study Methodology

Eight pump stations were selected for observation; three serving the Westside facility (Table 1) and five serving the Marine Park facility (Table 2) so that approximately one half of the introduced material was received at each facility. The criteria considered in choosing locations included:

a. Pump impeller type, with the goal of testing a variety of designs
b. Sewage type (domestic vs. industrial) collected by pump station
c. Distance between introduction manhole and pump station to provide adequate mixing time within the sewer line

To begin the test, 200 gDiaper disposable liner pads were colored with permanent, environmentally safe red dye. After the pads were dyed they were allowed to dry overnight to eliminate the possibility that the dye would leach on to other material in the collection system.

Table 1: Westside Pump Stations to be Impacted

Pump Station	Pump Type	Sewage Type	Test Entry Manhole	Drop Time	Travel Time to WSWRF
63rd Street	Maxi-prime centrifugal 2-vane impeller	Residential	11222	8 am	6.51 hrs.
Chateau Crest	Hydronics self prime	Residential	9796 or 9772	7:45 am	6.34 hrs.
Pebble Creek	Submersible	Residential	16859	7:30 am	6.59 hrs.

Table 2: Marine Park Pump Stations to be Impacted

Pump Station	Pump Type	Sewage Type	Test Entry Manhole	Drop Time	Travel Time to MPWRF
Andresen	2 Submersible 4 Ingersoll-Dresser Dry Pumps	Residential, Commercial, Industrial	NA[8]	(flow from 136th Ave PS)	5.79 hrs.
Kelly's Landing	Centrifugal 2 vane	Residential	7587	7:30 am	7.36 hrs.
Sand Castle	2-vane impeller	Residential	8092 or 8086	7 am	6.11 hrs.
Twin Peaks	Vortex	Residential	7603	7:30am	6.97 hrs.
136th Ave	Flooding Suction Head	Commercial	7939	7am	5.98 hrs.

[8] There is no introduction manhole for Andresen pump station because it is in direct sequence with the 136th Avenue pump station.

Part 1, performed June 13, 2006

1. Manufacturer's instructions were followed in preparing gDiapers disposable liner pads for insertion into the sanitary collection system:
    a. The outer linings of the pads were torn.
    b. The cellulose fluff and PAC were dumped into a 5-gallon bucket at a dilution of three diapers per five gallon bucket of water to simulate toilet flushing. At 3.79 l/gal, this is equivalent to 6.1 liters per flush or roughly 3 flushes per 5-gallon bucket[9].
    c. The contents of each bucket were stirred to break up the pad material.
2. 20 diapers (6 2/3 buckets) were dropped into each of the seven selected manholes. Observations on the behavior of the gDiaper pad material were recorded.
    a. Pump stations were monitored to detect impacts. Observations were recorded.
    b. WRF facilities were monitored to detect impacts. Observations were recorded.

Part 2, performed July 11th, 2006

1. Four whole, dyed gDiapers disposable liner pads were soaked in water and dropped into each of the same four manholes used in Part 1 which serve Marine Park WRF. The sides were torn open but the complete disassembly and stirring required by the product's instructions were not done. This procedure was an effort to simulate the impact from those consumers who may not strictly adhere to the manufacturer's instructions for disposal. Observations were recorded.
2. Pump stations were monitored to detect impacts. Observations were recorded.
3. Observations of any impact on relevant WRF were recorded.

Research, Data, and Observations

Individual Component Properties & Degradation Mechanisms

Sodium Polyacrylate (PAC) - Sodium Polyacrylate is a cross-linked organic polymer synthesized from acrylic acid monomers ($CH_2CH(CO_2Na)$). Polyacrylate is commonly used in most disposable diapers as well as in gDiapers. It is a super-absorbent material due to its great affinity for water. It is a highly stable chemical and not easily degradable. When dry, the molecules are highly bent and form an opaque solid. When wet, the cross-linked polymer bonds with water molecules and expands to a more linear structure but does not dissolve. Instead, the PAC molecule expands in size to accommodate water molecules bonding to both the interior and exterior surfaces of the polymer allowing the

[9] The Energy Policy Act of 1994 required all new toilets to operate with 1.6 gallons per flush. Older models typically flush 3.5 – 5.0 gallons per use.

molecule to capture up to 100 times its own weight in water (12). PAC is not biodegradable in nature (12, 14), although some research has identified specific consortia of microbes that can break down PAC (3, 6) and another study indicates that the molecule undergoes some mechano-chemical and photo-degradation (13). The length of the PAC polymer chain has been found to be the most significant factor affecting degradation rates, with consumption of 27.9% and 30.1% of the 2-monomer and 3-monomer species, respectively, after 5 days using activated sludge as inoculum. Polymer chains longer than 3 units were not observed to be degraded by activated sludge (3). No mention of adverse microbial impact was found in any of the studies which examined the biodegradability of PAC. However, no instances of directed toxicological research on PAC were found during the course of this study, either. PAC is considered to be non-toxic (9, 12) despite this apparent lack of data[10].

Cellulose[11] - Cellulose is an organic polymer that makes up the primary physical support systems of plants. It is non-toxic, insoluble, and can be biodegraded by terrestrial and aquatic fungi and several species of bacteria that typically inhabit soils, sediments, and the digestive tracts of some multi-cellular organisms. In oxic aquatic environments, *Cytophaga* and *Sporocytophaga* bacteria are the primary digesters of cellulose (10, 11). Bacterial degradation of cellulose is slow, with appreciable decomposition occurring only after a period of several months, and occurs more rapidly under anoxic conditions (5, 7). Hoeniger reports half-lives for water column cellulose decomposition ranging from a minimum of 70 days in the supernatant above anoxic sediment to many years in water over-lying oxic sediments, and reports half-lives for oxic sediment decomposition ranging from 25 – 50 days. Cellulose does not biodegrade in typical aeration basins found in many municipal wastewater treatment facilities. This is due in part to relatively short detention times of 3 to 6 days.

gDiaper Decomposition Analysis

M.A. Line, University of Tasmania

The observed degradation rates are presented in Table 4. The author states simply that "no ill effects of earthworm exposure to polyacrylate was [sic] apparent", but does not explain how that determination was made. No difference was observed in microbial colony number, size,

Table 4: Degradation Rates

Environment	Half-life Days
Soil	67
Septic Tank	55
Earthworm Compost	35.5-40

[10] M.A. Line notes that PAC does impact the pigmentation of exposed microbes but does not investigate the biochemical mechanism at work. Narsavage-Heald indicates that PAC presents environmental concerns due to it's persistence but accepts that there is no toxicological risk. Thus the actual environmental impact of PAC remains inconclusive.

[11] Viscose rayon, as simply a re-arrangement of cellulose monomers, is subject to the same environmental biochemistry as natural cellulose with respect to applicable degradation mechanisms.

or diversity between agar plates cultivated with or without polyacrylate. The author notes a difference in the pigmentation between those colonies exposed to polyacrylate and those in the control group but does not offer any further discussion or possible explanation.

BOD_5 and COD Analyses

Allison Laboratories

Results are provided in Table 3. As this was a simple chemical analysis and not a directed study, no discussion of methodology or results accompanies the data. The BOD5/COD ratio resulting from this analysis is 0.006875 for the pad/water suspension and 0.0625 for the supernatant. Domestic sewage is typically 0.3 to 0.6. A lower number indicates lesser biodegradability of the material.

Table 3: BOD_5 & COD Results

Sample	BOD_5 mg/l	COD mg/l	Ratio BOD/ COD
Blank	<1	-	-
Pad / Water	11	1,600	0.007
Supernatant after settling	5	80	0.06
Raw sewage	200	625	0.32

Physical Property Analyses

COV

Using ¼ cup of filler material from the gDiaper disposable pad, after 30 minutes a slurry/suspension was present from 4 ml/L to ~ 990 ml/L of the 1,000 ml Imhoff cone. Using ½ cup of filler material, at 30 minutes a slurry/suspension was present from 2 ml/L to ~ 1000 ml/L. It should be noted that in both tests the suspended solids from the wastewater did not settle as expected, but were suspended in the slurry. However, running the same settleability test on the raw wastewater alone, the suspended solids did settle as is typical and desirable. When combined with clean water the fluff/PAC filler material forms an opaque gel-like substance that incorporates both the cellulose and PAC. The content of one small gDiaper liner pad was observed to absorb 1 liter of water as the material formed a gel and expanded in size. Water in excess of 1 liter was not absorbed but dispersed the gel solids into a suspension.

NSF Engineering & Research Services

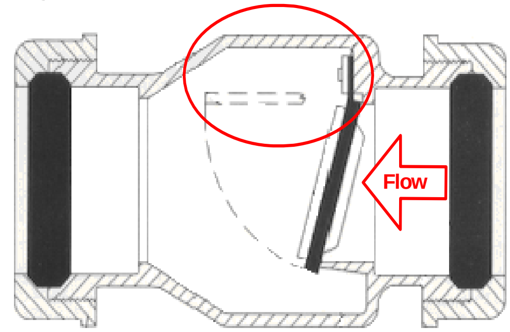
As previously stated with regard to methodology, the content of the NSF report has been restricted by NSF and does not constitute an endorsement or certification. Therefore, the results are not detailed in this report except to state that they were primarily positive with respect to the ability of a large gDiaper disposable liner pad to clear standard North American toilet fixtures. The focus of the NSF study was flushability, not treatability.

Field Study

Collection System – Cellulose fluff and PAC were observed to blend readily with the raw sewage mix during low flow and normal flow conditions in the collection system. The fluff/PAC remained suspended at mid-level in the effluent stream and was not observed to adhere to concrete pipe surfaces.

- Part 1 - The sodium polyacrylate/fluff gel left sticky residue on the down-stream side of a check valve at the Sand Castle pump station (Figure 1). Clogging occurred at the Sand Castle pump station and had to be manually cleared. The material removed included dyed gDiaper liner pad rayon and cellulose fluff as well as other cloth rag material. No adhesion or clogging was observed in the other pump stations.

Figure 1: Area of Gel Accumulation



Part 2 - Although the sides of the disposable pads were ripped, they did not fall apart as expected. After the disposable pads had become saturated with water (about 10 minutes), they were roughly the size of soccer balls and did not move down the line until additional water was introduced with a flush truck. Significantly more water than an average toilet flush had to be introduced in order to move the gDiaper disposable pads. After arriving at the pump station, the swollen pads could be seen floating in the wet well. The disposable pads did not pass through the pumps at the pump stations.

WRFs - Sticky residue from the cellulose/PAC mixture was observed adhering to bar screens at MP WRF. Red fluff and rayon pad liners were observed on the bar screens at the Marine Park plant. In the primary clarifiers, the gDiaper disposable pad material became too dilute to observe in further WRF treatment processes. It is presumed that the combination of substantial dilution and agitation in the aeration basins fully disaggregated any remaining cellulose/PAC gel into its component materials.

Calculations

Based on the most recent U.S. Census data, The City of Vancouver had 11,497 residents under the age of 5 in 2000, or 8% of the total population of 143,560. Assuming a similar age distribution still exists, 8% of the city's 2005 population of 154,800 is 12,397 toddlers. Assuming that half of these children are under 2.5 years and that 2.5 is the average age of toilet-training, there are approximately 6,200 toddlers in diapers in the City of Vancouver. Finally, assuming 6 changes per day for these children, Vancouver is generating roughly

37,200 soiled diapers per day[12]. The equivalent volume of dry cellulose generated through gDiaper disposables use is calculated with the following conversion:

$$\#\frac{gDiapers}{day}\times 0.5\frac{liters}{gDiaper}\times 0.264\frac{gallons}{liter}=\#\frac{gallons}{day}$$

The estimates in Table 4 were calculated based on the proportion of the COV parent population using gDiapers disposables and flushing the liner pads rather than using cloth diapers or sending their disposable diapers directly to a landfill in the solid waste stream.

Table 4: Cellulose/PAC Solids Added to COV Wastewater

Percentage of COV Infants in gDiapers	# of gDiapers Disposed of Daily	Gallons of Fluff Discharged to WRFs
1	372	49.2
5	1860	246
10	3720	492
50	18600	2460
100	37200	4920

The volume of gDiapers disposable pads used in the COV field study (approximately 200 medium sized diapers) represents approximately one-half of the expected daily load if 1% of the parents in the City of Vancouver with children in diapers used gDiapers.

Discussion

The adhesion observed in the Sand Castle pump station is a cause for concern, but it should be qualified by the fact that this pump station was operating at 50% capacity because one of the two pumps was off-line for maintenance. It should also be noted that the adhered mass was not due solely to the gDiaper disposables material. However, the gDiaper was clearly a contributing factor. The accumulation of PAC gel on the down-stream side of the check valve (figure 1) was likely significant, as this could cause the valve to mal-function. The result would be a flow constriction through the valve.

The residue observed on the bar screens at MPWRF provides further evidence of the adhesive properties of the PAC/cellulose gel. Thus it appears that the gelatinous PAC/cellulose conglomerate can be expected to behave in a similar

[12] Estimates of diaper use were found to vary widely from a maximum of 10 diapers per day to a minimum of 3.3 diapers per day. 6 is thought to represent a reasonable average based on this range (8).

fashion to fats, oil & grease (FOG). FOG forms congealed deposits and is the cause of extensive clogging in municipal collection systems, which is now significant enough that it has begun to be targeted by municipal regulations[13].

The amount of incompatible solids present in the COV sanitary collection system should be managed such that pump stations can undergo routine maintenance activities without experiencing the level of dysfunction that was observed during this study. It seems reasonable, given the amount of problematic solid material that inadvertently ends up in the collection system, that materials shown to cause disruption should not be introduced intentionally.

Wastewater treatment plants in the City of Vancouver are aerobic physical-biological processes, which is typical of most US municipal plants[14]. Poor settleability results indicate that the cellulose fluff material will pass through primary clarifiers into aeration basins. Low BOD_5 and an extremely low BOD_5/COD ratio of 0.006875 indicate that this material is largely not treatable in aeration basins[15]. Over all, the indication is that this material is not readily treatable in City of Vancouver WRFs and will pass through the plants to the receiving waters of the Columbia River.

There is an additional risk to the receiving waters due to the potential for interference with the ultra-violet (UV) treatment at COV WRFs. UV treatment is the method of disinfection used by the City to reduce pathogens in wastewater effluent. The proper function of a UV disinfection system requires that the effluent be free of excess suspended solids and particulates so that the UV light can impact and disrupt the cellular DNA of pathogens. This renders the pathogen cell unable to reproduce itself. Suspended solids can absorb UV light, effectively providing a shield for pathogen cells and allowing them to be discharged into the Columbia River as viable organisms. If this were to occur, this would present an elevated health risk for people who come in contact with river water.

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[13] The City of Los Angeles, California has completed a definitive study of the impact of FOG and the importance of eliminating this type of input to maintain good flow conditions and prevent the over-flow of raw sewage to surface areas where it may pose a public health risk. The reader is referred to www.calfog.org for additional FOG information.

[14] The reader is referred to the EPA wastewater division's Wastewater Primer for a more complete description of municipal wastewater treatment processes. It can be accessed at www.epa.gov/npdes/pubs/primer.pdf.

[15] BOD_5/COD is a common measure of biodegradability; a value of 1 indicates ideal biodegradability while a value of 0 indicates that a material is not biodegradable at all. Wastes that are readily treatable in COV WRFs have a minimum BOD_5/COD value of around 0.32. Any oxygen demand not consumed or settled during treatment will be passed through to the receiving water.

A Summary of gDiapers' Likely Route through COV Wastewater System

Collection System

If disposed of in accordance with the manufacturer's instructions, the gDiaper material blends readily with the raw sewage upon entry into the collection system. The majority of the fluff and PAC will flow through to the WRFs while a small portion will remain adhered to surfaces within the sewerage system. If introduced into the sewer system, some of the rayon pad covers will be intercepted at various pump stations where rag material can accumulate. The remainder will flow through to the WRFs.

Solids Screening

Any rayon coverings which pass through pumps in the collection system will be removed by the bar screens at MP and sent to a landfill. At WS, which uses a barminutor, the rayon coverings will be chopped up and sent into the primary clarifiers.

Primary Clarifiers

At WS, the pieces of rayon rag generated in the barminutor will settle in the primaries. Both field and laboratory investigations indicate that the cellulose fluff and PAC will not settle out to a significant extent in primary treatment. Laboratory investigation further indicates that the cellulose/PAC material may trap some additional suspended solids that would otherwise settle out in the primary clarifiers. This conglomerate of cellulose/PAC and suspended solids will flow through to the aeration basins.

Any PAC that does settle out in the primary clarifiers will trap additional water in the primary solids, thereby increasing the water content of the primary sludge. All material that settles in primary treatment is ultimately sent to the fluidized bed furnace.

Aeration Basins

Neither cellulose nor PAC is biodegradable in the aeration basins and neither is expected to be incorporated into the microbial cell mass cultivated in the aeration basins. Some additional conglomeration may occur with the PAC and other suspended solids prior to discharge to the secondary clarifiers.

Secondary Clarifiers

The conglomerated or "flocculated" PAC/cellulose should settle out in the secondary clarifiers, becoming secondary sludge, which is ultimately incinerated. The remaining PAC and fine cellulose fibers are expected to continue as suspended solids into the effluent channels.

Gravity Belt Sludge Thickener

The super-absorbent properties of PAC will hamper the removal efficiency of the sludge thickening process. Because PAC absorbs large quantities of water, it is very likely to increase the water content of the sludge that is burned in the fluidized bed furnace.

Fluidized-Bed Furnace

The additional solids (cellulose, PAC and rayon) and additional water content of the sludge would reduce the efficiency of the furnace and possible unwanted residues may be deposited in the furnace due to incomplete combustion. More diesel fuel would be consumed due to the higher water content of the sludge. Ultimately, more carbon dioxide would be discharged to the atmosphere, and more ash would be created for disposal.

Ultra-Violet Disinfection

The cellulose particulate matter that remains in the effluent is likely to interfere with the proper functioning of the UV disinfection system. The cellulose particles absorb the UV wavelength that would otherwise disrupt the cellular DNA of the pathogens in the effluent. The result would be final effluent discharging to the Columbia River which is higher in suspended solids and COD, and contains a greater number of viable pathogens.

Impact Summary

- Increased rag material to be removed at pump stations and increased rag-related maintenance at pump stations
- Increased rag material to be screened and landfilled at MP
- Increased volume and water content of the sludge which in turn increases:
    - the number of hours the furnace is run
    - the consumption of diesel fuel
    - the amount of atmospheric pollutants discharged
    - the amount of ash to be disposed
- Increased suspended solids content of final effluent
- Increased viable pathogens in final effluent
- Increased environmental impact of COV wastewater

Additional Questions

- How much PAC (by weight) is in each gDiaper disposable liner pad? This figure could be used to calculate an estimate of the additional water retained by the sludge at various levels of market-saturation of the gDiaper product. This might then be used to estimate the increased concentration of other constituents in the primary effluent as well as the increase in polymer & diesel required in the furnace. PAC & fluff are integrated and not easily isolated from one another, thus an accurate quantifiable dry mass is extremely difficult to determine.

- Could clogging be exacerbated in high-density housing areas? Specific to COV, if the Multi-Ceptor pilot is successful at controlling fats, oils and grease, and this device is added to COV infrastructure, is the pump system in a Multi-Ceptor capable of handling the high rag-load of gDiapers from an apartment complex?

Conclusions

The City of Vancouver operates a wastewater collection system and two water reclamation facilities that use physical and biological processes to treat the City's wastewater. Treated water is discharged to the Columbia River under the strict requirements of a discharge permit issued by the Washington State Department of Ecology.

The City has both a regulatory mandate and a civic responsibility to protect our collection and treatment system's employees and physical assets, the public, and the environment, including the receiving waters of the Columbia River.

Incompatible and untreatable materials, substances and other wastes being introduced into the collection system present an ongoing issue for wastewater collection and treatment systems. Some examples of these include rags, plastics, diapers and wipes, feminine hygiene products, dental floss, cooking grease, kitty litter, cigarette butts, household hazardous waste, pharmaceuticals, and personal care products.

These wastes can cause maintenance problems within the collection and treatment system, increase the need for system cleaning, damage collection and treatment system equipment, upset treatment processes, endanger employees, and ultimately remain partly or wholly unchanged by treatment processes and pass through to the receiving waters. The results are increased operating costs that must be borne by customers and the potential for pollutants to be discharged to receiving waters, such as the Columbia.

A disposable diaper product (gDiapers) that markets itself as a flushable alternative to cloth diapers and traditional disposable diapers was recently introduced into the marketplace. Questions were posed to the City as to the potential impacts on the collection and treatment system and the ultimate treatability of this new product. After being unable to locate relevant research on the product, the City chose to conduct a basic study to examine these issues. To date, the City's study is the only such effort of which we are aware that has investigated the potential impacts of this product on a typical municipal wastewater collection and treatment system and the capacity of such a system to treat wastewater containing this product.

The City's study raises some concerns about potential impacts on the City's collection and treatment system and the treatability of the product in this particular environment. Primary among these were the potential for increased suspended solids discharge and related impacts and the apparent non-treatability of cellulose and sodium polyacrylate polymer. Secondary concerns related to potential impacts on the collection system of increased ragging and congealed solids deposits, particularly at the City's sanitary pump stations.

The City's study reflects the City's system. It was not meant to be exhaustive or the definitive study concerning this product and its potential impacts on universal wastewater collection and treatment systems and treatability. The City strongly recommends additional in-depth research be done to fully explore the collection and treatment system impacts and treatability issues raised. The City believes this work would be ideally suited to an academic institution, such as Washington State University, University of Washington, Portland State University, Oregon State University or other similarly qualified research university.

Until further research adequately addresses the issues raised by the City's study and conclusively demonstrates that the product is both safe and treatable, it is the City's recommendation that gDiapers, when used by the City's sewer customers, be managed as a solid waste and not flushed down the toilet. Consumers should bag the used product and place it in their garbage container for disposal. Those consumers who have an active and well-managed compost system may also choose to carefully include urine-only gDiaper discards with their compostable wastes.

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COV Engineering

MPWRF - gDiapers Treatment Routes

gDiapers Components:
Rayon Pad Cover
Cellulose Fluff
Sodium Polyacrylate Absorbent

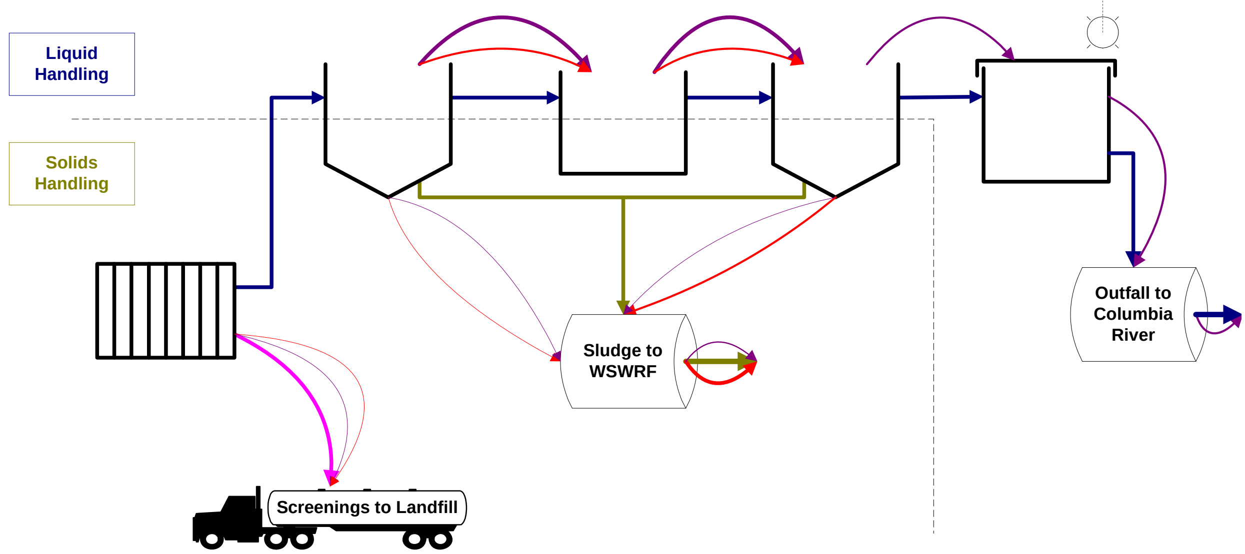
Bar Screens
Large solids, such as rags, are removed and landfilled to prevent clogging in WRF systems

Primary Clarifiers
Physical settling of large suspended solid particles, sludge is extracted and effluent sent to Aeration Basins

Aeration Basins
Biological digestion of sewage through constant injection of air via diffusers in the bottom of the basins

Secondary Clarifiers
Physical settling of remaining solids and bacterial cells generated in ABs

UV Array
Disinfection of effluent using ultra-violet radiation, which disrupts the cellular DNA of pathogens prior to discharge



COV Engineering

WSWRF - gDiapers Treatment Routes

gDiapers Components:
Rayon Pad Cover
Cellulose Fluff
Sodium Polyacrylate Absorbent

Barminutor
Large solids, such as rags, are chopped into smaller pieces to prevent clogging in WRF systems

Primary Clarifiers
Physical settling of large suspended solid particles, sludge is extracted and effluent sent to Aeration Basins

Aeration Basins
Biological digestion of sewage through constant injection of air via diffusers in the bottom of the basins

Secondary Clarifiers
Physical settling of remaining solids and bacterial cells generated in ABs

UV Array
Disinfection of effluent using ultra-violet radiation, which disrupts the cellular DNA of pathogens prior to discharge