Study into the Biodegradation and Ecotoxicity of Aquapak's Hydropol Laundry Bags in Effluent streams

Scope

Minimizing the number of hospital-acquired infections is a primary concern for healthcare facilities worldwide. Contaminated hospital linen poses a particularly high infection risk and infection control measures are described under HTM 01-04[i]. Colour coded water soluble bags are used to bag-up soiled and fouled items (white bags) and infectious linen (red bags). The solubilized bag material is discharged into the environment for further treatment as part of the intended use. As such their environmental impacts need to be quantified. A number of soluble laundry bags are available on the market but limited information appears to be available to confirm their fate and impact once dissolved and released into the environment.

This document examines primary and secondary information sources to assess the fate of Hydropol (polyvinyl alcohol-PVOH) used as hospital laundry bags following its dissolution during the industrial washing process and release into the foul sewer for biological treatment. Secondary research examined available scientific and trade literature from suppliers of PVOH in detergent applications as well as hospital laundry treatability studies. Primary research input was obtained from a supplier of laundry bags to NSW Health, Australia.

This document is intended to provide insights into the fate of soluble laundry bags which form a critical part of hospital infection control. Additionally, the document is intended to invite comments from hospital laundry operators to generate new case study information which can be shared to raise awareness and improve best practice across the sector.

Summary of findings

In summary:

1. Effluent treatability studies confirm high rates of PVOH biodegradation within acclimatized activated sludge biological treatment processes which are operated at 15°C and above
2. Absence of acute and chronic toxicity effects. Acute toxicity data and its extrapolation to evaluate chronic effects indicate low ecotoxicity. PVOH is inherently biodegradable and does not persist in the environment
3. The potential contribution from soluble Hydropol cytotoxic bags to effluent organic strength (as measured by Chemical Oxygen Demand - COD) for three hospitals is considered. Estimates suggest that low percent increases in COD would be observed when using Hydropol bags to contain 1.5% and 20% of linen. These scenarios lead to a maximum COD increase of 0.25% (if 1.5% of laundry bagged up in Hydropol bags) and 3.31% (if 20% of laundry is bagged up in Hydropol bags). These slight increases are unlikely to affect effluent treatment or effluent disposal costs.

Background to the study

Hot water soluble Hydropol laundry bags are designed to dissolve during the high temperature wash cycles which are applied to clean infectious linen arising within hospitals and care homes (65°C

temperature hold for a minimum of 10 minutes within the wash cycle or 71°C for not less than 3 minutes; followed by chemical disinfection[ii]). The dissolved Hydropol is discharged for effluent treatment as part of its intended use, where it is mineralized (biodegraded) together with other biodegradable organics which are generated during laundry cleaning.

A highly polluted effluent is generated during the cleaning of hospital laundry which needs to be treated by a dedicated on-site effluent treatment facility or discharged to a municipal effluent treatment plant. In the case of the latter, laundry effluent is categorized as 'Trade Effluent' and will incur treatment costs based on its volume, strength (COD) and suspended solids content (Annex 1).

Using dissolvable laundry sacks reduces the occupational risks associated with handling contaminated laundry. However, three important questions remain:

1. Once dissolved, is Hydropol biodegraded within activated sludge plants used by municipal sewage works?
2. Are there any acute and chronic environmental impacts from the usage of Hydropol?
3. Will the use of dissolvable laundry bags change the laundry effluent characteristics, overload the effluent treatment plant and increase treatment costs making their use difficult to justify technically and economically?

Effluent treatability of HWS Hydropol within laundry effluents

Schonberger et al (1997)[iii] compiled extensive laboratory test data which confirms the biodegradation of PVOH within activated sludge treatment plants which are used widely in the treatment of laundry effluents. Of the 15 tests described, the extent of biodegradation was noted as follows:

- 7 tests (90% biodegradation or higher)
- 5 tests (80% biodegradation or higher)
- 2 tests (60-75% biodegradation)
- 1 test (29% biodegradation).

It was noted that an activated sludge which is acclimatized to PVOH together with effluent temperatures in excess of 15°C were required if high rates of biodegradation were to be achieved.

Assessment of acute and chronic effects

P&G first introduced its Tide Pod range of laundry detergent pods, with a soluble PVOH coating in 2012[iv]. Since then, soluble PVOH coatings have been widely adopted by many companies for the delivery of 'unit-dose' chemicals for domestic and commercial dishwashers and washing machines.

Soluble coatings are discharged into the environment as part of the intended use and as such their environmental impacts need to be quantified. Henkel carried out an in-depth environmental safety assessment of PVOH associated with its liquid laundry detergent[v]. An extensive set of aquatic toxicological and biodegradation information was collated to develop scenarios on detergent use and to assess the risk associated with the raw material use in the respective scenarios. Dual tests which examined Total Organic Carbon and mineralization to CO_2 qualified PVOH as inherently biodegradable and that a significant proportion would be removed from sewage during biological treatment. The REACH regulations[vi] classify persistent substances as those that display a half-life of

60 days or more in aquatic environments. Since PVOH is inherently biodegradable it was concluded that PVOH is not persistent and does not accumulate in aquatic environments. Acute toxicity data against algae and *Daphnia magna* revealed low toxicity. When extrapolated, it was concluded that chronic effects would not be expected for a range of end-use scenarios. Henkel concluded for all scenarios addressed, that the use of PVOH with its liquid laundry detergent was safe.

Impacts of HWS Hydropol laundry bags on laundry effluent and treatment costs

Around 40 tonnes of laundry were reported to be generated daily by two hospitals in Sweden[vii]. The washing process uses between 6.9 and 9.4 litres water per kg of linen. A supplier of cytotoxic bags to an Australian hospital indicated that almost 43 tonnes of linen were generated daily with each kg requiring 16 litres of water for the washing process[viii]. Contamination includes body wound exudates, urine, vomit and faeces[ix] which results in a high strength organic effluent with a COD of between 8,000 mg/l and 12,000 mg/l[x]. There is also the potential for contamination from a wide range of specialized pharmaceutical compounds, such as cancer drugs which can be excreted by patients via urine and faeces. Taking the data together, there is the potential to release between 2,176 and 4,656 kg of COD per day from the two Swedish hospitals and between 5,488 to 8,232 kg of COD per day from the Australian hospital which needs to be treated by on-site or municipal effluent treatment plant.

The increase in COD from Hydropol bags used to contain 1.5% and 20% of contaminated linen is shown in Table 1. For the Swedish hospitals, the % COD increase is estimated to be between 0.12 and 0.25% (if 1.5% of linen is contained in Hydropol bags) rising to between 1.57 and 3.31% if 20% of linen is contained in Hydropol bags. In the case of the Australian hospital where 1.5% of contaminated laundry is contained in Hydropol bags then % COD increase is estimated to be between 0.07 and 0.11%. If 20% of contaminated laundry were to be contained in Hydropol bags then the % COD increase would increase to between 0.95% to 1.43%.

Such small percentage increases in COD would not impact on effluent treatment plant or incur increased trade effluent treatment charges.

Table 1 Estimated organic loadings from laundry effluents at three hospitals. The contribution to COD from containment of 1.5% and 20% of highly contaminated laundry in Hydropol bags is indicated

					1.5% Cytotoxic waste contained in Hydropol bags			20% Cytotoxic waste contained in Hydropol bags		
	Linen washed (tonnes/ day)	Water use/day (m3)	COD kg/day (min)	COD kg/day (max)	Additional COD from Hydropol bags (assumes 1.5% of hospital laundry bagged in Hydropol bags) kg/day	% increase from Hydropol (assumes minimum COD of 800mg/l)	% increase from Hydropol (assumes maximum COD of 1200mg/l)	Additional COD from Hydropol bags (assumes 20 % of hospital laundry bagged in Hydropol laundry bags) -kg/day	% increase from Hydropol (assumes minimum COD of 800mg/l)	% increase from Hydropol (assumes maximum COD of 1200mg/l)
Sweden - Hospital 1	39.4	272	2,176	3,264	5.41	0.25	0.17	72.00	3.31	2.21
Sweden - Hospital 2	41.3	388	3,104	4,656	5.70	0.18	0.12	73.1	2.36	1.57
Australia Hospital	42.9	686	5,488	8,232	5.92	0.11	0.07	78.36	1.43	0.95

Conclusions

The occupational risks associated with the handling of contaminated and infected laundry are high. Hydropol cytotoxic laundry bags offer an opportunity to reduce contact with contaminated linen. The evidence presented in this document demonstrates that the PVOH used to make the Hydropol cytotoxic bags would contribute a very small percentage increase to laundry effluent organic load, it would mostly be mineralized and removed by existing activated sludge systems, has low ecotoxicty and does not persist in the environment.

Annex 1

The Mogden Formula is used UK water companies to calculate the trade effluent charges a business will incur when it disposes of its industrial effluent to sewer for treatment by the municipal effluent treatment plant:

Trade Effluent Charge = R + [(V + Bv) or M] + B(Ot/Os) + S(St/Ss)

VARIABLE	DESCRIPTION
R	This is the charge for receiving the effluent, given per cubic metre.
V	The charge for primary treatment, per cubic metre.
Bv	An additional charge if the wastewater needs to be treated biologically. This doesn't apply in every case.
M	Extra charges per cubic metre if the water is discharged into the ocean.
B	Charge depending on the biological oxidation of sewage.
Ot/Os	Chemical oxygen demand measurements.
S	Charge for getting rid of primary sewage sludge, in kg.
St/Ss	Measurement of total suspended solids in the effluent, measured per litre.

[i] Department of Health (2016). Health Technical Memorandum 01-04: Decontamination of liner for health and social care. Social Care
[ii] https://www.hse.gov.uk/biosafety/blood-borne-viruses/laundry-treatments.htm
[iii] Schonberger, H; Baumann A and Keller W (1997). Study of Microbial Degradation of Polyvinyl Alcohol (PVA) in Wastewater Treatment Plants. American Dyestuff Reporter

[iv] https://www.freedoniagroup.com/Content/Blog/2017/08/03/Water-Soluble-PVOH-The-Material-Behind-the-Booming-Detergent-Pod-Market
[v] Meier F, Stelter N, Zeese NJ and Tolls J (2013). Raw material supplier and detergent manufacturer cooperate in Environmental Safety Assessment of a new detergent raw material – a case study
[vi] EC (2004) Regulation (EC) No 648/2004 of the European Parliament and of the Council of 31 March 2004 on detergents, Offic. J EU. L104,1
[vii] RISE/Enviroplanning Microplastics from industrial laundries – A study of laundry effluents. Report prepared for the Swedish Environmental Protection Agency. Dec 2018
[viii] Personnel communication (17 March 2020) – DB Packaging http://www.dbpackaging.com.au/

[ix] https://www.azuwater.com/solution/laundry-wastewater-treatment-plant/
[x] Full scale advanced wastewater treatment at Herlev Hospital. Treatment performance and evaluation https://www.dhigroup.com/global/news/2016/08/hospital-wastewater-from-a-pollution-problem-to-new-water-resources