Disposal of PFAS containing wastewater to trade waste

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Purpose

The purpose of this paper is to determine what level of PFOS in waste water from the decontamination of fire trucks and other fire protection assets, after pre-treatment, could be acceptable to discharge to waste water treatment systems, in order to provide guidance to local authorities in setting consent conditions for such disposal, or to set as regulated limits in Trade Waste Bylaws.

The analysis, and recommended limits in the paper are considered applicable to controllable discharges of waste water of known source and quantity. They should not necessarily be considered as applicable to other sources of discharge, particularly of a continuous nature and unknown composition.

The paper draws on findings from overseas, in the absence of New Zealand data, and a consideration of regulatory/guidance levels used, and of the process for establishing trade waste bylaws in New Zealand. It has not been based on a risk assessment exercise and does not consider effects on specific receiving environments, or on human health.

Background

When equipment, such as fire trucks, which has contained the now non-compliant PFOS containing fire-fighting foam products, are cleaned out, a significant volume of contaminated waste water can be generated, in addition to the discarded foam concentrate.

Foam concentrate and other wastes containing over 50 ppm (parts per million, mg/litre) of PFOS must be treated as POPs (persistent organic pollutant) waste and disposed of in accordance with the provisions of the Stockholm Convention (as incorporated into the HSNO Act). At present, no facility in New Zealand can dispose of materials with high PFOS content to meet these international disposal standards, so these wastes must be exported.

Contaminated waste water, at below the 50 ppm level, can be readily pre-treated by filtration through granular activated carbon (GAC), or by reverse osmosis, to reduce the contamination to low- or sub-ppb (parts per billion, µg/litre) levels. Water with this reduced level of contamination should be acceptable to discharge to waste water treatment systems, as this level of contamination is likely to be of a similar order of magnitude as the background levels of PFAS found in waste water treatment plant (WWTP) inflows.

From the scientific literature, it is known that PFAS substances are not readily removed in WWTP operations, but there may be some implications for contamination of biosolids if such discharges are not controlled. The Australian and New Zealand Biosolids Partnership has proposed some criteria for the acceptance of PFOS in biosolids and regulators in Australia are considering the suitability of these for inclusion in the update of their PFAS National Environmental Management Plan.

Typical levels of PFAS in WWTP influent and effluents – establishing background concentrations

No values for PFAS (PFOS/PFOA) concentrations in inflows or effluents from WWTPs in New Zealand are available. However, a number of such studies have been undertaken overseas and some of these results are summarised in the following table (given in ng/litre (ppt or parts per trillion).

Location	PFOS (ng/litre, ppt)		PFOA (ng/litre, ppt)		Reference
	Influent	Effluent	Influent	Effluent	
China	1.8-176.0	1.1-74.8	2.6-66,000	2.8-160,000	Chen et al., 2012
*Chinese Taiwan	175-216.7	162.7-264.7	17.6-23.6	19.3-25.4	Lin et al., 2010
*Japan	14-336	42-635	14-41	10-68	Murikami et al., 2009
*Korea	<0.5-68.1	<0.5-8.9	2.3-615	<0.5-591	Guo et al., 2010
*Singapore	7.9-374.5	7.3-461.7	214.1-638.2	15.8-1057.1	Yu et al., 2009
*USA	6.9-33	8.7-61	9-24	8.2-15	Schultz et al., 2006
*Germany		<0.06-82.2		12.3-77.6	Ahrens et al., 2009
Thailand	381-465	190-553	6.6-142	16.9-150	Kunacheva et al.,2011
Australia		2.2-5.0 (Plant A) 23-38.6 (Plant B)		6.7-16 (Plant A) 15-27 (Plant B)	Thomson et al., 2011
Australia	0.6-14	3.4-17	1.1-16	0.6-23	Power and Water, NT, 2017
European Union (survey across 90 WWTPs)		<0.5-2,101 (median 12.2)		<1-15,950 (median 12.9)	Loos et al., 2012
USA (New York)		3-68		58-1050	Sinclair and Kannan, 2006
Denmark		<1-1115 (median 4.3)		<2-115.4	Bossi et al., 2008
Switzerland		16-303		12-35	Huset et al., 2008

* From Chen et al., 2012

From the above results, it can be seen that conventional waste water treatment methods do not efficiently remove PFAS. In some cases, increases can be seen in the concentrations of particular PFAS from influent to effluent, which would likely arise from the degradation of precursor PFAS.

Typical levels of PFAS in WWTP biosolids

No values for PFAS (PFOS/PFOA) concentrations in biosolids from WWTP in New Zealand are available. However, a number of such studies have been undertaken overseas and some of these results are contained in the following table (given in mg/kg dry weight, ppm). Taken from Hopewell and Darvodelsky, 2017

Contaminant	Country	Year	WWTPs	Mean	Min	Max	Reference
PFOS	USA	2001	12	0.58	0.06	3.12	3M Environmental Laboratory (2001)
	USA	2006	*	0.100	0.081	0.160	Schultz et al. (2006)
	USA	2006	10	0.031	0.010	0.065	Sinclair and Kannan (2006)
	USA	2007	8	0.073	0.008	0.110	Loganathan et al. (2007)
	Denmark	2008	7	*	0.005	0.074	Bossi et al. (2008)
	Overall		37	0.196	0.005	3.12	
PFOA	USA	2001	5	0.049	0.002	0.244	3M Environmental Laboratory (2001)
	USA	2006	*	<0.003	*	*	Schultz et al. (2006)
	USA	2006	10	0.107	0.018	0.241	Sinclair and Kannan (2006)
	USA	2007	8	0.068	0.0083	0.219	Loganathan et al. (2007)
	Denmark	2008	7	*	0.001	0.020	Bossi et al. (2008)
	Overall		30	0.075	0.001	0.244	

A more recent study in Australia across 16 WWTPs found that the concentration in biosolids of PFOS (0.011-0.37 mg/kg) typically exceeded the concentration of PFOA (0.00026 – 0.030 mg/kg) (Gallen et al., 2016).

Typical levels of PFAS in landfill leachate

Leachate from landfills is known to be a source of PFAS contamination, and, in many cases, this is discharged to waste water treatment plants.

One unpublished result for a landfill in New Zealand is available and this shows PFOS at 0.14 µg/litre and PFOA at 0.57 µg/litre.

A recent Australian study across 13 landfills found concentrations in leachate of PFOS at 0.037-1.1 µg/litre and of PFOA at 0.019-2.1 µg/litre (Gallen et al., 2016).

Similar levels, up to 3.6 µg/litre total concentration of PFOS + PFOA have been found in leachate from landfills in the USA (Lang et al., 2017).

PFAS removal by granular activated carbon (GAC)

The ability of GAC filtration to remove organic contaminants, including PFAS, from water is a known and proven technology, both for drinking water and waste water.

Chemwaste are currently undertaking trials with GAC filtration in Auckland to assist with the disposal of PFOS contaminated waste water that will arise from the cleaning of fire appliances which have been found to contain PFOS containing fire-fighting foams. Limited results are available so far, but they indicate that the concentration of PFOS in 1,000 litres of water can be reduced from 28 µg/litre to 0.029 µg/litre (29 ppt) (i.e. by a thousand-fold), with a single pass through a series of GAC filters.

Other results (unpublished) reported to the EPA are:

- Initial concentration of 57.2 µg/litre PFOS+PFHxS reduced to 0.04 µg/litre (40 ppt), with a single pass through a GAC filter;
- Initial concentration of 200-300 µg/litre PFOS reduced to <0.01 µg/litre (<10 ppt), with a single pass through two GAC filters in series;
- Initial concentration of 800 µg/litre PFOS reduced to 'undetectable' (likely <1 µg/litre), with a single pass through two GAC filters in series, also 10 µg/litre PFOS+PFOA reduced to <0.05 µg/litre (50 ppt).

The above results would suggest that treatment of PFAS contaminated waste water by filtration through GAC can readily reduce the contamination levels to below 0.1 µg/litre (100 ppt).

Current regulatory levels

From discussions with counterpart officials in Australia and in Europe, no jurisdiction has been identified where regulatory limits have been set for PFAS levels in in-flows, effluents, or biosolids from WWTPs.

In Australia, HEPA (Heads of EPAs Australia and New Zealand) and the (Australian) National Chemicals Working Group are currently working on a revision to the PFAS National Environmental Management Plan. It is planned that this will go out for public consultation in October 2018. EPA (NZ) is linked into this work. One of the priority topics in this revision is the development of a framework for the management of discharges of PFAS to WWTPs, possibly including maximum trade waste acceptance criteria, and criteria for biosolids.

Anecdotally, information has been received from:

- EPA Victoria that, in an operation involving the decontamination of fire trucks from the Melbourne Fire Brigade, total PFAS concentrations in waste water less than 1 µg/litre (1,000 ppt), were allowed to be discharged to WWTP (it is not known whether this was a general provision or applied to a specific WWTP);
- NSW EPA that water authorities are using the latest drinking water guidelines as thresholds for discharges to WWTPs. This would be 0.07 µg/litre (70 ppt) for PFOS and 0.56 µg/litre (560 ppt) for PFOA.

Environmental guideline levels

Australian HEPA PFAS National Environmental Management Plan:

	PFOS	PFOA	Exposure scenario
Freshwater	0.00023 µg/L	19 µg/L	99% species protection – high conservation value systems
	0.13 µg/L	220 µg/L	95% species protection – slightly to moderately disturbed systems
	2 µg/L	632 µg/L	90% species protection – highly disturbed systems
	31 µg/L	1824 µg/L	80% species protection – highly disturbed systems

Drinking water guideline levels (also adopted by NZ Ministry of Health): PFOS+PFHxS <0.07 µg/litre (70 ppt), PFOA <0.56 µg/litre (560 ppt).

Queensland Government Operation Policy: Environmental Management of Firefighting Foams:

States that no water contaminated with PFAS may be released to the environment if the levels of PFOS exceed 0.3 µg/litre, PFOA exceed 0.3 µg/litre (300 ppt), or total PFAS exceed 1.0 µg/litre (1,000 ppt).

New Zealand Trade Waste Bylaws

Wastewater systems across New Zealand have strict rules about what they can and cannot accept as trade waste into their systems. Acceptance criteria for various types of liquid trade waste are controlled by the local territorial authority. The acceptance criteria are different for each system and the wastewater treatment plant that receives the trade waste. The discharge consents for each wastewater treatment plant are controlled by the relevant regional council.

Many territorial authorities trade waste bylaws are based on the New Zealand Standard Model General Bylaws Part 23 – Trade Waste (NZS 9201: Part 23:2004). This Model Bylaw contains lists of characteristics (physical and chemical) which must be met in order for a discharge to the waste water system to be considered as a permitted discharge. This includes maximum permissible concentrations for a range of organic compounds, including some which are classified as POPs (persistent organic pollutants). Since PFAS is a relatively new ‘emerging contaminant’ issue, it is not addressed in the Model Bylaws (2004). However, limits are set for the POPS polychlorinated biphenyls (PCBs) and polybrominated biphenyls (PBBs) at 2 µg/litre (2 ppb), each.

In addition to maximum concentrations for particular contaminants, there is also the provision in the Model Bylaws to set daily mass limits (calculated as the volume or a discharge x the concentration of the contaminant in the discharge). In setting mass limits, a wastewater authority can have consideration of a number of matters including:

- risks to the ultimate receiving environment;

- whether or not the levels proposed pose a threat to the planned or actual beneficial use of biosolids; and

- how great a proportion the mass flow of a contaminant of the discharge will be of the total mass flow of that contaminant in the sewerage system.

As stated above, several TLAs generally adopt the concentration limits given in the Model Bylaws, and the provisions for mass limits, directly into their Trade Waste Bylaws. Examples of this include the Wellington City Council, Hutt Valley City Council, and Christchurch City Council Trade Waste Bylaws.

Recommendations

Waste water discharges

It is recommended that (interim) acceptance criteria (maximum concentration) for PFAS in discharges to trade waste be adopted as follows:

PFOS	0.1 µg/litre (100 ng/litre or 100 ppt)
PFOA	0.1 µg/litre (100 ng/litre or 100 ppt)
PFAS (total)	1 µg/litre (1,000 ng/litre or 1,000 ppt) (method of analysis to be advised) Note: this level is for information as only PFOS and PFOA are restricted compounds under the HSNO Act

Rationale

The proposed maximum concentrations are consistent with background levels found in WWTP influents and effluents overseas, taking into account the level of dilution of any discharge in the WWTP, but also considering that conventional waste water treatment methods do not efficiently remove PFAS.

The proposed maximum concentrations are comparable to, and possibly lower than, levels in landfill leachate that may already be discharging to WWTPs.

The proposed maximum concentrations are readily achievable by pre-treatment of waste water by GAC filtration.

The proposed maximum concentrations are consistent with current environmental guideline levels, such as; HEPA PFAS NEMP freshwater value for 95% species protection (0.13 µg/litre PFOS), Queensland Firefighting Foam Operational Policy (0.3 µg/litre PFOS, 1.0 µg/litre total PFAS), Drinking Water Guidelines (0.07 µg/litre PFOS+PFHxS).

The proposed maximum concentrations are consistent with acceptance criteria reportedly used in New South Wales and Victoria.

Setting of maximum concentrations and use of daily mass limits is consistent with the NZS Model Trade Waste Bylaws and with Trade Waste Bylaws adopted by several metropolitan centres. Levels recommended are more conservative that those set for comparable persistent and bioaccumulative POPs (PCBs, PBBs) in those Bylaws.

These should be considered as interim levels until the revision of the HEPA PFAS National Environmental Management Plan is complete.

If daily mass limits are set, then a higher maximum concentration could be acceptable, say 1 µg/litre for PFOS and for PFOA.

Mass limits for a trade waste discharge could be calculated as:

Daily total volume x Background concentration x Allowable % increase above background.

Where:

Daily total volume = average total volume of waste water entering a WWTP per day (litres);

Background concentration = average background level of PFOS in waste water currently entering WWTP (ng/litre);

Allowable % increase above background = % of the daily total background mass flow of PFOS entering the WWTP allowed in the trade waste discharge. This could be dependent on a number of factors such as the nature of the receiving environment, whether there is any beneficial use of biosolids, frequency of the discharges, and size of the WWTP.

Example:

Daily total volume = 250 x 10^6 litres waste water /day

Background concentration of PFOS = 5 ng/litre

Allowable % increase above background = 1%

Daily mass limit of PFOS in trade waste discharge = 250 x 10^6 x 5 x 1% = 12.5 x 10^6 ng/day (12.5 mg/day).

This would correspond to a daily discharge of 12,500 litres of waste water with a PFOS concentration of 1,000 ng/litre (1 µg/litre), or of 125,000 litres with a PFOS concentration of 100 ng/litre (0.1 µg/litre).

Biosolids acceptance criteria

It is recommended that a (interim) limit for PFOS in biosolids be adopted as follows:

- Unrestricted use = 0.3 mg/kg dry weight of biosolids

Rationale
Values are as recommended by Australian and New Zealand Biosolids Partnership, in Hopewell and Darvodelsky, December 2017. Derived using same tolerable daily intake values used for establishing current drinking water guidelines. Value not set for PFOA as this is less retained in biosolids than PFOS and levels detected are significantly below health investigation levels set by Australian Department of Health. These should be considered as interim levels until the revision of the HEPA PFAS National Environmental Management Plan is complete.

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