MINNISBLAÐ

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Veitur ohf.

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Efni:

ReSource International ehf. reports on the method used to quantify microplastics in inlet and outlet liquid wastewater fractions at Klettagarðar wastewater treatment plant, as requested by Veitur ohf. Measurement took place on 30th November 2017.

Method

Microplastics

Microplastics are defined for the purpose of this work as *synthetic polymers <5mm in all dimensions*. This study did not attempt to measure microplastics that passed a 263µm filter.

Sampling method

As of the time of this work, there was no international standard method for measuring microplastics in wastewater. Untreated wastewater is heterogeneous in content within different depths of a stream or sump (top, middle and bottom) and a high degree of heterogeneity is also to be expected within these fractions. Thus, sampling equipment was designed to be able to sample in any area and process as high a volume as possible of wastewater.

Following a pilot study and development of method, sampling at Klettagarðar was done on 30th November 2017 at the inlet sump (Figure 1), at the inlet stream, at the outlet sump and at the outlet stream. Three samples were taken in each location, one from the top, middle and bottom of each body except in the outlet stream, which was shallow, highly turbulent and fast-flowing to the point where the pump was carried away from the bottom; there, the middle was sampled in all cases, assuming low stratification of small particles within the stream.

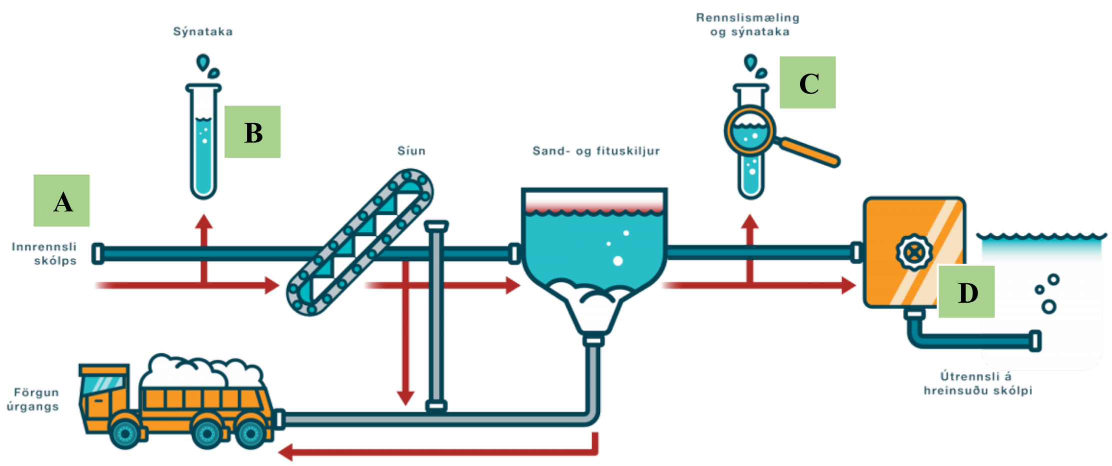

Figure 1 - Layout of a Veitur sewage treatment plant (Veitur ohf.). Measurements took place at points A-D; A and D denote collection sumps providing hydraulic head for pumps transferring wastewater into and out of the system; B and C denote streams, B being directly after inlet pumping and C being the drain from the filtration tank.

Figure 2 – Example of a sump; filter stack

The sampling equipment consisted of an all-stainless submersible pump, a 20m PVC hose, and a custom stainless steel force-filtration container (Figure 1). This contained a stack of 5mm, 915µm and 263µm stainless filters of 135mm diameter (Inoxia, UK) and was connected to a high-precision household water flowmeter. Sizes were selected based on a common sampling size of 1000-5000µm for large microplastics and 300-1000µm as a smaller fraction. To sample wastewater, the submersible pump was lowered into the stream and the full equipment (pump, hose, filter holder and flowmeter) was flushed with approximately 100 l of wastewater without filters; filters were then added and the pump was then run until clogging of the filters occurred, typically after 35-60 l of wastewater was sampled.

Figure 3 - Filters after sampling. 915µm on the left and right 263µm on the right.

915µm and 263µm filters were then transferred inverted to Pyrex glass petri dishes and sealed with parafilm for transport to the laboratory, where they were stored at 4°C until analysis. Prior to sampling, stainless filters and petri dishes were incinerated at 550°C to remove the possibility of contamination. PVC overalls and cotton clothes were worn throughout to minimise fibre contamination. Due to the number of fibres measured, contamination was likely not an influence on the variability of results.

Analysis method

Filters were submerged in 10% H_2O_2 (hydrogen peroxide) for 24-72 hours at 60°C with time, depending largely on the level of organic contamination (particularly cellulose) remaining on the filters. This chemical treatment was chosen after review of past studies and direct experimentation with several other temperatures, concentrations, and acid and alkali ingredients as the least destructive method that still allowed inspection of microplastics.

After processing with peroxide, the samples were washed from steel filters with deionised water and transferred from petri dishes onto 0.45µm gridded cellulose esther filters (Whatman) in a stainless 47mm filter funnel. Samples were then stained with approximately 1 ml of 200 mg/L Rose Bengal, which binds to organic material and helps in distinguishing of plastics from biogenic material (Figure 3). Samples were then visually examined under dissecting microscope and counted completely for presence of fibres, flakes (i.e. films), spheres and fragments (irregular 3D shapes) – see Figure 5 to Figure 8 for examples. Where uncertainty existed for fibres, they were placed in a hot flame to ascertain if they melted.

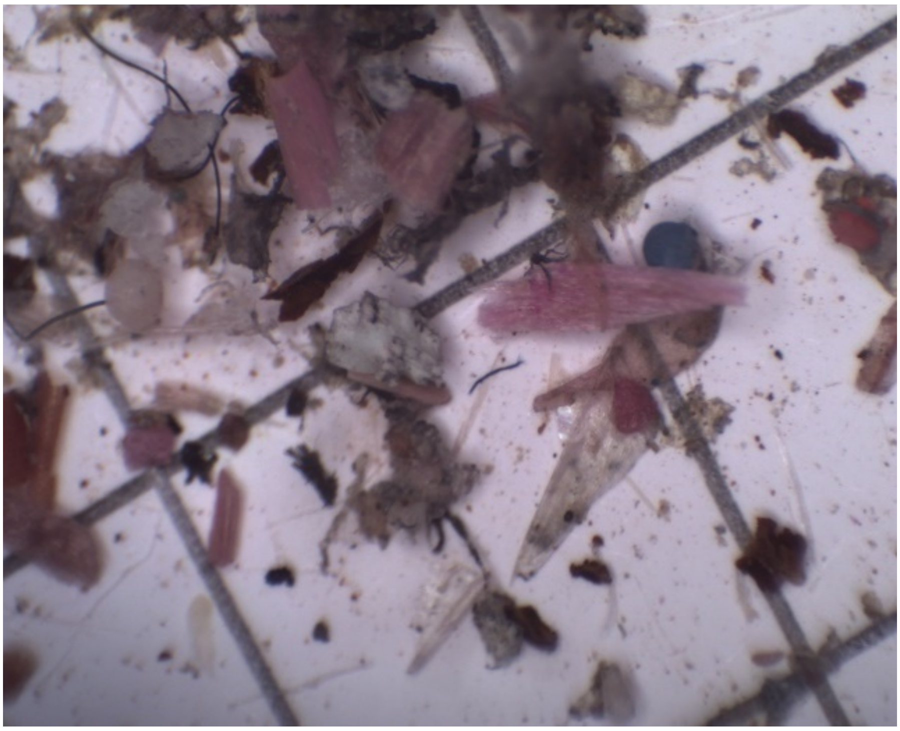

Figure 4 - Sample showing dyeing of organic material

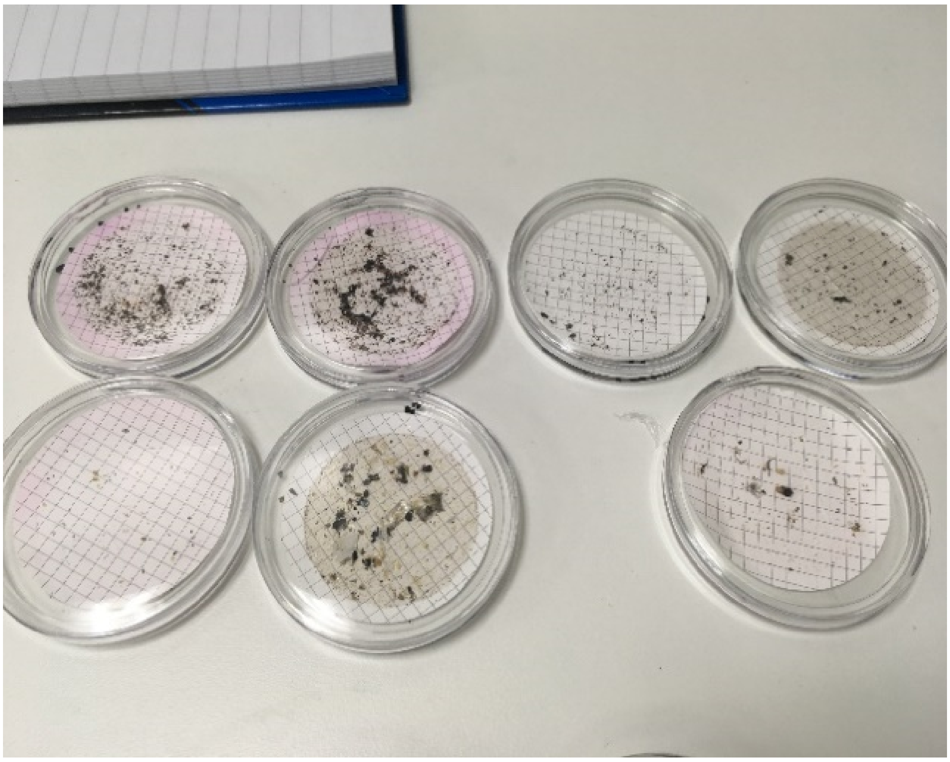

Figure 5 - Processed samples

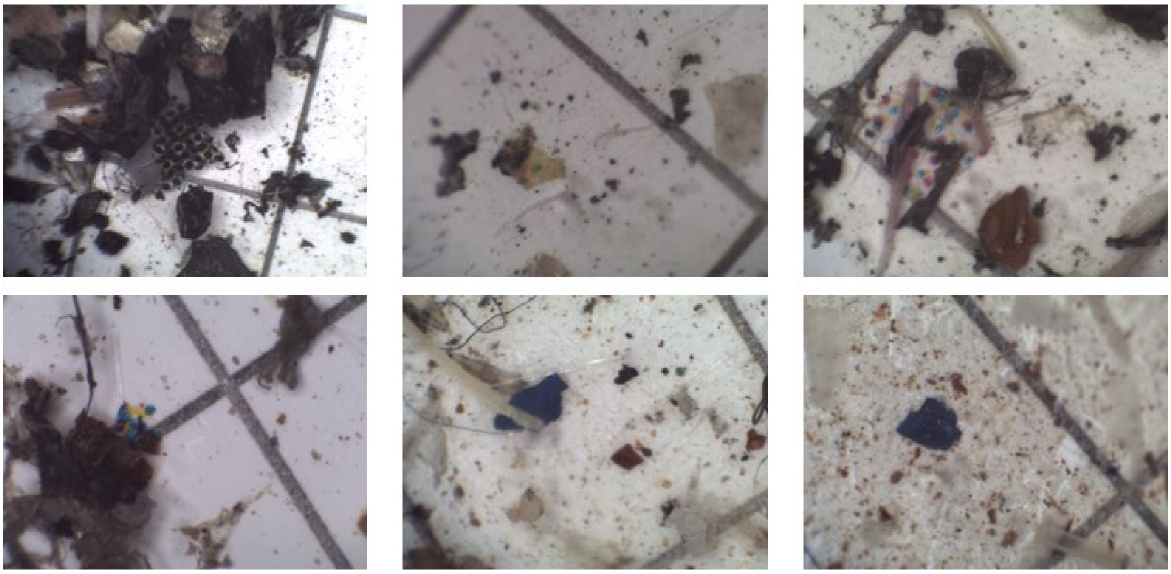

Figure 6 - Example of flakes

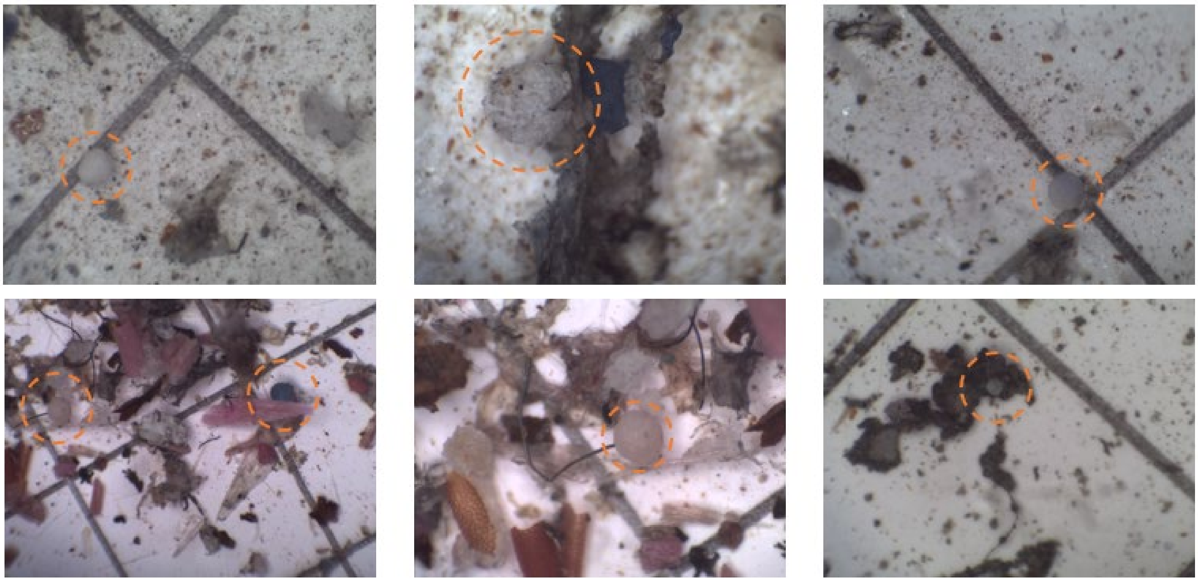

Figure 7 - Examples of spheres

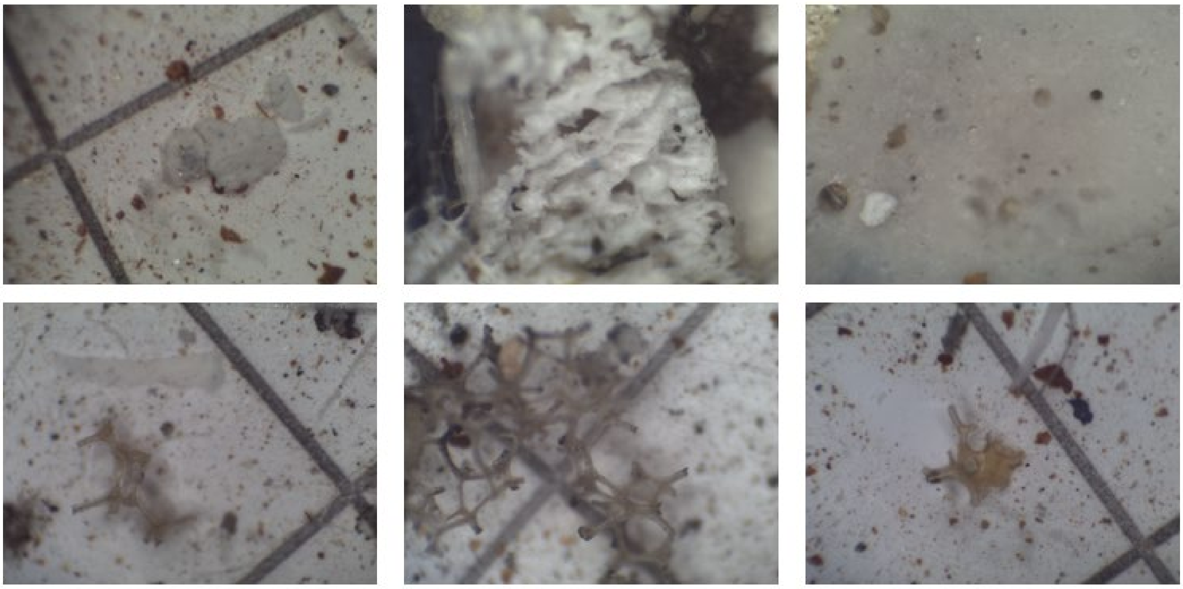

Figure 8 - Examples of fragments

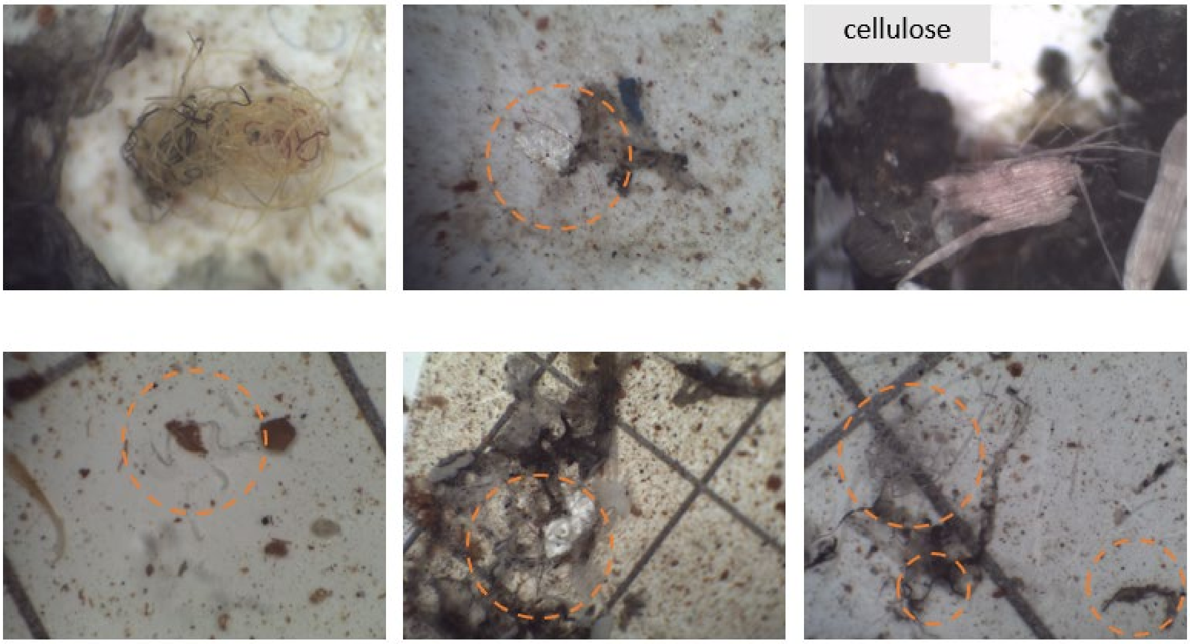

Figure 9 - Examples of fibres, including cellulose

One sample was discarded due to breakage: the 263μm micron sample from the bottom of the intake sump.

Results

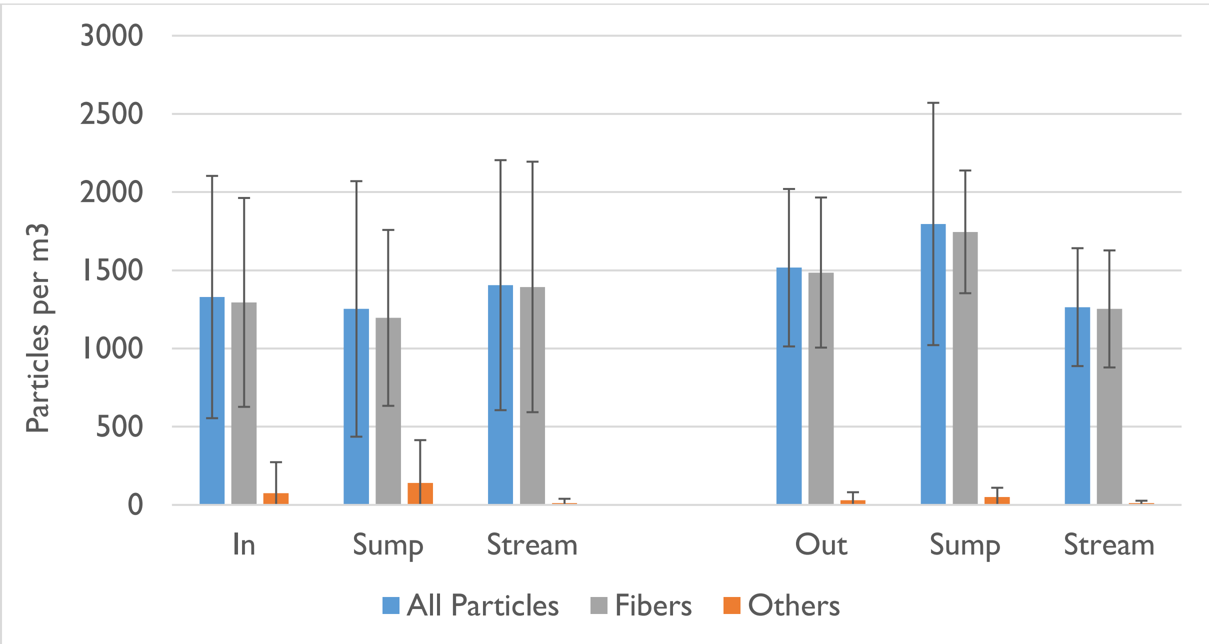

Figure 10 – Microplastics measured in Klettagarðar on 30th November 2017.

The results (Figure 9) show that the inlet and outlet of Klettagarðar contain eseentially the same number of plastic particles, indicating that there is little filtration of particles. Any differences between inflow and outflow are non-significant and can be attributed to the heterogeneous nature of samples and/or breakdown of plastic fibres in transit through the treatment plant.

Although there were similar numbers of particles coming out of the plant than into the plant, there were significantly (p=0,045; 1-tailed t-test) more fibres on the 263-micron filters after treatment, indicating that larger fibres may be breaking down further within the treatment system. It may be that some mass of plastic is in fact being removed in the treatment system and the number of particles is kept constant by the breakdown of larger particles. However, in terms of relevance to potential environmental effects, number and size of particles is a more relevant dimension to measure than mass.

Results were independent of sample size (Figure 10). The individual results can be seen in Figure 11 and the raw data are shown in Table 1.

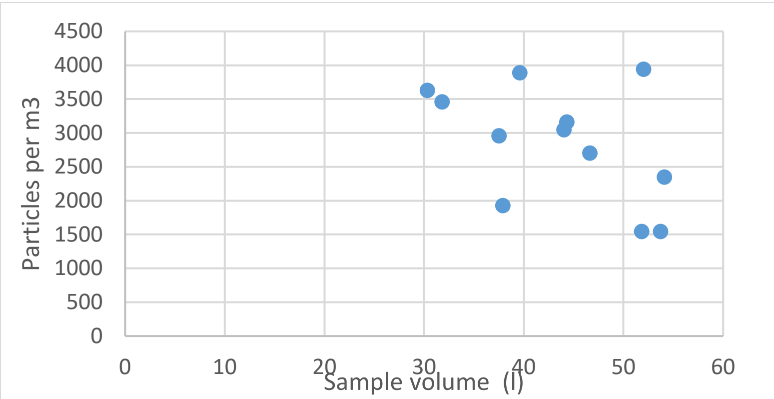

Figure 11 - Sample volume and particles counted per sample point (combining both size categories).

Fibres make up the vast majority of all particles; only twelve spheres (so-called "nurdles" or "microbeads") out of 1428 particles were counted despite them being a focus of some prominent NGO campaigns and media attention internationally[1]. Clothes washing is likely to release enormous numbers of fibres, so this is not an unexpected result. However, it seemed that some fibres unstained with Rose Bengal were not plastic; not all of these were removed by the addition of peroxide. In future studies, an enhanced Nile Red fluorescent dye technique should be used, as later developed by ReSource International ehf. for analysis of drinking water. In addition, further refinement of chemical treatment of samples should be done, as it is sub-optimal to vary treatment (in this case length of chemical processing) when treatment may have the effect of breaking down or destroying samples.

It should be noted that this has no effect on the main conclusion, that there is little difference in the number of microplastics in the inlet and outlet at Klettagarðar.

[1] See e.g. https://echa.europa.eu/hot-topics/microplastics; https://www.nurdlehunt.org.uk; https://www.wired.com/story/little-plastic-nurdles-are-flooding-beaches-and-waterways/;

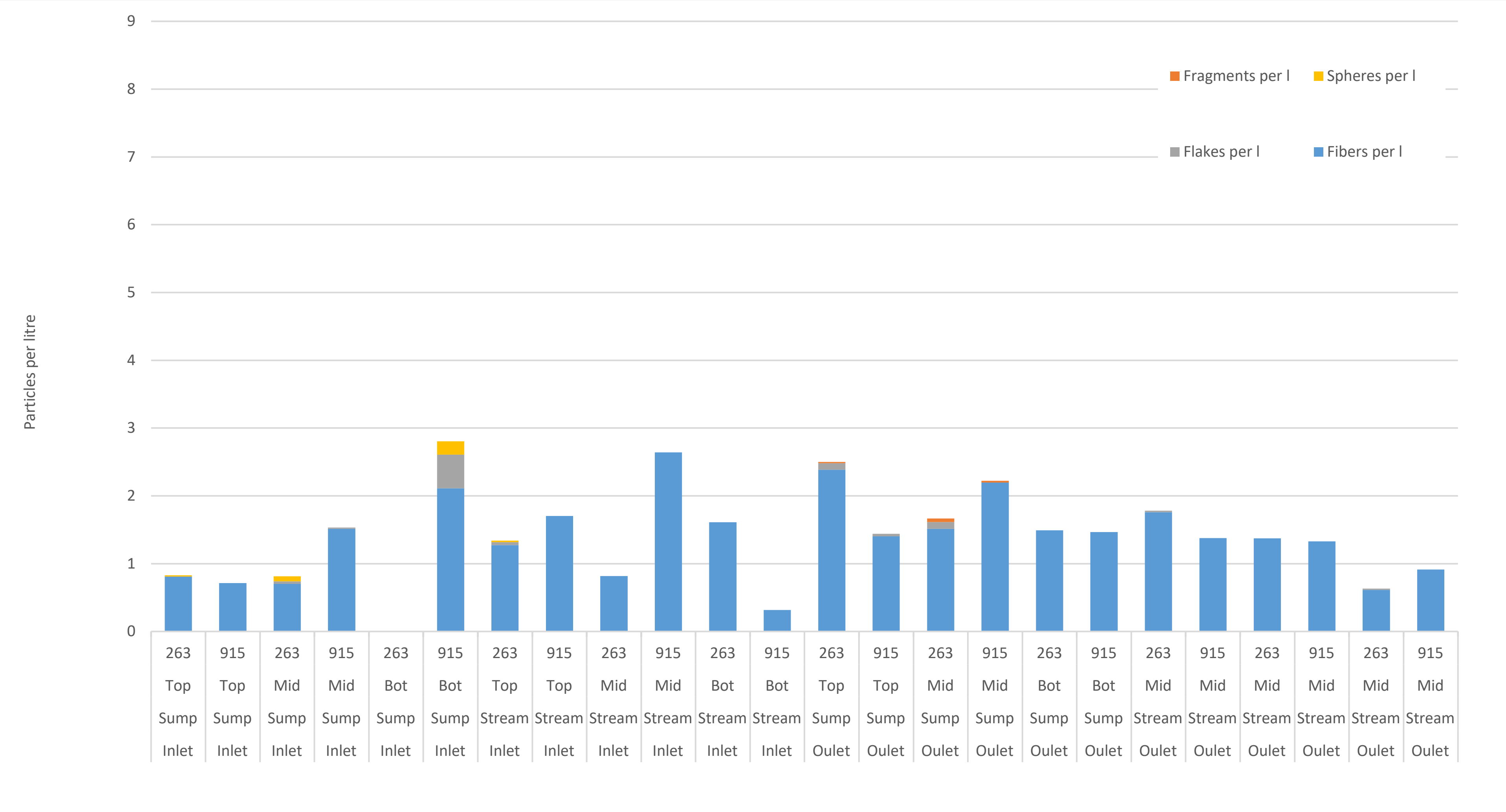

Figure 12 – Results from individual sample points

Table 1 - Data collected during sampling campaign

Location	Location	Stratum	Filter	Volume (l)	Fibers	Flakes	Spheres	Fragments	Particles per m3	Fibers per l	Flakes per l	Spheres per l	Fragments per l
Inlet	Sump	Top	263	51.8	42	0	1	0	830	0.81	0.00	0.02	0.00
Inlet	Sump	Top	915	51.8	37	0	0	0	714	0.71	0.00	0.00	0.00
Inlet	Sump	Mid	263	54.1	38	2	4	0	813	0.70	0.04	0.07	0.00
Inlet	Sump	Mid	915	54.1	82	1	0	0	1534	1.52	0.02	0.00	0.00
Inlet	Sump	Bot	263	30.3									
Inlet	Sump	Bot	915	30.3	64	15	6	0	2805	2.11	0.50	0.20	0.00
Inlet	Stream	Top	263	44	56	2	1	0	1341	1.27	0.05	0.02	0.00
Inlet	Stream	Top	915	44	75	0	0	0	1705	1.70	0.00	0.00	0.00
Inlet	Stream	Mid	263	31.8	26	0	0	0	818	0.82	0.00	0.00	0.00
Inlet	Stream	Mid	915	31.8	84	0	0	0	2642	2.64	0.00	0.00	0.00
Inlet	Stream	Bot	263	37.9	61	0	0	0	1609	1.61	0.00	0.00	0.00
Inlet	Stream	Bot	915	37.9	12	0	0	0	317	0.32	0.00	0.00	0.00
Outlet	Sump	Top	263	52	124	5	0	1	2500	2.38	0.10	0.00	0.02
Outlet	Sump	Top	915	52	73	2	0	0	1442	1.40	0.04	0.00	0.00
Outlet	Sump	Mid	263	39.6	60	4	0	2	1667	1.52	0.10	0.00	0.05
Outlet	Sump	Mid	915	39.6	87	0	0	1	2222	2.20	0.00	0.00	0.03
Outlet	Sump	Bot	263	37.5	56	0	0	0	1493	1.49	0.00	0.00	0.00
Outlet	Sump	Bot	915	37.5	55	0	0	0	1467	1.47	0.00	0.00	0.00
Outlet	Stream	Mid	263	44.3	78	1	0	0	1783	1.76	0.02	0.00	0.00
Outlet	Stream	Mid	915	44.3	61	0	0	0	1377	1.38	0.00	0.00	0.00
Outlet	Stream	Mid	263	46.6	64	0	0	0	1373	1.37	0.00	0.00	0.00
Outlet	Stream	Mid	915	46.6	62	0	0	0	1330	1.33	0.00	0.00	0.00
Outlet	Stream	Mid	263	53.7	33	1	0	0	633	0.61	0.02	0.00	0.00
Outlet	Stream	Mid	915	53.7	49	0	0	0	912	0.91	0.00	0.00	0.00