Bio-Bead pollution on our beaches

A Cornish Plastic Pollution Coalition report

Second edition, July 2018

1. Statement

The Cornish Plastic Pollution Coalition has produced this report due to growing concern about the impact of Bio-Bead pollution on our local waterways, beaches, seas and wildlife.

The aim of this report is to help identify the mechanisms by which Bio-Beads are entering the aquatic environment, so that measures can be put in place as soon as possible to limit and control this previously little-understood problem.

We are very grateful to everyone who has helped by providing information and sightings so far. However, there are still many questions to answer. We very much welcome input and updates from all and any stakeholders with a view to building up a clearer picture and developing and implementing solutions.

If you have any facts, comments, corrections, figures, suggestions for future areas to research, images (particularly photos of fresh finds, with location and date) or any other useful contribution to add, please send them to claire.wallerstein@gmail.com

Thank you.

Cover photo: Black Bio-Beads among other industrial plastic pellets at Colona beach, St Austell Bay, September 2015, Rob Wells

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2. Executive summary

Bio-Beads (also known as Brightwater / BAFF media) are tiny plastic pellets used by many UK water companies as part of the wastewater treatment process at some of their plants. They may also be used in other industrial applications, such as the treatment of leachate and industrial wastewater.

Bio-Beads are found on many Cornish beaches in vast numbers. Although further sampling will be useful, surveys to date indicate that they often account for more than half of all industrial plastic pellets (nurdles) found.

Many questions remain to be answered about how Bio-Beads end up on our beaches. However, this study shows that our local water company, South West Water (SWW), has lost them to the environment historically in major spills, and is continuing to do so from at least some plants through ongoing, lower level leaks. Bio-Beads may also be entering the environment through other mechanisms, for example during transport and through poor handling/ storage.

This report focuses primarily on SWW as it is our local water company, meaning we have been able to do much more research here. Information to date also indicates that Cornwall and the English Channel coast are major hotspots for Bio-Bead pollution within the UK, with these beads reported less often elsewhere in the country. Nevertheless, spills and incidents involving losses of Bio-Beads have also been reported by other water companies, as discussed later, and could potentially occur anywhere this system is used.

Once released to the environment, pellets such as Bio-Beads are almost impossible to remove and are known to be consumed by marine wildlife that mistakes them for food. Chemical tests conducted on Bio-Beads from our beaches show that they contain high levels of toxic compounds likely to have a significant effect on the health of seabirds and marine animals.

Water companies are keen to prevent plastics of all sizes from getting into (and being released by) their wastewater systems, and are becoming increasingly aware of the issue of microplastics being inadvertently discharged to the environment via their plants (e.g. cosmetic microbeads, laundry fibres, car tyre dust).

However, the possibility of plastics used by the water companies themselves in the wastewater treatment process contributing to the problem of sewage-related plastic debris is an emerging issue. This is something that does not appear to have been recognised or considered until very recently, and is an area that requires much more investigation.

We have been in discussion with South West Water about these issues since early 2017, and the company is putting in place some measures to investigate this problem with a view to minimising it in future. We hope the analysis and measures being undertaken by SWW could prove useful to other water companies using the Bio-Bead system.

This report contains an in-depth initial analysis of all possible sources of Bio-Bead loss, and the 'Recommendations' section on page 55 provides a list of measures that we believe should be implemented by water companies as soon as possible to minimise any possible losses of this environmental contaminant through use, storage, transportation, handling, etc.

The marine plastic problem is notoriously hard to tackle given its varied sources and entry points. However, as a discrete form of marine debris, we hope the Bio-Bead issue is one that will be relatively easy to address.

3. Microplastics on Cornish beaches – general background

Microplastics have become a serious problem on many Cornish beaches, being visible particularly on fine sand beaches such as Tregantle (Whitsand Bay) on the south coast and Penhale Sands, Hayle, Towan Sands and Watergate Bay on the north coast (beaches with a fine substrate generally also receive the smallest debris).

A common scene in winter and spring. A tideline of mixed microplastics stretching for hundreds of metres at Tregantle, Whitsand Bay, April 2017
Picture: Rob Arnold

Detail of typical mix of organic material, microplastic pieces, nurdles and Bio-Beads – extremely hard to remove and to sort. Hayle, March 2017
Picture: Tracey Williams

While many of these microplastics (defined as pieces of plastic smaller than 5mm) started out as larger items that have been broken down over time through photodegradation and the mechanical effects of wave action, a sizeable proportion of them are industrial plastic pellets that originally entered the sea at this size (i.e. primary microplastics).

Many of these pellets are 'nurdles', or pre-production plastic – i.e. the building blocks of all the plastics we use. These are manufactured then transported around the world to plastics plants where they are melted down and formed into everything and anything from car parts to shampoo bottles, toys and biscuit packets.

They may have entered the marine environment through spills from shipping containers or other transport, or through losses caused by poor handling procedures at plastics plants (eventually washing down drains and back into waterways and the sea).

Pellets such as these are a significant pollutant – not least because, once released into the environment, they are incredibly hard to remove. One study[1] showed that plastic abundance in the Austrian Danube was higher than that of drifting larval fish, with most of this plastic being in the form of industrial raw materials such as pellets and flakes.

Until recently we had believed that all the pellets on our Cornish beaches were these pre-production nurdles. However, after first learning about Bio-Beads in 2016, we have come to realise that these make up a substantial proportion, in fact often a majority, of the pellets on our beaches.

4. What are Bio-Beads and why are they used?

Bio-Beads are a type of BAFF (biological aerated flooded filter) media. They are tiny plastic pellets (3.5 to 4mm across) used as part of the filtration process in some wastewater treatment plants.

Many BAFF plants were set up in the early-mid 1990s at a time when recently-privatised water companies were needing to overhaul infrastructure on a large scale and meet EU environmental requirements and increasingly strict discharge consents. They were useful in delivering high effluent quality in confined or visually-sensitive locations because of their small footprint. However, they are also quite complicated and expensive in terms of maintenance, energy and the pellets themselves (£1,000 per m^3).

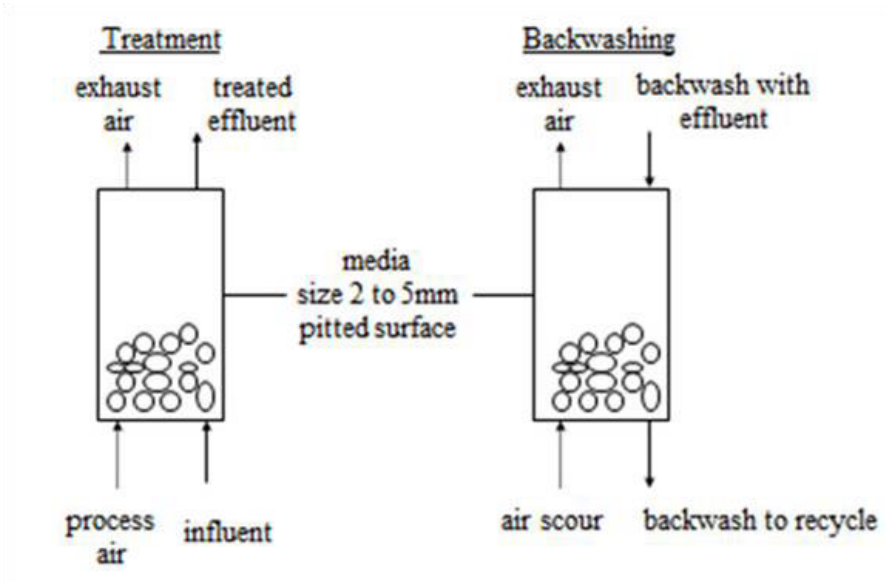
Information supplied by South West Water explains: "BAFF plants were chosen for the water industry as suitable processes for small footprint wastewater treatment

[1] http://ec.europa.eu/environment/integration/research/newsalert/pdf/377na1_en.pdf

sites. Conventional activated sludge systems are generally not installed at coastal treatment sites as a result of the large area of land they require. BAFF systems are fixed-film processes where biomass is attached to a well-defined support medium through which wastewater is passed so that it operates with the medium in a flooded condition. Process air is introduced into the system to satisfy the requirements of the micro-organisms. A typical BAFF system occupies about 20%-50% of the area required by an equivalent activated sludge process.

Many key features of BAFF plants such as the small footprint, ability to treat high salinity sewage, and the operating costs were considered important in the 1990s and early 2000s, the period when many of South West Water's BAFF plants were installed.

Brightwater Engineering Ltd (now FLI Water Ltd) developed a BAFF plant system in the early 1990s. This resulted in a patented process and a specific patented design of a bead type to support media for use within their process. This bead is known as a Bio-Bead. Many of these plants were installed in UK water utilities from 1992 onwards. The BAFF process was developed extensively by different suppliers in the 1970s and 1980s in the USA, France and Canada."



Above: Outline scheme of the BAFF process

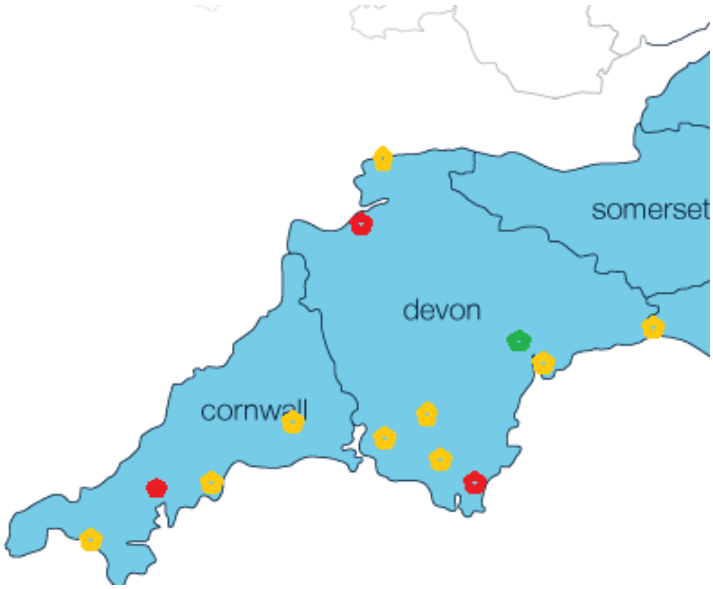
South West Water currently uses Bio-Beads at 9 out of its 600+ wastewater treatment plants, serving around one-eighth of the total population of the region.

Gorran Haven (commissioned 1994, population served: 2,200)
Porthleven (commissioned 1998, population served: 5,000)
Liskeard (commissioned 1993, population served: 10,000)
Ivybridge (commissioned 1994, population served: 14,000)
Plympton (commissioned 1994, population served 85,000)
Combe Martin (commissioned 1995, population served: 5,200)
Exmouth (commissioned 1996, population served: 60,000)

Modbury (commissioned approx. 2005/6, population served: 1,300)
Lyme Regis/ Sleetchwood (commissioned 1993, population served: 10,500).

In addition, its Countess Wear plant near Exeter uses a polystyrene-based bead. Three plants commissioned in the early-mid 1990s have since been decommissioned: Bideford, Slapton and Truro (Newham).

SWW's other wastewater treatment plants use media made from natural materials, such as basalt, grit, clay, etc.



From left to right on south coast: Porthleven, Truro, Gorran Haven, Liskeard, Plympton, Ivybridge, Modbury, Slapton, Countess Wear, Exmouth, Lyme Regis.

From left to right on north coast: Bideford, Combe Martin

Map showing the location of SWW Bio-Bead BAFF plants (yellow – current, red – no longer in use, green – polystyrene bead)

Bio-Beads are used in enormous quantities, packed together to a depth of 2.6m floating in 'reactors' or 'cells' measuring approximately 9.5m x 9.5m and held down by a steel mesh with holes of 3mm across. We estimate that each reactor contains around 5.4 billion of them – meaning a plant like Plympton, in Plymouth, which currently serves around 85,000 people, has a total of approximately 43.24 billion beads in operation.

To make these figures easier to visualise, if the Bio-Beads in a single reactor were lined up end to end they would stretch for almost 19,000km – further than the distance from Plympton to Auckland, New Zealand.

Data supplied to us by the various UK water companies show that there are at least 55 BAFF plants using Bio-Beads in the country, serving a population of at least two million people.

View of reactors in operation, from above (SWW Plympton plant, June 2017). Water bubbles up through the Bio-Bead bed, then through the steel mesh above it, before running down the raised channels, visible above the tanks, to the outflow.

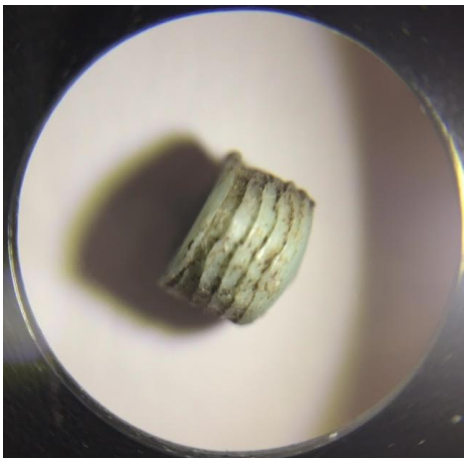
Picture: Rob Arnold

Image of an empty tank (SWW Plympton plant, June 2017), showing the position of the steel mesh screen in the reactors.

Picture: Rob Arnold

5. Identifying Bio-Beads

Bio-Beads are quite different from ‘true’ virgin or recycled pre-production plastic nurdles, which are smooth and more regular in shape. Bio-Beads appear either wrinkled, knobbly, ridged with a ‘screw thread’ type profile on the sides, or otherwise non-uniform. They are manufactured deliberately in this way in order to increase the surface area available for attachment of the biofilm of bacteria.



Top left: Magnified picture of a green Bio-Bead, showing distinct ridges. This image was taken by a plastics industry expert as part of a physical analysis of pellets submitted from Cornish beaches.

Above right: ‘True’ pre-industrial nurdles (the ones on the right are discoloured due to lengthy exposure to UV light and the elements). Picture: Claire Wallerstein

Left: Smooth black pre-industrial nurdles, either virgin or recycled plastic (left) and misshapen, ‘knobbly’ black Bio-Beads (right)

Picture: Claire Wallerstein

Members of the Cornish Plastic Pollution Coalition were invited to visit SWW’s Plympton wastewater plant in January 2017 to see how the BAFF system works. Large quantities of Bio-Beads were observed lying on the ground around the area of the reactors (of which there are eight at Plympton), presumably spilled during maintenance/ top ups.

We sent samples of these Bio-Beads from the plant to a UK plastics company for analysis, asking them to compare them with a selection of mixed nurdles and presumed Bio-Beads collected from two different Cornish beaches.

Although he prefers to remain anonymous for commercial reasons, the company's commercial manager is keen to help identify the various kinds of industrial pellets found on UK beaches in order to promote environmental responsibility and good housekeeping measures among plastics processors and to help prevent avoidable pollution.

He has extensive knowledge of the plastics industry, having sold nurdles internationally since 1985, and says: "Personally I consider myself to have seen everything regarding nurdles produced around the world."

He was quickly able to identify the composition and purpose of the various types of regular nurdles among the samples of mixed beached pellets we sent him.

However, he was mystified by the Plympton Bio-Beads and the similar-looking pellets found from Cornish beaches, saying both the 'screw thread' and knobbly types appeared "bespoke", as if they had been produced for a specific purpose.

Intrigued, his company even sent some of the 'screw thread' pellets to a specialist moulding company with 50 years' experience in the trade. This company had no idea how the grooves would have been made or what the pellets could be used for.

Of the gnarled black pellets, our expert said: "I would not know how to achieve that distorted, knobbly look," saying it was likely they had been made with the addition of a blowing agent.

In summary, he told the CPPC: "In my professional opinion there is no way these are used in pre-production plastics. I have never come across anything of this physical shape and nature being used for the manufacture of plastic products."

Although SWW's original briefing sheet on nurdles and Bio-Beads (since corrected - see Appendix 1) stated that the Bio-Beads used by the company are usually blue and white or mixed, and the company advised us during the tour that the Bio-Beads used at Plympton were 70% blue and 10% black, this was not reflected in what we observed on the ground during our visit. From the sample of 354 Bio-Beads we picked up, 68 (19%) were blue/ grey/ violet, 72 white-ish (20%), 52 green-ish (15%), and 162 (over 45%) black – not dissimilar to the colour breakdown of Bio-Beads found on our beaches.

The Bio-Beads on our beaches are predominantly black, but also come in other colours similar to those mentioned above. These muted, 'natural' colours mean they can resemble grit, and to the untrained eye they can be easily overlooked unless present in enormous numbers, as they blend into the beach so well.

In a telephone conversation in early February 2017 with Melvyn Rose, business development director of FLI Water (www.fliwater.com), the company supplying Bio-Beads to SWW and other UK water companies, he told the CPPC that the black beads are a more recent development, with better microscopic properties than the coloured ones. We do not know how recently the black Bio-Beads were developed, and unfortunately the company has failed to respond to all subsequent requests for information.

Left: Image of Bio-Beads taken from the FLI Water website

Below left: Black Bio-Beads collected from Plympton site in January 2017 (picture: Claire Wallerstein)

Below right: Coloured Bio-Beads collected from Plympton site in January 2017 (picture: Claire Wallerstein)

SWW told us that the colour proportions of Bio-Beads used may differ from plant to plant. We are not sure if there is a reason for this, for example whether the different colours have different properties, or if different colours were simply bought in at different times in different batches.

Our plastics industry contact said: “It is an extra cost. The cheapest pellet to produce is milky white then black and next green … so my question is why are the beads so different?”

We believe that most if not all of the UK water companies using Bio-Beads are supplied by FLI Water, which is based in Kempston, Bedford. (While some of the water companies declined to identify their supplier, all those that did so confirmed they are supplied by FLI Water). FLI Water sources the Bio-Beads from a French company called Plasti-Negoce.

6. Why are pellets such as nurdles and Bio-Beads so harmful?

Each year, according to United Nations estimates[2], marine plastic debris in general kills at least one million seabirds and 100,000 marine mammals, either through ingestion or entanglement. More than 660 marine species worldwide are documented as having been affected by plastics[3], and the impact is seen on everything from tiny zooplankton – the foundation of the entire marine food chain – up to whales.

Industrial plastic pellets such as nurdles and Bio-Beads are often consumed by birds, fish and other marine species, possibly because of their similarity to fish eggs. Some 98.6% of dead fulmars autopsied from the English Channel area (2007–2011) were found to have ingested plastics[4], while 61% of fulmars sampled in the Netherlands between 2010-2014 were found to have specifically ingested industrial plastic pellets[5].

Many animals are killed by marine plastics because their digestive tracts become blocked with this indigestible material, or because the sensation of satiety in their stomachs stops them from feeding normally, eventually leading to starvation.[6]

However, this is not the only problem. Research[7] has demonstrated that microplastics such as industrial plastic pellets also readily adsorb hydrophobic chemical toxins from the surrounding seawater.

Northern fulmar (fulmarus glacialis)

Picture: Andrew Colenutt

[2] http://www.unesco.org/new/en/natural-sciences/ioc-oceans/focus-areas/rio-20-ocean/blueprint-for-the-future-we-want/marine-pollution/facts-and-figures-on-marine-pollution/
[3] https://phys.org/news/2017-08-marine-microplastics-bottom-dweller-bellies.html
[4] https://link.springer.com/article/10.1007/s00300-015-1657-4 (see figure 3)
[5] http://edepot.wur.nl/365964 (see table i)
[6] http://rstb.royalsocietypublishing.org/content/364/1526/2013
[7] http://europepmc.org/articles/PMC2873017

The Japan-based International Pellet Watch (IPW) programme (www.pelletwatch.org/) has found persistent organic pollutants (POPs) – some of which were banned decades ago, such as DDT and PCBs – on the surface of nurdles and pellets collected from beaches all around the world, sometimes at concentrations thousands of times higher than the background water level.

Above: different kinds of fish roe – the similarity with nurdles and Bio-Beads is striking

Left: fish eggs in situ (picture Alexander Semenov)

Left of the tweezers: average quantity of plastics removed from stomachs of North Sea fulmars

Right of the tweezers: the same category items scaled up to a fulmar of human body size (mass). Note the industrial pellets at bottom right

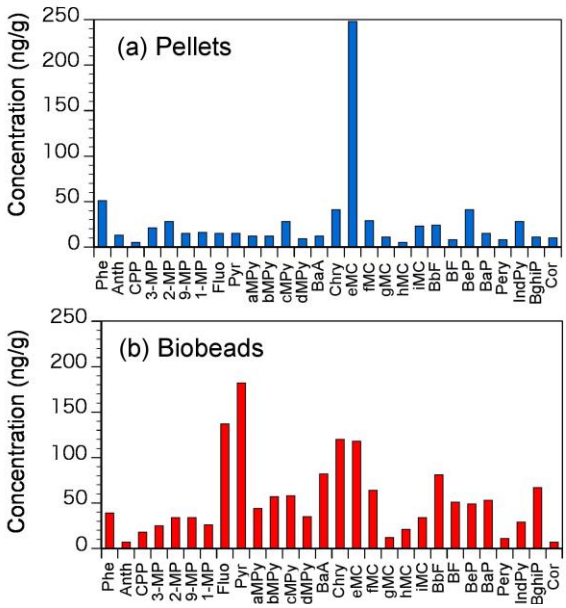
Picture: Jan van Franeker

Leaching of these persistent toxins into body tissues can cause serious health and reproductive impacts for marine creatures. These pollutants cumulatively concentrate in apex predators at the top of the food chain through a process known as biomagnification. This is well illustrated by the case of a Scottish killer whale known as Lulu, which died in 2016[8].

Lulu was a member of the UK's last pod of killer whales. In the 23 years that this pod has been studied not a single calf has been born. Lulu was found to have a PCB load of 950mg/ kg of blubber – more than 100 times the accepted toxicity threshold for marine mammals of 9mg/kg.[9] Exposure to elevated levels of PCBs causes a range of health impacts – most notably infertility.

The CPPC asked International Pellet Watch to test the contaminant load on pellets collected from our local beaches, conducting a comparative analysis on 200 nurdles and Bio-Beads collected from a single metre square area on Tregantle beach, Whitsand Bay.

The results showed that while the levels of DDT, PCBs, etc. were similar on both types of pellets, the Bio-Beads showed levels of polycyclic aromatic hydrocarbons (PAHs) three to four times higher than those on the nurdles – confirming that the two types of pellets, although made of the same kind of plastic, had entered the marine environment from very different sources.



Left: Charts showing the very different chemical signatures of Bio-Beads and nurdles from Tregantle beach, SE Cornwall, in terms of the levels of adsorbed polycyclic aromatic hydrocarbons.

Source: Dr Hideshige Takada, International Pellet Watch, Tokyo University of Agriculture and Technology

PAHs derive from burning hydrocarbons, so the most logical explanation is that the Bio-Beads (unlike the nurdles) would have been exposed to vehicle exhaust emissions in roadwater runoff while in the wastewater plants.

This finding shows with a high degree of certainty that the Bio-Beads (a) originated from wastewater treatment plants, (b) did not come from a container ship spill as

[8] http://pubs.acs.org/doi/abs/10.1021/es0702519

[9] http://discovery.ucl.ac.uk/1473078/1/Jepson%20et%20al%202016_cetacean%20PCBs_Sci%20Rep.pdf

they would then not have been exposed to the PAHs and (c) are not regular recycled plastic pellets that have been wrongly identified as Bio-Beads, as South West Water has previously suggested.

PAHs are also harmful to health, having been shown to be both carcinogenic and endocrine disruptors.[10]

The evidence linking Bio-Beads back to wastewater treatment plants has been further confirmed in tests conducted by Dr Andrew Turner from the University of Plymouth's School of Geography, Earth and Environmental Sciences, who specialises in analysing the properties of black plastics.

He has found that the samples of black Bio-Beads sent to him from Tregantle beach in South East Cornwall have the same chemical signature as those collected from within the confines of the SWW wastewater plant at Plympton – but are quite different from the regular black nurdles collected from the same beach. Bio-Beads tested from various other sites around Cornwall, the Isles of Scilly, South Wales, Sussex, Jersey, northern France and Texel Island in the Netherlands have a similar chemical profile to those on Tregantle too.

The defining feature was that these black Bio-Beads were found to contain significant levels of toxic elements such as lead, antimony and bromine – indicating that they had been made from recycled electronic equipment, which would have incorporated these additives as flame retardants.

Recycling of waste electronic plastics into the general waste stream has not been permitted since the Restriction of Hazardous Substances Directive 2002/95/EC took effect in July 2006.

Tests conducted on pellets currently being produced at the Bio-Bead manufacturing plant in France found that they did not contain these contaminants. However, many of the Bio-Beads still in use in UK wastewater treatment works (and apparently those that have been lost into the environment) will date back to the start-up of such plants in the mid-1990s, well before the regulation came into force.

The chemical additives found in the Bio-Beads littering our beaches can cause a wide range of potential health impacts. Lead, for example, for which there is no safe level of exposure, can cause a variety of sub-lethal effects such as damage to tissues and organs, damage to the immune system, damage to the reproductive system, high blood pressure and neurological impairment.[11]

These toxic additives within the pellets would make Bio-Beads harmful to any wildlife consuming them. In some of the beads, levels of bromine are so high that Dr Turner suggests they should be classified as hazardous.

[11] https://www.sciencedaily.com/releases/2014/05/140509131557.htm

7. How significant is Bio-Bead pollution on our beaches?

Bio-Beads are found on some Cornish beaches in huge numbers – for example over five million were removed from a 100m-stretch of Tregantle beach, Whitsand Bay, using a special microplastics separation machine in just seven sessions over a year from March 2017. (This figure was calculated by removing all extraneous organic and plastic material to leave a mix of pure pellets (nurdles and Bio-Beads). A one-litre jug filled with this mix yielded approximately 19,500 pellets, and the final estimate of over 10 million was reached by adding the number of litres. From a random sample of 3,311 of total pellets collected, over 52% were positively identified as Bio-Beads, with a further 3% possible Bio-Beads.)

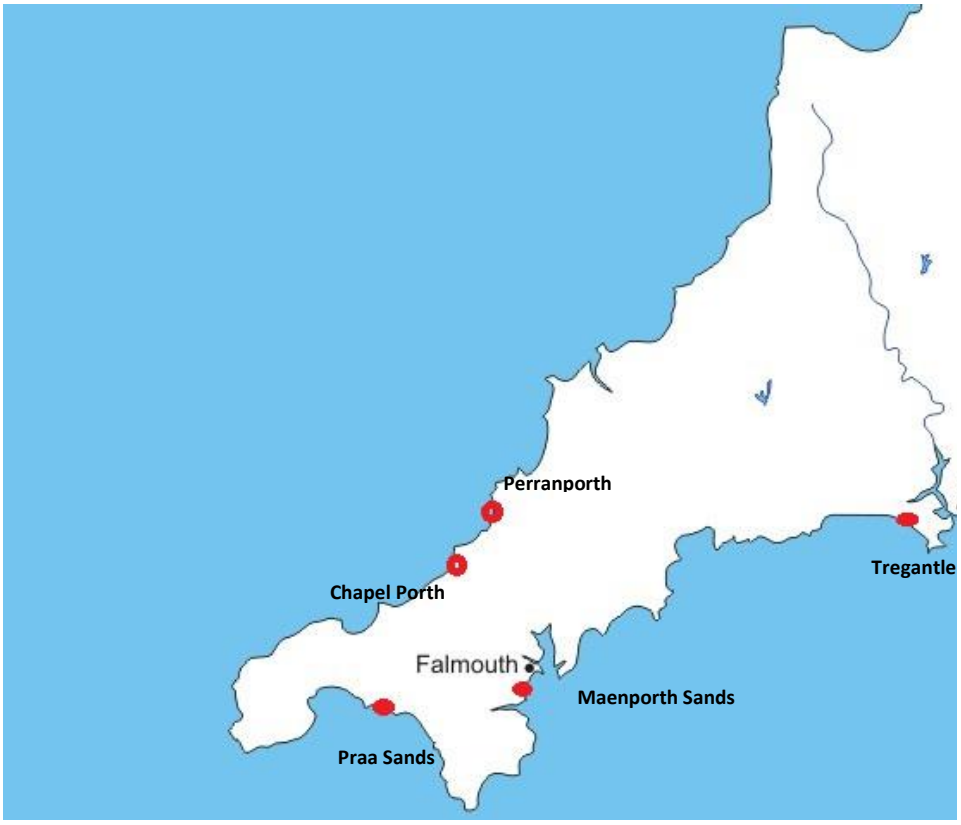
Further sampling is planned and will be very useful. However, all the surveys done to date, as well as anecdotal reports of Bio-Bead finds, indicate that these pellets, like other microplastics, tend to be deposited predominantly on fine sandy beaches. Shingle/ pebble beaches, with a larger substrate, tend to receive larger pieces of debris, with pellets being much less common.

The table below shows a breakdown of pellet types from random samples collected from five Cornish beaches in 2017.

'Possible' Bio-Beads are pellets without visible ridging but that resemble the pellets found downstream of the Liskeard plant outfall (see section 8.2). Note that a few of the pellets found at the Plympton SWW plant were not ridged or misshapen either.

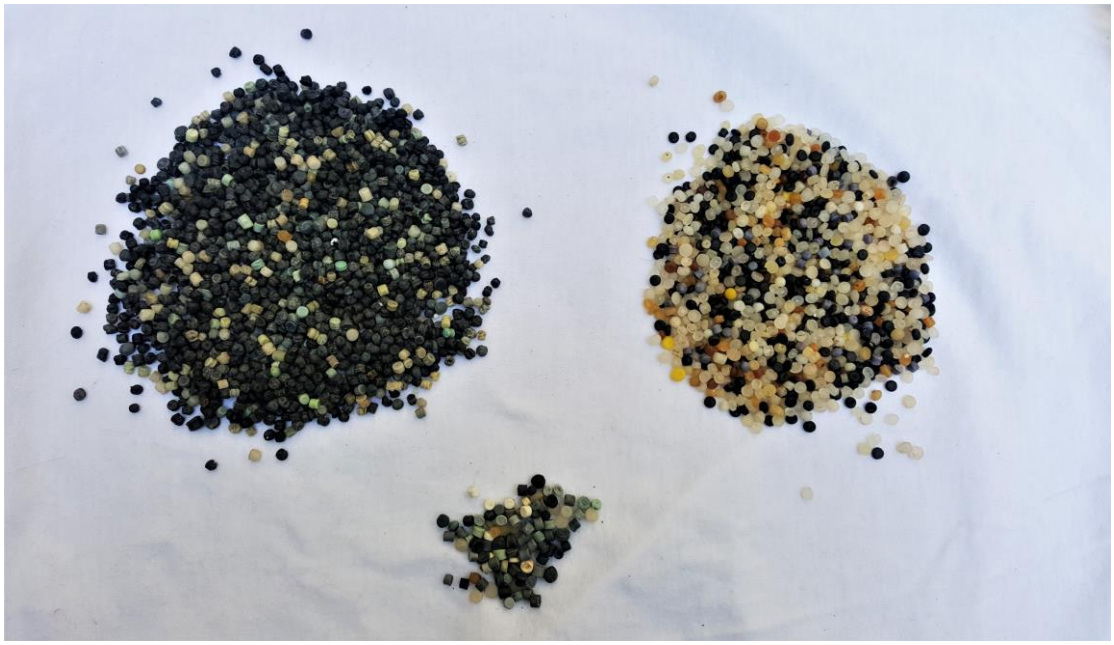
Site	**Maenporth Sands, Falmouth**	**Tregantle, Whitsand Bay**	**Praa Sands**	**Perranporth**	**Chapel Porth**
Date	February	March	March	May	June
Total pellets	590	3,311	287	609	587
Bio-Beads	421 **(71.36%)**	1,731 (**52.28%)**	152 **(53%)**	140 **(23%)**	323 **(55%)**
Nurdles	105 (17.8%)	1,480 (44.7%)	104 (36%)	433 (71%)	144 (24.5%)
Possible Bio-Beads	64 (10.85%)	100 (3.02%)	31 (10.8%)	36 (6%)	120 (20.4%)

NB The Bio-Beads in the Maenporth sample appeared particularly new, clean and unweathered.



Left: Sites of specific sampling to date. Many more areas need to be covered in order to build up a clearer picture of Bio-Bead prevalence around the Cornish coast.

More sampling of pellets from a wider range of locations would be useful. However, the evidence of the surveys to date – which have covered some of the Cornish beaches most frequently affected by significant microplastic deposits – indicates that, while the density of Bio-Beads may fluctuate, they often account for more than half of all pellets on the beaches where microplastics occur.



Tregantle sample showing Bio-Beads (left), nurdles (right) and possible Bio-Beads (bottom)

Picture: Claire Wallerstein

8. How do Bio-Beads end up on Cornish beaches?

Bio-Beads are out there in their millions. However, it is not clear how they have all got there. The following section considers some possible explanations – the real answer could very well be a combination of several of these.

Bio-Beads among debris on Polkerris beach, February 2017

Picture: Nick Waddington

8.1 Major spills from wastewater plants?

South West Water experienced a significant spill of Bio-Beads from its Newham plant near Truro in 2010. This happened when the steel mesh holding the beads in place in one reactor split, allowing all of the beads – probably around 5.4 billion – to escape, most of them reaching the nearby river.

SWW also had another unquantified but probably smaller spill from its Modbury plant in 2009.

We have also learned that Wessex Water had a spill of approximately 50 million Bio-Beads in 2015, while Thames Water has also suffered an unquantified loss.

Southern Water has also experienced losses of Bio-Beads, though these were apparently all contained. Many of these incidents seem to have been related to failures of the retaining mesh above the tanks, which should hold the beads inside the reactors.

SWW have told us that ‘most’ of the Bio-Beads from the Newham spill were retrieved, with boats deployed on the river and nets used to collect the floating beads. However, these tiny, hard-to-spot beads would quickly have become dispersed once outside the tight confines of the reactor and in the dynamic environment of the river. We believe large numbers would have been lost downstream on the current and through deposition on river banks and entanglement with vegetation.

Even in the optimistic scenario that a significant majority, say 5.3 billion, were successfully collected, this would still have left one hundred million at large. Placed end to end, this would be enough Bio-Beads to create a continuous line 350km long – almost the length of the entire Cornish coastline.

A letter dated 12 February 2010 from Mark Pilcher, the Environment Agency’s Environment Management Team Leader for West Cornwall to Richard Gilpin (then Waste Water Manager at SWW) also shows that the spill was not immediately resolved, with the plant still leaking Bio-Beads some time after the initial accident.

The letter reads: “I recently received a communication from Hilary Benn’s office regarding his concerns about plastic beads found and reported by a local person on the Tresillian River near St Clement in Cornwall. Defra were very keen to understand where these beads were coming from … I was provided with a sample of the beads found in the Tresillian River and I have compared these with the beads from Newham STW which have escaped from your BAFF unit. A visit to Newham STW by one of my officers confirmed that the BAFF beads were still escaping from the BAFF to the works and then to the river.”

The Newham plant was decommissioned following the spill. However, Mary James, a kayaker who regularly cleans up plastic waste along the length of the Truro river, finds Bio-Beads still deposited on the banks in large numbers if she digs down deep enough under the leaf litter and grass – over eight years after the spill.

Pellets found by kayaker Mary James along a small area of riverbank on the Truro River at Malpas on February 18, 2018

Could a big spill happen again?

The SWW briefing sheet on nurdles and Bio-Beads[12] (see Appendix 1) states: "All BAFF plants that use Bio-Beads have bead traps and are fitted with mesh grating over the cells. If a bead loss occurred it would be immediately obvious within the sewage treatment works, where they would be seen floating on tanks and in the backwash. South West Water staff would then carry out an urgent inspection to determine where the break was and repair it as well as to contain the Bio-Beads on site. Media is expensive and we want to keep it in the process units."

A SWW spokesperson added in an email to the CPPC dated 3 February 2017 that: "Our coastal bio bead plants have ultra violet disinfection plants downstream of the BAFF process and any spilt media would be caught in these."

However, it was later clarified that the UV disinfection channels are not designed to trap Bio-Beads to any significant degree, and would only retain a small number, acting more as a possible alert to operatives than as any kind of meaningful way of stemming a major release. The Newham plant, for example, did have these UV disinfection channels in place.

SWW has assured us that the integrity of the mesh screens above the reactors is regularly monitored as part of daily operator checks, with any faults reported to the site supervisor so they can be quickly addressed.

However, we are extremely concerned that there is currently no physical means of quickly stopping the loss of Bio-Beads in the case of another catastrophic event – an inherent vulnerability in the design of the system.

8.2 Ongoing trickle of low-level losses?

South West Water advised us that they have to periodically 'top up' the Bio-Beads used in their plants.

At Plympton, for example, where the BAFF system has been operational for approximately 24 years, there have been two top-ups, with 7 – 10% of the Bio-Beads being replaced on each occasion (approximately 16% overall). Top-ups have also taken place at other SWW plants, although we have no details on which ones, when or how much.

SWW say these replenishments are not related to any major spillage, and that the top-ups will be partly to do with having to increase the depth of media beds to improve performance due to very strict consents on the quality of water discharged from their plants, and also probably due to losses to sewage sludge (see section 8.6, below). They also say they are one of only a few water companies to regularly check their Bio-Bead levels.

A SWW spokesperson told the CPPC by email on 4 February 2017: "The manufacturers (FLI Water) cite an approximate loss of 1% per year, although we

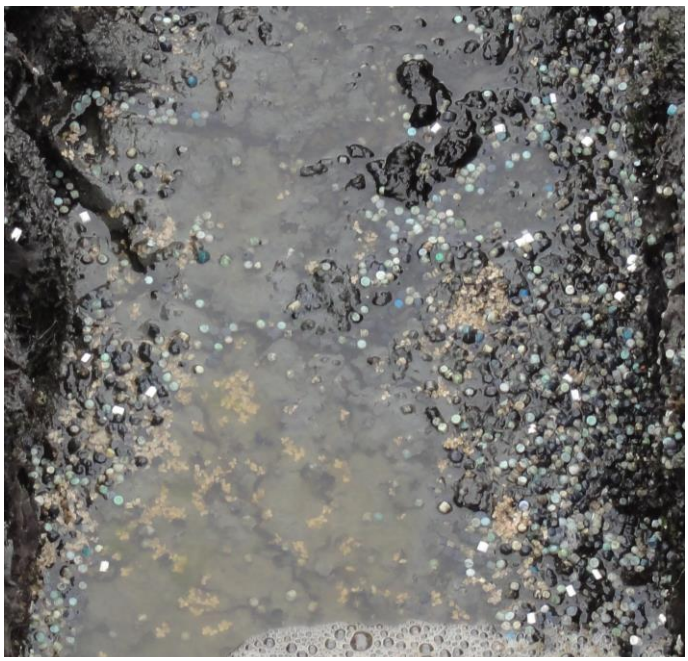
[12] https://www.southwestwater.co.uk/environment/rivers-and-bathing-waters/nurdles-and-bio-beads/

have not consistently observed this. We monitor levels annually and arrange for media replacement when levels are noted to be below optimum operation."

However, Melvyn Rose of FLI Water told the CPPC by telephone in early February 2017 that the '1% loss per year' figure is simply something the company builds in as a process guarantee when bidding for projects. These are upper margins that they know cannot possibly fail, as otherwise they would be at risk of punitive penalties.

He said that, in fact, losses should be zero, citing the case of a plant similar to Plympton in the Anglian Water region, which has been operational for the same period of time and yet has never been topped up.

Many (though not all) of the other water companies we have heard from say they have not needed to top up their Bio-Beads. However, few plants have been operational for as long as the SWW ones (for example the Welsh Water plants are only about 15 years old).



Source of some losses? Bio-Beads visible in the channel of treated water above a BAFF reactor at Plympton in June 2017 (image below is a close-up of the marked section at left). Water travels from these channels straight to the outfall and into the River Plym.

Picture: Rob Arnold

In March and July 2017 Rame Peninsula Beach Care (RPBC) volunteers conducted a brief survey of the banks of the East Looe river (the river into which South West Water's Liskeard plant discharges).

Bio-Beads were discovered both along the banks of the tidal part of the river (at Sandplace) and higher up in the non-tidal part, only a short distance downstream of the wastewater plant outfall.

The East Looe river at Sandplace, March 2017

Picture: Claire Wallerstein

Right: Hunting for Bio-Beads in the grass banks of the East Looe river at Sandplace, March 2017

Below: Pellets found along a 10m stretch of riverbank at Sandplace

Pictures: Claire Wallerstein

Above left: Bio-Beads in situ on the banks of non-tidal part of the East Looe river, March 2017

Above right: pellets caught in a small sieve a short distance downstream of the wastewater plant outfall over a 10-day period in July 2017. All these pellets measure more than 3mm. However, rust deposits on some of them may indicate possible deterioration in the steelwork of the reactor.

Pictures: Rob Arnold

This shows that Bio-Beads can escape from plants and are certainly doing so at Liskeard. However, RPBC was only able to carry out short surveys and the scale and pattern of these losses are not clear. Although some of the beads caught here looked quite worn, none measured less than 3mm so it seems unlikely they are escaping through the holes in the retaining mesh screen. However, rust deposits on some of them could possibly indicate deterioration in the steelwork of the reactor.

Bio-Beads seem to have been lost from the Liskeard plant over a long period of time. The image to the left was taken in 2014 by a Cornwall Wildlife Trust ecologist undertaking surveying at Higher Coombe, just a short way downstream of the Liskeard plant outfall. She took this photo as she was shocked to find the river with so many beads in it, though she had no idea at the time what they were.

While most are evidently Bio-Beads, several of the pellets caught in both our March and July samples near Liskeard and seen in the 2014 photo above are different in

colour and shape to those seen at Plympton (opaque white or opaque pale grey), and are also quite smooth and cylindrical, looking more like regular die-cut nurdles.

During our visit to Plympton in January we were told that different coloured beads may be used at different plants, so does this mean these unusual pellets are Bio-Beads too? If not, and they are in fact nurdles, this would seem to suggest they have been lost down storm drains due to poor housekeeping at a local plastics plant (of which there are very few). However, since rainwater would also be treated through the BAFF reactors at the wastewater plant, except during storm conditions when the combined sewer overflow system would kick in, this would tend to reconfirm that pellets (be they Bio-Beads or nurdles) can escape the plant and are doing so.

Above: 249 Bio-Beads found in a 50cm2 area of riverbank downstream from the Plympton plant at the Blagdon's Meadow County Wildlife Site. Some beads were lying on the surface of vegetation, others were buried right down into the sediment, apparently having been there for a long time.

Right: yellow circles denote density of Bio-Beads beneath grass on the river bank. **Pictures: Claire Wallerstein**

Bio-Beads were also found in high density on a small sample area along the banks of the River Plym around a mile downstream of the Plympton wastewater plant, with 249 beads found in only about 50cm2. Researchers from Plymouth University have confirmed that they have found similar pellets along the River Plym for many years.

Are losses from these two Bio-Bead plants, where no significant spills are believed to have occurred, continuous? Or do they only occur at certain times, for example when the reactors are disturbed during maintenance, etc? Are these plants unusual, or are biomedia being lost on a low-level basis from the other Bio-Bead plants too?

The Environment Agency is currently investigating at Liskeard and hopes to extend this research to the other Bio-Bead plants in future. We hope this investigation will

include lifting the mesh on one of the reactors at Liskeard to see exactly what type of beads are used in it.

8.3 Losses during heavy rains?

Many of the pellets we found on the banks of the East Looe river were high up in the grass, at a level that would seem only to be reached during periods of extremely high water.

Interestingly, some of the reports we have received about beached Bio-Beads – especially 'pure' dumps comprising only Bio-Beads as opposed to apparently older Bio-Beads found mixed up with other nurdles and microplastics – have coincided with exceptionally heavy rains.

However, during heavy rain scenarios SWW is permitted by the Environment Agency to discharge excess water directly to the environment via the CSO (combined sewer overflow) system to prevent wastewater treatment plants from being overwhelmed. This bypasses the Bio-Bead/ BAFF part of the process, so it is not immediately clear whether or how excessive rain could have any impact on the Bio-Beads.

Bio-Beads and nurdles in situ at Colona beach in St Austell Bay (left) and a handful collected from a whole tideline of similar beads at Watergate Bay (below right), both in September 2015, after Cornwall had experienced double the normal amount of rainfall in August (Met Office). Pictures: Rob Wells and Bex Allen

Left: Bio-Beads found by Andy Dinsdale at Camber Sands, East Sussex following torrential rains in February 2017

Picture: Andy Dinsdale

8.4 Abrasion?

During our site visit to the Plympton plant in January 2017, one SWW wastewater scientist questioned whether the process of the wastewater being pushed up through the tightly-packed beads could result in abrasion, eroding the beads down into smaller microplastics that can be lost through the 3mm holes in the mesh screen holding them down.

Melvyn Rose of FLI Water insisted that this would not be happening, explaining that the beads are tightly packed in the reactors and don't move at all except during the approximately 30-minute weekly air scouring cleaning process. The only rough surface with which the Bio-Beads could come into contact would be the concrete edges of the tanks, which would only be the case for relatively few of them.

However, given that a plant such as Plympton has been operational for 23 years (with two replenishments/ top-ups), 30 minutes per week could work out as possibly 200+ hours of scouring in the lifetime of a Bio-Bead. We also wonder whether abrasion could be a factor for the Bio-Beads pushed up against the steel mesh.

Ruth Barden, Director of Environmental Strategy at Wessex Water, told the CPPC by email (30 May 2017): "As with all filter media, over time, there can be a need to 'top up' the media due to degradation, abrasion, and movement of media within the sewage treatment process, for example in backwash tanks. This does not mean that there have been losses to the environment but that the media gets worn over time due to use."

Any losses attibutable to abrasion would suggest that the beads in question are being worn down to sizes small enough to slip through the screen mesh – and/ or

that the ‘missing’ parts of abraded beads are being lost as even smaller microplastic particles.

We have certainly found that some of the Bio-Beads on our beaches seem very small, barely measuring 3mm across – but is this the result of wear after a long time in the sea, or did they become worn down to this size prior to being lost from plants?

However, we consider abrasion to be unlikely (see section 8.5 below).

Many beached Bio-Beads are very small (barely 3mm) – but were they worn down before or after being lost?

Picture: Claire Wallerstein

8.5 Production of sub-size Bio-Beads?

Melvyn Rose of FLI Water advised us that the beads measure 3.5-4mm across and so could not be lost through the 3mm mesh holes.

The former manager (until March 2017) of Plasti-Negoce, the French company that produces the Bio-Beads, told the CPPC by email on 14 March 2018 that “no bead may be smaller than 3.2mm in diameter. Following production they are carefully sifted to eliminate any pellets that are smaller than this”.

However, from the sample of Bio-Beads collected from two areas of spills at the Plympton plant, we found that some of these beads seem to measure just barely 3mm across. It seems unlikely that they have been worn down to this size by abrasion, since they still retain their distinctive ridging on the outside.

Some pellets collected from the South West Water plant at Plympton in January 2017 seem to measure only just 3mm – the same width as the holes in the screen over the top of the BAFF reactors. The fact that they still have their original ridging suggests that abrasion is not the cause. Picture: Claire Wallerstein

8.6 Losses to sewage sludge?

Melvyn Rose of FLI Water suggested that losses in Plympton could be due to an excess of solids in the system causing build-up on the beads.

This build-up means beads need to be cleaned through an 'air scouring' process, which changes their buoyancy. If there is too big a build-up of biomass before cleaning takes place, this can make the beads clump together, and could result in them sinking down into the sludge at the bottom of the tank, which is subsequently drained off, dried and processed, and sold as solid sewage ‘cake’ to local farmers as fertiliser.

A SWW spokesperson told the CPPC by email on 4 February 2017 that any losses of Bio-Beads are most likely to be explained in this way, i.e. by the beads sinking down to the sludge. However, she believed any beads lost in this way would end up in the fraction of non-compostable solids going to landfill, and not the cake going to farmers.

She described the process as follows: “Once the media has been air scoured and washed the sludge is removed via a low level desludge line. This does have siphons and bead traps to minimise any beads that may not have been entirely separated from the sludge. However, nothing is perfect and this is the source of any losses.

“The sludge removed is very thin – like dirty water really and this is returned to the settlement tanks (where any beads would float on the surface and be immediately noticed, removed and investigated). If some beads were so heavily contaminated they could sink into the sludge they would move into the sludge treatment plant. Before any sludge is recycled to agriculture it undergoes rigorous treatment. This includes further screening – to remove plastics that have been flushed thoughtlessly down the loo, conditioning and then anaerobic digestion to reduce pathogens and solids. Part of this process involves de-gritting (heavier sand particles are settled out) and then further storage before being made into a cake for export to agriculture.

“These stages would capture escaped beads so very few, if any, would be included in the exported product. Our separated grit and screenings are composted, to remove organic material and then the residue goes to licensed land fill.”

However, she confirmed that no sampling has been done to date of either the solids going to landfill or the cake going to farmers to see whether Bio-Beads are present and if so in what numbers.

Given the size of Bio-Beads (and the fact that they'd be mixed up and the same colour as the sludge), and the fact that the mesh used to remove solids from the sludge has 6mm holes, it seems possible that Bio-Beads could be sent out in the sewage cake and be injected unnoticed into agricultural land.

However, during the CPPC’s June visit to the Plympton plant we were able to have a brief look at the sewage cake and were not able to see any beads.

According to best practice guidelines set by Defra on the use of biosolids in agriculture[13], untreated sludge cake should be incorporated into the ground within 24 hours (although treated sludge may be spread on the soil surface). There are also safeguards designed to prevent run-off to watercourses.

However, while immediate losses to watercourses may be prevented or minimised, the non-degradable nature of plastic and the impossibility of retrieving small particles such as Bio-Beads from the biosolids means they would likely remain in the earth for hundreds or thousands of years and/ or eventually run off into aquatic environments, in either case with potential ongoing environmental impacts that we cannot yet gauge.

8.7 Losses due to poor management and handling on site?

Like all other industrial plastic pellets, Bio-Beads are by their nature easily spilled and, if not quickly cleared up, can potentially be lost to the environment.

In addition to the large numbers of Bio-Beads observed lying on the ground in January 2017 at the Plympton site near the BAFF reactors, we also became aware of another disturbing incident.

This happened after a member of the public slipped on a large number of Bio-Beads strewn over an asphalted public path running between the River Plym and the fence of the SWW Plympton site in April 2017.

This was reported to the National Trust at the adjoining Saltram estate. NT staff went out and found an area of around 10m² covered in Bio-Beads, which they cleared away as best they could. They did not take any photographs, but said they removed a black rubbish sack over half full (given that around 10,000 pellets will fit in a jam jar this will have been many tens of thousands of Bio-Beads at a minimum.)

This spill apparently occurred after vandals had broken through the fence to an area adjoining the Plympton plant, which was being used by SWW contractors to store Bio-Beads in scores of open dumpy sacks under the A38 dual carriageway flyover.

When the Cornish Plastic Pollution Coalition was alerted to this by a NT volunteer on 12 May 2017 (3 to 4 weeks after the incident had happened), we contacted the Environment Agency, who in turn alerted SWW.

EA officer Chris Barnes told the CPPC by email on 15 May 2017: “Several dumpy bags of biomedia had been vandalised (slashed) resulting in the loss of the biomedia. It appears that SWW had been unaware of this until your report and subsequent notification by us. SWW had thought that the storage location was secure. They confirmed this morning that they will be arranging for a full clean up although they did think that some of the media had entered the watercourse.”

[13] https://www.gov.uk/government/publications/sewage-sludge-on-farmland-code-of-practice/sewage-sludge-on-farmland-code-of-practice

On 17 May 2017, we went to look at the area, finding two large holes in the fence where the intruders had presumably entered, and observed scores of dumpy sacks with Bio-Beads spilling out of them behind the fence. Using binoculars, we counted around 60 sacks of Bio-Beads. Forty more sacks appeared to contain the same material but were too far away for this to be confirmed.

Bio-Beads spilling out of open dumpy sacks in the SWW storage area near the Plympton plant.

Picture: Claire Wallerstein (17 May 2017)

Large numbers of Bio-Beads were still present among the grass on the adjoining riverbank. Bio-Beads (presumably tracked away on the feet of passers-by) were also found on a pedestrian bridge 100m away and on the small beach at Saltram further downstream.

Left: A hole through the fence to the SWW storage area along the public footpath adjoining the Plympton plant site, dumpy sacks visible in the background, Bio-Beads in the foreground , 17 May 2017 (Claire Wallerstein)

Below: Spilled Bio-Beads along the Plym riverbank, 12 May 2017 (Lynne Bracegirdle)

Given the significant amounts of graffiti on the pillars supporting the A38 dual carriageway above, it seems that the site must have been frequently entered by intruders. The location – alongside a public foothpath and right by a river – also seemed to be a poor choice for storing a material of this kind.

SWW have since had all the dumpy sacks removed from this site to a more secure location.

SWW confirmed that the biomedia arrive from the suppliers in dumpy sacks. Although the sacks are tied when they arrive, the bags we observed were open. We do not believe these flexible bags are a safe way of storing an easily-lost material such as Bio-Beads, potentially over long periods of time, or of transporting the media around a site.

Trail of black Bio-Beads spilled along the length of a road within the Plympton site, following removal of the vandalised sacks of beads to a more secure location, June 2017

Picture: Rob Arnold

8.8 Legacy from plants no longer using Bio-Beads?

Many of the reports of beached Bio-Beads that we have received from Coalition group members, wildlife surveyors and beach cleaners have been on west-facing beaches to the east of known BAFF plants, e.g. Poldhu – east of Porthleven, Polkerris beach – east of Gorran Haven, both in Cornwall, and Camber Sands, East Sussex – east of Eastbourne.

This seems to make sense given the generally-accepted understanding of currents around Cornwall and along the south coast of England travelling from west to east in line with the North Atlantic current.

However, Bio-Beads are also found on the mid-north Cornish coast, around areas such as Newquay and Widemouth Bay.

There are no plants using Bio-Beads to the west of these, with the closest BAFF plants being at Bideford (now closed) and Combe Martin.

We wondered whether there could previously have been more plants in the region using Bio-Beads that have since been decommissioned (like the Truro Newhaven plant, following the 2010 spill). However, SWW have confirmed to us that the only other previously-existing BAFF plants were at Slapton and Bideford, both in Devon.

SWW also confirmed that BAFF media are not used in any of their mobile wastewater treatment plants, which can be moved around according to need.

Is it possible that Bio-Beads could have tracked west, rather than east, along the north Cornish coast, for example due to the influence of the River Severn?

This is far from clear. However, oceanic and river currents, river flows, water salinity, temperature, turbidity, tides and wind can sometimes have quite significant and complex interactions and impacts on marine debris.

For example, a 2015 study (*Physical processes in a coupled bay-estuary coastal system: Whitsand Bay and Plymouth Sound* – Uncles et al.) demonstrated that particles from the Tamar River at Plymouth can travel west over a period of 25 days to reach Whitsand Bay – the opposite direction of what might naturally be expected.

8.9 Losses from other sources?

Bio-Bead type filters may also be used in other applications, for example for filtering water in fish farms/hatcheries.

However, Cornwall Wildlife Trust marine officer Matt Slater, who has extensive knowledge of local fisheries, says there are very few fish farms in Cornwall. Two trout farms in Hayle and Boscastle use natural river water to flow through their facilities, while oyster and mussel farms, being in situ, tend to use sand filtration and UV sterilisation.

Ben Marshall, senior technician at the National Lobster Hatchery in Padstow, confirmed the centre uses highly-calcified argonised sand as a filter, as well as some plastic biomedia. However, these media are large (cotton reel sized).

The National Marine Aquarium in Plymouth and the Blue Reef Aquarium in Newquay have also confirmed that they do not use this kind of biomedia.

Other uses not associated with SWW wastewater treatment have also been suggested, for example small scale water treatment plants at off-grid sites, swimming pool cleaning, hobby and commercial aquaria, and in the treatment of leachate, industrial effluent and industrial wastewater.

We have no confirmation of this kind of biomedia being used in any of these other possible suggested applications. FLI Water has unfortunately failed to respond to follow-up information requests, so we do not know whether it is supplying other industries or companies in the UK with Bio-Beads as well as wastewater treatment plants.

8.10 Container ship spills?

Given the relatively high densities of Bio-Beads on the mid-north coast, and the fact that they are also found on the Isles of Scilly (28 miles west of mainland Cornwall), there is a possibility that some of the Bio-Beads could be coming from the sea rather than land-based sources.

Bio-Beads found on Scilly to date have predominantly been found on a south-facing gravel beach on the island of St Mary's.

Some Bio-Beads among a collection of industrial pellets picked up on the Isles of Scilly. (Bio-Beads make up a minority of the pellets here and were collected from more than one beach over a period of time).

Picture: Nikki Banfield

In June 2017, strandlines of Bio-Beads were reported by French NGO SOS Mal de Seine along a stretch of the northern French coast from the Baie de Somme nature reserve in Picardy to Boulogne-sur-Mer (note that Bio-Beads are used, at most, at just one plant in France). Around the same time, Andy Dinsdale of the Rye Bay Beachcombing group heard from a kayaker who reported seeing 'many Bio-Beads' floating at sea off the Sussex coast.

There was also an earlier significant stranding event of Bio-Beads along the French coast from Saint-Vaast-la-Hougue near Cherbourg in Normandy through Boulogne-sur-Mer and up to Belgium in 2010/ 2011 (soon after the major spill at Truro).

Could these be the result of spillages at sea? Could a past spilled shipment of Bio-Beads somewhere to the west of Cornwall explain why beads appear on the north Cornish coast, where no Bio-Bead plants operate, as well as along the (more heavily affected) English Channel coast?

This is a possibility but currently seems unlikely, because the company supplying the Bio-Beads to UK water companies, FLI Water, imports them from a French company called Plasti-Negoce, which is based in Lormaison, France, around 50km outside Paris. Bio-Beads produced in France would be transported to the UK by road rather than ship and to date it seems that the only trade in Bio-Beads is between France and the UK. We have no evidence of Bio-Beads being produced or processed elsewhere in this country, shipped in from other locations, or of companies based in the UK or elsewhere in northern Europe producing them and shipping them across the Atlantic or eastwards through the English Channel.

In addition, the results of the toxicological analysis of Bio-Bead contaminants undertaken for us by International Pellet Watch in Japan (see section 6) strongly suggest that the Bio-Beads (or at least the ones found on Tregantle beach in Cornwall) originated from losses at wastewater treatment plants rather than from container ship spills.

Plasti-Negoce started making Bio-Beads at the Lormaison site in 2005. A business file shows that the company exports 100% to the UK, although it has considered expanding production to Algeria. Its nominal annual production of Bio-Beads in 2009 was listed as 600 tonnes (approximately two dumpy sacks per day), worth €300,000.

However, the former director of Plasti-Negoce, who asked not to be named, mentioned in an email to the CPPC on 14 March 2018 that there were other manufacturers of Bio-Beads in Europe, although he did not reveal where else they were made, and did not answer further information requests.

He also said Bio-Beads were used at one plant in France but would not elaborate on this either.

So far we have only been able to confirm Bio-Bead use in the UK, although FLI Water is known to have attended the Smagua trade fair in Zaragoza, Spain, to exhibit its Brightwater/ Bio-Bead system in 2008[14].

It is also possible that Bio-Bead technology is used in Ireland, given that FLI Water's parent company FLI Environmental is based in Waterford, Ireland[15]. However, we have not been able to confirm this.

Bio-Beads washed up in June/ July 2017 in the Baie de Somme, northern France, an important site for migratory birds

Pictures: Laurent Colasse

8.11 Could they be coming from even further afield?

We periodically find plastics and other debris on our beaches that can be identified as having come right across the Atlantic.

As well as sea beans from the Caribbean and lobster pot marker buoys and tags, many of them from Maine and Newfoundland, we also sometimes find Hooksett discs – flat plastic mesh discs used as biomedia in a sewage treatment plant in New Hampshire, up to eight million of which were lost to the environment following heavy rainstorms in 2011.

Interestingly there have been various other reported cases of US sewage treatment plants losing their plastic biomedia after heavy rains, e.g. the Groton Plant in Connecticut lost around one million similar discs in March 2010, while the

[14] http://www.interempresas.net/Reciclaje/Articulos/20939-Brightwater-FLI-presente-Smagua-2008-busca-reducir-elevado-impacto-energetico-tratamiento.html

[15] http://www.irishexaminer.com/business/fli-buys-two-britain-based-companies-48336.html

Mamaroneck wastewater plant in New York lost a large number of plastic K3 biomedia in March 2011.[16]

If these small discs have travelled in large numbers across the Atlantic, is it possible that much more of the plastic waste littering our beaches – including Bio-Beads – could also have made this journey?

Although this is a possibility, we consider it to be unlikely. While similar trans-Atlantic drift material such as sea beans, lobster pot tags, marker buoys and Hooksett discs are also found on beaches in Brittany, France, and Kerry, Ireland, Bio-Beads seem to be totally or virtually absent in magnified photographs of pellet samples from these areas examined by the CPPC, and local beach cleaning groups there do not report them (although small numbers of Bio-Beads have been recorded in South West France by the Surfrider Foundation).

Hooksett disc found at Tregantle, Whitsand Bay in June 2014

Picture: Claire Wallerstein

We have not been able to ascertain whether Bio-Beads are in fact used anywhere in America.

Typical pellets collected from St Finian's Bay, Co. Kerry, Ireland – just four or five possible Bio-Beads.

Picture: Rosemary Hill

Distinctively-ridged Bio-Beads found between Le Porge and Contis in Aquitaine, SW France.

Picture: Vanessa Balci

Sample of pellets collected near Le Conquet, Brittany (above) and a similar sample from Tregantle, Whitsand Bay (below). It is striking that the Brittany sample comprises predominantly white pre-production nurdles. The black pellets all seem to be lentil-shaped, smooth pre-production plastic nurdles. Bio-Beads are not apparently present in this

In the Tregantle sample, a large number are black Bio-Beads.

NB: The bright yellow pellets in both samples are believed to have come from a container lost from the MSC Napoli, which started to break up between England and France due south of the Lizard in January 2007, while on route from Belgium to Portugal.

Pictures: Gilbert Mellaza (top), Claire Wallerstein (bottom)

8.12 Losses from manufacturing plants?

It is probable that all the Bio-Beads supplied to the UK water industry are imported from France by FLI Water. However, we have no information about whether similar pellets are also produced by UK-based companies for use in other water treatment applications.

Research into pellet loss from the plastics manufacturing industry in general shows that pellets – being tiny and easily spilled – are frequently lost from plants.

Without specific containment and clean-up protocols in place, such as those suggested by the British Plastic Federation's voluntary Operation Clean Sweep programme[17], it is all too easy for pellets to end up being washed down storm drains and from there back into waterways and ultimately the sea.

Losses of this kind are not to be underestimated. A recent study by Eunomia[18], commissioned by Fidra, estimated that up to 53 billion pre-production pellets could be lost by the UK plastics industry each year.

It is therefore possible that Bio-Beads are being lost to some degree from sites where they are manufactured/ handled/ processed and then transported – as well as from handling procedures once at the water plants themselves.

8.13 Are most of the Bio-Beads on (or in) our beaches all the time?

Large tidelines of Bio-Beads, churned up with weed and other microplastics, often appear in their millions on our beaches in late winter/ spring time – usually associated with stormy weather. These deposits of smashed up microplastics, which can stretch for hundreds of metres, always contain large numbers of cotton bud sticks, another item of sewage-related plastic debris, which can end up in the sea during heavy rainfall when water companies are permitted to discharge excess water without treatment through CSOs (combined sewer overflows).

If these dumps have arrived freshly from the sea it would seem there should be large rafts of them floating around offshore. As far as we know nothing like this has been reported (apart from one anecdotal report by a Sussex kayaker of large numbers of floating Bio-Beads in July 2017). However, the tiny size of microplastics/ Bio-Beads, the vastness of the sea and the frequently stormy conditions at the times of these winter dumps would obviously make them very hard to spot.

[17] http://www.bpf.co.uk/Sustainability/Operation_Clean_Sweep.aspx

[18] http://www.eunomia.co.uk/reports-tools/study-to-quantify-pellet-emissions-in-the-uk/

An alternative explanation is that they have been temporarily released after spending most of the year buried under the sand on the same beaches.

Many of the Bio-Beads in this jumble of mixed microplastic could well have been in the system for years or even decades and some of them do appear to be quite weathered.

Among the mixture we always find one dateable item – pieces of Lego from the 1997 Tokio Express cargo spill off Land's End (when a container holding around 5 million pieces of sea-themed Lego fell into the sea). This Lego is now found as far east as the Netherlands – showing just how far material from Cornwall can potentially travel.

The Lego in these winter/ spring dumps of microplastics probably spends most of the year buried under the sand, since it is not seen in nearly such large quantities during the rest of the year.

It would be useful to find out when the black Bio-Beads were first introduced (the company FLI Water told us these were the most recently-added type). Since black Bio-Beads are the most prevalent on our beaches (often accounting for around 50% of all pellets found), this would help to give an oldest possible age for many of the Bio-Beads we find. Unfortunately, however, the company has failed to respond to subsequent requests for information following an initial telephone conversation in February 2017.

Lego flippers, spear guns, scuba tanks and cutlasses from the 1997 Tokio Express container ship spill, found among semi-buried Bio-Beads and microplastics removed from Tregantle beach over a three-hour period on 10 March 2017

Picture: Claire Wallerstein

We have evidence that plastics often are buried and then liberated by the very active sand-shifting and beach-reprofiling action of the sea. For instance, after the storms of 2014, beach cleaners suddenly started finding large amounts of 'vintage' plastic washing up on Cornish beaches, with products priced in pre-decimal pounds, shillings and pence. These had almost certainly been released from sand dunes, having lain buried there for decades.

There is still much to learn. In future we hope to undertake a 'sand core' analysis in one of the areas worst afflicted by microplastics on Tregantle beach, to try to find out how far down these plastics in fact penetrate.

We hope also that, by doing our best to remove as many pellets as possible from this one section of beach, we will see if this has any impact on the microplastics load appearing there in subsequent years.

9. Which companies use Bio-Beads?

We contacted all the UK water companies and submitted public access requests for Environmental Information to find out more details on which companies are using Bio-Beads and whether they have experienced any losses or spills – as well as more data on the various other types of plastic biomedia used in wastewater treatment around the country.

What has been particularly striking in requesting this information is how awareness of the Bio-Bead system may be limited to only a few specialists within the companies, who in turn may not focus much on the beads themselves.

With Bio-Beads being just one of many forms of plastic biomedia used today in wastewater treatment, each with their own specific terminology, there was some difficulty in accessing the information requested for this report. One company said it used plastic media, but not Bio-Beads, before subsequently clarifying that it did. Another told us it uses no plastic media at all – despite FLI Water having named it as one of its customers. Following a request for clarification, the company's Environmental Information Request Officer offered 'unreserved apologies' for the misinformation, but said it would be impossible to provide information about the specific types of plastic biomedia used at different plants without conducting a comprehensive site survey. Wastewater staff at SWW and the company's original briefing sheet on Bio-Beads (since corrected) described Bio-Beads as predominantly blue and white or mixed, even though the evidence on the ground at the Plympton water treatment plant visited in January and June 2017 was that they are predominantly black. Another water company asked for an additional 20 days on top of the initial 20-day deadline for answering the CPPC's information requests, due to the 'complex nature' of the information we had asked for.

Another type of biomedia, this one wheel shaped, commonly used in wastewater treatment in the UK as well as elsewhere. This image is from a spill in Corbeil Esssone (near Paris) in February 2010 when a municipal wastewater treatment plant lost 800m3 of biomedia into the river Seine.

Picture: Renaud Francois

Out of the 12 national companies, we have found that two (Severn Trent Water and Northumbrian Water) do not use Bio-Beads, while one (Thames Water) was unable to confirm the nature of its plastic media. The remaining eight (possibly nine with the addition of Scottish Water) do use them, although none do so at a large number of their plants.

Of these, five (South West Water, Anglian Water, Northern Ireland Water, Southern Water, Wessex Water) are definitely supplied by FLI Water. For the other companies, this information was either not known or was not supplied.

The information received from the water companies, combined with some added data from a 2004 internal SWW list on commissioning dates and populations served, shows the following Bio-Bead BAFF plants in operation throughout the UK in addition to those in the SWW region.

From the population figures provided for some plants in the 2004 SWW list, it seems that BAFF Bio-Bead plants around the country serve a total population of well over two million people.

Anglian Water

Sible Hedingham	(opened 1992, population served 5,800)
Framlingham	(opened 2003, population served 4,000)
Hempnall	(opened 2002, population served 2,400)
Wymondham	(opened 1997, population served 20,000)
Over	(opened 2000, population served 13,900)
Manby WRC	
Whilton WRC	
Harleston WRC	
March WRC	
Flag Fen WRC	
Bourne WRC	now disused
Saffron Walden WRC	now disused

Northern Ireland Water

Larne (seven reactors) Opened 2005, population served: 30,000
Derrynoose (three reactors)

Northumbrian Water

No plants use Bio-Beads.

Scottish Water

Information has been harder to glean from Scotland, where the water company is operated quite independently in the different regions.

Madeleine Berg from the NGO Fidra had conversations with various process scientists from Scottish Water in July 2017, as a result of which it seems that Bio-Bead-type media are being used at just one plant in South Ayrshire at Crosshill near Girvan. It only serves around 200 people.

The plant has been in operation for approximately 10 years. The process scientists were not aware of there having been any top ups, although they did comment that the plant is not performing very well, especially in dry weather. They said no spare beads are stored on site.

Severn Trent Water

No longer have any BAFF plants used in wastewater and have never had a Bio-Bead BAFF.

Southern Water

Eastbourne	Opened 2002, population served: 130,000 (6 reactors)
Broomfield Bank (Dover)	Opened 2003, population served: 183,000 (6 reactors)
Beckley	Opened 2004, population served: 1,200 (3 reactors)
Peacehaven (10 reactors)	
Sandown (6 reactors)	

Thames Water

In response to our enquiry, Thames Water told the CPPC by email on 5 July 2017 that it does not use plastic biomedia at any of its plants. Following a request for clarification, on 24 July the company's Environmental Information Request Officer confirmed that it does indeed use plastic media – but that it would be impossible to provide information about the type of biomedia used at different plants without conducting a comprehensive site survey.

United Utilities

Madeley	1996	12,000 (4 reactors)
Ainsdale	1997	17,600 (5 reactors)
Knutsford	1997	26,200 (5 reactors)
Macclesfield	1997	150,000 (5 reactors)
Worsley	2000	28,000 (4 reactors)
Bury	2003	300,000 (9 reactors)
Barnoldswick	2004	53,700 (4 reactors)
Woolton	2004	81,100 (6 reactors)
Burscough	2004	56,100 (4 reactors)
Rossendale	2004	244,300 (5 reactors)

Alderley Edge	2004	34,700 (4 reactors)
Altrincham	2004/5	100,000 (4 reactors)
Leigh	2004/5	161,700 (4 reactors)
Arvin	2004/5	11,700 (3 reactors)
Mere Brow	2004/5	7,500 (3 reactors)

In addition there are a further six plants with a total of 70 reactors using a polystyrene bead media (Biostyr).

Welsh Water

Llanmadoc, Gower	(two units)
Llanedi, Carmarthenshire	(one unit)
Llanfyrnach, Pembrokeshire	(one unit)
Llandovery, Carmarthenshire	(two units)
Laugharne, Carmarthenshire	(two units)
Porthgain, Pembrokeshire	(one unit)
Betws y Coed	(one unit)
Criccieth	(opened in 1995, population served 3,900)

Wessex Water

Bridgwater	(opened 2000, population served 47,000)
Kingston Seymour	(opened 2000, population served 72,300)
Urchfont	(opened 2003, population served 1,300)

Yorkshire Water

Hunmanby	(opened 1997, population served 2,300)
Dewsbury	(opened 1999, population served 320,000)
Driffield	(opened 2002, population served 45,000)

Bio-Bead technology may also be used in the Republic of Ireland, given that FLI Water's parent company FLI Environmental is based in Waterford, Ireland[19]. However, we have no confirmation on this yet.

An anomaly in the South West Water region is the Isles of Scilly, where the water authority is the Council of the Isles of Scilly – the only local authority in the country to also have this role.

The Council of the Isles of Scilly provides sewage treatment on St Mary's and Tresco through a combination of an antiquated 1939 system for the Hugh Town area (St Mary's) and systems installed in 2001 and 1989 for Old Town (St Mary's) and Tresco. The rest of St Mary's and the other islands are served by private septic

[19] http://www.irishexaminer.com/business/fli-buys-two-britain-based-companies-48336.html

tanks. We do not know whether the newer systems installed on St Mary's and Tresco use any form of plastic biomedia.

Map of UK water company areas

Reported losses, spills or top-ups

Anglian Water:

None reported.

Northern Ireland Water:

NI Water has been operating BAFF filters for over 12 years and has not recorded any loss of media to local watercourses.

In an email dated 11 July 2017, John Collins, head of corporate information, told the CPPC that their BAFF units are emptied every five years for maintenance and inspection of the plastic media is then undertaken by a specialist BAFF Unit team of engineers.

Northumbrian Water:

Northumbrian Water does not use Bio-Beads. However, it does use another type of plastic media (B-Max) supplied by FLI Water at 'certain sites' (locations and number of sites not yet confirmed), and has experienced losses of media in incidents at three of these plants.

B-Max media (picture from FLI Water website www.fliwater.com **)**

In an email from the company's Information Access Team to the CPPC on 3 August 2017 we were told: "Barton Sewage Treatment Works (STW) (DL10 6SL) had a 'bubble over' in May 2015, exact date unknown, and all apart from a very small amount (estimate 1kg) was recovered and replaced, there may have been a very small amount that were not found and lost to ground from this the exact quantity unknown albeit very small. No media left the confines of the site.

We lost approximately half of the media content from Longhorsley STW (NE65 8SY) in 2015 when the unit's outlet became blocked with debris. This was recovered back into the process. Again no media left the confines of the site.

At Sedgefield STW (TS21 2HR) we lost about a small quantity during commissioning when the outlet valve failed allowing the units to fill up a spill to the ground. Again this was recovered back into the process. Again no media left the confines of the site."

Scottish Water:

From information gleaned by the NGO Fidra, it seems that Bio-Bead-type media are being used at just one plant in South Ayrshire at Crosshill near Girvan. It only serves around 200 people.

The plant has been in operation for approximately 10 years. Scottish Water process scientists were not aware of there having been any top ups, although they did comment that the plant is not performing very well, especially in dry weather. They said no spare beads are stored on site.

Severn Trent Water:

Andy Martin from Severn Trent's Service Recovery Team told the CPPC by email on August 7 that the company no longer have any BAFFs in wastewater and have never had a Bio-Bead BAFF.

He added: "We do used fixed film IFAS at one wastewater site, we have numerous RBCs which are plastic media but are fixed discs, we have 4 or 5 sites with fixed plastic media in bacteria beds (secondary treatment) we have a number of small works with SAFFs which contain a floating plastic media (not Bio-Bead), we also have a couple of either trade waste or secondary treatment SAFFs with floating plastic media (not Bio-Bead)."

He said the company was not aware of having any spills of plastic biomedia.

Southern Water:

In an email on 11 July 2017, Oliver Eley, Customer Solutions Case Handler, said: "If pellets (Bio-Beads) are lost from the process, this occurs during the backwash phase and the pellets will transfer to the sludge stream. All our sludge is recycled to agricultural land as a fertiliser. The pellets are topped up occasionally depending on loss. The design allows for some regular losses of pellets through backwashing. We do not hold a record of the numbers of pellets lost in this way.

"During the last 5 years, we have experienced a failure of the retaining mesh at both Broomfield Bank WTW and Eastbourne WTW.

"Our Operational Team have checked our records and our first incident at Eastbourne was in February 2015 with BAFF number 5. We believe we captured all of the pellets in the catchers before any were spilled to the environment.

"We had another incident at Eastbourne towards the end of February, beginning of March last year [2016], with BAFF number 1. The mesh split, however, the pellet catcher is set up in a way that it will not release pellets into our outfall.

"Following this, we have added extra support to any BAFF cells showing signs of the mesh warping. We have also captured pellets in other process tanks during repairs and cleaning, which we put back in the BAFF cells.

"The average annual expected loss of pellets from our Eastbourne BAFF treatment plant is 0.3%. Unfortunately, collecting any lost pellets from the sea or the sludge treatment stream is simply not practical.

"We have also had a mesh failure at our Broomfield Bank Wastewater Treatment Works around March 2016. We believe this was caused by contractors, however, no pellets were lost to the outfall."

Concern about the potential for beads to be lost to the environment was obviously high enough as far back as 2002 for Southern Water to commission the design of a device to act as a final point of capture in the event of a problem with the retaining mesh, and four bead-catching baskets were finally installed following a re-design in 2006.

In an email dated 3 November 2017, customer solutions case handler Deklan Green told the CPPC: “Bead loss was seen as a serious enough risk to install the bead catchers, because the meshes in the BAFFs retaining the beads were the last line of defence and could be considered to be vulnerable to leakage or breakage.”

Each of these catchers has a volume of 1.763m3 – enough to hold ‘only’ around 47 million pellets and so certainly not enough to trap a whole reactor full of Bio-Beads. However, this is the only instance we have found of a wastewater company recognising the inherent vulnerability of this system and taking steps to address it.

Thames Water:

Thames Water’s Environmental Information Request Officer told the CPPC by email on 24 July: “Several years ago we had one recorded episode at our Henley treatment works, when bead-based media did escape the treatment process and were found in the receiving water. There was a comprehensive clean up but neither the amount lost, nor that recovered, was recorded. We subsequently replaced the bead media with a different type of plastic media and have had no losses since.”

United Utilities:

United Utilities’ Regulatory Solicitor Rajat Jain told the CPPC by email on 8 August: “We confirm that we do not hold any specific records on specific bead losses, as this may or may not be included in any waste losses. We do however confirm that pellets can be replaced as a result of end-of–life use rather than necessarily due to losses into the watercourse.”

Welsh Water:

BAFF media have been in use for around 15 years, with no reported losses.

The company said in a letter to the CPPC dated 30 June 2017: “Plastic media can become weakened by several factors such as UV radiation from sunlight, or collapse due to media welds/ adhesives failing under the weight of biomass and age of the material. When this occurs the media must be removed from the process, disposed of appropriately and replaced with new or alternative materials. Typical life expectancy of most of the media is circa 20 years and since plastic media has been a relatively recent material to be used in the wastewater industry, there have been relatively few media changes required.

In the case of Bio-Beads we have had an instance at Laugharne where contaminated media had to be replaced. Media had become full of leaf matter after surcharging the unit (it all remained within the bunded area with no loss to the environment). Approximately 8m³ of media was installed into the unit in 2016 and the contaminated media disposed of”.

Wessex Water:

In an email to the CPPC dated 30 May 2017, Ruth Barden, Director of Environmental Strategy, reported the following losses:

(1) "Urchfont STW, Wiltshire (March 2016) – blockage on the outlet from the BAFF cells caused them to overtop. A small amount of Bio-Beads were found in the vicinity of the BAFF plant and on the road within the site boundary, but there was no evidence of any Bio-Beads in the river when it was checked up to 300m downstream from the point of impact.

(2) Chilton Trinity STW, Somerset – there have been bead losses on 2 occasions. On the first occasion, an issue with the filling process led to loss of beads, but none left the site. The problem with the filling process which caused the loss has since been rectified by our teams.

The second occasion was on the 19th October 2015 whereupon a section of one BAFF cell was lost following failure to secure a lid which led to loss of Bio-Beads. The majority of the lost beads were retained on site, but the incident was reported to the Environment Agency as there was visual impact to the river bank near the outfall. Beads were collected from the primary tanks and sludge process and we do not have an accurate figure on the amount of beads lost to the River Parrett, but this is estimated to be a maximum of $2m^3$. Unfortunately, recovery of the media was not possible from the location."

The Cornish Plastic Polllution Coalition estimates the number of beads lost in this incident will have been over 50 million.

With regard to top-ups, Ms Barden at Wessex Water added: "Whilst we do not quantitatively monitor bead loss through the system, we do undertake a visual check of media levels as part of our routine operational checks. As with all filter media, over time, there can be a need to 'top up' the media due to degradation, abrasion, and movement of media within the sewage treatment process, for example in backwash tanks. This does not mean that there have been losses to the environment but that the media gets worn over time due to use."

Yorkshire Water:

No losses of Bio-Beads reported. In addition to their Bio-Bead plants, Yorkshire Water have over 200 units using a variety of other plastic media at a large number of sites. However, they say none of these use media smaller than 3cm in size, and so do not experience losses.

10. Where else are Bio-Beads found?

Around the UK

During the Great Nurdle Hunt, a nationwide citizen science initiative in February 2017 organised by Scottish NGO Fidra, a total of 279 beaches were surveyed across the country. Nurdles were found at 73% of these locations. However, Bio-Beads were found to be predominantly concentrated on beaches around Cornwall and the south coast of England.

The Great Nurdle Hunt team also identified Bio-Beads in photos sent to them from beaches in Wales and the Isles of Scilly.

Bio-Beads were not identified on Scottish coasts, despite large numbers of true nurdles being found on some beaches there.

However, volunteer nurdle hunters have not, to date, been systematically asked to differentiate between Bio-Beads and nurdles, so there may be occurrences elsewhere that have not been documented.

Confirmed Bio-Bead finds during the Great Nurdle Hunt in early 2017[20]

Cornwall and Devon

- Widemouth Bay, North Cornwall
- Tregantle, South Cornwall
- Towan beach, North Cornwall
- Woolacombe, North Devon
- Spit beach, St Austell, South Cornwall
- Marazion beach, South Cornwall

South and South-east coast of England

- Isle of Wight, Solent
- Rye Bay, East Sussex
- Shoreham-by-Sea, West Sussex
- Brighton and Hove, East Sussex

Andy Dinsdale, who lives in the Southern Water region, has been finding large concentrations of apparent Bio-Beads on his local beach at Camber Sands in East Sussex for several years.

[20] http://www.nurdlehunt.org.uk/images/Leaflets/TGWNH_Results.pdf

Left: Picture of Bio-Beads used at Southern Water plants

Image supplied by Caroline Tyler, Southern Water Customer Solutions Team

Bio-Beads at Camber Sands, East Sussex, November 2012

Picture: Andy Dinsdale

Meanwhile a whole tideline of what appeared to be black Bio-Beads was also reported in early April 2017 on Ovingdean and Hove beaches near Brighton[21].

[21] http://www.brightonandhovenews.org/2017/04/05/thousands-of-plastic-nurdles-washed-up-on-city-beaches/

Tideline of black pellets on Ovingdean Beach, East Sussex, on 5 April 2017

Picture: Mike Murphy

Left and below: Bio-Beads found at Freshwater West, South Wales, in early 2016

Picture: Jenny Axon

Left: A collection of predominantly bright blue Bio-Beads found during a beach clean at Charmouth, Dorset, on 17 February 2018 at which an estimated 6,500 such pellets were recovered. SWW told the CPPC it does not know what colour pellets are used at its nearby Lyme Regis plant, and it would cost too much to use a crane to lift the reactor lid to check.

Picture: Philip Strange

Left: Black Bio-Beads collected by the Dorset Wildlife Trust at Kimmeridge, Dorset, on 22 June 2018

Bio-Beads in the centre of a dish of other microplastic debris collected on Jersey in early 2018.

Picture: Sheena Brockie

10.1 Bio-Beads on the coasts of neighbouring countries

Bio-Beads wash up on the Channel coast of France and all the way along to the Netherlands in the east.

In an email to the CPPC on 27 April 2017, Jeroen Dagevos of the Plastic Soup Foundation said Bio-Beads were first reported on beaches in the Netherlands around five years ago, and have been seen increasingly since then, although not in high numbers.

Bio-Beads are apparently used at only one plant in the whole of France – location unknown (source: Plasti-Negoce), and are not thought to be used in the Netherlands either (source: Plastic Soup Foundation).

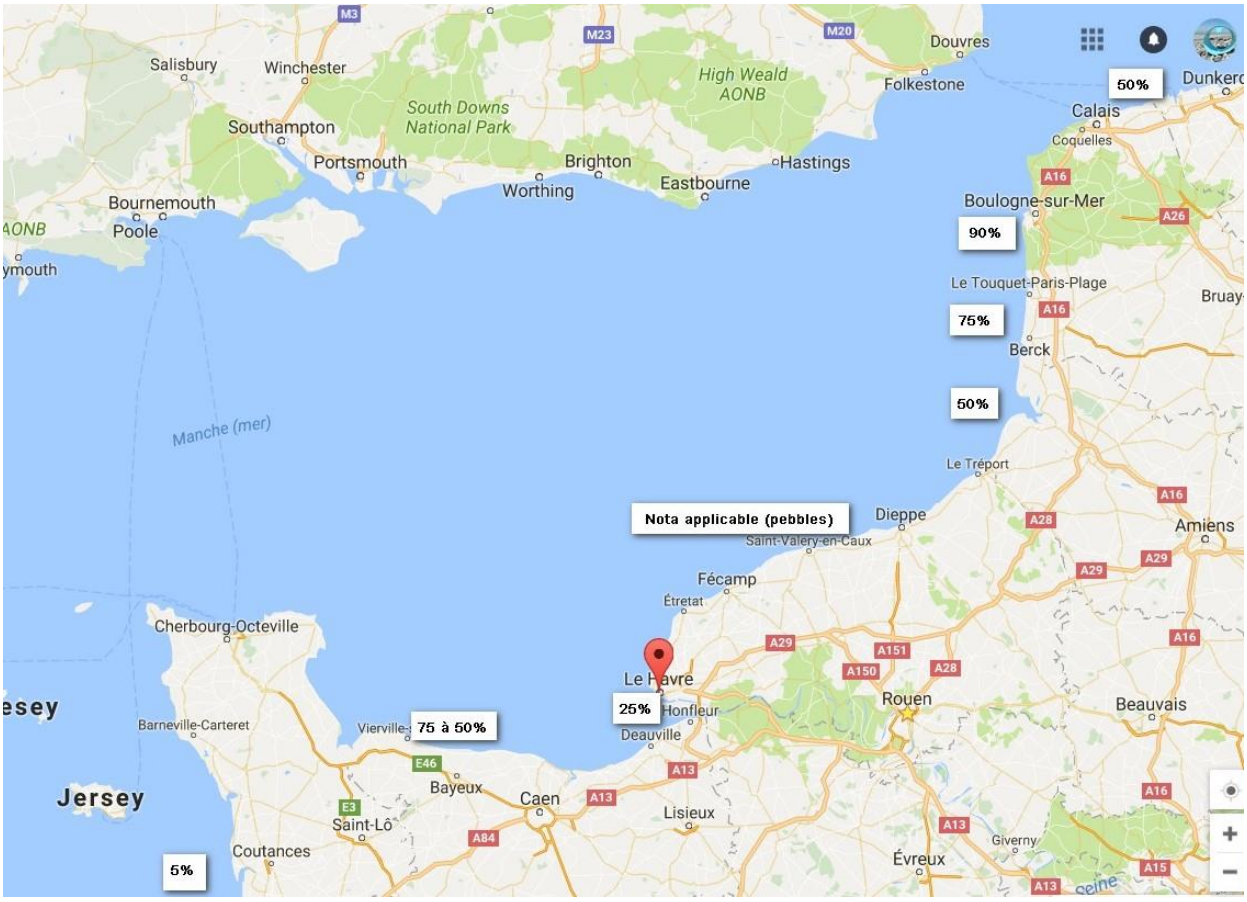
The appearance on beaches in the Netherlands of identifiable Lego from the Tokio Express container spill off Land's End in February 1997 shows that plastic debris entering the sea in Cornwall or from even further west is quite capable of making this journey.

There have been two particularly significant recorded appearances of large numbers of Bio-Beads along the French Channel coast – the first from Saint-Vaast-la-Hougue near Cherbourg in Normandy through Boulogne-sur-Mer and up to Belgium in 2010/ 2011 (shortly after the major Truro spill), and the second from the Baie de Somme in Picardy to Boulogne-sur-Mer in June 2017 (source: SOS Mal de Seine).

The map below, based on data collated by Rouen University plastics expert Laurent Colasse of the NGO SOS Mal de Seine, shows percentages of Bio-Beads as a proportion of all industrial pellets found on beaches in the French Channel region during the 2010/2011 incident – notably rising to 90% of all pellets found in the area of Boulogne-sur-Mer.

This NGO and others have conducted in-depth research into plastic pollution around the whole French coast. As far as we can ascertain, Bio-Beads have not been reported on beaches elsewhere in France, apart from an occasional few in South West France (reported by the Surfrider Foundation).

Below: Bio-Beads as a proportion of all pellets found on French Channel beaches in 2010/2011. They are reportedly still present in the same area in significant numbers.



We have also received reports of Bio-Beads found much further east on the German coast, while the image below shows Bio-Beads among other microplastics collected at Buntje-Ballum in south west Denmark (picture: Henning Volmer).

11. Removing pellets and Bio-Beads from Cornish beaches

Given their size, microplastics have always been incredibly hard to remove from the beach, and so beach cleaners have largely had little option but to leave them in situ – although an estimated 400,000 pellets (mixed nurdles and Bio-Beads) were removed by Rame Peninsula Beach Care (RPBC) volunteers during an intensive deep clean of a 25m-wide cove at Tregantle, Whitsand Bay in 2014 (calculation extrapolated from 4,030 pellets counted in one pint of mixed pellets/ organic material and microplastic pieces).

Although microplastics are sometimes deposited superficially on the beach in massive quantities, when they can be picked up with a dustpan and brush, this necessarily also leads to the removal of large amounts of sand – making sacks very hard to carry from the beach – as well as removing organic material (seaweed, wood, and often sandhoppers and kelp fly larvae – an important part of the strandline ecosystem and food chain).

However, in 2016, RPBC volunteer Rob Arnold invented a machine that can separate the microplastics from both sand and most organic material.

Although the machine has its limitations (it needs to be transported right down to the beach by vehicle, requires a fresh water source and plenty of volunteer help to sweep the beach), it has been extremely effective at Tregantle.

In just three sessions on the area of beach at the bottom of the slipway (approximately 100m wide), Rob removed approximately four million pellets (including over two million Bio-Beads) in March 2017 (counting methodology as described in section 7), with a further five to six million removed over the next year.

Trying to sweep up the tangle of microplastics – often trodden into the sand and buried inches deep – with dustpans and brushes, January 2016 and March 2017.

Pictures: Matt Robertson (left) and Petra Kalocova (below)

Using the machine to separate microplastics, including Bio-Beads, from the sand, March 2017

Picture: Petra Kalocova

RPBC has also purchased a static charge filtration screen for use in the summer, when the sand is totally dry.

Given that microplastics seem to make landfall repeatedly in the same places, it could be possible to remove large quantities from the marine system by targeting these areas with removal devices such as the machine and screens.

We will try to share these devices in future with other groups around Cornwall when possible, so that the worst-affected places can be targeted.

12. What is the water industry doing about the issue?

South West Water is currently making efforts to investigate the issue of potential Bio-Bead loss so that, depending on the results, it can put in place appropriate measures to deal with any problems that come to light and contain any losses found.

A Duplex straining filter has been installed on the BAFF effluent manifold at Plympton in an attempt to trap lost beads and give a greater idea of the scale of any losses. However, the CPPC does not consider this filter to be particularly helpful as it is taking only a very small sample of water from the outfall.

An application has also been made for funding for a full-flow filter at the Liskeard plant, although the funding cycle means this will not be possible for some time.

Given the history of spills, the clear evidence of Bio-Beads found downstream of several plants and on our beaches, and the fact that there is no structure in place to catch beads to any meaningful degree in the event of spills, we believe that efforts should be focused more heavily on installing failsafe pellet-catching devices.

South West Water has confirmed that in its next five-year planning period it will be looking at new technologies with lower energy consumption than the Bio-Bead BAFF plants. Many of the SWW Bio-Bead plants are already approaching the end of their 25 to 30-year lifetime (although FLI Water's literature suggests the plants have a lifetime of 40 years). None of the SWW plants will be replaced with the same system – although a straight swap to a non-plastic mineral system will not be possible.

An SWW spokesperson told the CPPC that: "The design of the BAFF plant and nature of flow is engineered around a buoyant media, therefore it would not be possible to simply replace with a mineral media. However different plastic media may be considered if it has the right characteristics for wastewater treatment."

SWW are also drafting a new technical standard regarding every aspect of the Bio-Bead handling process, requiring all in-house staff and contractors to abide by the advice given in the Operation Clean Sweep[22] manual. This is a very good first step,

[22] http://www.bpf.co.uk/Sustainability/Operation_Clean_Sweep.aspx

although we believe this information requires better clarification, with specific instructions to cover each aspect of Bio-Bead use and handling within a specific wastewater plant setting. Compliance with this code would also ideally involve auditing in order to ensure effectiveness.

We hope the experience and research being undertaken by SWW can soon be shared more widely with the national water industry, given how poorly understood this issue has been to date, and the likelihood that the same problems will be experienced to a greater or lesser degree at other plants using the same system.

Rachel Dyson at Anglian Water, who is also chair of the Water UK SNAP (Sewerage Network Abuse Partnership) Network, told the CPPC by email (26 April 2017): “As this is an emerging topic no water company yet knows if artificial fibres/media from our own processes are contributing to microplastics in the environment.”

She explained that the issue of microplastics in wastewater overall being investigated, saying: “We are working with the rest of the water industry, Defra, the Environment Agency and academia to develop the approach, and plan the key activities of the investigation programme to better understand the role of wastewater treatment in microplastics and the environment. This will inform a programme of work in our next investment period from 2020 as well as future Defra policy decisions in these areas.”

She emphasised, however, that the main sources of microplastics being released into the environment via treatment works are clothing fibres from laundry, and road run-off from tyre particles. Recent research by Plymouth Marine Laboratory, for example, found 15,000 synthetic fibres in every m^3 of water tested in the mouth of the River Plym, downstream of the Plympton wastewater plant.

She added: “Anglian Water would like to see collaborative cross-industry research and solutions with white goods and sanitary items /wipes manufacturers, cosmetic industry and retailers, working with Defra and the water industry.

“Research into microplastics in sewage sludge is currently being undertaken. However, there is still some way to go before we understand the full scope and any impact. Studies are being planned by UK Water Industry Research, which Anglian Water part funds, so we can better understand the issue and what alternatives we may consider in the future.”

13. Recommendations

The CPPC has the following initial recommendations for action that could usefully be addressed by all water companies in efforts to better understand and control this significant environmental pollutant in our local marine environment.

13.1 Code of Conduct

Given the vast numbers of Bio-Beads that wastewater companies use at their plants and the demonstrated potential for these to be lost in various ways, we believe a code of conduct for best practice should be drawn up immediately by the water industry, to be followed by anyone handling or overseeing the use of these biomedia, whether in-house staff or contractors.

The Operation Clean Sweep scheme (www.operationcleansweep.co.uk) is a code of practice promoted by the British Plastics Federation to encourage best practice throughout the plastics production industry, providing a manual to help companies put measures in place to ensure safe storage/ containment and clean-up of beads during production/ loading/ transport, etc.

Many of the suggestions in the manual are likely to be applicable to the handling of Bio-Beads during water treatment too, and we would recommend further research to examine adoption of relevant aspects of this scheme by water treatment companies.

Some of the measures that most urgently need addressing include better handling, containment and clean-up practices. A protocol should also be put in place to ensure that any spills or issues are reported to the Environment Agency and other relevant authorities immediately to aid with rapid containment and clean-ups. (We understand that the spills and losses to date in the South West Water region have only become known to the Environment Agency following reports by concerned members of the public).

Due to their size and the complex and varied nature of the work they undertake, wastewater companies often rely on contractors and sub-contractors to carry out certain aspects of their work. It is essential that these outside contractors are also required to follow the codes of conduct established – and critically that there is some way for this to be audited, ideally by independent, external specialists.

13.2 Storage

We do not believe that the flexible dumpy sacks currently used are a safe way of storing an easily-lost material such as Bio-Beads, potentially over long periods of time, or of transporting the media around a site.

We believe that tough, closed, tamper-proof and continuously-reusable rigid HDPE drums would be a much better choice of storage container for biomedia.

HDPE storage drum

Picture: www.air-sea.co.uk

Storage sites should also be dry, secure, well away from rivers and unprotected storm drains and on hard standing areas (to enable any spills to be effectively cleaned up).

13.3 Sampling

Water companies should conduct sampling at each of their plants to check whether losses are occurring at one or more of their wastewater treatment centres.

The sampling should test 100% of the outfall and should be conducted over a sufficient period of time to take in operational procedures such as maintenance and top-ups – which could be the most likely times for any losses to occur.

Sampling would also be useful during specific weather conditions such as heavy rain, along with testing of the sewage cake and sludge/ grit going to landfill.

13.4 Dedicated Bio-Bead trap systems

Given that there is currently no way of plants retaining a significant number of beads in the event of a catastrophic incident, we believe the manufacturer of the Bio-Bead system (FLI Water) should design and produce all future reactors with an integrated failsafe trapping mechanism, and that plants currently in use should have a similar system retro-fitted as a matter of urgency.

13.5 Phase out Bio-Bead plants

Given past spills, current losses through a variety of channels, the potential for these to reoccur in future, the environmental impact of spilled Bio-Beads and the difficulty of retrieving them, we believe water companies should be planning to phase out Bio-Bead systems, and certainly not to install any new ones unless they are fitted with a failsafe system to trap all the media in the event of a spill.

Before the Bio-Bead plants (which can only function with a floating media) come to the end of their natural lifetimes, water companies could talk to their suppliers to see

if they could be made compatible for use with larger types of wheel/ disc-type plastic biomedia such as the Kaldnes system. Although losses of Kaldnes-type media have also been reported in some cases, they may be less prone to escape given their much larger size, and in the case of losses should at least be easier to spot and retrieve.

The ideal end point would be the phasing out of all plastic biomedia, given the possibility of their contribution over time to marine plastic pollution not just through direct losses but also in the form of microplastics through abrasion.

13.6 Assurances on Bio-Bead size

Bio-Bead manufacturers/ suppliers should urgently be required to give assurances that the product they are supplying is too big to slip through the 3mm holes in the BAFF reactor mesh. Checks should also be conducted of existing stock bought in by the water companies, and if beads are too small they should be rejected and replaced.

Bio-Beads should be significantly larger than the holes in the protective mesh to make it impossible for any to slip out.

14. Conclusion

Bio-Beads are prevalent in large numbers on many Cornish beaches where microplastics are deposited, often accounting for a majority of all the industrial pellets found.

We are only starting to gauge numbers now that we have the capacity to remove Bio-Beads on a significant scale from one beach (Tregantle) through use of a separation machine. Millions have been removed here in just a few sessions and from just a short stretch of sand.

Research has shown that pellets such as Bio-Beads are frequently consumed by marine wildlife that mistake them for food. Independent tests to analyse adsorbed persistent organic pollutants as well as chemical additives within the plastic structure of the Bio-Beads have both revealed very high levels of hazardous compounds such as polycyclic aromatic hydrocarbons, lead, antimony, bismuth and bromines, which would impact on the health and/ or reproductive capacity of animals eating them.

Many of the beads may have been in the marine environment for a long time, possibly decades, as the legacy of historic spills, since they are often associated with 20-year-old Lego and sometimes have a weathered appearance.

However, we sometimes also see what look like new Bio-Beads appearing on our beaches (uniform in size and colour, not mixed up with other materials). On occasions, these appearances seem to be associated with periods of heavy rain.

Bio-Beads could be reaching our beaches in several different ways.

South West Water has experienced two significant spill events in the past. Wessex Water and Thames Water have also had spills of bead media. These spills could not be contained before the Bio-Beads reached the discharge rivers. Southern Water has also experienced losses of beads. Many of these incidents seem to have been related to failures of the retaining mesh above the tanks, which should hold the beads inside the reactors.

Given the evidence of beads found downstream, we strongly believe that SWW is losing beads from at least two of its plants (Liskeard and Plympton), either on an ongoing or occasional basis. The scale of these losses is currently unclear. It is evident that Bio-Beads have also been lost due to poor handling and storage.

SWW is topping up the biomedia in its plants – to the tune of 16% over 23 years at Plympton (probably around seven billion beads), with the amounts at its other plants unknown.

Increased media bed depths to meet strict consents will partly explain the top-ups. Degraded media are also sometimes disposed of (being sent to landfill, where they are used to fill in voids, increasing landfill stability while still allowing methane and other gases to escape).

SWW assumes that any remaining lost media are sinking down into the sewage sludge. However, this cannot be 100% confirmed without testing. There are also other possible and untested explanations for losses, including abrasion and sub-size beads.

Wastewater companies are becoming increasingly aware of the issue of microplastics inadvertently discharged to the environment through the wastewater they are treating (e.g. cosmetic microbeads, laundry fibres, car tyre dust), all of these being far too small to be trapped at present.

However, the possibility of plastics used by the water companies themselves in the water treatment process contributing to the problem of sewage-related debris is an area that requires much more investigation, along with the development of, and adherence to, a specific code of conduct for all operatives working with Bio-Beads at any point in the process, to ensure the prevention and containment of any spills.

SWW is starting to investigate possible mechanisms whereby its Bio-Beads could be lost. It is hoped that its findings in this area can help to inform the rest of the UK wastewater industry – and anywhere else where Bio-Beads may be used – in order to promote better practices and stem any flow of this hazardous environmental pollutant into the marine ecosystem.

However, the CPPC strongly believes that the only effective way of ensuring against any further losses of the scale that have led to such heavy environmental pollution (aside from phasing out Bio-Bead plants) is to install a specific mechanism to act as a final point of capture to trap **all** beads in the case of any problems with the retaining mesh on reactors – which seems to have been the cause of most if not all previous spills.

The Bio-Bead system is inherently vulnerable given that no such trapping mechanism exists, and particularly given that the Bio-Bead reactors are the last stage in the system before treated water is returned directly to the environment.

While Southern Water recognised as long ago as 2002 that this system was potentially vulnerable to major losses, and took steps to design and install bead traps at its own plants back in 2006, we believe that ensuring against any possible losses should be the responsibility of FLI Water, the company manufacturing and marketing the reactors.

We would like to see FLI Water making any future reactors with an integrated failsafe trapping mechanism, and retro-fitting plants already in use with a similar system as a matter of urgency.

It is a sad irony that a wastewater treatment system that has significantly improved the chemical and biological quality of effluent released to the environment also carries the potential to cause significant environmental harm by polluting our watercourses and sea with this form of irretrievable microplastic pollution.

15. Acknowledgements

Many people have contributed their time, sightings and photos to this report – we thank you all. The more information we can collect, the greater our understanding will be.

We would also particularly like to thank, in no particular order:

Laurent Colasse, for being the first person to make us aware that most of the pellets on our beaches, which we had believed were all pre-industrial nurdles, were in fact something else – Bio-Beads.

Rob Arnold, for inventing the microplastics separation machine, and for all the hundreds of hours of dedication and work put in to helping to solve the insidious problem of microplastic pollution.

South West Water, for their time in talking to us and trying to answer our many questions about the use of plastic biomedia in wastewater treatment, and their readiness to acknowledge the problem and to start to take steps to investigate this.

Dr Hideshige Takada at International Pellet Watch in Tokyo, Japan, and Dr Andrew Turner at Plymouth University's School of Geography, Earth and Environmental Sciences for their tests on the Bio-Beads, which have revealed much more about their toxicity and their differences from other industrial pellets found on our beaches.

Lt Col (Ret'd) Andy Westcott, for his enthusiasm in facilitating access to Tregantle, an MoD-owned beach, for using the microplastics separation machine.

Melvyn Rose at FLI Water for providing us with initial information about the Bio-Bead/ BAFF system. We hope that the company may be willing to provide more information in future, which could help to answer some of the remaining questions on this issue, and to minimise its environmental impact in future.

Mix of microplastics floating in a pool at Tregantle, February 2016.

Photo: Louise Slee

16. Glossary

Bio-Beads: Bio-Beads, or BAFF (biological aerated flooded filter) media, are small plastic pellets (approximately 3.5 to 4mm in size) used as part of the filtration process in dozens of wastewater treatment plants across the UK, serving an estimated total population of over two million people.

Bio-Beads are different from ‘true’ virgin or recycled plastic nurdles, which are smoother and more regular in shape (see below). Bio-Beads are wrinkled, knobbly or ridged with a ‘screw thread’ type profile on the sides, or otherwise non-uniform. They are manufactured deliberately in this way in order to increase their surface area, which is coated in a biofilm of bacteria used in sewage treatment and some other applications.

Unfortunately Bio-Beads can be lost to the environment, where they pose a risk to marine wildlife. They are found in large numbers on many beaches around the Cornish coast.

Biomedia: A base structure supporting the growth of a film of bacteria used to digest unwanted organic compounds in wastewater, for example ammonia. Biomedia can come in a range of natural and manmade materials and forms, either fixed or floating.

Microbeads: Microscopic flakes or beads of plastic used in some cosmetics, toothpastes, etc. as an abrasive. These beads are designed to be washed off with the cosmetic product and down the sink. They are far too small to be trapped by wastewater treatment plants (a tube of facial scrub may contain up to two million of them). Given their potential environmental impact, the impossibility of retrieving them once released, and the fact that many non-harmful natural alternatives exist, many forms of cosmetic microbeads will be banned in the UK from the end of 2017.

Microplastics: This is a general term for small pieces of plastic waste measuring 5mm or less. These might be primary microplastics (i.e. pieces of plastic debris that have entered the environment at this size, such as cosmetic microbeads, tyre dust particles, nanofibres from laundry, or industrial pellets such as nurdles or Bio-Beads) or secondary microplastics (i.e. pieces of larger plastic debris that have been broken down over time and through the action of the waves and UV light into small, usually unrecognisable pieces). Both forms of microplastics pose a serious risk to marine wildlife, since they are extremely hard to remove from the environment and can be readily ingested by many creatures including birds, fish, crustaceans, etc. When microplastics are broken down to a small enough size they can even be consumed by marine worms, corals, molluscs and other filter feeders, including zooplankton – the base of the entire marine food web. Persistent environmental pollutants (POPs) readily adhere to the relatively large surface area of microplastic pieces, with the impacts having the potential to be bio-magnified up the food chain.

Nurdles: Nurdles, sometimes also called ‘mermaids’ tears’, are pre-industrial plastic resin pellets. They are the building blocks of all our plastic items, being melted down and then formed into the finished product.

Bio-Beads are a form of nurdle that has been specially machined to provide a larger surface area for the attachment of a film of bacteria, used to digest unwanted compounds in wastewater.

Pellets: Bio-Beads and nurdles are both pellets, and may both sometimes be referred to as such in plastics/ wastewater industry terminology.

17. Appendix 1

South West Water briefing sheet on nurdles and Bio-Beads

(https://www.southwestwater.co.uk/environment/rivers-and-bathing-waters/nurdles-and-bio-beads/)

What are nurdles?

Nurdles, sometimes called mermaid's tears, are tiny pellets of plastic.

They come from many sources and most pre-production industry plastic is supplied in the form of tiny pellets.

What are BAFF media / Bio-Beads?

Plastic pellets are sometimes used as a filtering media at sewage treatment works. These are called biomedia, Brightwater media, BAFF media or Bio-Beads. Not all BAFF (Biological Aerated Flooded Filter) plants contain Bio-Beads – some have a mineral media and others have a fixed structural media.

South West Water has nine BAFF plants with Bio-Bead media across the region, some of which are inland. The smallest serves a population of 1,200 and the largest, at Plympton, serves a population of around 85,000.

There are at least 46 BAFF plants with Bio-Bead media in the country, which range in size and population served.

How can you tell the difference between nurdles and BAFF media?

The colour of BAFF media is determined by the supplier but they can be any colour including black, blue, white or mixed.

It is very difficult to positively identify the source of a nurdle in the environment.

How do nurdles get into the environment?

Nurdles are tiny – less than half a centimetre wide – and it is quite easy for them to be spilt from containers or be lost down drains from plastic production or recycling plants.

Are BAFF media sometimes lost from sewage treatment works?

Water companies work very hard to prevent this. BAFF media are expensive as well as harmful to the environment so we really don't want to lose them. Bio-Beads are contained within a mesh frame which should prevent them passing through the treatment process. Any losses would occur in the desludge / backwash line and should be retained within the works.

Some BAFF media were lost at Newham Sewage Treatment Works in Truro in 2010, when the mesh failed. The plant in question was decommissioned soon afterwards. However, due to their nature these pellets do not go away once they have been released – they can be picked up by the tides and deposited and redeposited on different beaches.

What is South West Water doing do to prevent the release of Bio-Beads?

All BAFF plants that use Bio-Beads have bead traps and are fitted with mesh grating over the cells. If a bead loss occurred it should be immediately obvious within the sewage treatment works, where they would be seen floating on tanks and in the backwash. South West Water staff would then carry out an urgent inspection to determine where the break was and repair it as well as to contain the Bio-Beads on site. Media is expensive and we want to keep it in the process units.

We use appropriate disposal methods which prevent the release of Bio-Beads into the environment at the end of their life.

How does South West Water monitor for the release of Bio-Beads?

The nature of Bio-Beads is such that any escape is immediately obvious as coloured beads float on tanks and accumulate in works return systems. Additionally media levels within BAFF sites are monitored to ensure levels remain optimal.

We are confident that Bio-beads are retained within the treatment process, but to be sure we are we are installing a duplex filter at Plympton Sewage Treatment Works (due to be delivered by the end of 2017) as part of an ongoing research and development project.

Is there an alternative to using these pellets in the treatment process?

For the nine sites across the region that are designed to run with plastic media there is no alternative media that would comply with the required buoyancy needed by that process. However, many BAFF plants do not use plastic beads and there are no current plans to install new Brightwater BAFF plants across the region.

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19. About the Cornish Plastic Pollution Coalition

The Cornish Plastic Pollution Coalition (https://www.facebook.com/yourshoreplastic/) is a grouping of over 30 environmental organisations, beach cleaning groups and marine science experts collectively representing tens of thousands of people in Cornwall and beyond.

We have come together to work in a targeted way to address particular aspects of plastic pollution affecting the coastline, seas and wildlife of Cornwall.

Cornwall Wildlife Trust

Isles of Scilly Wildlife Trust

Cornish Seal Sanctuary

Truro Cathedral

Rame Peninsula Beach Care

#2 Minute Beach Clean

Friends of Portheras Cove

Looe Marine Conservation Group

Prof. Brendan J. Godley, Chair in Conservation Science, Director of the Centre for Ecology and Conservation, University of Exeter

Newquay Marine Group

Transition Falmouth

Polzeath Voluntary Marine Conservation Area

Cornwall Seal Group

Newquay Beach Care

Falmouth Marine Conservation

Fathoms Free

British Divers Marine Life Rescue

Newquay Sea Safaris

Widemouth Task Force

St Agnes Marine Conservation Group

RSPB

Helford Voluntary Marine Conservation Area

Friends of Poldhu

Polzeath Beach Care

Fishy Filaments

Newquay Crab

Fourth Element

Friends of the Fowey Estuary

Falmouth/ Exeter Uni Students Union

Friends of Polurrian Beach

Lizard Peninsula Friends of the Earth

West Cornwall Friends of the Earth

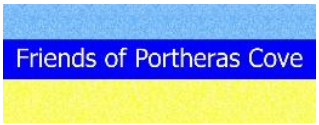
Transition Truro

Capturing our Coast

Atlantic Diving

Cornwall Wildlife Trust

Isles of Scilly Wildlife Trust



Cornwall SEAL Group

Helford Voluntary Marine Conservation Area

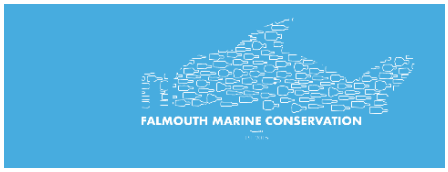
Truro Cathedral

giving nature a home


West Cornwall
Friends of the Earth


Fishy
Filaments


TRANSITION
TRURO
Adapting to the challenges of
Climate Change and Peak Oil


FALMOUTH MARINE CONSERVATION


SUSTAINABLE
ST AGNES


NEWQUAY
Sea Safaris
and
Fishing