Biomagnification of microplastic in local waters

Sea Defenders

Vordingborg Gymnasium & HF

Denmark

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1. Monitoring microplastic in our local environment

1.1 Abstract

Lately, there has been huge global focus on microplastic in the oceans. Vordingborg municipality is the municipality in Denmark with the longest coastline, wherefore we wonder why there still are not performed any research about microplastic in the waters at our municipality. Therefore, we have decided to investigate whether the global problems caused by the spread of microplastic also is relevant for our waters in Vordingborg municipality. To confine our project, we have chosen the focus biomagnification in the food chain and investigate bird-excrements for microplastic. Primarily, we will examine under microscopes and from that perspective picture the extent of microplastic in the sea environment in Vordingborg municipality. Additionally, we will contact Vordingborg municipality and ask if they have any interest in examining the waters in the municipality. We will discuss and consider biodiversity because we primarily touch issues like the food chain and the eco-system.

1.2 Keywords

Microplastic, bird faeces, biomagnification seagulls.

1.3 Introduction/purpose of research:

Through media, teachers and our own experiences, we have in the past year noticed a large focus globally on the extend of plastic in nature and especially in the oceans. We wondered therefore, if the large amount of plastic found globally also is relevant to our local waters.

In Denmark we are used to the idea of being front figures in climate and environment investigation, but when it comes to microplastic, there are not many initiatives or research made regarding the extend of microplastic in the Danish waters.

Since we are students at a gymnasium, we do not have the resources to make a far-reaching project which investigates fish, water, sediment and the beach environment. At last, we came up with a method to estimate the amount of plastic in our municipality's waters by investigating bird excrements around our municipal harbours.

1.3 Hypothesis

We estimated
that many birds are carrying great amounts of plastic because we were able to find 2 plastic fibres from the one excrement that we collected during our pilot experiment. We thought most of the birds had
to contain plastic fibres, and the fish,
the birds are eating are having even higher concentration of plastic in their bodies.

Figure 1

Seagulls and cormorants, the bird faeces we have investigated

http://www.birdspix.com/north-america/cormorants-phalacrocoracidae/double-crested-cormorant

1.3 Plastic Change

"Plastic Change" is an organization working for a healthier sea environment. The organization has begun the project "Plastfree Roskilde Fjord", an investigation of the microplastic pollution in the second longest fjord in Denmark. "Plastic Change's" project was our main motivation for this project. We contacted "Plastic Change" during our project, the scientists on the project invited us to visit their laboratory in Roskilde. Here we would able to bring our bird-faeces and examining them under a FTIR spectrometer (Fourier-transform-infra-red) and a FTIR microscope. The scientists inviting us were Fionn Murphy, Ph.D. in microplastic pollution, and his supervisor Jakob Strand, Ph.D. in aquatic toxicology. On figure 3 below is seen a complex filter for analysing water from Roskilde Fjord.

Figure 2

Picture from Plastic Changes, representing plastic and microplastic as a big problem in the sea environment [1]

https://plasticchange.org/our-documentation/microplastic/

Figure 3

Project “Plastfree Roskilde Fjord”

https://plasticchange.dk/media/40691/plast-i-roskilde-fjord-j-strand.pdf

1.4 Methods of research

To prove that the spread of microplastic is relevant for our waters, we decided to investigate bird-excrements. We collected 30 bird excrements in four different places in our municipality to get the most realistic view on how the spread of microplastic is in our area.

It all started with our pilot-project, which included investigation of one single bird excrement, we found 2 pieces of plastic. This started our interest for this project. By using the qualitative method, we determined what was plastic by visual inspection using a stereo magnifier. This means, we were looking for possible plastic fibres, we had some doubt, but through the colour of the fibres and their structure, we assumed what was plastic. If the piece was white we used acid to exclude that the sample was a piece of sea shell.

Light-optical microscopy

Fionn Murphy and Jakob Strand from Aarhus University helped us through laboratories-experiments with the FTIR microscope to analyse our possible plastic fibres.

1.4 FTIR Microscopy

The laboratory at Aarhus University uses complicated machines using infrared spectra to identify microplastic in samples. The wave-length in infra-red light together with a scanner makes it possible to analyse how the atoms in the molecules interact with each other, how much space there are between them and how they rotate around each other. We then receive a graph showing how the atoms in the molecules interact with each other and then a match of what material the sample is made from. This is a new way of processing microplastic and changes the method from a visual and subjective one to a measurable and quantifiable one.
In other laboratories they have determined how atoms in different types of plastic correspond with each other under infrared light and then we use the theoretic graphs for comparing with the graphs that the FTIR analyses for us.

1.4 Experiment

Materials:

Microscope

Funnel

Cone

Coffee filter

Weight

Spatula

Petri dish

Water

Procedure:

Collect bird excrements in small glasses

Weight the bird excrements

Dissolve the excrements by adding water to the glass

Pour the mixture into a funnel with a coffee filter and wait till the water ran through

Take up the coffee filter with the bird-excrement on and use a spatula to spread it out.
Cut the paper so it fits into a petri dish.

Place the petri dish in a microscope

Investigate the excrement for 10-15 minutes, we are not examining the excrements longer because we want to make sure we do not count a piece of microplastic several times. We always make sure to photograph the interesting microplastic fibres we find.

Figure 4

A typical experiment session. We use tweezers for collecting microplastic fibers and important areas in the feces, we mark with a black rubber ring.

1.5 Results

Below, the average occurrence of
plastics appears for each location and in total.
The estimations are stated in pieces of plastics per gram of bird excrements.
The estimations for each location can be misleading as

we have collected relatively few bird excrements at each lo cation (except Kalvehave), therefore the most interesting estimation is the average occurrence of plastics in total.

All the data that we have collected through our project is shown in the table (Table 1). It shows every samples weight, estimated number of plastic pieces and the finding place. Almost every sample contained potential plastic – only two samples did not. The number of potential plastic pieces vary from 0-19 and we found that there is no considerable correlation between the weight of the sample and the number of potential plastic. The average occurrence of plastic pieces is 5.9 (figure 2). The average occurrence calculated for Vordingborg, Stege, and Præstø can be misleading insofar the number of samples is too low to calculate a valid average occurrence of plastic.

Table 1. The finding places for the bird faeces.

Sample	Weight/g	Number of plastics	Location
1	1,45	5	Kalvehave
2	0,27	2	Kalvehave
3	1,33	7	Kalvehave
4	1,20	1	Kalvehave
5	0,88	8	Kalvehave
6	0,20	3	Kalvehave
7	2,33	0	Kalvehave
8	0,87	3	Kalvehave
9	0,62	19	Kalvehave
10	1,45	5	Kalvehave
11	0,34	1	Kalvehave
12	1,05	7	Kalvehave
13	0,48	7	Kalvehave
14	0,34	10	Kalvehave
15	0,41	7	Kalvehave
16	0,41	3	Kalvehave
17	0,30	10	Stege
18	0,20	16	Stege
19	0,50	6	Stege
20	0,90	9	Stege
21	1,70	4	Præstø
22	1,20	3	Præstø
23	0,10	5	Præstø
24	3,20	6	Præstø
25	0,70	11	Præstø
26	1,10	2	Vordingborg
27	1,20	3	Vordingborg
28	0,90	5	Vordingborg
29	0,60	3	Vordingborg
30	2,30	0	Vordingborg

Table 2. Average occurrence of plastic from the collected harbours

Average occurrence of plastic (pcs/g)	.
Stege	21.6
Kalvehave	6.45
Præstø	4.2
Vordingborg	2.1
Total	5.9

Our samples have been collected in Vordingborg munipalicity (the red area). The locations where they were found and how many samples collected from the specific location appear on the map (figure 5).

Figure 5

The potential plastic pieces had different appearances. The samples contained both orange, red, black and blue plastics. The majority was black and dark blue. Their one overall similarity was their shape – they were all long fibers. The size ranged from under 1 mm to 20 mm.

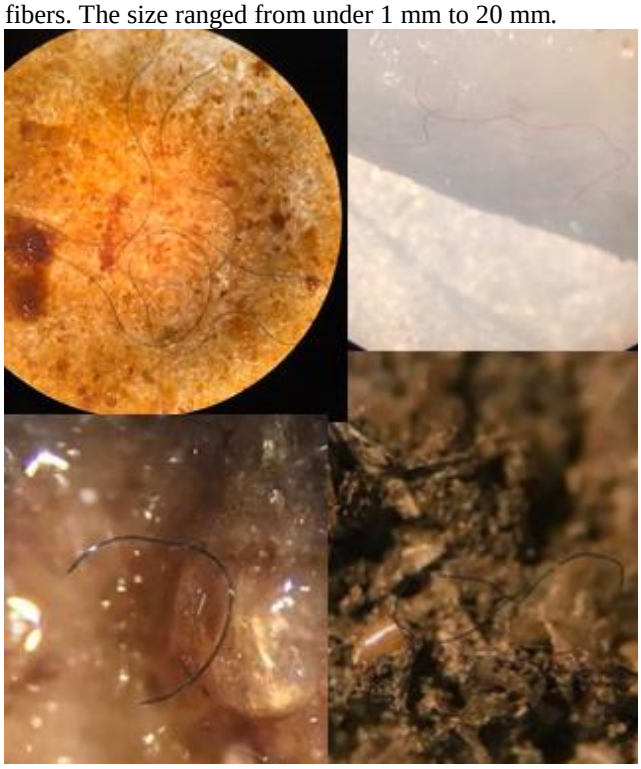

Figure 6

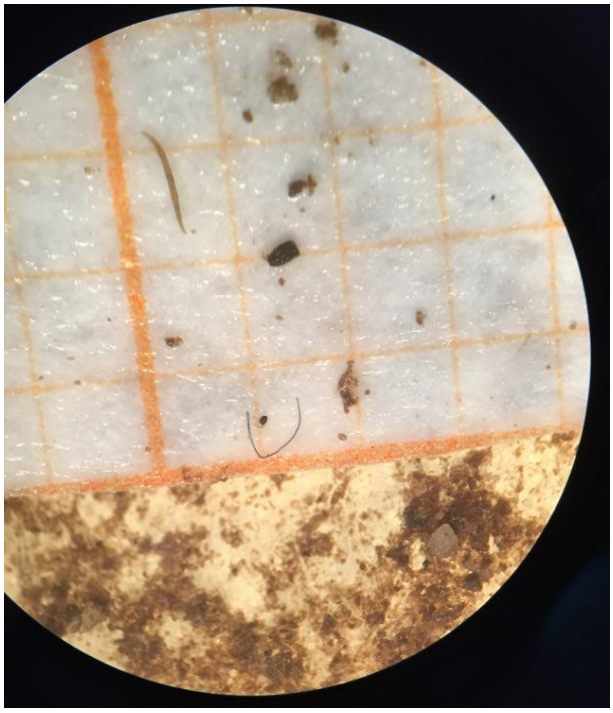

Figure 7

1.5 Sources of error

While during our experiment we had some sources of error, which should be considered before doing a further study:

1) We might have lost some possible plastic pieces when we cut of some of the filter to make it fit into the petri dish
2) The bird excrements were laying in layer, which mean we haven't been able to see everything
3) We could not be certain of what was plastic and what was not
4) Not all the excrements where totally dry when we weighted them, therefore there been an unknown amount of water
5) Microplastic have might gone through the filter

1.5 Discussion of our experiment

The results of our research showed a comparatively high occurrence of plastics. The bird-excrements are presumably gulls and cormorants which were highly abundant in the research areas. In the areas where the samples were collected we observed those species and the areas was alike their habitats. Given the fact that both gulls and cormorants consume fish, mussels etc. We assume that they consume mainly fish, mussels and other marine organisms. Several of the samples contained fish scales and bones. The plastics that we found presumably come from the marine organisms that the birds consume. The bioaccumulation of plastics causes a higher content of plastics in the bird's excrements because the plastics accumulate through the food chain.

We identified all the plastics by visual identification considering colour and structure. This method is important to consider because some of the identified plastics could be hair, cellulose, cotton or some other organic substance. The identification was subjective which causes varying estimations of whether a substance is potential plastic or not. After doing the researches we were presented a method to avoid this – the organic substances could have been eliminated by chemical treatment. If the researches were to continue this would be an advantageous method.

A remarkable finding during the research was that almost all the plastics were found in the edges of the samples. In a typical sample, all the substances were centred in the middle of the sample, which is a divergence since most of the plastics were found in the edges. An explanation could be that the plastics located in the centre among the substances are difficult, almost impossible, to detect because they are hidden among the other substances and only the plastics in the edges lying on the white filter was detectable If that is the case the samples could possible contain way more plastics than we detected. This could perhaps have been avoided using basic chemicals, but the layers were often very thick and the amount chemicals we would have to use could in the worst case also corrode the plastic fibres. Every sample was examined for 10 minutes and more plastics could very likely have been found if the samples had been examined for a longer time. Above on "Figure 6" is a photo of a typical excrement. The middle most of the excrements in a rather big pile, while the rest of filter is covered in a thin layer of excrements and it was in this thin layer of excrement we found the majority of potential microplastic.
We also had some fibers that were unable to identify, which means they can still be potential plastic. This means that the amount of microplastic was not as comprehensive as we first assumed. Though it can be concluded that the manmade cellulose still contains coloring and perhaps other chemicals that are not good for the environment. Hormone disruption substances are hydrophobic which means they cannot dissolve in water. These hormone disruption substances bind to plastic particles to avoid water. By consuming these plastic particles with hormone disruption substances bound to them, the organism will be exposed not only for a physical irritation but also for hormone disruption substances.

Figure 8

When we were almost at the end of the project we contacted Plastic Change in Roskilde. We contacted them because we had an interest for what they had been working with and wanted to see how they had worked with their

project, which also concerns micro plastics. We told them about our project and why we had an interest in theirs. We arranged a day where we could visit them in Roskilde on Aarhus University and they offered to analyze our potential micro plastic fibers. We were in their laboratory for a whole day analyzing about 10 plastic fibers. It turned out the pieces that were possible for us to analyze were cellulose. They were all man-made which we could determine because of their non-biological color. It was cotton fibers most likely to be from fishing nets and clothes.

Not all professional studies have had the FTIR method available which means they also base their investigations on light-optical microscopy [1]. This could eventually mean that some studies overestimate the actual amount of microplastic found. The Technical University of Denmark did a study in 1987 investigating fish in the Baltic Sea, they repeated the experiment in 2015 and surprisingly found that the fish's contained the same amount of plastic as in 1987 even though the production of plastic has increased rapidly. [2]. The study mentions that even though they found good results on the amount of microplastic we should keep investigating further because there are many aspects of microplastic in the oceans.

1.5 Interview

We interviewed Fionn Murphy, Postdoc, at Aarhus University. Before arriving at Aarhus University, Fionn Murphy did a Ph.D. in microplastic pollution, where he looked at sources, effects, and where microplastic ends up in the environment, and before the Ph.D. he did a degree in marine fresh water in biology in Ireland.

What are the consequences of the microplastic pollution?

Today we can basically find microplastics everywhere we look in the environment. We can find microplastic at the beach, in the sediments, fish and all different types of organism in the marine and fresh water. We know that fish and organism can't digest microplastic, but we aren't sure of the effects of this, it can potentially cause blockage and digesting issues. Microplastic itself contain a lot of harmful chemicals that once digested could be released and absorbed by the organism. Microplastic bind often with heavy metals or other harmful chemicals and when the microplastic is digested these heavy metals or harmful chemicals are released to the fish's

1.6 Conclusion

We have found a lot of man-made material, and the occurrence of these materials is most likely to be underestimated. We found many potential pieces of plastic but the results from the analysis at Aarhus University proved that a lot of them were cellulose. Professional studies that are used as proof in reports for the Danish Environment Institute use the same method to identify plastics, which might cause that even official reports overestimate the amount of microplastics. We suggest that microplastic should be investigated and mapped even further for a better understanding of the spread and consequences.

For future work there could be done in connection with our investigation of the release of microplastic in the marine, could if possible be going on a boat with a special designed filter, which we would collect 1 cubic meter of water with, and in addition to that analyse and determine how much plastic it contained. Furthermore, we could also have dragged the filter through the water trying to collect as many pieces of microplastic as possible and from the outcome of that, we would determine how bad the spread of microplastic in our local water/environment really is. Eventually, we could also have contacted the local water treatment plan, to make a cooperation with them, and get a permission to examine the wastewater they are letting out in the water again after the filtration, as there obviously still would be pieces of microplastic of importance going through. The water treatment plan stores the sludge from the water and produces fertilizer pills for our fields by using this, if possible, we would have liked to investigate these pills and see if they contained any plastic fibres, which could be released into our nature.

1.7 Acknowledgements

Studies:
Our inspiration-project, "Project Plastfree Roskilde Fjord": https://plasticchange.dk/vores-loesninger/plastfri-roskilde-fjord/ and:
https://plasticchange.dk/media/40691/plast-i-roskilde-fjord-j-strand.pdf

Ministry of environment and food of Denmark. Study over occurrence, effects and sources from microplastic in Denmark.
https://www2.mst.dk/Udgiv/publications/2015/10/978-87-93352-80-3.pdf

Interview:
A great thanks to Aarhus University for developing our project and thank to postdoc Fionn Murphy, Aarhus University.

1.8 References

[1]: http://mst.dk/media/143341/partnerskab-om-mikroplast-i-spildevand-2017.pdf

[2]:
Danish study examining microplastic in the Baltic Sea in 1987 compared to a similar study in 2015, revealing almost the same amount of microplastic in the examined fish.
https://www.sciencedirect.com/science/article/pii/S0048969717328024?via%3Dihub