Entry to the Stockholm Junior Water Price 2018

Microplastics in Sewage Effluent

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What is this project about?

Small plastic particles – called microplastic – can be found nearly everywhere nowadays. On the one hand they come from cosmetics on the other hand they come from abrasion from tyre or from washed clothes made out of plastic fibre. We analysed in which extend microplastic can be found in water after it went through the cleaning process in a water-treatment facility. With nets of different mash openings as well as a plankton net we filtered the water that flows out of the water works and into the nature. Especially particles between 25 and 40 micrometres were in our focus. We counted the remaining particles under a microscope and calculated the results of 9 plastic particles per cubic metre. But we only counted those particles which were clear to identify and also assumed that only 25 percent of the found particles are microplastics, so this figure must be seen as a minimum.

Contents

1 Introduction

Microplastics. From pursuing this topic last year, we noticed that it is far more important than first thought. It's not just that the topic is rarely spoken about, but that it has a much greater impact on the environment than people realise.

Many of us know the images: Trash vortexes horrify us, dolphins and fish perish because of trash in the sea, and garbage piles grow every day. If you now consider articles like „In 35 Jahren mehr Plastik als Fische im Meer" ("In 35 years more plastics in the sea than fish") or „Unsere Ozeane versinken im Plastikmüll"[1] ("Our oceans drowned with plastic garbage") you easily agree to the point that plastic is not especially a blessing. Yet there is still no halt to the production of plastic garbage. Unlike microplastics, you can see that normal plastic can be removed from the ecosystem with relative ease, though such cleaning costs a lot of money. Microplastics exist everywhere, but it nearly always finds its way into sewers and finally into our oceans, then entering the food chain and damaging many organisms. The direct effects of microplastics for the environment has been known a long time, but you cannot fish the microplastic out of the seas and we also barely see it. Eventually it is quite possible for microplastics to influence the food chain to such an extent that we finally consume it (fish, salt, etc.).

These and other questions encouraged us to continue to engage this topic. Most people in Germany know that most shower gels, shampoos and cosmetics contain small plastic particles but they do not know how the microplastics affect the ecosystem in which it finally lies. This is why we want to find out whether our sewage-treatment facilities are able to filter microplastics out of the effluent.

In the following we will explain what microplastics are, what research is already known to us, what research we did in the last year and explain our experiments with the filtered effluent from the sewage-treatment facility in Ludwigsfelde. At the end we draw a conclusion from our experiments and we answer our questions.

[1]http://www.wwf.de/themen-projekte/meere-kuesten/unsere-ozeane-versinken-im-plastikmuell/ 29.01.2017

2 Microplastics

There are many definitions for what exactly microplastics are. There is no standard, resulting in many different details in many different sources. Some say particles smaller than 5 mm are microplastics[2] and other sources mean particles that are already in the area of micro- or nanometres. For our scientific work we define microplastics as particles from 25 µm to 40 µm.

Problems mostly are created because microplastics are of nearly the same density as water. With an approximate density of 0.8 g/cm^3 to 2.2 g/cm^3 [3] most of the plastic particles float in the water and neither gather at the surface nor at the bottom of containers or stretches of water. In addition, most microplastics consist of polymers that are hardly decomposed.

For lots of products, such particles are specifically produced; for example, for shower gels, shampoos and even all kinds of cosmetics. In general, this is called primary microplastic. But while washing clothes you can also wash out little plastic particles, which then go into the sewage. This happens especially when you wash something like fleece or other synthetic materials. This kind of microplastic, which is produced by bigger plastic particles, is called secondary microplastic.[4]

Illustration 1: example for microplastics and one of its uses in cosmetics

That way it is possible for plastics to come into our environment and our ecosystem. To what extent microplastics still exist in treated water after going through a sewage-treatment facility will

[2] https://www.bund.net/themen/meere/mikroplastik/hintergrund/ 29.01.2017
[3] http://www.chemie.de/lexikon/Kunststoff.html 27.12.2017
[4] https://de.wikipedia.org/wiki/Mikroplastik 29.01.2017

later be explained in our work, but first we will take a closer look at the consequences of those plastic particles in the environment.

One of the problems that comes with those particles is the fact that they attract toxins which will then be eaten by various species such as fish or other smaller life forms. The mostly hydrophobic surface of microplastics is ideal for that, because water cannot wash away those toxins. And, when the particles are small enough, they will even get eaten by microorganisms. Also, when that happens, we will not be able to remove the plastics anymore from the food chain.

For example, it is possible for plankton to consume microplastic, which is then consumed by fish, which are consumed by other fish, which are eventually consumed by us, the humans, as supposedly healthy food. With microplastic not being able to be digested it becomes part of the food chain and the toxins which are transported by it get absorbed by various life forms. That way it comes to a depot effect inside of the cycle.[5]

It is easy to see that there is a fundamental threat, if we continue to have a negative influence on nature and do not put measures in place to fight against this problem. By now this problem has become so relevant that even at the local level efforts exist to make young people aware of this extremely serious problem. Though the project „Plastikpiraten – Das Meer beginnt hier“ only takes care of the pollution of regional stretches of water with macro plastic but it also is only a statistical investigation.[6]

To prevent long-lasting damage to the ecosystem, it is not enough to just do that, because microplastic is already noticeable and the necessity of methods for removing or preventing the microplastic from entering the food chain is growing steadily. According to our knowledge, it is still not possible to filter out microplastic in an efficient and effective way, and for industry, microplastic is so lucrative that they rarely use substitutes such as sand or sawdust. In a source from 2014 the government of the FRG estimates that the total quantity of polyethylene which comes from cosmetic products into the environment amounts to about 500 t.[7]

[5] https://www.bund.net/themen/meere/mikroplastik/hintergrund/ 29.01.17
[6]https://www.wissenschaftsjahr.de/2016-17/mitmachen/junge-wissenschaftsinteressierte/plastikpiraten.html 27.12.2017
[7] Drucksache 18/2985 Bundestag vom 27.10.2014

3 Previous results of research

There are already different kinds of research in the field of microplastics taking place at the moment. For example, the research done by the company *hanseWasser*. We will explain a part of it later in our thesis.

In October 2014 the Alfred-Wegener-Institute Helmholtz-Centre for polar exploration and oceanography did an investigation into microplastics in 12 different water-treatment facilities. The results varied widely. They found between 86 to 714 particles and 98 to 1479 fibres per cubic metre.

Also, they showed how parts of microplastic are already being removed in water-treatment facilities. In the rake and the grit chamber, some coarse and heavy parts of plastic are separated and then sedimented in the pre-treatment stage. In the activated sludge and the secondary purification some lighter plastics get removed. You can read more about the structure of water-treatment facilities at point 5.

The conclusion *hanseWasser* drew from their research was that microplastic is an explosive issue, to environmental policy and that there is definitely a requirement for further research about the impact on the environment. To what extent water-treatment facilities can eliminate microplastics throughout the treatment process has hardly been researched.

The explosive nature of this topic does not seem to be fully understood by the government. Responding to a request, the federal government answered that they cannot “rule out the possible irreversible environmental impact of microplastic particles used in cosmetics”[8] The government stated a desire to enter into a dialogue with the cosmetics industry to encourage a “voluntary microplastic particle phase-out in cosmetic products.” [9]

[8] Drucksache 18/2985 Punkt 4
[9] Drucksache 18/2985 Punkt 4

4 Experiments with cosmetics

The first experiments we did in the fields of microplastics, were foam ups of various articles such as shower gel and shampoos.

For those experiments we received support by the college for technology and economy Berlin, course construction engineering, which provided us with a sifter (see illustration 2) for filtration. The filters had mesh openings of 5 mm, 2 mm, 1 mm, 500 µm, 125 µm and finally 63 µm. Also, we used filters specially bought for that use with mesh openings of 40 µm and 25 µm.

Illustration 2: sifter with different filters

For every filtration we used 100 g shower gel (one time we used 50 g) from various products and the finest filters we had. In the following table you can see the results of these experiments. You can see that especially the product „*Pure&Basic* Dusch Peeling" contains a lot more microplastic than the other products with nearly 3 g per 100 g.

Cosmetics	Weight of contents	Share of microplastics
Axe Duschgel	50.09 g	0.002 g
Yves Rocher Schimmer Duschgel	101.02 g	0.057 g
Nivea Men Pflegedusche	100.84 g	0.773 g
Bebe Waschgel	100.36 g	0.139 g
Nivea Wasch-Peeling	100.28 g	1.026 g
Avene Körperpeeling	99.86 g	1.253 g
Kult Shower Peeling	100.18 g	1.658 g
Pure Dusch Peeling	100.02 g	2.901 g
Eldena Fuß-Peeling	100.21 g	17.328 g Sand

Table 1: Result of the analysis share of microplastics in cosmetics

6 Experiments with water discharge

On the basis of the preceding experiments we can presume that the plastic particles reach the sewage and we wanted to find out whether the water-treatment facility in Ludwigsfelde is capable of filtering out microplastics. For this we experimented with the water discharge of the water-treatment facility.

6.1 Experiments for qualitative determination of microplastics of a water-treatment facility

A qualitative determination of microplastics in the discharge water of the water-treatment facility in Ludwigsfelde was of great importance for the preliminary tests. Therefore, we used the same experimental set up we had already used for our experiments with the cosmetics. We looked at the deposits on the filters with a microscope.

The observations showed that even after purification there are still plastic particles in the water to be found, which reach the ecosystem that way. The size of the particles varied between 50 µm and 270 µm (measurements under a microscope). Regionally within the environs of Königs Wusterhausen you can clearly detect that even here microplastics are a problem. That means that the plastics problem is not just limited to the oceans, the qualitative proof was achieved with this.

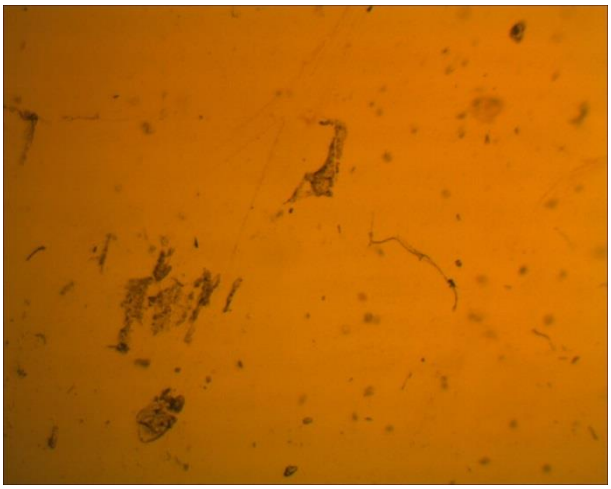

Illustration 3: Microplastics from a discharge water sample

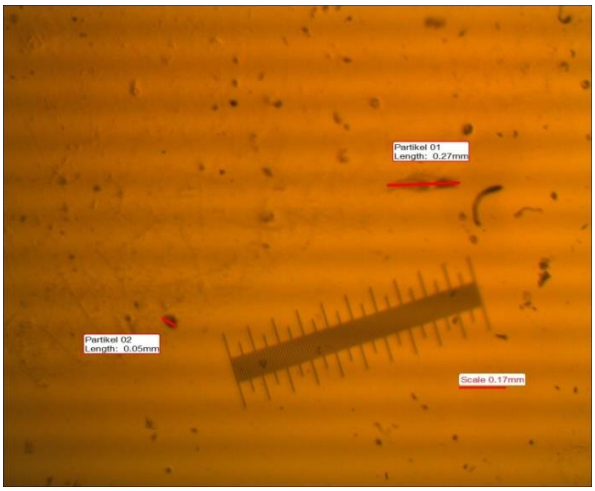

Illustration 4: Microplastics from a discharge water sample

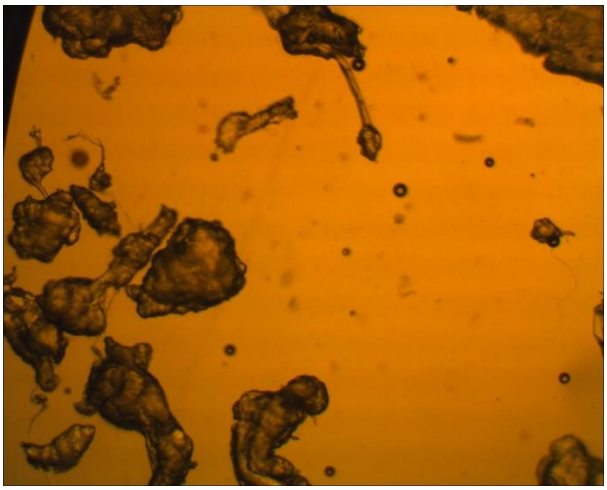

Illustration 5: Microplastics from a cosmetics sample (Pure&Basic)

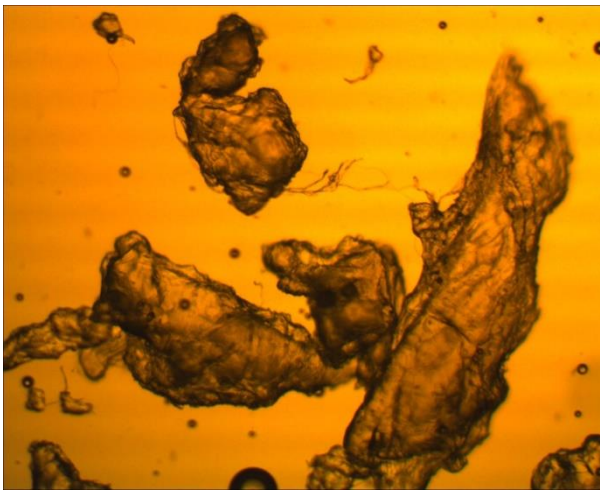

Illustration 6: Microplastics from a cosmetics sample (Pure&Basic)

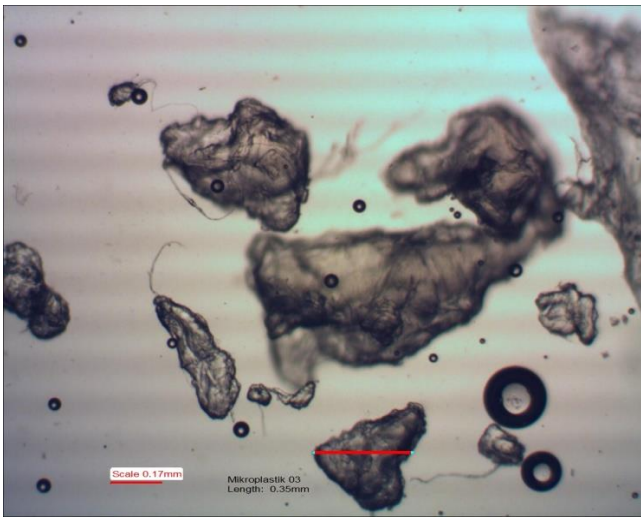

Illustration 7: Measurement of microplastics from a peeling product sample

6.2 Experiments for quantitative determination of microplastics

We still had the goal to obtain more representative results by filtering significantly more discharge water, as we wanted to try a comparison between the results of the study by *hanseWasser* and the results of our own experiments.

In the following we will describe the preliminary experiments first and then the execution of our actual research.

6.2.1 Preliminary experiments

As for our preliminary experiments we decided on using the Ludwigsfelde water-treatment plant, because the facility is big enough to be representative of the filtration of discharge water.

But first we calculated the average rate of water flow of our used pump by measuring the rate of flow before and after the experiment for fifteen seconds. With that we can eliminate a false calculation due to worsening pump performance. On the basis of those results we could describe the flow rates shown in table 2.

Preliminary experiments	
Average flow rate before experiment (l/s)	Average flow rate after experiment (l/s)
0.083	0.071
0.082	0.079
0.082	0.080
0.083	0.081
0.083	0.078
average: 0.0802 l/s	

Table 2: Calculated average rates of flow

For the preliminary experiments we used our three filters with mesh openings of 200 µm, 40 µm, and 25µm. The discharge water was filtered through them using the described pump.

We had to stop the experiments a few times after twenty minutes because one of the filters got overloaded because of sludge from the effluent. Also changing the pump's mount did not seem to have any positive effects on the results of our experiments.

We used our set up one last time at a day with better conditions. But we had the same results. The 40 µm filter got overwhelmed by sludge so it overflowed and we had to reject this set up.

Illustration 8: Set up of the preliminary experiments

Illustration 9: Set up of the preliminary experiments from above

6.2.2 Primary experiments

For the primary experiment we bought a plankton filter with a mesh opening of 20 µm, which was hung into the outlet of the water-treatment facility. The numbers for the complete water flow were offered by the DNWAB. With this we could calculate the total amount of water which passed through the plankton filter. The duration of the experiment amounted to 129 minutes.

Illustration 10: Outlet pipe of the water-treatment facility

The amount of 488,43 m^3 needs to be considered with deductions because not the whole water passed through the filter. We estimate a deduction of one half of the amount of water, which then is about 244.215 m^3.

Here too we found the plankton filter filling with sludge. Because of the size of the net it was no longer relevant for the experiment.

After the experiment we dried the plankton net. We rinsed the net out with so that the particles from the net collected in the container. The remains were filtered through our filter (200 µm, 40 µm, 25 µm).

The particles which remained in the 25 µm filter (which then have a size between 25 µm and 40 µm) were placed into a bottle of 100 ml and then we took 1 ml from it and counted the particles in it. The average number of particles amounted to 90 particles per ml.

Attempt number	Number of particles per ml
1	97
2	95
3	107
4	87
5	75
6	109
7	97
8	79
9	71
10	83
Average	90

Table 2: Calculated average rates of flow

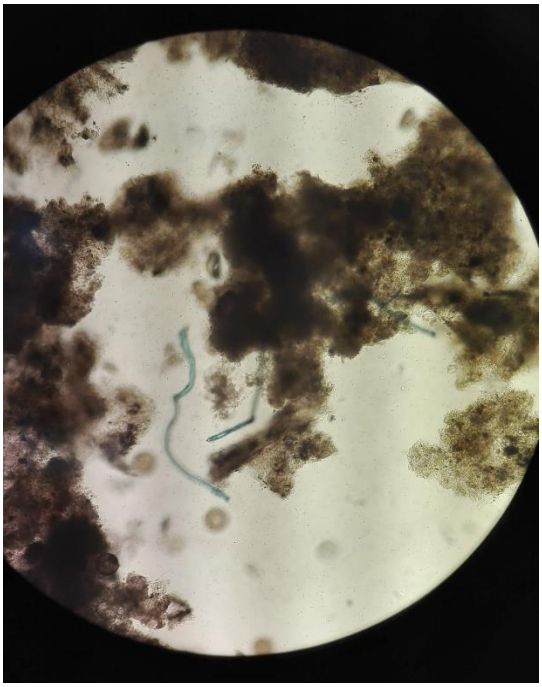

Illustration 11: microplastic particles in sludge

Illustration 12: microplastic particles from 20 µm net

6.3 Further studies

Apart from the experiments with discharge water we also did additional research on water from a nearby lake to investigate whether we could find microplastic particles there. Our predictions were confirmed. We determined that there is a clear case of pollution because under a microscope we found, for example, fibres with different colours or small plastic particles (see Illustration 13).

Also, we did an experiment to dispose of microplastics from the water discharge of regional water-treatment facilities. For example, we constructed a filter with diatomaceous earth. With this filter we found out that it can filter the water but the flow rate of the filter is so slow that it is not suited for practical use.

Illustration 13: microplastic particles in sludge

7 Results

The preliminary experiments showed that the amount of water which was filtered with the pump was too much for our filters which caused the overflow. The filters were blocked by the sludge that was deposited in the biological purification. The amount of sludge depends on different ambient conditions, but even when we tried the experiment again under better conditions, the results were the same.

The original experiment enabled us to determine the number of plastic particles in a specific amount of water in a quantitative way.

From our findings of 90 particles in 1 ml water from the 100 ml we can deduce that for the complete amount of water that passed through the plankton filter there were 9000 particles. We assume that only 25% of those particles are microplastics, which results in 22.5 particles per 1 ml or 2250 particles in the complete amount of filtered water, which results in 9 particles per 1 m^3.

As for the complete amount of water of 5500 m^3 per day flowing into the environment, we calculated that every day 49.500 particles flow into nature. And we only counted particles between 20 µm and 45 µm.

8 Conclusions

Our research confirmed our results from last year. Microplastics are a growing problem even in our regional sewage. It was possible for us to determine in a quantitative way the amount of microplastics that flows into the environment through the water-treatment facility. Though we have to look at those results more critically and we need to check the results one more time. For this we have to try different setups and develop more precise methods of measuring.

The dark sludge in the plankton net and the filters contained large amounts of microplastics which stay in the sludge and do not reach the 25 µm filter. So even with another cleaning phase it is very difficult to filter out microplastics in a sewage treatment facility. This sludge, which contains microplastics, is also a big problem for quantitative research into microplastic particles in the discharge water.

With this we now know that the problem of microplastics is even bigger than we thought. An additional cleaning phase is desperately needed to protect the environment from the bad effects of microplastics, but this is easier said than done. At the same time, it is essential to develop a method of analysis to measure more quickly and accurately how much microplastic is in one cubic metre of water. This would be another goal for our additional research.

9 Critical remarks

The projection of the microplastic particles from our experiment has to be judged with a critical eye and should better be considered a minimum because we had many sources for error. For example, we could not remove every last trace of particles from the 25 µm filter, which caused a

loss in particle amount. Also, we could see plastic particles in the sludge which were very hard to count, so we assume that there have to be many more particles that we simply could not see.

Up to now we are still not able to clearly differentiate microplastics from other particles in the water. Our research is based on the appearance of the particles under a microscope, because we can assume a material according to its surface.

10 Additional approaches

For the future we imagine using spectroscopy to identify the materials faster and more precisely. With this we could produce better results concerning the amount of microplastics and the proportion of the different kinds of microplastics.

In point 8 we wrote about a method of analysis for the amount of microplastic in water. Here we also see the need of additional research for the future of our project. We would like to develop this method.

Apart from that we also want to test different ways to filter out microplastics from the discharge water. For this we could possibly use the effect of electromagnetic charging.

11 Note of thanks

Finally, we would like to thank the DNWAB very much, without whom this project would not have been possible. They helped us with the project and gave us materials and information about microplastics and most of all the possibility of researching at the water treatment facility in Ludwigsfelde. We hope that we can intensify this relationship in the future.

Huge thanks also to the University for technology and economy at Berlin which helped us with some preliminary research.

12 Bibliography and references

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12.3 Sources of images

Statement of authorship

We hereby declare that we are the sole author of this thesis with the title

Microplastic in sewage effluent

And that we have not used any sources other than those listed in the bibliography and listed as references.

Königs Wusterhausen, 07.06.2018

Place/Date

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