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MICROPLASTICS AND PLASTIC PIPES

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SHORT SUMMARY

Plastic pipes for drinking water purpose made of 9 different materials have in two studies been tested in conditions, similar to normal use. Based on the applied methods, no levels of microplastics above the detection limit were found in the samples.

A third study with measurement of the wear in 30 years old storm water pipes showed that no wear of the plastics could be measured and therefore no microplastics seems to be emitted.

KEYWORDS
Microplastics, drinking water, abrasion, wear.

ABSTRACT

Microplastics in drinking water and in food in general has been a topic with ever increasing interest since a publication of a study in the British newspaper The Guardian. The microplastics topic has also high focus on governmental level, e.g. in Germany where a report of Fraunhofer Umsicht /1/ estimates the amount of microplastics coming from plastic pipe systems to be 12 grams per year per capita. Since then, we have seen several attacks from producers of piping systems made of traditional materials: Copper, concrete and ductile iron.

Measuring microplastics is considered as being difficult. Although it is challenging, it is important for the plastic pipe industry to understand and follow the development of technologies. TEPPFA has therefor initiated several studies to investigate if plastic pipes are a source for microplastics and to quantify if possible. Two studies have been performed on pipes for drinking water and one study for storm water pipes.

In the first drinking water study the Raman method was used and in the second the particles were analyzed using laser direct infrared imaging with a particle identification by help of a software.

The studies on drinking water pipes have been done in a test rig where a normal pattern

for drinking water supply in buildings are simulated: A pressure of 4 bars, a water flow of 1,2m/s and a start/stop schedule.

In the first study PE80, PE100, PErt and PVC-U were investigated. In the second study more polymers were added and also PB, PVC-C, PP-rct and PPr were tested. Furthermore, the second study also included test at 60 degree Celsius.

Results of the studies were very encouraging although it also was evident how complicated it is to measure microplastics in an environment where you constantly have fibers and particles in the air in the laboratories.

The third study was concentrating on storm water gravity pipes. When comparing to sewer pipes, it must be expected that abrasion and wear inside the pipes are more likely to happen in pipes transporting surface water. A PVC and a PP storm water pipe, that has been in use in around 30 years in Denmark were dug up and inspected by an accredited institute. After inspection it could be concluded that no wear was found, and therefore storm water pipes cannot be a significant source of microplastics in the aquatic environment.

The paper will explain the test-set-up, the methods used and the results of both the study on drinking water and the study on storm water pipes.

INTRODUCTION

The first study on drinking water pipes was carried out in 2020 by Danish Technological Institute (DTI) in Aarhus, Denmark as partner. The objective of the test was to investigate the amount of microplastics (if any) coming from plastic pipe systems due to abrasion and migration in drinking water installations. In parallel, a test of commercially available Cu pipes was performed.

Next to the Copper pipe - acting as a blind test - four plastics products will be tested: PE80, PVC-U, PEX-a, and PErt. Each pipe was 50 meters long.

EXPERIMENTAL

The test setup consisted of the following components:

- A pump with a magnetic drive system (to avoid plastics sealing elements)
- A reduction valve to adjust the water velocity
- Start/stop device
- A container of 35 liters for buffering
- A cooling system to maintain a constant water temperature

- Thermometer, pressure gauge and flowmeter
- Coupling devices and piping for connecting test pipes

The pipes are assembled in a way that resembles daily routine work with deburring of ends, but with extra care in order to avoid internal impurities. The pipe between the red arrows shown is removed and replaced by the pipe to be tested.

The test procedure took place as follows:

- Pre-flushing of the pipes with drinking water according to EN 806-4:2010 with a velocity of 2 m/s and a volume of 20 times the volume of the pipe.
- The water to be used during the test is QW.
- According to the Danish Code of Practice for domestic water supply installations, DS 439:2009, the dimensional design flow for cold water supply for a single-family house can be set to 1.1 m3/h. For the smallest pipe, PEX-a, this results in a velocity of 1.2 m/s which will be set for all pipes during the operations.
- Start/stop intervals as follows: After a flow of 30 seconds, a pause of 30 seconds will interrupt the flow.

- Pressure during the circulation: 4 bars (the typically maximum pressure in house installations).
- Pressure when the flow is paused: 4 bars.
- Temperature: 23 °C plus/minus 2 °C as specified in EN 12873-1.
- After the testing period, 20 liters will be poured into glass bottles.

During the pre-flushing, the container is filled with drinking water while the pump presses the water through the test pipe, the water meter, the reduction valve, the solenoid valve and to the drainage. During the pre-flushing, the temperature in the container and a momentary value of the flow are recorded.

After pre-flushing, the container, the pump and the pipe of the setup are drained. The surface water in the container is also drained separately in the attempt to avoid leaving potential floating impurities inside the system.

The container is filled with QW. The pump uses the QW to press the rest of the DW to the drainage. Afterwards the drainage is removed, the solenoid valve is reconnected to the container, and the taps are plugged again.

During the operation, the flow will be calculated and adjusted. Two times daily the recordings of temperature, flow and pressure are performed,

After the first test run (7 days), sampling is carried out. The first liters are tapped and discarded due to old water in the pipes of the taps and in the ball valves, etc. Afterwards, 20 liters are sampled in a blue cap glass bottle and the taps are plugged again. The samples are submitted to the laboratory.

The microplastic analysis was based on an existing method that uses Raman spectroscopy for micro-plastic characterization. The analysis method applied has been developed and optimized by the Danish Technological Institute in several R&D projects during the past five years. In essence, the method is based on particle recognition in high resolution microscopy images, followed by chemical characterization using a Raman spectrometer. This enables chemical identification of the material type of each found particle. Extracting the particle size from the picture makes it possible to quantify of the amount of any given type of plastic present in the sample.

The results are shown in the overview below:

Sample	PE80-2	PEX-A-2	PERT-2	PVC-U-2	Cu-2
Concentration of microplastic (µg/L)	0.9	1.3	0.6	0.2	13.1
Contribution form PE (µg/L)	0.3	0.7	0.14	0.03	0.09
Contribution from PVC (µg/L)	0	0	0	0	0
Number of particles consisting of:					
PA	0	0	0	0	0
PE	27	5	15	1	7
PEMA	0	0	0	0	0
PET	0	1	1	0	0
PMMA	2	0	0	0	0
PP	11	9	7	7	9
PS-b-PIS-b-PS	0	0	0	0	0
PS	2	1	0	1	14
PTFE	1	0	4	3	8
PVC	0	0	0	0	0
PC	0	0	0	0	0
PPSU	0	0	0	0	0

Based on the applied method, no levels of microplastics above the detection limit (2 µg/l) were found in the samples of the tests of PE80, PEX-A, PE-rt and PVC-U. In the sample of the test copper pipe, a microplastic level of 13 µg/l was found. It is noted that this mass was caused by a single polystyrene particle measuring approximately 200x350 µm. The contribution to the total microplastic concentration from the mass of this particle alone accounts for 11.4 µg/l. Aside from this particle, the microplastic level in the test of the copper pipe was below the detection limit. For the microplastic measurements, the particle detection limit was 15 µm, and measurements of particle size distributions showed that most of the material present in the investigated samples were above this threshold.

In 2021 we decided to replicate and extent the investigation with more products, measurements at both 23 degree end 60 degree and using another method for detecting and measuring the microplastics. The Dutch KWR water testing institute was selected to the job.

The test equipment and test setup as used at DTI in Denmark was copied and also used in this test.

The products tested were copper (reference, blank test), PE100, PVC-U, PE-Xa, PB, PE-rt, PVC-C, PP-rct and PP-r. The products for the hot & cold applications was tested at both 23 degree and 60 degree.

Chemical characterization was done with infrared: Particles were analyzed using laser direct infrared (LDIR) imaging from the company Agilent. The particles were identified by the Agilent software (Clarity). Infrared particles in the samples were compared to the infrared spectra of the pipe-materials. The spectra of each of the different pipe-materials were acquired prior to the analysis of the samples and added to the spectra library. As a threshold for a positive identification a value of 0.85 was handled. If an infrared spectrum of a particle had a match of 0.85 or higher with a spectra from the library, this particle was identified, otherwise this particle is labelled unidentified.

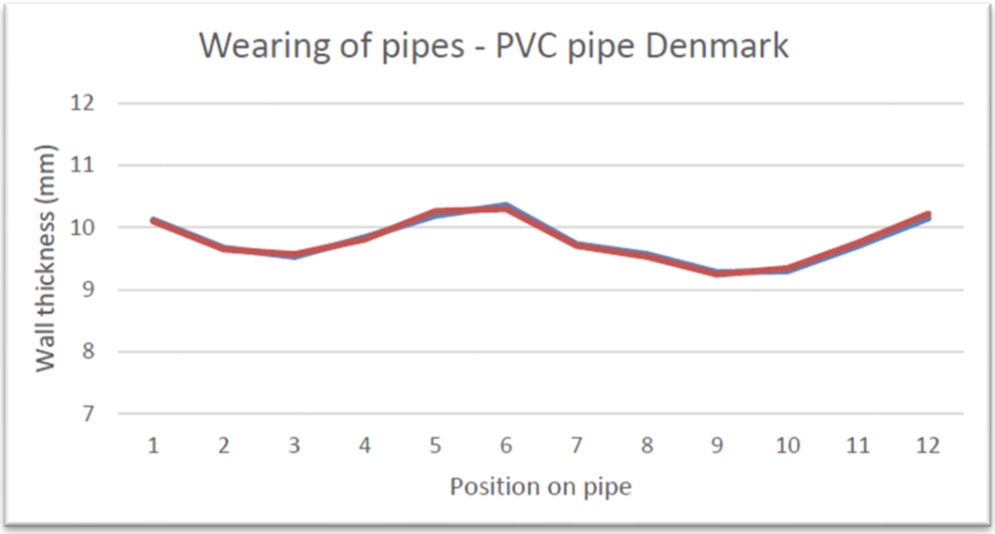
The result can be seen in the table below:

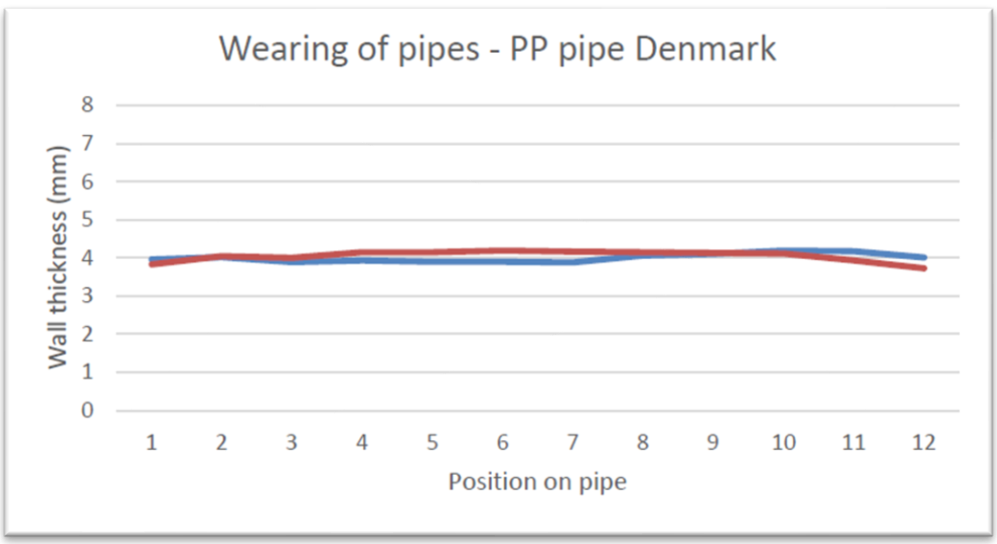
	Copper 20°C	PE100 20°C	PVC-U 20°C	PEX-a 60°C	PB 60°C	PE-rt 60°C	PVC-C 60°C	PP-rct 20°C	PP-rct 60°C	PPr 60°C
PB	0	0	0	0	0	0	0	0	0	0
PE-rt	0	0	0	1	1	3	0	2	1	0
PEX-a	8	4	0	0	2	4	0	4	0	0
PE100	1	3	0	1	0	2	0	10	10	21
PPr	0	0	0	0	0	1	0	2	0	0
PP-rct	2	3	0	1	1	0	0	4	6	0
PVC-C	2	11	0	3	7	5	0	22	3	8
PVC-U	72	11	0	24	9	252	0	121	24	134
Unidentified	944	840	359	766	284	2209	24	959	382	923

You will see that there are very little correlation between the pipe material (as indicated in the horizontal top-line) and the particle found. This shows indeed the difficulties in measuring microplastics as background pollution from the air or from clothing have a huge influence by contamination the samples. In general, we can conclude that the microplastics analysis did not show any evidence for release of particles from the corresponding pipe materials into water.

The third study was focusing on storm water pipes. In certain countries plastic pipes have been accused for emitting microplastics to the aquatic environment due to abrasion of the inner surface as a result of the flow of sand and small stones from the surface water.

In 2020 TEPPFA requested therefore DTI in Denmark to detect wear in two approx. 30-year-old storm water pipes: One DN 315mm PVC solid wall pipe and one PP structured wall pipe. Two sections of the pipes were dug-up and send to the laboratory of DTI. The wall thickness of the pipes was measured in 12 different positions around the clock to estimate any change in wall thickness from other than the expected eccentricity of the extrusion process. The variation in profile can be seen in the two graphs below:





Position 1 is the upper part of the pipe, and position 7 is the lower part of the pipe and therefore the area where the main flow of the storm water runs. DTI concluded on basis of the measurements that: “The wear of the wall thickness is too miniscule to be measured with normal gauge used for measuring wall thickness. No wear could be detected.”

CONCLUSIONS

The two studies clearly show that measuring microplastics is a difficult task. In the European recast drinking water directive, which will come into force in 2025, article 13 states that “Following the entry into force, the Commission shall adopt delegated act….to measure microplastics…..to include them on the watch list.” In other words, microplastics

in drinking water will be monitored as of 2025, and the commission will define a standardized test method /2/.
As a very logic first focus, we can state that in real life good craftmanship is the main influential factor on the number of shavings and particles that are left inside the pipes when cutting/sawing and deburring the pipes.

REFERENCES

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