THE EFFECT OF BACTERIA ON THE DESTRUCTION OF THE DRINKING WATER DISTRIBUTION SYSTEM POLYMER PIPES

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Introduction

- Polymer pipes are widely used in water supply systems.
- Organic additives are used in the pipe manufacturing.
- Additives may leach organic substances into water.
- These organic substances may serve as nutrients for bacteria leading to increase of concentration of bacteria in water → possible undesirable effects to human health.
- If nano/micro cracks are present in pipe walls, the bacteria can get into the cracks and widen them further → deterioration of mechanical strength of the pipes.

The aim of the research:

- To study the influence of bacteria on mechanical properties of the polymer pipes.

Materials and Methods

1) Polymer pipe samples

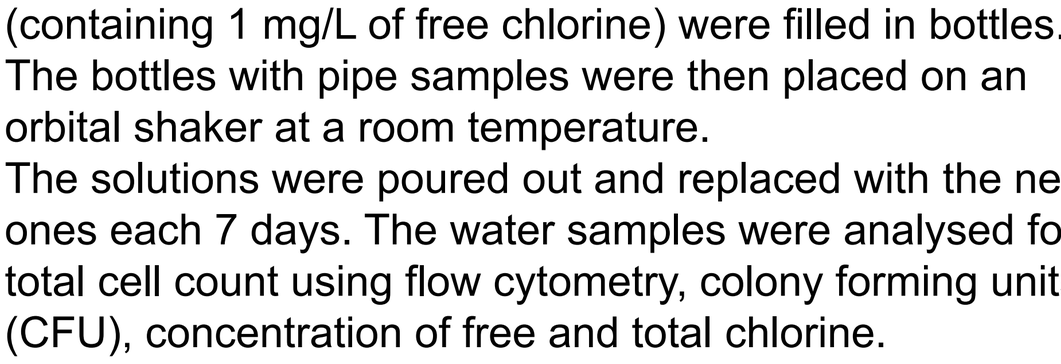
Dogbone shaped samples were cut out of PE80 (polyethylene) water pipes

2) Treatment with bacteria and chlorine

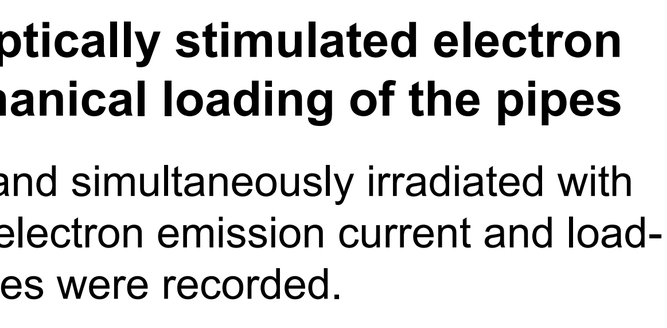
- Five times concentrated tap water or chlorinated tap water (containing 1 mg/L of free chlorine) were filled in bottles.
- The bottles with pipe samples were then placed on an orbital shaker at a room temperature.
- The solutions were poured out and replaced with the new ones each 7 days. The water samples were analysed for total cell count using flow cytometry, colony forming units (CFU), concentration of free and total chlorine.

3) Measurements of optically stimulated electron emission during mechanical loading of the pipes

Samples were deformed and simultaneously irradiated with ultraviolet (UV) light. Photoelectron emission current and load-strain curves were recorded.



Electron emission curves were analysed in the elastic deformation region – the region of early destruction when nano/micro cracks begin to form.



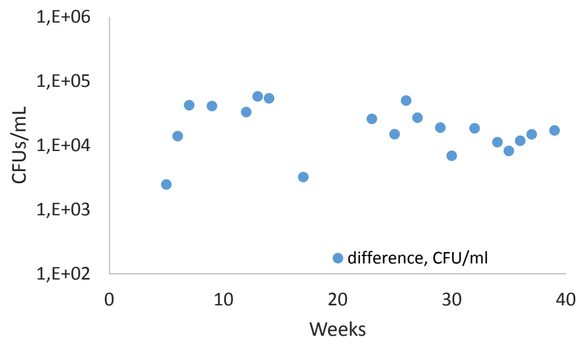
Results

1) Cell count and chlorine amount measurements

The concentrations of total and free chlorine when just applied to water solutions were 4,40 ± 1,02 mg/L and 3,56 ± 1,13 mg/L respectively. After one week both concentrations of free and total chlorine were 0 mg/L, meaning that all the chlorine reacted with the bacteria from water or other organic substances.

The average initial concentration of bacteria able to multiply (CFUs) in concentrated water samples was $5{,}23 \cdot 10^3$ per mL. After a week average CFUs concentration was $1{,}94 \cdot 10^4$ per mL.

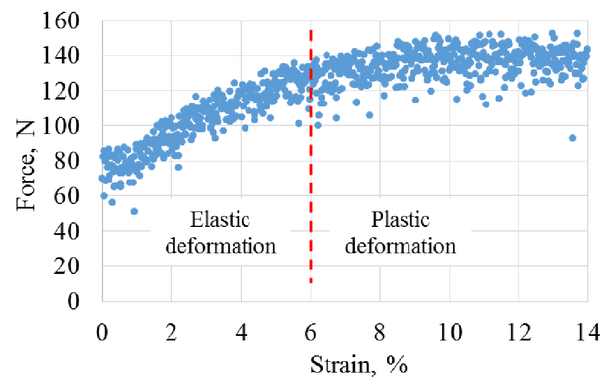
This leads to the conclusion that PE pipe samples affect bacterial growth. However, total cell concentration (measured by flow cytometry) did not change significantly.



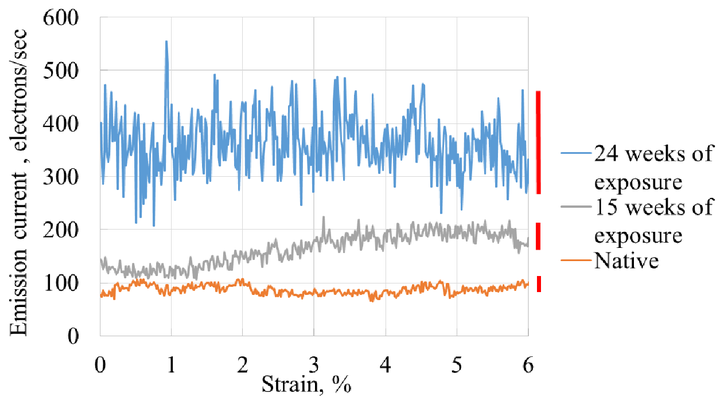
2) Emission of electrons from the pipes depending on time of the exposure with bacteria

A typical load-strain curve of a PE80 pipe shows that elastic deformation occurs to 6% strain.

Therefore, the electron emission was analysed within this region.

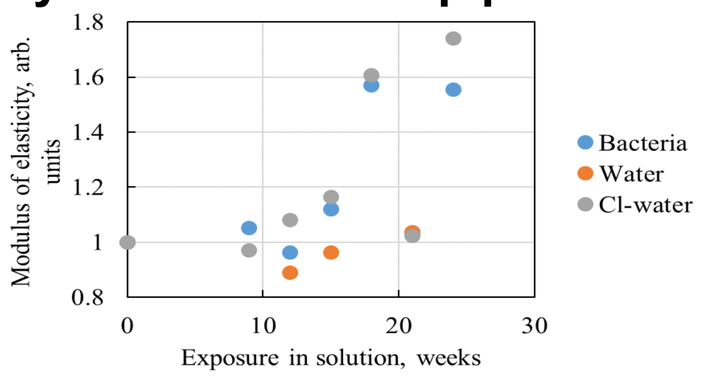


The amplitude of the emission oscillations increases upon increase in exposure time to bacteria. It means that nano/micro cracks start to appear.



3) Changes in elasticity modulus of the pipes

The elasticity modulus increases upon increase in the exposure time to bacteria or chlorine.



Conclusions

1) Concentration of the bacteria in the solutions (measured as CFUs) increased weakly by $1{,}34 \cdot 10^4$ per mL.
2) Electron emission measurements show that nano/micro cracks start to appear in the pipe walls when the pipes are exposed to bacteria.
3) The elasticity modulus of the pipes increases with increasing duration of exposure to bacteria or chlorine.

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