Underground career – bacteria as the builders of sediments

Benthic bacteria and microalgae that live at the bottom of rivers and lakes secrete substances that contribute to the stabilisation of sediments and hence to the stabilisation of aquatic ecosystems. Researchers from the University of Stuttgart are investigating the biostabilising effects of a number of bacteria and microalgae. One major research focus involves the investigation of the effects of foreign substances on microbial activity.

What makes the tiny organisms so important is their excretion products. Throughout their lifetime, bacteria and microalgae release a mixture of carbohydrates and proteins into the aquatic sediment. This mixture is generally referred to as extrapolymeric substances, EPS for short. The composition of EPS differs from one species to another. EPS form a matrix in the form of a protective shell around the organisms, thereby protecting them against toxins and predators as well as drought. In addition, EPS also function as reserve in times of nutrient deficiency. So much for the biological aspects of EPS. What about the geological ones? EPS play an important role in sticking bacteria as well as sediment (clay, sand, silt) particles together, which increases the stability of aquatic sediments.

The relatively thick bacterial biofilm can be lifted with a spatula

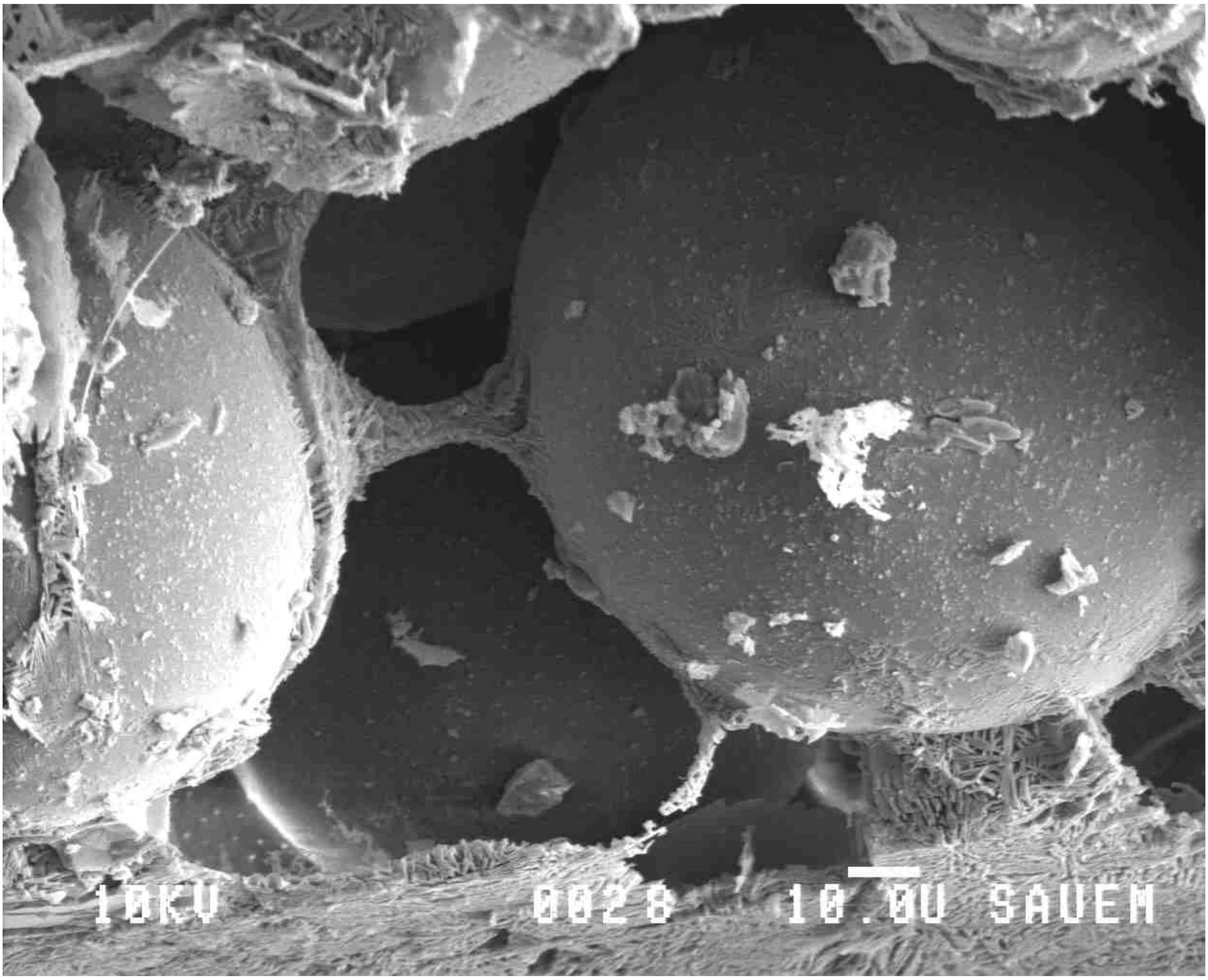
Dr. Sabine Ulrike Gerbersdorf is investigating these processes in detail and hopes to obtain an understanding of how the stabilisation and the bacterias' "ecosystem services" function. Supported by a grant from the EU's Marie Curie Programme, Dr. Gerbersdorf carried out some initial work at the University of St. Andrews in Scotland, which she is now continuing in Stuttgart. The next stage of the research focuses on classifying bacteria and microalgae living in and on aquatic sediment as well as on the composition of EPS and the effect of individual compounds on the stabilisation of cohesive sediments. In addition, research will also be done on the effect of novel environmental toxins (pharmaceuticals, sanitary products) on bacteria as well as on what makes the sediment stick together or disperse.

Gerbersdorf particular focus is the effect of triclosan, an antibacterial and antifungal agent she has already worked with in a previous EU-funded project. "Triclosan is toxic to aquatic bacteria, affecting population size and functions. We are planning to investigate whether this has any consequences for the sediment as an important ecosystem," said the researcher. Triclosan holds a particular interest for Gerbersdorf and many other researchers like her because it is one of the most frequently used disinfectants and is increasingly found in the water cycle. Triclosan is present in deodorants, toothpastes, soaps, washing agents and many other products.

Is the “ecosystem services” company in danger?

Previous investigations have shown that triclosan leads to an increased EPS concentration, suggesting that larger quantities of EPS increase the stability and solidity of the sediment. However, Gerbersdorf’s investigations showed that exactly the opposite was the case: “In our initial experiments, we exposed pure bacteria cultures and biofilms consisting of bacteria and microalgae to different concentrations of triclosan. The result was unambiguous: triclosan inhibits the growth of bacteria and microalgae; in addition, the microbes produce lower quantities of EPS, i.e. smaller quantities of sediment “glue”.

The tests have also shown that it is not only the quantity of carbohydrates and proteins that is key in the stabilisation of the sediment. The researchers also found that the combination and composition of EPS affects the stability of the sediment. Dr. Gerbersdorf plans to combine her findings on the EPS matrix with findings obtained by her cooperation partners, Prof. Dr. Werner Manz from Koblenz, Dr. Sebastian Behrens from Tübingen and Prof. Dr. Henner Hollert from RWTH Aachen, who bring their expertise on the microbiological and molecular genetic characterisation of biofilms and ecotoxicology to the project. Gerbersdorf is also looking for cooperation partners at the University of Stuttgart and is mainly interested in working with researchers in the chemical analysis of biofilms. Gerbersdorf hopes that these investigations will help her substantiate the hypothesis that proteins play a major role in the stabilisation of sediment. "Photometric and gas chromatographic investigations have provided insights into the carbohydrate proportion of EPS; the majority of secretions produced by diatoms are carbohydrates. However, these unicellular organisms move across the sediment rather than remaining at a fixed spot, which is why their EPS has a different composition from that of microalgae and bacteria. It does not play a huge role in the stabilisation of sediment," said Gerbersdorf. Detailed analysis of the biofilm will also provide information about the small, but highly important step of adhesion. "The initial contact leads to the formation of reversible bindings, Van-der-Waals forces then lead to the establishment of further bindings, and a bacterial secretion somehow brings bacteria and substrate together to form a biofilm that is subsequently colonised by microalgae," said Gerbersdorf.

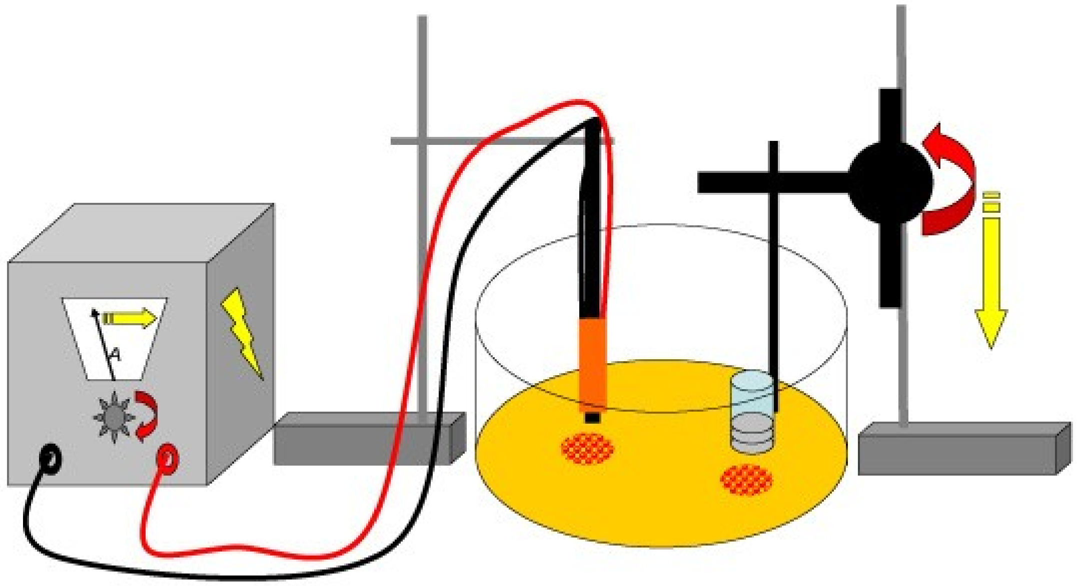


Electron microscope image shows in detail how the bacterial biofilm links glass spheres with each other
© Gerbersdorf / Lubarsky

Biofilm monitoring with MagPI: the development of a device would be a nice secondary outcome of the investigations

Dr. Gerbersdorf has been involved in developing a method for measuring the adhesive power of EPS. "How fast do the sediment particles stick together? We worked on this area during my research period in Scotland where we carried out some experiments with a magnetic field. MagPI, which is an acronym for magnetic particle induction, involves ferromagnetic particles that are placed on the biofilm. An electromagnetic field with increasing field strength is applied to capture the force that is required to remove the particles from the biofilm using a magnet. We hoped to be able to define the adhesive power of biofilm on the basis of information relating to how many particles are ripped off the biofilm," said Gerbersdorf explaining the principle of the test.

Unfortunately, the researchers found it more difficult than originally anticipated to define the adhesive power, which was so strong that particles stopped detaching from the biofilm after an incubation period of only two hours. Instead, the magnet blew. "We are now using a stronger magnet as well as testing the adhesive power immediately after applying the particles," said Gerbersdorf who was surprised to discover that the bacterial biofilms had such strong adhesive powers. In the not-too-distant future, Gerbersdorf hopes to further develop the test with partners from industry or applied research. Her idea is to develop a device that can be used universally, i.e. in the fields of biotechnology, medicine or wastewater technology, to analyse the adhesive power of biofilms. The



Magnetic particle induction, MagPI for short, can be used to analyse the adhesive power of biofilms. Dr. Sabine Ulrike Gerbersdorf is very keen on the idea of developing the principle into a new device. The schematic shows two application variants. In the variant on the right, the distance of the magnet to the surface can be varied, and in the variant on the left, the supply of electricity can be varied.

conditions for this are now in place; the only thing missing is the right partner.

Risk assessment: Do harmful substances remain bound to sediment particles?

The stabilisation of sediment can have another side to it, especially as far as environmental toxins are concerned. In some cases, it might prove positive if harmful substances are embedded into the sediment by way of consolidation and biostabilisation, i.e. if they are fixed and removed from the environmental cycle. In addition to the toxic effects of harmful substances on benthic microorganisms, the sediment is also permanently exposed to physical environmental influences: the stronger flow of water during floods might cause a greater dispersal of sediments, thereby leading to harmful substances being released again, thus making them bioavailable. “In this case, it is extremely important to be able to predict sediment behaviour under certain environmental conditions. And this is what our work focuses on,” said Gerbersdorf.

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