Continuous monitoring of environmental air quality has been mandatory in the EU since 1996. However, state-of-the-art technical measurement systems are expensive and lack mobility. A European consortium led by biologist Prof. Dr. Ralf Reski has developed a new system that uses peat moss in so-called “MOSSpheres” for monitoring air pollution. The project MOSSclone started in April 2012 and funding ended in March 2015.

Continuous monitoring of environmental air quality and measurement of airborne pollutants such as nitrogen oxides and sulphur oxides that could endanger human health has been mandatory in the EU since 1996 and is aimed at enabling appropriate action to be taken when threshold values are exceeded. Since 2008, EU countries have also been required to measure heavy metal concentrations. The EU has only approved certain technical measurement systems for measuring the quality of environmental air. The disadvantage of such systems is that they need electric power and are not mobile. They are also extremely costly and have only been installed at a few sites.

Biomonitoring is an alternative method that uses biological materials such as plants to bind pollutants or that analyses the plants’ response to pollutants. The members of the consortium MOSSclone set out to develop an alternative system for monitoring air pollution. As the name suggests, this involved using moss. Moss is particularly suitable for such a purpose as it has no real roots and, therefore, takes up nutrients and pollutants from the air by way of rain rather than soil. In addition, peat mosses have a particular surface structure that enables them to effectively take up and store water and hence also pollutants.

Professor Reski proudly presents a MOSSphere, developed by the European “MOSSclone” consortium. © BIOPRO/Schüsseele
This knowledge has already been put to good use in measuring air pollution since the 1960s; however, there has always been one major drawback. The moss used is collected in the wild and, therefore, has an unknown pollutant history. In addition, the moss continues to grow while the pollutants are being measured, and therefore moss quantities are constantly changing. In short, it is impossible to obtain reliable measurement results. Over 30 experts at 5 universities and 5 SMEs in 5 EU countries (Spain, Italy, France, Ireland and Germany) joined forces in the MOSScope project funded by the EU’s “Eco-Innovation!” programme to try and improve this error-prone method and turn it into a marketable commodity.

Peat moss from the bioreactor

Reski’s group at the University of Freiburg was in charge of a particularly important task, namely selecting a suitable moss species and cultivating it under laboratory conditions. Reski has many years of experience cultivating the moss Physcomitrella patens in bioreactors and was therefore invited to join the consortium to provide advice on practical issues related to moss cultivation.

The scientists carried out extensive research and tests and eventually selected the peat moss Sphagnum palustre, a species found throughout Europe. Initial practical tests showed that the moss could effectively take up pollutants. The next step was to cultivate and grow it under controlled conditions in bioreactors. The major advantage of the method is that all the plants are grown from one moss clone, so they are all identical. Hence the name MOSSclone. The moss is grown in a controlled environment, which ensures it does not come into contact with bacteria, fungi or pollutants whose concentration will later be measured. Therefore, when the moss is first grown there is zero pollution. This controlled growth of one particular moss also takes into account that many moss species are on the red list and must not be collected.

The researchers have also been able to solve the problem of permanent growth. They have shown that a large proportion of pollutants attaches to the finely branched moss surface. It therefore doesn't matter whether the moss is alive or not when measurements are taken. In practical terms, this means that the moss is heated and inactivated at about 120 °C before being packed into moss bags.

Advantages of moss vis-à-vis technical systems
The system’s first functional tests came up with something quite unexpected, which generated much enthusiasm. When the moss bags were collected and examined in the laboratory for the presence of pollutants, it turned out that, apart from being able to detect nitrogen oxides, sulphur oxides and heavy metals, the moss could be used to determine the quantity of polycyclic aromatic hydrocarbons (PAH), most of which are carcinogenic. This is a major advantage over technical devices. Although technical devices can directly measure gaseous substances with their built-in gas chromatograph, huge bowls would be needed to collect PAHs and heavy metals in order to measure these relatively large molecules. The MOSSpheres can also be used to determine the quantity of mercury. Mercury evaporates at room temperature and remains present in the air. It sinks back to the ground at lower temperatures. Therefore, technical systems only measure fluctuating daily peaks, whereas the mercury particles that stick to the moss provide information about pollution over the entire measurement period.

### MOSSpheres - the final product

After successfully cultivating and testing the moss, the researchers needed to increase production volume, a process known as upscaling. This was done in the large bioreactors owned by the Spanish company Biovia. The Biovia team was trained by Reski’s team and has since stayed in contact with the researchers from Freiburg to exchange information about problems that have arisen as well as opportunities for optimisation. The packaging of the moss was also optimised by further developing the simple “tea bags” into uniform, size-, and geometry-optimised MOSSpheres. The researchers then filed a patent application with the European Patent Office. Reski comments: “It is rare to end a three-year project with all your milestones met, a finished product and a patent application filed.”

After successfully completing the project, the researchers are now working on the publication of a number of scientific papers. In addition, they are trying to convince the EU to change existing guidelines, so that the newly developed biological system can be used alongside technical systems for measuring airborne pollutants. In addition to the aforementioned advantages, the MOSSpheres...
are relatively cheap and can be used almost anywhere, thus resulting in more effective monitoring of environmental air quality.

Everyone in the project team is extremely excited about the results they have achieved and delighted with the excellent cooperation to the extent that they can well imagine developing a similar system to monitor water quality. The consortium for this new challenge is raring to go as soon as funding is found.

Biomonitoring as an alternative for monitoring the quality of air. The photo shows the pilot use of MOSSpheres at a measurement station.
© MOSSclone.eu

---

**Article**

07-Dec-2015
Christian Schüssele
BIOPRO
© BIOPRO Baden-Württemberg GmbH

---

**Further information**

Prof. Dr. Ralf Reski
Department of Plant Biotechnology
University of Freiburg
Schänzlestr. 1
Tel.: +49 (0)761 203-6968
E-mail: ralf.reski(at)biologie.uni-freiburg.de

- MOSSclone
- University of Freiburg, Department of Plant Biotechnology
The article is part of the following dossiers

- Environmental biotechnology

Keywords:
- environment
- analytics
- plant
- biomaterials
- moss
- biosensors
- bioeconomy