DISINFECTION OF WASTE WATER WITH ULTRASOUND

E. DORGELOH[1], A. KAISER[1], Patricia KHAN[1], I. DUTU[2]

[1] Development and Assessment Institute in Waste Water Technology at RWTH Aachen University, Germany
e-mail: info@pia-gmbh.com

[2] The National Research and Developement Institute for Optoelectronics 2000–Branch: The Hydraulics and Pneumatics Research Institute (INOE 2000-IHP), Bucharest

In the rural areas the decentralized water treatment systems represent more efficient and economical solutions than the ones offered by the centralized system. Due to the fact that the droughts in Europe has become more severe the use of purified sewerage water for irrigations can be an optimum solution for agriculture.

The paper pursues to present the ultrasound disinfection of water which generates cavitation. The institute from Aachen studies this method. This method is applied in small water treatment stations, being estimated that in 2015 will be runned about 20 millions of such stations in Europe.

***Key words**: rural areas, sewerage water, treatment method, ultrasounds*

In the countries of central and eastern Europe, the population proportion living in the rural areas is relatively high. Despite the migration from the countryside to the towns, 5-6 million people in Romania still live in rural areas, which make up ca. 50 % of the entire population. In rural areas, the connection to public canalisation is often combined with disproportionately high costs. Here, decentralised systems offer a suitable solution, they are, in the majority of cases, the most economical alternative. Decentralised systems nowadays achieve treatment efficiencies comparable to the specifications of centralised sewage treatment systems.

Considering the increase of longer drought periods in many European regions, the reuse of treated wastewater is indispensable. The disinfection of waste water will gain importance, if economical solutions for the agricultural irrigation in arid regions need to be found.

Nowadays, primarily three techniques for the commercial disinfection of sewage treatment plant discharge are used. These are the chlorination, the membrane filtration and the UV radiation. Because of the technical and environmental-toxicological problems, the chlorination of waste water has fallen into disrepute. The membrane technology, which offers many advantages as a

purely physical procedure, requires a high energy intake to achieve high output. The third tested disinfection method is UV radiation. The guarantee of the process stability of UV equipment can only be realised with a raised monitoring effort, because the intensity of the UV radiation depends greatly on the turbidity and the total solid amount of the water.

Together with the project partner Ultrasonic Systems GmbH (USS), the Development and Assessment Institute in Waste Water Technology at RWTH Aachen University (PIA) is currently researching the domain of ultrasound combined with ozonisation with the goal of developing a technology which will enhance the disinfection of waste water for decentralised waste water treatment and support the conventional purification methods.

MATERIAL AND METHOD

With the use of ultrasound, cavitation can be produced in waste water. This causes a deagglomeration of particle clusters. Bacterium cells are isolated and a damage of the bacteria's cell walls leads to the disinfection of water.

Laboratory examinations have shown that it is possible to disinfect waste water samples simply with low-frequency ultrasound. Because of the strong shear forces induced by the supersonic sounding, the cell walls of the bacteria are destroyed. Since the disinfection rate of this method is low and the energy input is very high, an industrial application does not seem reasonable at the moment. Instead, ultrasound can be used to increase the efficiency of tried disinfection methods. A low ultrasound dose breaks apart agglomerates and sets free pathogenic germs, so that they are exposed to the following disinfection unit. (Blume, 2005).

Figure 1 shows the design of the system developed by USS GmbH, based on the combination ultrasound-ozone. After the mixing with ozone-rich oxygen gas, the waste water is repeatedly exposed to ultrasonic energy. Two factors influence the disinfection. On one hand, the ozone is brought into the waste water very quickly and effectively with a mixer. The OptiMixer, which consists of one rapidly rotating disc onto which the gas is carried, is a development of the USS GmbH. On the other hand, the ozone-waste water mixture is treated with high ultrasonic energy. Here, the disinfection process succeeds within few seconds, which allows high waste water amounts to be treated within a short time.

The system of the USS GmbH is based mainly on the generated pressure of the ultrasonic oscillator. Additionally, the increased production of hydroxyl radicals has a synergetic effect on the ozone equilibrium. This results in a facilitated infiltration of ozone and its products into the cell with a respectively fast disinfection effect and a lower ozone consumption.

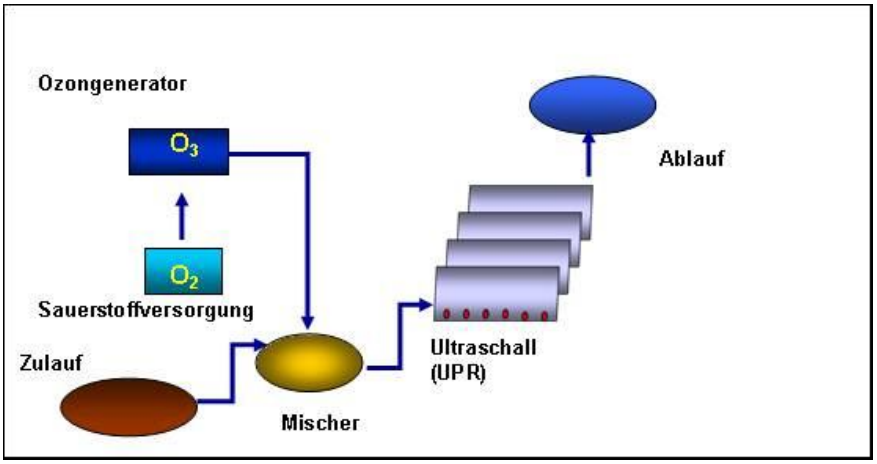

Figure 1 **Design of the Ultrasound-Ozone System for the Disinfection of Waste Water (Dorgeloh, Oliveri (2008)**

On a laboratory-scale, there are many examples for the influence of ultrasound on different flow parameters. It was shown that the BOD of sludge can be influenced by ultrasound to a greater or lesser extent depending on the applied frequency (Riedel, Neis (2006)). Commercially, this method is used for the disintegration of sludge (Eder (2005)).

Figure 2 shows that ultrasound can be used for the reduction of ammonium and COD. In a very short time period, a COD reduction of more than 70% could be reached.

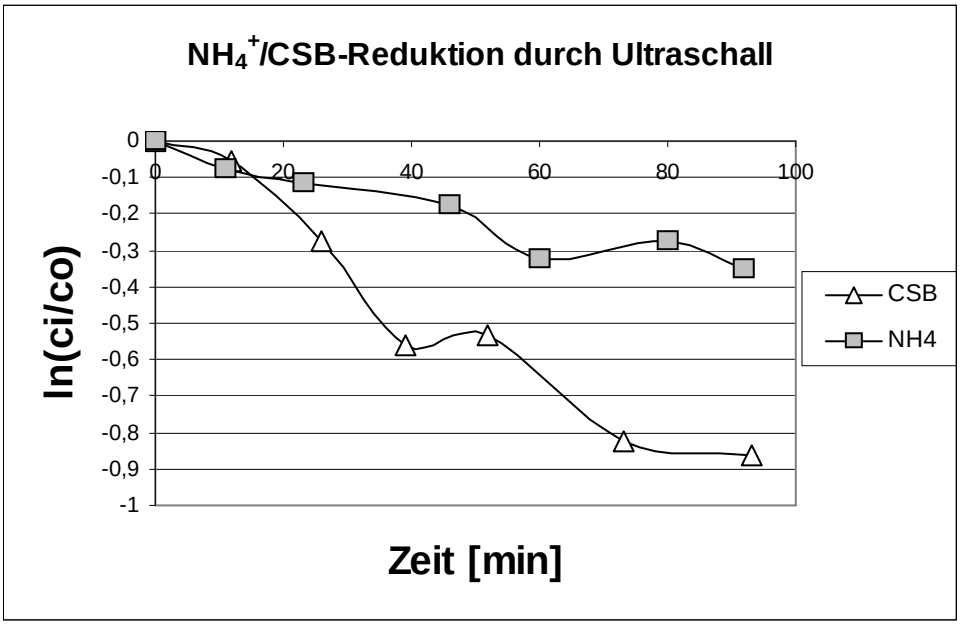

Figure 2 **Effect of Ultrasound on NH_4 and COD (100 W/1000 kHz) (Dorgeloh, Oliveri (2008))**

RESULTS AND DISCUSSIONS

Small waste water treatment systems are sewage treatment plants for the decentralised sector with a population dimension of maximum 50 PT. In Europe, more than 20 million small sewage treatment plants will be in operation by 2015.

Since ultrasound in combination with ozone has already been used on an industrial scale, a new requirement for the effective insertion of ultrasonic energy into the waste water of small sewage treatment plants was developed by the Ultrasonic Systems GmbH in collaboration with the Development and Assessment Institute in Waste Water Technology at RWTH Aachen University. The following figures show the Ultrasonic Plasma Resonator (UPR) developed for this purpose.

Figure 3 **Ultrasonic Plasma Resonator (UPR) by USS (Test Facility), (Dorgeloh, Oliveri (2008)**

The innovative approach of the applied technology lies in the form of the employment of the ultrasound. Contrary to conventional ultrasound systems, no sonotrode is required to guarantee the transfer of the ultrasonic energy into the waste water. The ceramic oscillation body is linked directly with the medium which is to be treated. The construction of the ceramic oscillator as a free swinging oscillator, which can bring energy into the liquid on both sides, causes an increase of the electrical efficiency by a factor of three or four. This makes the UPR system cost-effective. Moreover, the production of the ceramic oscillator is inexpensive.

Figure 5 depicts the test facility for the disinfection of small sewage treatment plant waste water. With this technique, not only the disinfection efficiency but also the cleaning capacity regarding the standard parameters COD, BOD, ammonium, phosphate and suspended solids shall be examined.

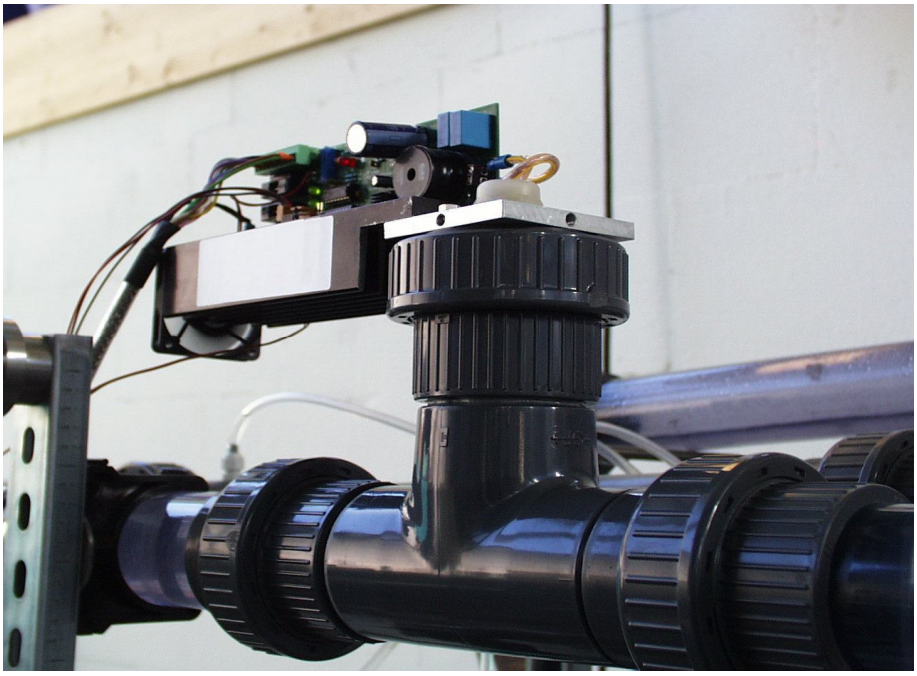

Figure 4 **UPR-Technology for the Application in Small Sewage Treatment Plants (Dorgeloh, Oliveri (2008))**

Figure 5 Test Facility for the Disinfection of Small Sewage Treatment Plant Waste Water (Dorgeloh, Oliveri (2008)

CONCLUSIONS

The Ultrasonic Plasma Resonator (UPR) developed by Ultrasonic Systems GmbH was developed as a method for the disinfection of waste water in the decentralised sector. Because of the low energy consumption compared to hitherto examined ultrasound methods, energy costs can be saved with the UPR. Previous experiences allow the conclusion that this method is also suitable for pre-treated waste water, which is to be used as irrigation water for the agriculture.

BIBLIOGRAPHY

1. Blume, T., 2005 - *Kombinierte Methoden mit Ultraschall zur Desinfektion von Abwasser, Ultraschall in der Umwelttechnik III*, Hrg. Uwe Neis, Hamburg.
2. Dorgeloh, E., Oliveri, C., 2008 - *Desinfektion durch Ultraschall*, GWA 211, Aachen.
3. Eder, B., 2005 - *Großtechnische Erfahrungen mit der Ultraschallbehandlung von Klärschlamm*. Ultraschall in der Umwelttechnik III, Hrg. Uwe Neis, Hamburg.
4. Riedel, C., Neis, U., 2006 - *Modification of Enzymatic Reaction Kinetics by Sonication of Biomass*, 10th Meeting of the European Society of Sonochemistry, Hamburg.