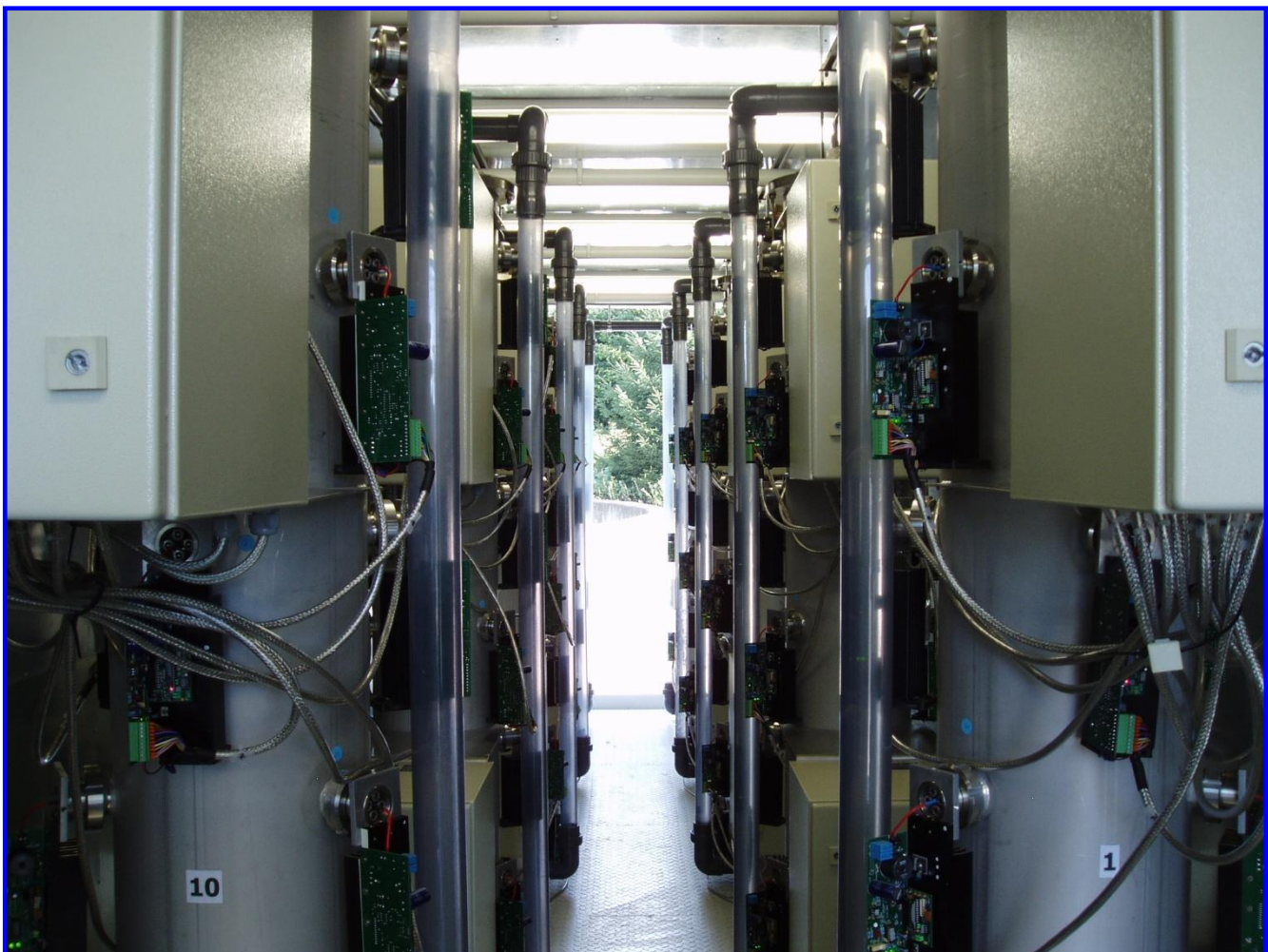
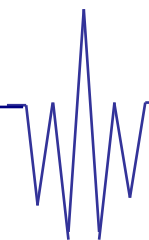


## REMOVAL OF CHEMICALS OF CHEMICALS FROM EFFLUENTS OF WASTEWATER TREATMENT PLANTS BY ULTRASONIC OZONE ACTIVATION ( $U_sO_3$ )

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The elimination of organic trace compounds in effluents of waste water treatment plant was analyzed at a large wastewater treatment plant of the US west coast using a combination of ozone and ultrasound.

Within the scope of the project 13 micropollutants, including male and female hormones, pharmaceuticals and personal care products, were analysed at different effluent flow rates (8 and 10 cubic meter per hour), different ozone concentrations up to 25 mg/L and at different ultrasound power inputs.

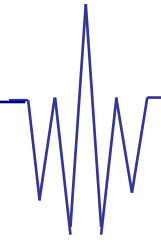
For substance specific evaluations, the measured effluent concentrations and the concentration of the micropollutants after treatment with ozone and ultrasound were compared.

## 1. METHODS

### 1.1. Compounds analysed

Table 1: List of micropollutants analysed and their analytical detection limits

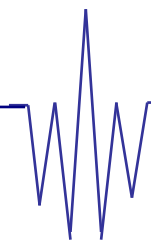
Compound	Detection limit [ng/L]
<i>Acetaminophen</i>	1
<i>Caffeine</i>	1
<i>Carbamazepine</i>	5
<i>Esterone</i>	10
<i>Estradiol</i>	1
<i>EthyinyEstradiol</i>	5
<i>Fluoxetine</i>	1
<i>Iopromide</i>	5
<i>Progesterone</i>	1
<i>Sulfamethoxazole</i>	1
<i>Testosterone</i>	1
<i>Triclosan</i>	5
<i>Trimethoprim</i>	1



### 2. TREATMENT UNIT

Wastewater was passed through the treatment unit at flow rates from 8 and 10 m<sup>3</sup>/h. The treatment unit consists of cylindrical tanks (10 tanks, 30 mm of diameter), equipped with piezo ultrasonic transducer with a power of 100 Watt each. The ultrasonic transducers (600 Hz) were operated in a pulsed mode (5 sec ON / 5 sec OFF). Ozone was injected through two cavitation discs at 3000 rpm situated at the entrance and in the middle of the treatment unit. Ozone was generated *in situ* using ozone generators of Ozonia<sup>R</sup> from oxygen. Ozone concentration, pH, temperature, oxygen, turbidity, redox potential and conductivity were recorded continuously. Sample were taken for laboratory investigation of micropollulants, BOD, suspended solids, total dissolved solids and total COD, before and after treatment. Total coliform, fecal coliform and Enterococcus were analysed for disinfection. Residual ozone in the wastewater was measured immediately after sampling.





### 3. RESULTS

The initial concentration of the micropollutants in the effluent of the wastewater treatment plant was found in the range below 200ng/l. The highest concentration was measured for the antiepilepticum Carbamazepine and for the antibioticum Sulfamethoxazole.

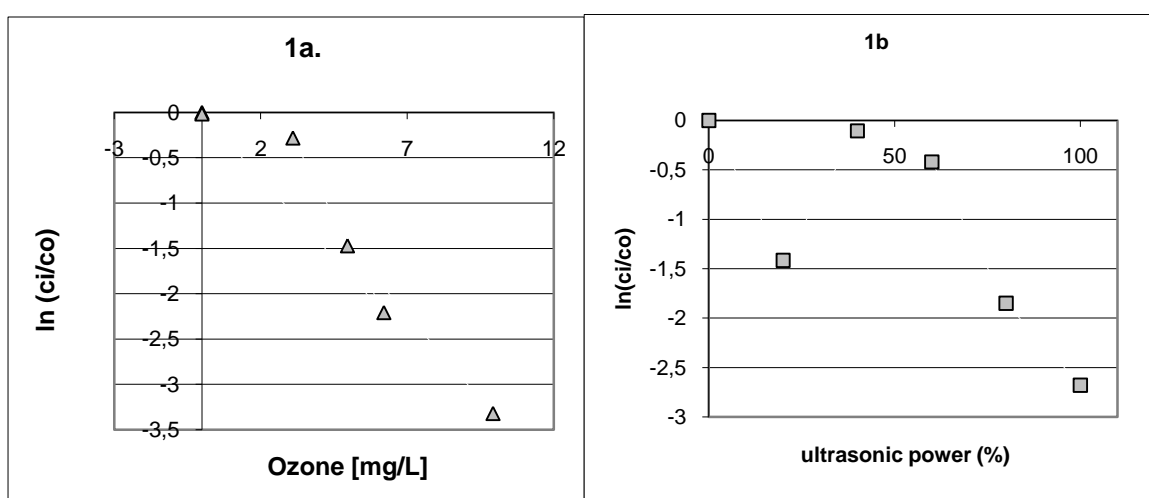


Fig. 1: a. Elimination of caffeine from wastewater at different ozone concentration and constant ultrasonic power of 100% (caffeine effluent concentration: 61 ng/L); b. Elimination of caffeine at different ultrasonic power and constant ozone concentration (caffeine effluent concentration 70 ng/L; ozone concentration 10,56 mg/L)

Acethaminophen, Caffeine, Estradiol, Iopromide and Triclosan (personal care product) were found to be in the average of 50-70 ng/L. The human hormones Esterone, EthynylEstradiol, Progesterone and Testosterone as well as Fluoxetine were found in the low detectable ng/L range. Ozone and ultrasound were demonstrated to act synergistically. As can be seen from Fig. 1a and 1b, the removal of caffeine is dependent from the applied concentration of ozone as well as from the ultrasonic power, separately.

All compounds analysed were affected by the ultrasound/ozone treatment. Fig.2 shows the amounts of pullulants, as listed in Table 1, after treatment of the wastewater effluent with different amounts of ozone.

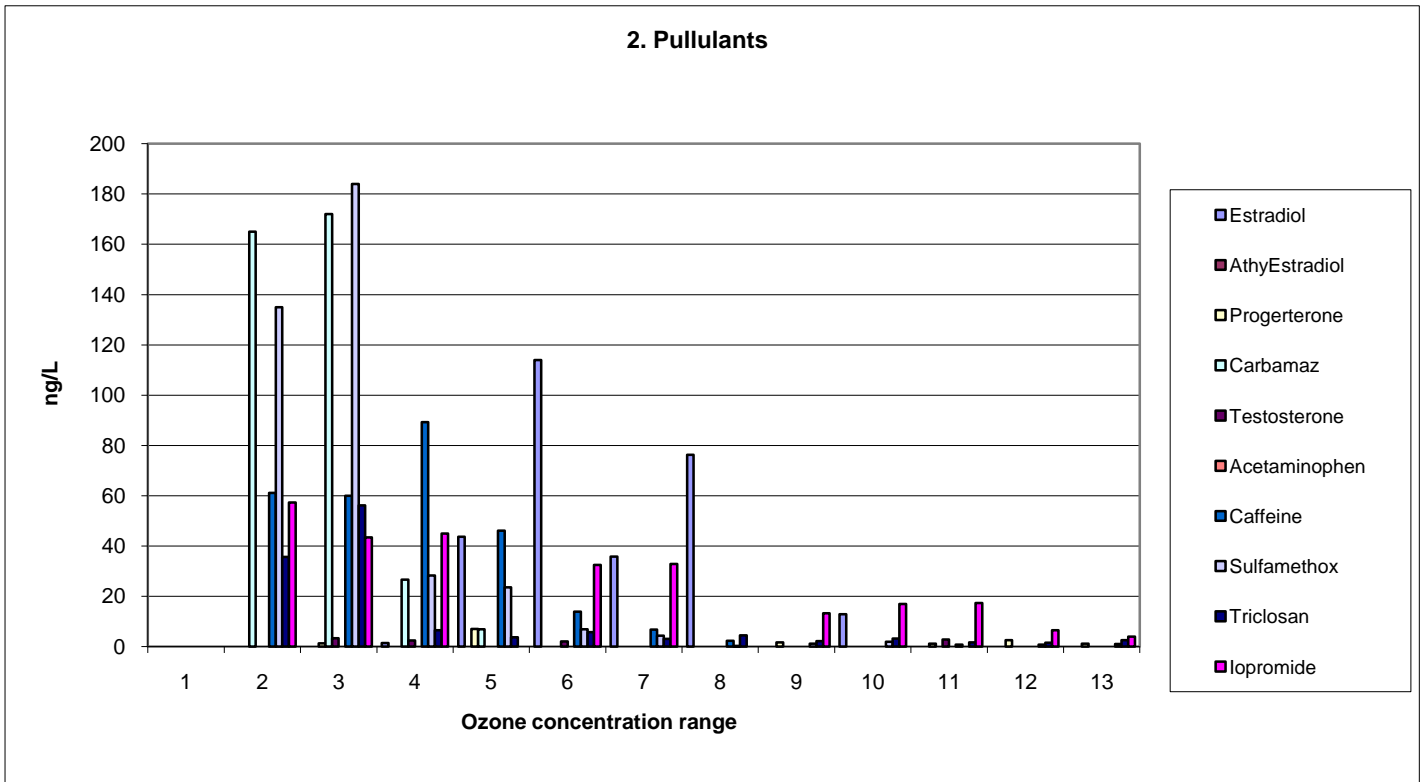
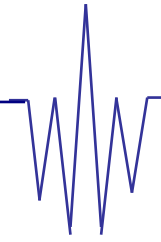


Fig. 2: Elimination of micropollutants from wastewater effluent at different ozone concentration. Ozone range: 2-3: 0 mg/L; 4: 2,48 mg/L; 5: 3,1 mg/L; 6: 4,96 mg/L; 7: 6,2 mg/L; 8: 9,92 mg/L; 9: 12,4 mg/L; 10: 14,88 mg/L; 11: 18,6 mg/L; 12: 19,84 mg/L; 13: 24,8 mg/L.

As can be seen from Fig. 2 the micropollutants are removed exponentially with respect to the ozone concentration applied. The pharmaceuticals Carbamazepine and Sulfamethoxazole were the fastest to be eliminated followed by the human hormones. Iopromide and the personal care product Triclosan are usually not so easy to disintegrate even at highest ozone concentration. The Ozone-Ultrasound treatment, however, shows very good results also for these high halogenated compounds. Fig. 3 shows the exponential character of the removal of all chemicals analysed. In comparison to the over-all removal of chemical trace compounds, in Fig. 4 and 5 is shown the behaviour of the human hormones (mean of all hormones analysed) and of Iopromide.

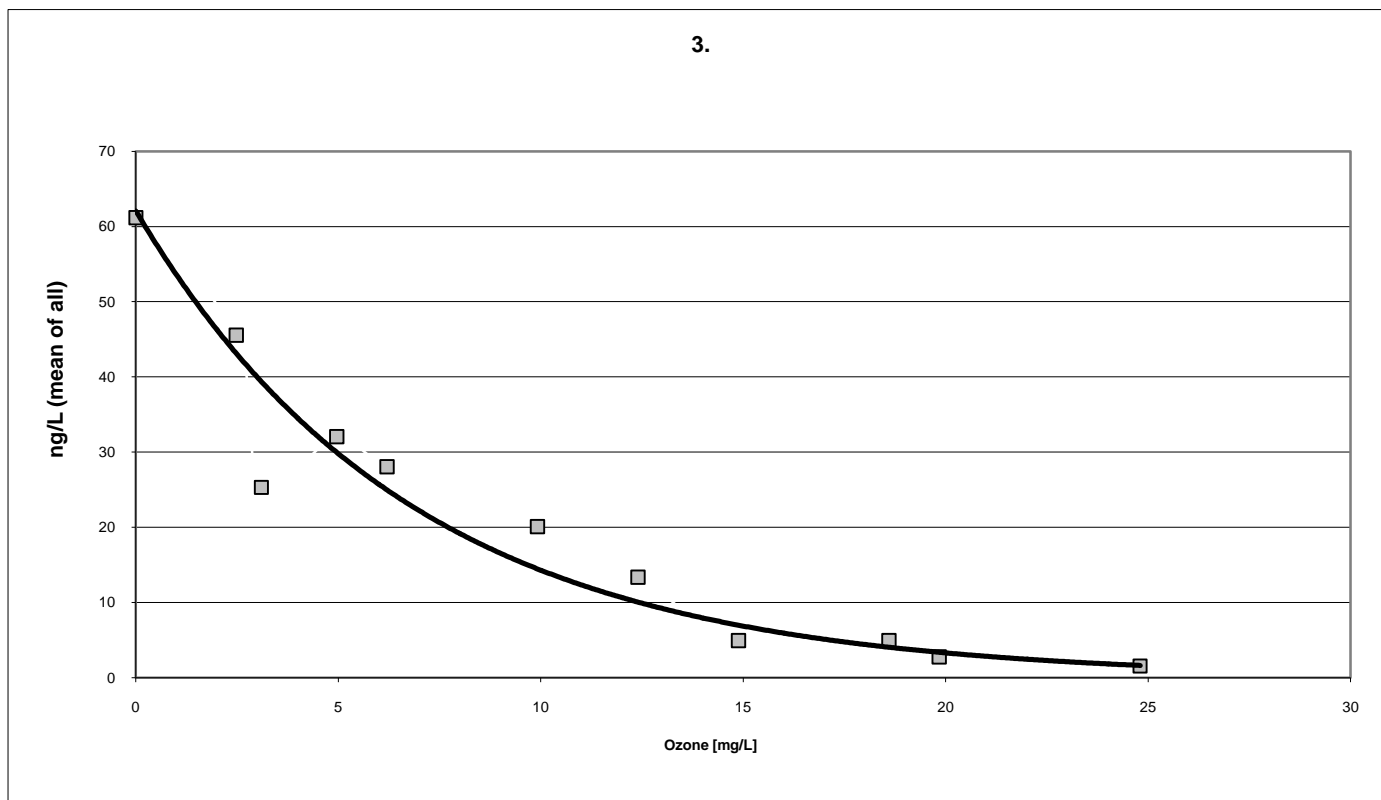
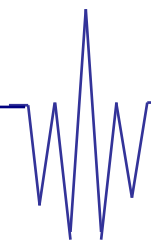


Fig. 3: Exponential elimination of endocrine disruptor substances as a function of the ozone concentration applied.

The constant of elimination of the micropollutants analysed can be seen to be in the range of about 5 mg/L ozone for half decay of the over-all elimination, calculated as a mean of all compounds. As shown from the Fig. 4 and 5 the 50% decay of human hormones (mean of all hormones), in the range of 3,5 mg/L ozone, is much faster than the half decay of the mean of all compounds analysed, whereas the half decay of Iopromide with a value of about 7,5 mg/L is slower than the over-all half decay, as can be seen from Fig 5.

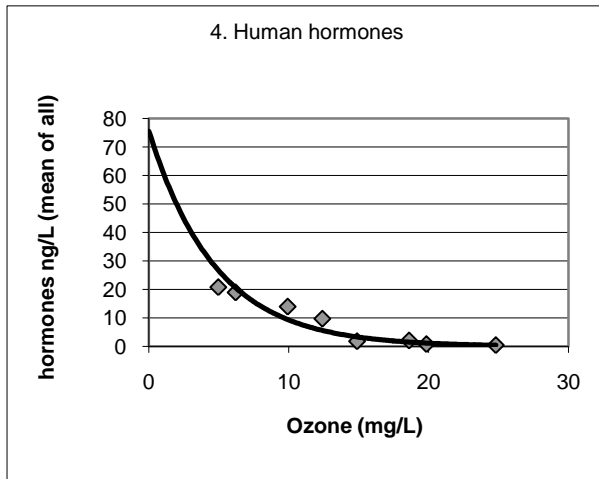
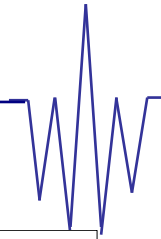


Fig. 4: Elimination of male & female hormones from waste water treatment plant effluents at different ozone concentr.

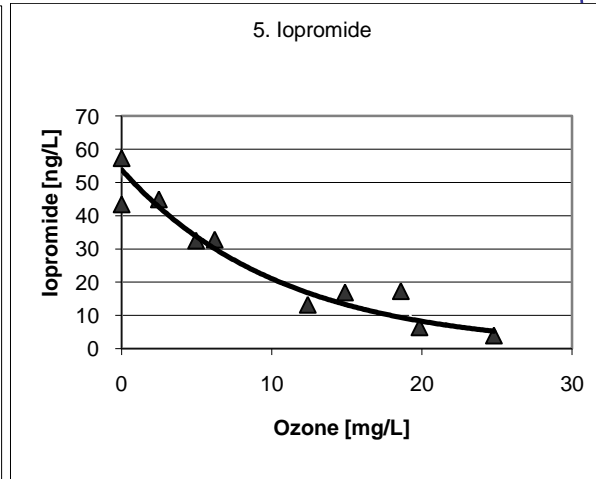


Fig. 5; Elimination of Iopromide after treatment of waste water with ultrasound and ozone.

#### 4. CONCLUSIONS

The micropollutants from wastewater effluents of wastewater treatment plants can easily be removed using a technique which combines ultrasound and ozone. Both, ultrasound and ozone act synergistically. It should be mentioned here that ultrasound, independently of its own degradation power, reduces the contact time of ozone from 5 to 10 minutes to a few seconds. The speed up of the reaction kinetics of ozone through ultrasounds enables a much faster degradation of the micropollutants, and allows the treatment of large amount of wastewater effluents at reasonably low contact times and at relatively low ozone input.

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