Ultrasound-aided processes of water treatment and sludge dewatering

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The paper presents ultrasonic field action for particular environmental engineering applications. The research aimed to intensify coagulation process by use of ultrasounds and also to evaluate influence of ultrasonic field action on the organic compounds. Application of ultrasounds for processes of sewage sludge conditioning results in improvement of dewatering effect. The investigated water sample was sonificated for 5 minutes and efficiency improvement of 20mg/dm^3 of aluminium sulphate dose was achieved: 16.9% and 37.9% for turbidity and colour respectively. During that time the reduction of organic contamination (ca. 40%) was observed as well. The attempt was made to determine the influence of ultrasonic field modification on chemical compounds applied for sewage sludge conditioning, prior to dewatering process. The polyelectrolyte dose of 3 mg/g d.m. sonificated for 2 seconds resulted in 12% decrease in final hydration of investigated sludge.

1. Introduction

Pre-oxidation applied prior to coagulation and methods of intensifying coagulation in water treatment are issues frequently discussed. Employing ultrasonic field energy is one of the approaches. The energy can support chemical reagents used in coagulation of colloidal contaminants in water (Bien, Stepniak, Wolny, 2002). As an agent of physical nature, it facilitates reduction of sludge quantity. Ultrasonic field can act as an oxidant in the removal of organic compounds (Petrier et al., 1998).

Technological sequence of sewage treatment and sludge management requires the application of more efficient equipment and use of more effective chemical reagents. Despite the technological advancement, the quantity and nature of sludges, in particular the possibility of hazardous sludge occurrence, entail great problems associated with the costs of sludges processing and disposal. A new technological solution that will reduce costs as well as improve the efficiency of applied processes is necessary. Ultrasounds have influence on the sedimentation properties of sludges and also intensify fermentation and may improve dehydration as well (Bien, Wolny, 1997), (Neis, Tiehm, 1999).

These effects come from diversity of ultrasonic phenomena, which causes among other things: processes of separation, degradation and direct or indirect radical-type oxidation. The selection of parameters influencing the intensity of ultrasounds such as amplitude or sonication time is a crucial issue.

2. Experimental

The source of ultrasounds was a UD-20 ultrasonic disintegrator of a maximum output power of 180W. Variable ultrasonic field intensity was achieved at variable vibration amplitude (A) or a sonification time (t).

Samples of surface water were subjected to volumetric coagulation by the vessel test method. The coagulation process was performed in two test systems, i.e. with the participation of ultrasounds and a coagulant (US+C) and, for comparison, with a coagulant (C) alone. As coagulant 18-hydrate aluminium sulphate was used. The effectiveness of the systems examined was assessed based on two main water contamination indices – turbidity and colour. On this basis, a percentage increase in the effectiveness of the applied coagulant dose, resulting from the influence of ultrasounds was determined.

Variations in the contents of organic compounds in the water were evaluated from the TOC and DOC indices (a Culomat 702 Li/S apparatus) and oxygen consumption. Each measurement in the raw water and after sonication (t = 2 i 5 min.) was made.

The investigations of ultrasonic field application in sewage sludges were carried out on sludges taken from municipal sewage treatment plant. Sludges characteristics was as follows: pH=6.2; initial hydration of 96.2%; dry matter content (d.m.) of 39g/dm^3; capillary suction time (CST) of 1660.4 seconds. In the preliminary tests were used several polyelectrolytes to sludges conditioning process and only two of them (Zetag 92 and Renfloc 27484 - high cationic) were chosen to the further tests. The proper doses of polyelectrolytes and the optimal time of sound amplification were determined on the base of the capillary suction time. Sonification time was only several seconds. Sludges dewatering process was conducted in the laboratory vacuum filter.

3. Results

3.1 Water treatment process

The performed tests showed a promoting action of the ultrasonic field on the process of coagulation in water, conducted with the use of aluminium sulphate. The result was an additional reduction in both the turbidity and colour of the water compared to the non-sonicated system. The effectiveness of ultrasounds in coagulation of the contaminants of the water tested increased, while as the exposure time was elongated and amplitude was higher. The everage increase of efficiency (ΔE) of applied coagulant dose (20mg/dm^3) was higher for colloids bringing about the colour (37.9%) than for turbidity (16.9%) (Fig.1). In water samples subjected to coagulation with ultrasounds, an earlier formation of flocs took place. At the same time, a decrease in the electrokinetic potential ζ was noted, particularly at higher initial absolute values of this parameter.

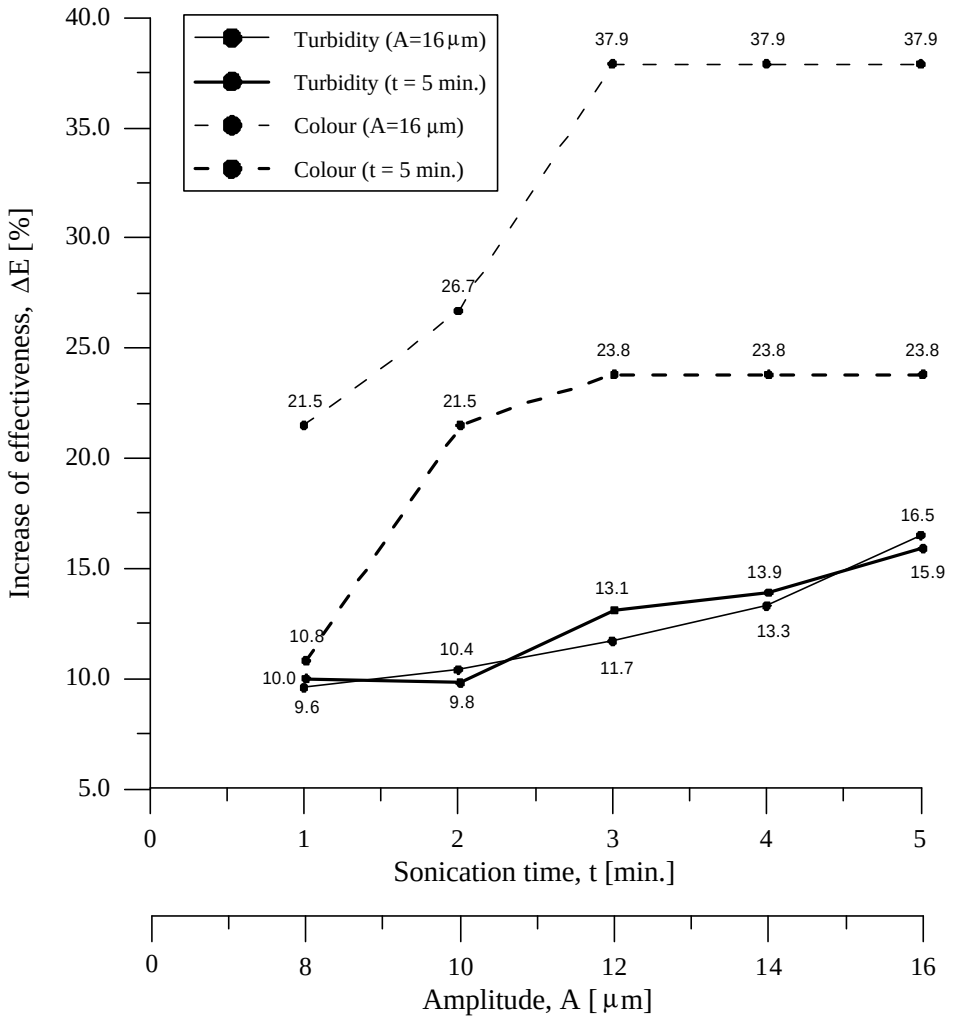

Fig.1. Dependence of the increase of effectiveness in water turbidity and colour reduction on the vibration amplitude and sonication time in the US+C system

Test results also confirm advantageous influence of ultrasonic field on decreasing the contents of organic compounds in treatment water (Tab.1). Only at the maximum parameters (A=16 μm, t = 5 min.) a noticeable reduction (almost 40%) in both indices of organic contamination was obtained. This result is concurrent with a reduction in water oxygen consumption, which, to some extent, indicates oxidation processes occurring under the influence of the ultrasonic field. In order to achieve such advantageous results in this range, applying high intensity of ultrasonic energy is required.

Tab. 1. Changes in the TOC and DOC indices in the water under the effect of the ultrasonic field

A [μm]	TOC [mgC/dm^3]			DOC [mgC/dm^3]			Oxygen consumption [mg/dm^3]	
	Raw water	US		Raw water	US		Raw water	US
		t=2min.	t=5min.		t=2min.	t=5min.		t=5min.
8	75.76	75.16	75.49	74.38	73.18	68.96		6.8
10	105.44	105.11	104.96	102.75	102.26	89.78		6.8
12	148.00	147.88	134.38	136.82	132.91	127.93	7.0	6.7
14	153.02	152.75	151.34	151.02	150.49	149.88		6.7
16	106.64	100.56	65.51	103.73	96.15	63.26		6.6

3.2 Sludges dewatering process

The influence of polyelectrolyte dose on changes of tested sludges CST and final hydration is presented in Fig.2. At Zetag 92 dose of 0.5mg/g d.m. the CST was already reduced above 50% in comparison with unconditioned sludges, whereas the lowest CST of 20.1 seconds was obtained at the dose of 4.0mg/g d.m. For sludges prepared with the optimal dose of Zetag 92 (3mg/g d.m.) after sonification within 2 seconds it was noticed the better effect of sludges dewatering (Fig.3). A drop in final hydration value occurred. It should be noted, however, that this positive effect was not always reflected in the remaining parameters of the filtration process. The obtained values of the parameters of sludges dewatering prepared with a dose of sonicated polyelectrolyte reduced by half in relation to the optimal dose are comparable with the results obtained for the latter. The changes in the indices and parameters of sludges in the dewatering process, prepared with sonicated polyelectrolytes can be associated with the intermolecular regrouping of these chemical compounds under the influence of ultrasounds (Wolny, et al., 2001).

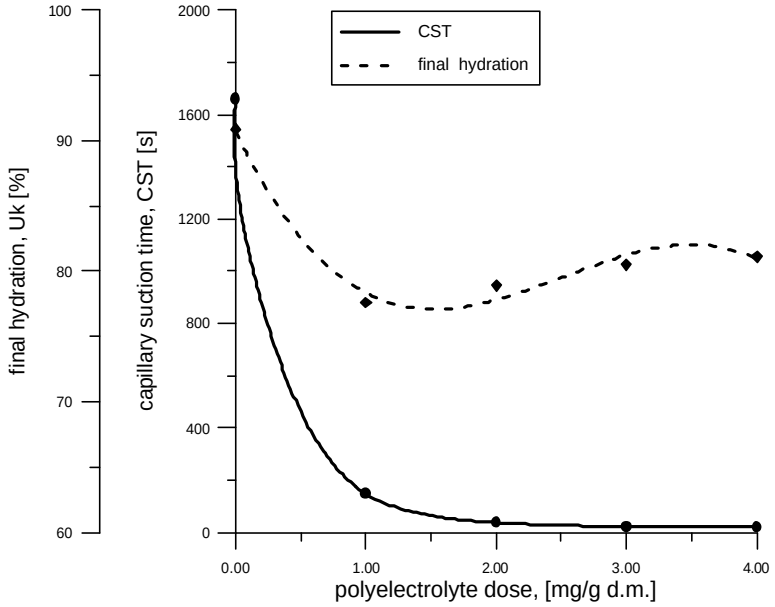

Fig.2. The influence of polyelectrolyte Zetag 92 dose on sludges dewatering parameters

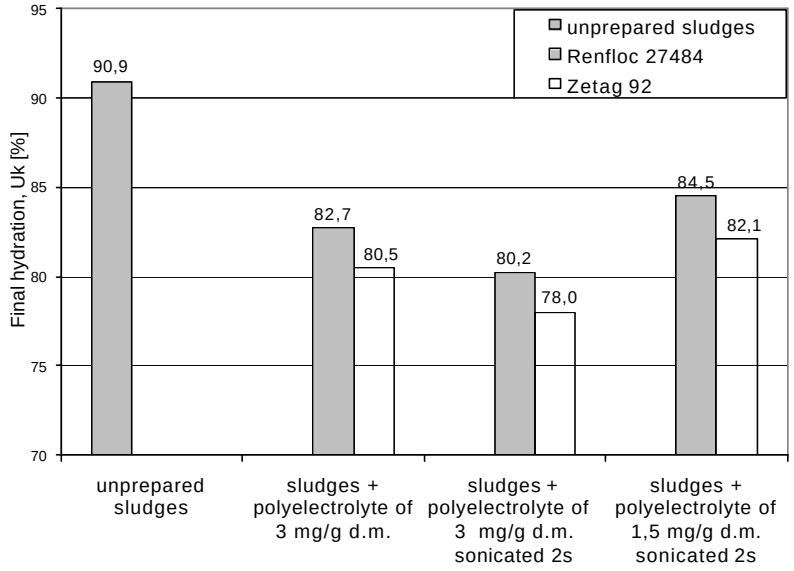

Fig.3. Changes of sludges final hydration conditioned with polyelctrolytes before and after sonification

4. Conclusions

In the tests the beneficial influence of ultrasonic field energy on the investigated processes was confirmed. This effect depends on ultrasonic field parameters such as intensity and agents characterizing sonicated medium (for example contaminant removal from water and sludge types or chemical compounds used for dewatering).

For sewage sludges the advantageous influence of energy input to polyelectrolyte by ultrasonic field on the ability of sludges conditioned in this way to mechanical dewatering was confirmed.

The obtained results allowed for decreasing application of chemical reagents (coagulants, polyelectrolytes) therefore the limitation of their consumption as well as reduction of water sludges formed after coagulation and wastewater sludges was observed.

5. References

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