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THE USE OF PERSULFATE FOR CHEMICAL DISINTEGRATION OF WASTE ACTIVATED SLUDGE

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The new concept described in this paper is based on the process of waste activated sludge (WAS) chemical disintegration by a thermally activated sodium peroxodisulfate (PDS, $Na_2S_2O_8$). PDS salt dissociate in the liquid phase to persulfate anion - strong and stable oxidant: $Na_2S_2O_8 \rightarrow 2Na^+ + S_2O_8^{2-}$.
Persulfate anion is one of the strongest oxidants used in remediation. The standard oxidation – reduction potential for the reaction $S_2O_8^{2-} + 2H^+ + 2e^- \rightarrow 2HSO_4^-$ is 2.01 V it is higher than hydrogen peroxide - 1.8 V but lower than that of ozone at 2.2 V. In addition to direct oxidation, sodium persulfate can be induced to form sulfate radicals and hydroxyl radicals, thereby providing free radical reaction mechanisms similar to the hydroxyl radical pathways generated by Fenton's chemistry: $S_2O_8^{2-} + initiator \rightarrow SO_4^{\bullet-} + (SO_4^{\bullet-}$ or $SO_4^{2-})$
The sulfate radical is one of the strongest aqueous oxidizing species with a redox potential estimated to be 2.6 V, similar to that of the hydroxyl radical, 2.7 V.

Our study was conducted for chemical disintegration of WAS by persulphate in doses 0.2, 0.4, 0.6, 0.8 and 1% activated by temperature in the range 50-90^{o}C over 30 minutes. The efficiency of this method was evaluated in term: of release of organic matter to supernatant - expressed as soluble chemical oxygen demand (COD) - and better dewaterability of WAS - expressed as changes of sludge volume index (SVI).

Samples of activated sludge were taken from a Liberec Waste Water Treatment Plant, the biggest WWTP in both the Liberecký and the Ústecký regions. With the intention of phosphorous and nitrogen compounds removal, anaerobic, anoxic and aerobic sectors have been distinguished. The plant was designed for a flow of 103 880 m^3/d. At present, the amount of treated wastewater is about 54 800 m^3/d.
All chemical analyses were performed for samples before and after each phase of disintegration. Soluble chemical oxygen demand (SCOD) and sludge volume index (SVI) were determined following the standard methods for examination of water and wastewater procedures 5220D an 2710D, respectively. For colorimetric determinations, a spectrophotometer XION 500 DrLange was applied.

RESULTS AND DISCUSSION

Persulfate oxidation activated by increased temperature (50–90°C) was demonstrated to be efficient in enhancing the dewaterability of sludge (Photo 1, Figure 1-2).

In order to assess the impact of the chosen method of disintegration on WAS the COD value was measured (Figure 3).

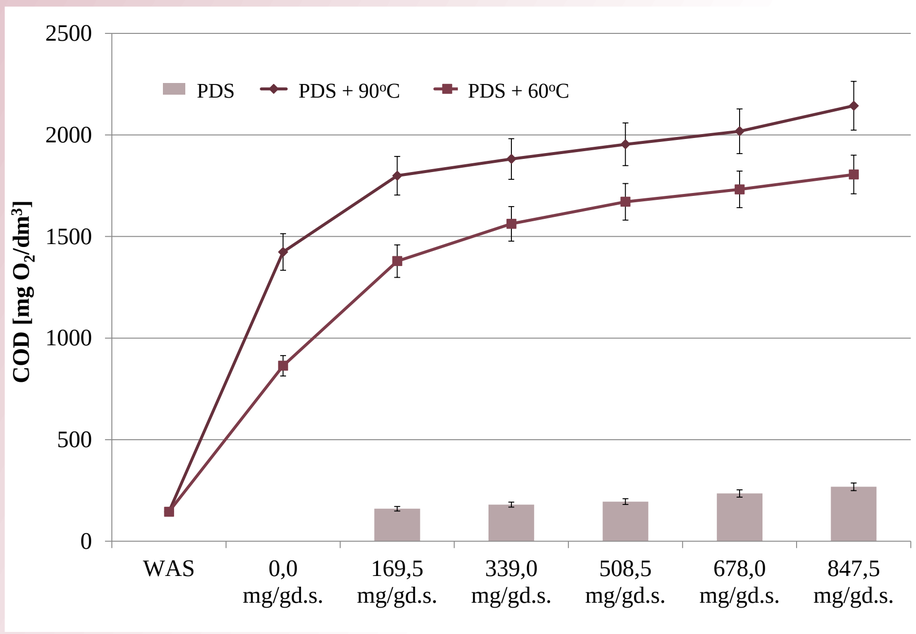

Figure 3. Impact of PDS dose and thermally activated PDS on COD release.

SEM observations confirmed the disintegration/rupture of sludge flocs at the colloidal scale, inducing the release of EPS-bound water, also, interstitial water trapped between the flocs were released, which enhanced the dewaterability. In addition, they are evidence of reduction of particle size of WAS.

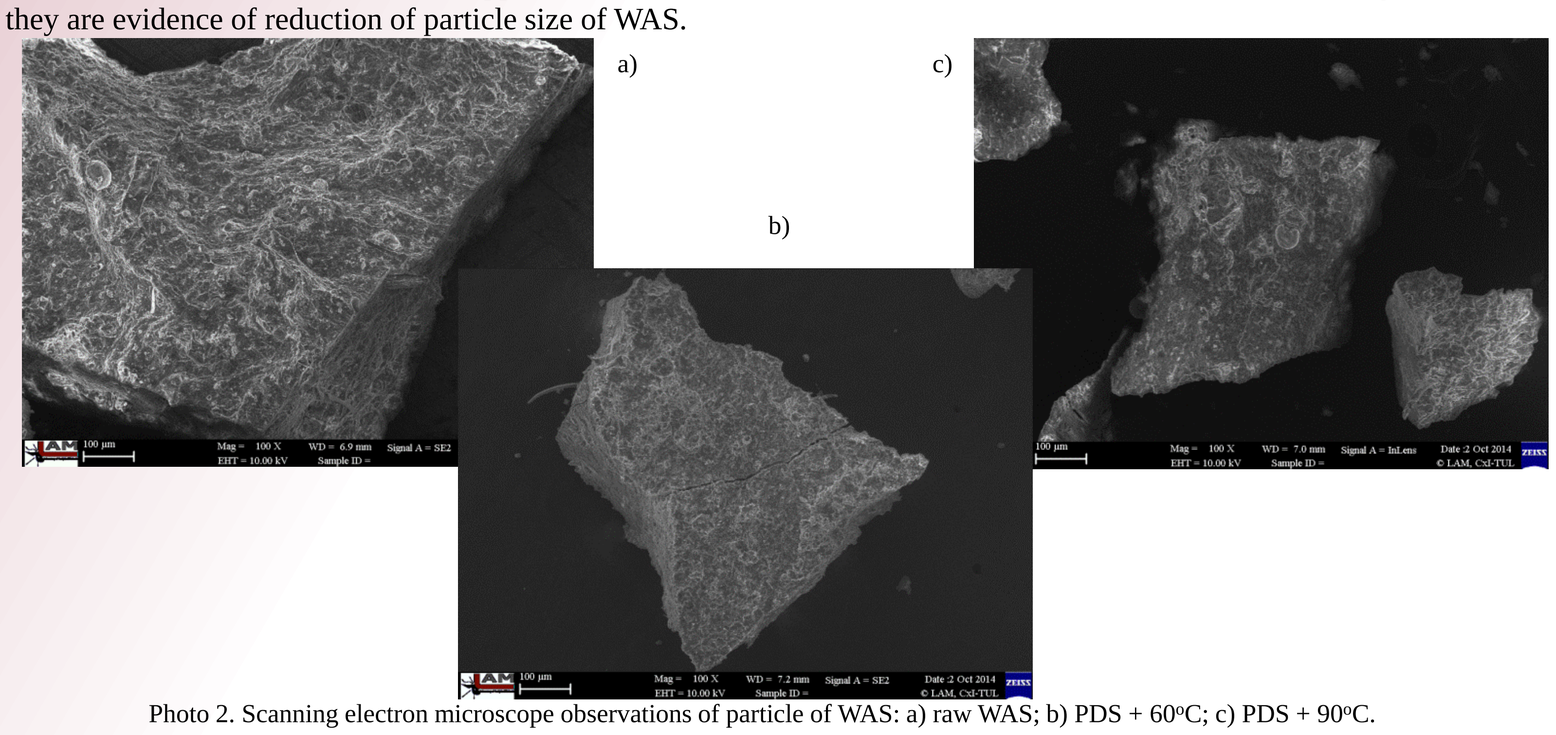

Photo 2. Scanning electron microscope observations of particle of WAS: a) raw WAS; b) PDS + 60^{o}C; c) PDS + 90^{o}C.

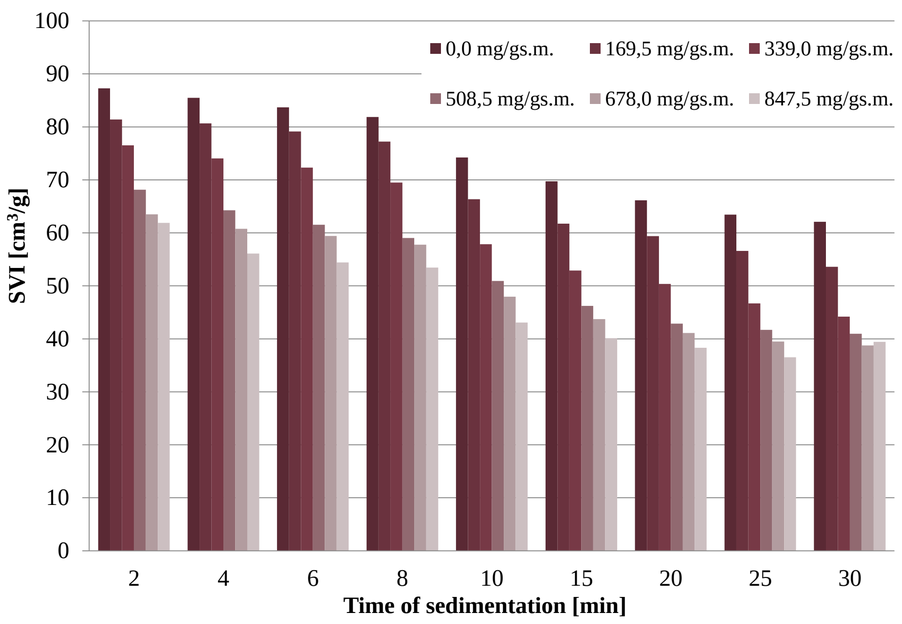

Figure 1. Impact of PDS dose and 60^{o}C on SVI.

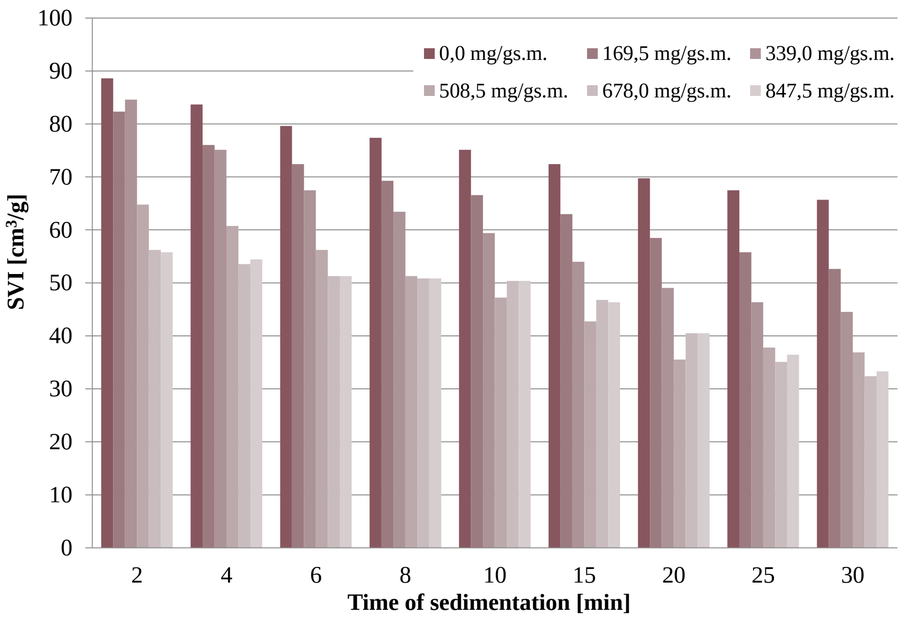

Figure 2. Impact of PDS dose and 90^{o}C on SVI.

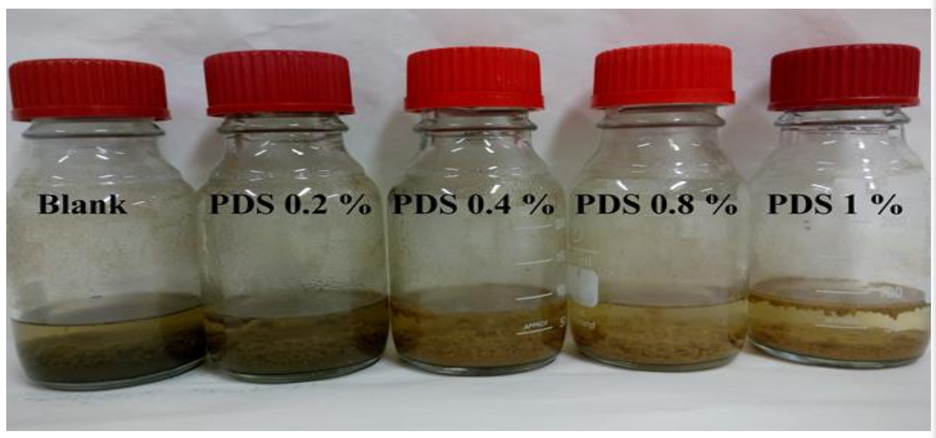

Photo 1. Photography of the reactors with PDS activated by heat - 90^{o}C.

CONLUSIONS

The experiments have clearly demonstrated that chemical disintegration of WAS by PDS is a suitable method to disintegration of WAS and achieved better dewaterability. The most important conclusions are:

- The chemical disintegration of WAS by persulfate destroys the flocs structure of sludge and ruptures the cells of the microorganisms. As a result of sludge disintegration, organic matter was transferred from the sludge solids into the liquid phase (expressed as COD). COD increased from 145 mg/dm^3 to 268 mg/dm^3 in direct proportion with dose of persulfate.
- Thermally activated PDS caused a several times higher organic matter release. COD increased to 1800 mg/dm^3 and 2100 mg/dm^3 after thermal activation in 60^{o}C and 90^{o}C, respectively.
- Disintegration of WAS by thermally activated PDS caused decreased of particle size of WAS.

Acknowledgments
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