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IMPACT OF TEMPERATURE ON VISCOSITY OF SEWAGE SLUDGE AFTER CONDITIONING

WPŁYW TEMPERATURY NA LEPKOŚĆ KONDYCJONOWANYCH OSADÓW ŚCIEKOWYCH

Abstract: The technology of wastewater treatment is always associated with utilization of sewage sludge. The process of sewage sludge utilization aims at transforming (biologically, physically or chemically) sewage sludge into a state which does not pose any threats for human health and natural environment. Conditioning – a process which has an impact on the structure and properties of sewage sludge – allows for more efficient removal of water from sewage sludge. Also, temperature is a crucial parameter in the final stage of utilization and transportation of sewage sludge.

The paper presents the results of the investigations on viscosity of chemically conditioned sewage sludge exposed to selected temperatures and variable sheer velocity gradients. Municipal sewage sludge and sludge from cellulose industry were used as substrates. The impact of temperature on viscosity of fermented sewage sludge and also the impact of a polyelectrolyte dose and a velocity gradient on sewage sludge viscosity were investigated. Viscosity of sewages sludge was determined in the temperature range of 20 to 36 ^oC for every 2 ^oC at variable sheer velocity gradients (60, 100, 200 r/min). The HAAKE Viscotester 7L/R plus and the Termostat DC 10 bathtube were used in the investigations.

Keywords: sewage sludge, conditioning, viscosity, temperature

The sewage treatment technology is closely associated with the disposal of sewage sludge. This process involves the transformation of sewage sludge (by biological, physical or chemical methods), which is intended to bring the sludge to a state that does not pose any hazards to the life or health of population or to the natural environment [1].

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Until recently, the sewage sludge treatment process went unnoticed. Unfortunately, the sewage sludge management in sewage treatment plants continues to be a topical and not completely resolved problem. Failures in this field bring about serious consequences and may be a source of risk to the natural environment of man. The construction of new sewage treatment plants and the intensification of treatment processes is accompanied also by the increase in the amount of sewage sludge which accounts for 1–2 % of the total volume of sewage flowing to the sewage treatment plant. Of the treatment plant's overall costs, the costs of the construction and operation of sewage sludge treatment equipment can account for as much as 50 %. By treating sewage sludge as a raw material of some fertilizer or energy value, at least a partial return on the incurred outlays could be obtained [2, 3].

The neutralization of sewage sludge in treatment plants involves the removal of water that it contains, whereby a reduction of the sewage sludge volume is achieved. The process whereby this effect is achieved is conditioning, that is one of the processes which have the effect of changing the structure and properties of sewage sludge, enabling a more efficient removal of water contained in the sewage sludge. Change in the form of sewage sludge is the change of its structure, which also influences its viscosity [4, 5]. For the majority of sewage sludges, physical and chemical conditioning processes are used, which can run either under natural conditions or with the use of mechanical devices. The selection of the sewage sludge conditioning method is most often influenced by the possibility of subsequent use and utilization of the sewage sludge, as the conditioning process determines the final products formed [6, 7]. One of the conditioning methods is by changing the temperature. The temperature is one of the important parameters in the final stage of neutralizing and transporting sewage sludge (rheological parameters) [8, 9].

The purpose of the studies undertaken was to determine the viscosity of chemically conditioned sewage sludges subjected to the action of temperature and variable magnitudes of the shearing velocity gradient.

Experimental

The substrate of the tests was the sludge from municipal wastewater treatment plant after aerobic stabilization process. Its sewage treatment capacity was 1000 m^3/d. The characteristic of sludge was as follow: dry matter 18.38 g/dm^3, initial hydration 97.3 %, *capillary suction time* (CST) was 154 s, resistivity $21.4 \cdot 10^{12}$ m/kg and viscosity was equal 132 mPa · s. Sludge was conditioned with low and high cationic polyelectrolytes. The capillary suction time was used to determine polyelectrolyte dose. Viscosity of sludge was measured in the range of temperatures from 20 to 36 ^oC with the step of 2 ^oC (20, 22, 24, 26, 28, 30, 32, 34, 36), for the variable shear velocity gradient (60, 100 and 200 rpm) and for different polyelectrolytes doses. The viscosity was measured with HAAKE Viscotester 7L/R plus – rotational viscosimeter designed to perform the fast determination of viscosity in accordance with the ISO 2555 standards (Fig. 1). To maintain the required temperature thermostat DC10 was used.

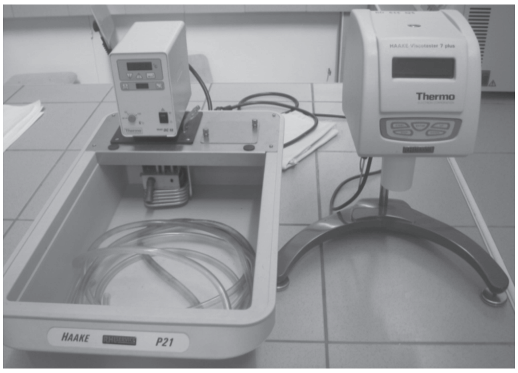

Fig. 1. Viscosity measurement set

Analysis of investigation results

The effect of temperature on the change in the viscosity of sewage sludges examined

By analyzing the curves of the viscosity of sewage sludges conditioned with polyelectrolytes versus temperature it was found that the sewage sludge viscosity decreased with increasing temperature. Already at a slight temperature increase by 2 ^{o}C, a drop in viscosity was noted. Variations in viscosity with increasing sewage sludge temperature at different shearing velocities (60, 100, 200 rpm) are illustrated in Figures 2 to 4. Similar relationships can be observed for sewage sludges conditioned with a weak-cationic polyelectrolyte (Praestol 650BC).

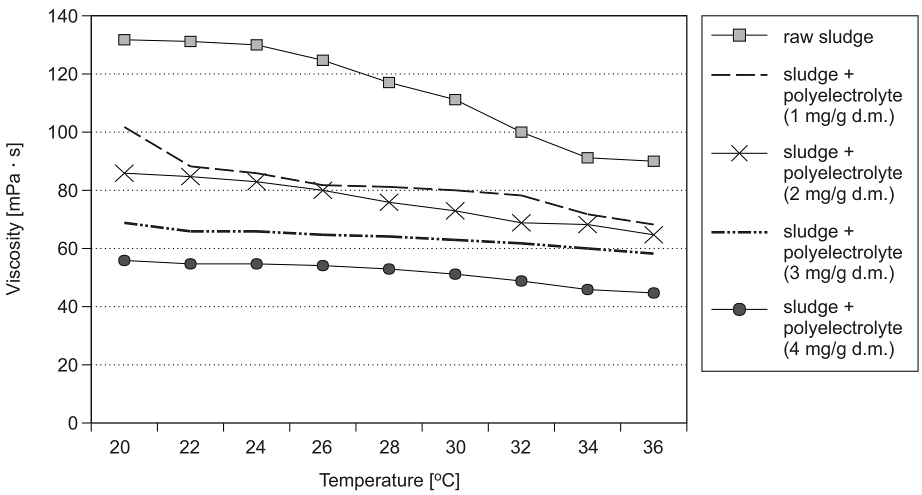

Fig. 2. Influence of temperature on the viscosity of the sludge conditioned with different doses of polyelectrolyte Praestol 658BC-S (rotational speed 60 rpm)

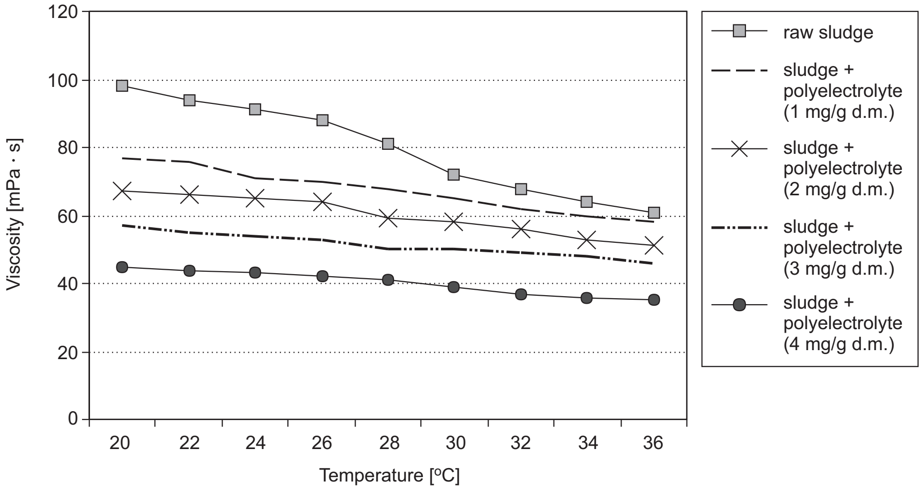

Fig. 3. Influence of temperature on the viscosity of the sludge conditioned with different doses of polyelectrolyte Praestol 658BC-S (rotational speed 100 rpm)

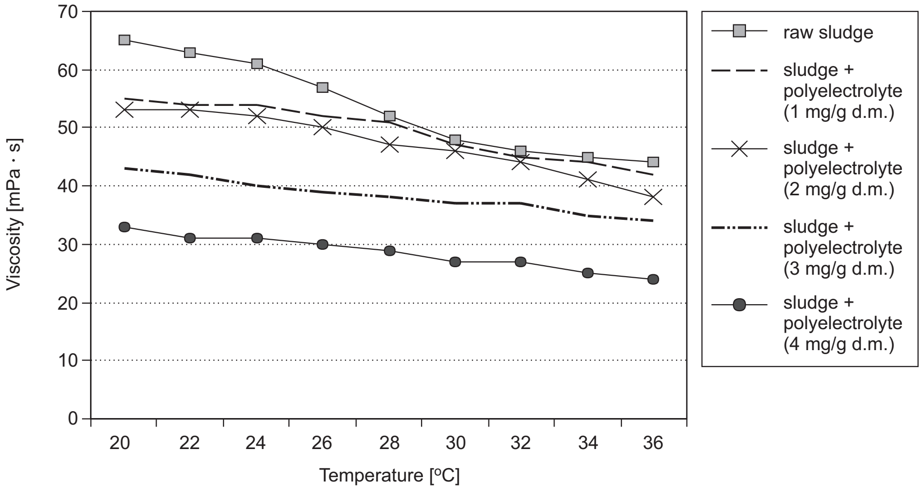

Fig. 4. Influence of temperature on the viscosity of the sludge conditioned with different doses of polyelectrolyte Praestol 658BC-S (rotational speed 200 rpm)

The effect of the dose of polyelectrolyte on the change in the viscosity of sewage sludges examined

From the analysis of the graphs showing the effect of the polyelectrolyte dose on sewage sludge viscosity it was found that the increase in the polyelectrolyte dose caused a decrease in sewage sludge viscosity (Figs. 5–7). With increasing polyelectrolyte dose, the sewage sludge viscosity decreased, reaching minimum values at the highest doses applied.

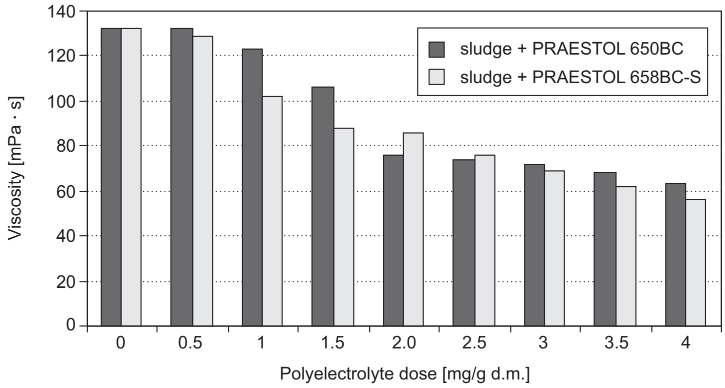

Fig. 5. Influence of polyelectrolytes dose on the viscosity of tested sludge (rotational speed 60 rpm; temperature 20 ^{o}C)

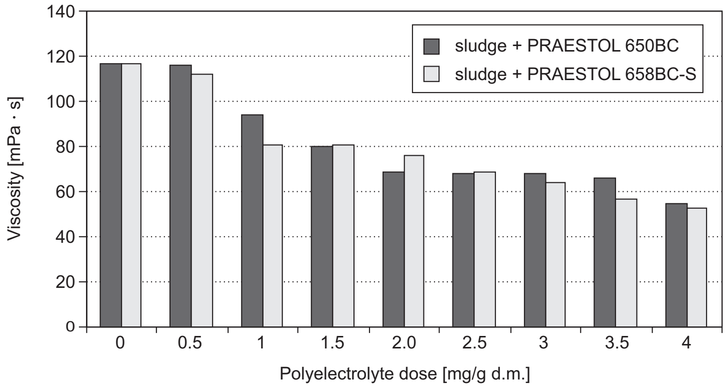

Fig. 6. Influence of polyelectrolytes dose on the viscosity of tested sludge (rotational speed 60 rpm; temperature 28 ^{o}C)

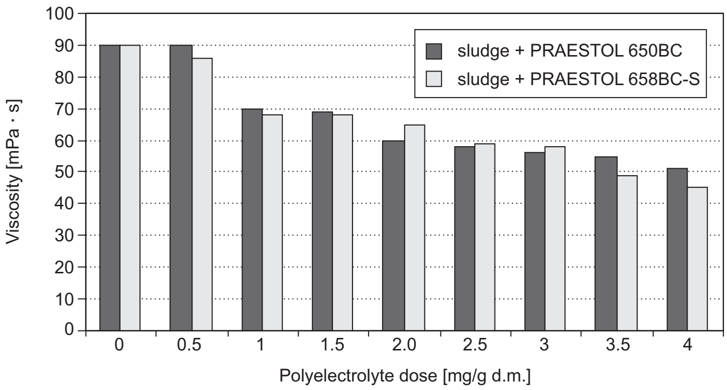

Fig. 7. Influence of polyelectrolytes dose on the viscosity of tested sludge (rotational speed 60 rpm; temperature 36 ^{o}C)

The effect of the velocity gradient on the change in the viscosity of sewage sludges examined

By analyzing the effect of the gradient of velocity on the change in the viscosity of sewage sludge it was found that the increase in shearing velocity was accompanied by a decrease in viscosity (Fig. 8). The viscosity curves show a drop in viscosity against the increase in shearing velocity. The decrease in viscosity with the increase in shearing velocity was noted for the entire of temperature examined (20–36 ^{o}C).

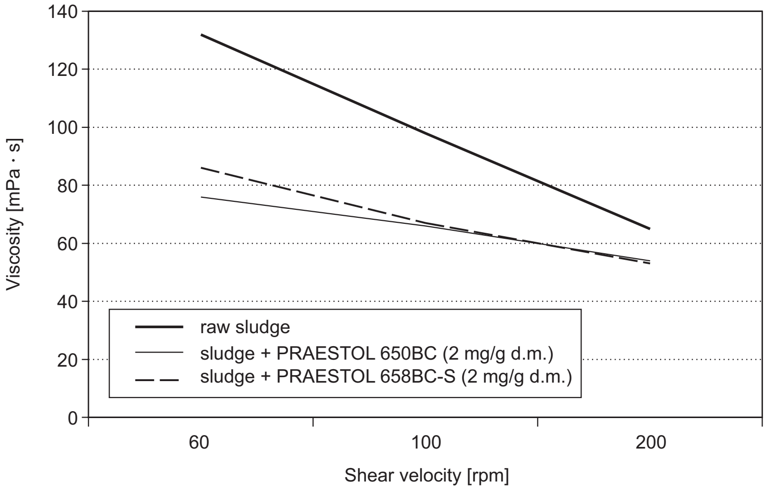

Fig. 8. Influence of shear velocity gradient on the viscosity of tested sludge in the temperature 20 ^{o}C

Conclusions

From the investigation carried out it was found that the viscosity of sewage sludge decreased with increasing temperature. Already at a slight temperature increase by 2 ^{o}C, a drop in the viscosity of sludges examined was noted.

By analyzing the effect of polyelectrolyte doses on the sewage sludge viscosity it was determined that the increase in the polyelectrolyte dose results in a decrease in sewage sludge viscosity. With the increase in the dose of polyelectrolytes used, the viscosity decreased, reaching minimum values at the highest doses applied. In most cases, introducing doses of a strong-cationic polyelectrolyte, Praestol 658BC-S, caused greater viscosity decreases compared with the weak-cationic polyelectrolyte Praestol 650BC with the identical doses. The viscosity of sludge treated with the strong-cationic polyelectrolyte Praestol 658BC-S at a temperature of 20 ^{o}C and a rotational speed of 100 rpm was 98 mPa · s, while with the highest doses of this polyelectrolyte and under the identical temperature and rotational speed conditions it was 45 mPa · s.

The investigation carried out indicates that the increase in shear velocity is accompanied by a decrease in the viscosity of sewage sludges examined. This applies to untreated sludge, as well as to sludge conditioned with different doses of polyelectrolyte. The values on the viscosity curves decrease from the first examined velocity of 60 rpm, then consecutively increased to 100 rpm and 200 rpm, against the increase in shear velocity.

Acknowledgements

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WPŁYW TEMPERATURY NA LEPKOŚĆ KONDYCJONOWANYCH OSADÓW ŚCIEKOWYCH

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Abstrakt: Oczyszczanie ścieków jest ściśle związane z problemem unieszkodliwiania osadów ściekowych. Proces unieszkodliwiania jest przekształceniem, które ma doprowadzić osady do stanu, który nie stwarza zagrożeń dla życia lub zdrowia ludności oraz dla środowiska. Kondycjonowanie, czyli jeden z procesów mający wpływ na zmianę struktury i właściwości osadów, pozwala na bardziej skuteczne usuwanie zawartej w osadach wody. Również temperatura jest ważnym parametrem w końcowym etapie unieszkodliwiania i transportu osadów ściekowych. W artykule przedstawiono wyniki badań dotyczące wyznaczenia lepkości kondycjonowanych chemicznie osadów ściekowych, poddanych działaniu temperatury oraz zmiennym wartościom gradientu prędkości ścinania. Przeprowadzono badania komunalnych osadów ściekowych oraz osadów z przemysłu celulozowego. Ocenie poddano zarówno wpływ temperatury na lepkość przefermentowanych osadów ściekowych, jak i wpływ dawki polielektrolitów oraz gradientu prędkości na lepkość badanych osadów ściekowych. Lepkość osadów została wyznaczona w zakresie temperatur od 20 do 36 ^{o}C, co 2 ^{o}C, przy zmiennym gradiencie prędkości ścinania (60, 100, 200 obr/min). W badaniach wykorzystano wiskozymetr HAAKE Viscotester 7L/R plus oraz wannę Termostat DC10.

Słowa kluczowe: osady ściekowe, kondycjonowanie, lepkość, temperatura