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ULTRASONIC STABILIZATION OF THE ACTIVATED SLUDGE SAMPLES FOR PARTICLE SIZE DISTRIBUTION PSD MEASUREMENTS USING LASER DIFFRACTION METHOD

ULTRADŹWIĘKOWA STABILIZACJA OSADU CZYNNEGO W POMIARACH ROZKŁADU WIELKOŚCI CZĄSTEK PRZY WYKORZYSTANIU METODY DYFRAKCJI LASEROWEJ

Abstract: Laser diffraction method is one of recently applied method for measurement of active sludge particles size distribution. This method requires mixing of the suspension and then pumping it through the measurement unit. Energy of mixing and process of pumping may destroy flocks of the active sludge and change its properties during the measurement. Thus, stabilization of the active sludge flocks before measurement is required. The purpose of this paper was to determine the possibility of flocks sample stabilization for measurements with application of laser diffraction method. This stabilization should allow comparison of various sludge flocks' diameters, obtained in different conditions. Resuming our results, we may state that according to practical application, usage of stabilization based on ultrasounds was sufficient. However, in order to obtain the replicable results for various types of the active sludge it is necessary to precise describe the ultrasound energy provided to flocks before the measurement.

Keywords: laser diffraction method, activated sludge particles diameter, stabilisation of the activated sludge by sonication

Physical parameters of an active sludge, in particular its flocks diameter have significant effect on the proper operation of bioreactor chambers and secondary sedimentation tanks of wastewater treatment plants. Parameters connected with size of activated sludge flocks are also resulting from the species composition of active sludge organisms and may inform about possible malfunction of biological part [1-3]. Measurement of the dimensions of an active sludge flocks may be conducted in many ways [4-6]. Microscopic methods were used as one of the first [4, 7, 8]. However, time-consuming application of microscopic analyses resulted in search for the other methods, allowing quick and precise measurements. One of the methods recently gaining popularity in flocks dimensions measurements is laser diffraction [6, 9-13].

Description of particle size distribution by the laser diffraction method is based on measurement of light intensity dispersed on particles located in measuring unit - the smaller particle, the larger angle of dispersion is. Though, the particle size distribution obtained in this method is a volumetric distribution (informing about the share of given granulometric faction in the total volume of the sample), various then mass distribution (portion of a given faction mass in the mass of a whole sample) obtained by methods based on sedimentation process [14]. Assuming that the spherical shape of all particles (for both sedimentation and laser diffraction methods) and identical densities the volumetric particle distribution agrees

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with mass distribution. Recently used laser diffractometers have relatively wide measurement range - from fractions of micrometers to several millimeters. According to this wide range, in particular measurements of the larger particles, the dynamic flow of measured suspension through the measuring unit is required.

Lack of mixing and pumping of suspension through measurement installation would result in sedimentation and leaving the measurement range by the following fractions. In order to laser diffractometer construction (various models of different producers) the structure/composition of mixing units may vary. Volume and shape of reservoir, construction of stirrer, integration (or its lack) of stirrer and pump result in delivering various amount of energy to the mixing suspension. On the other hand, high intensity of mixing may result in incidence of bubbles of air in fluid body, which may be treated by measuring unit as measured particles agglomeration [15].

The dynamic mixing and pumping may also effect the properties of measured particles. This situation occurs during studies over particle size distribution of the active sludge. Any type of mixing causes destruction of spatial structure of the sludge. Thus, it becomes that dynamic of mixing will affect on rate and range of structures decomposition.

The aim of this paper was to determine the possibility of samples stabilization applicable to laser diffraction method to avoid changes of samples properties during the measurements. This stabilization could simultaneously allow comparison of diameters of various sediments, obtained in different process conditions or sampled in different points/units of biological part of wastewater treatment plant.

Materials and methods

Method

The measurements were performed using laser diffractometer Mastersizer 2000, Malvern, UK, with Hydro MU dispersion unit. The measuring range for material analysed in liquid dispersion was 0.02÷2000 µm. The Mie theory was applied for recalculations of light intensity measured on detectors into PSD of the activated sludge. According to the Mie theory the identification of optical parameters is necessary. The value of light refraction index for the continuous phase was set as for water (1.33). The values for dispersed phase were assumed as follows: index of refraction for light - 1.53, and absorption coefficient - 0.1. The assumed optical parameters can be must be treated as average when the measured mixture is heterogeneous [15].

Materials

Activated sludge sampled at a municipal *waste water treatment plant* (WWTP) with a capacity of approx. 80 000 m^3/day and employing C, N and P treatments served as the test material in the presented study. The sludge was sampled from the aeration chambers using 1.5 dm^3 containers.

Sample preparation

Samples of the activated sludge were prepared using sonication. Exposure duration of sonication covered the time of 4 minutes and the power of the applied ultrasound probe was 35 W (maximum power of ultrasound probe built in the device).

Measuring procedure

The measurement in Hydro MU unit was carried in 1000 cm^3 beaker which was filled in about ¾ of the maximum volume. The speed of stirrer and pump (the stirrer and pump are integrated in Hydro MU dispersion unit) was 1200 rpm.

Each measurement of particle size distribution was conducted as a series of 20 replications. A single measurement was adopted as 30,000 counts registered on the detectors during 30 seconds for red as well as for blue light. Hence, the duration of a single measurement was equal to one minute. The measurement replications were realized in a sequence, so the measurement time for one full studied series was equal to 20 minutes.

Mean values were not calculated for the results obtained for the 20 replications because it was assumed that intensive stirring and pumping might disintegrate the studied flocks. The change of the median in the subsequent measurements (from the 1^{st} to the 20^{th}) was the measure of the disintegration of the flocs made by the stirrer and pump.

The volume of sludge used for the measurements was determined by *obscurance* - a parameter measured by the device during the dosing process. With respect to measurement reliability, the number of particles for which the *obscurance* parameter value covers the range of 10 to 20% is optimal [16]. Concentration of the studied suspension, obtained directly from the wastewater treatment plant, was too high, so the suspension was added to filtered water to obtain the recommended standard of the *obscurance* parameter. When because of overdosage of suspension to the measuring system obscuration was too high the procedure of dilution was used [17].

Results and discussion

The change of the median in the subsequent measurements (from the 1^{st} to the 20^{th}) is presented in Figure 1.

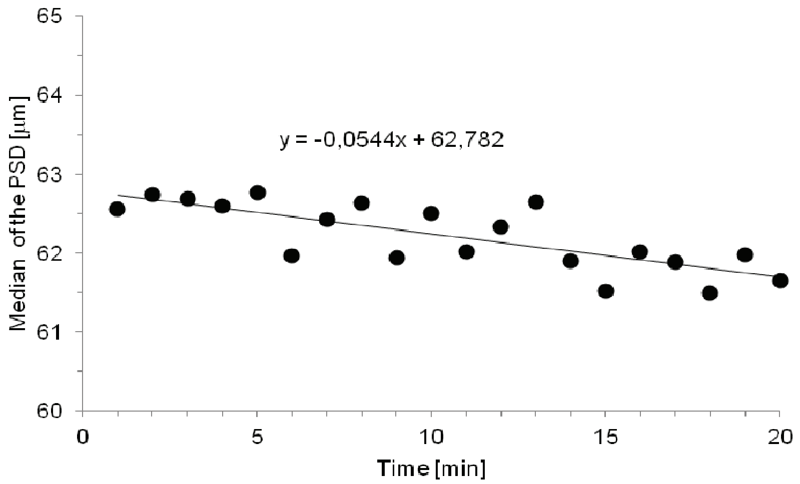

Fig. 1. The change of the median in the subsequent measurements (from the 1^{st} to the 20^{th}). Each single measurement lasted one minute

The distinct decrease of the values of flock diameter medians from 62.55 μm to 61.65 μm can be observed in Figure 1. It means that 4 minutes of ultrasounds before the measurement is not enough to definitively stabilize size of the flocks and the stirring and pumping has are still able to break them. However the changes of the median are small - less than 1.5% during 20 subsequent measurements. Additional argument for the small decrease of the flocks size is the small value of slope (–0.05). It seems that for the practical purposes this change can be neglected the more so the first few median values were nearly the same and there was not the decrease. This is consistent to the other our researches [18].

Summary and conclusions

1. The ultrasound can by the good way for preparation of the activated sludge for PSD measurements.
2. The energy of ultrasounds should be established very precisely if one wants to compare the results oft he PSD for different sludge samples.

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Abstrakt: Jedną z metod ostatnio wykorzystywanych do pomiaru rozkładu wielkości cząstek osadu czynnego jest metoda dyfrakcji laserowej. W metodzie tej konieczne jest mieszanie mierzonej zawiesiny w celu homogenizacji próbki, a następnie przepompowywanie jej przez układ pomiarowy. Energia mieszania i pompowanie mogą rozbijać kłaczki osadu czynnego, przez co zmieniać jego właściwości w czasie pomiaru. Dlatego też niezbędna jest stabilizacja cząstek osadu czynnego przed realizacją pomiaru. Celem niniejszej pracy było określenie możliwości stabilizacji próbki kłaczków osadu czynnego w pomiarach z wykorzystaniem dyfrakcji laserowej. Stabilizacja taka miałaby umożliwić porównywanie ze sobą wielkości (średnic) różnych osadów, uzyskiwanych w różnych warunkach. Podsumowując wyniki, należy stwierdzić, że do celów praktycznych wystarczająca jest stabilizacja przy wykorzystaniu ultradźwięków. Jednakże, aby umożliwić porównywalność wyników uzyskiwanych dla różnych osadów, niezbędne jest dokładne określenie energii ultradźwięków, którymi kłaczki są stablizowane przed pomiarem.

Słowa kluczowe: metoda dyfrakcji laserowej, średnica cząstek osadu czynnego, stabilizacja osadu ultradźwiękami