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M. A. Sazanovets, PhD student (BSTU);
A. V. Ignatenko, PhD (Biology), assistant professor (BSTU).

METHOD OF ANALYSIS OF PARTICLE SEDIMENTATION RATE IN AQUEOUS MEDIA

This article deals with the analysis of particle sedimentation velocity in water media with application of video information and pictures management. Kinetics of particles sedimentation in model suspensions and in wastewater were studied by gravimetric method and also by method of video recording of sedimentation with digital photo camera and pictures processing in computer program *Adobe Photoshop CS3*. In the result of research it was found that analyses of histograms of brightness make it possible to determine particles sedimentation velocity in water media with less time and labor expenditures than in gravimetric method.

Introduction. Determination of parameters of the particle granulometric composition is an important task in various fields of science and industry [1, 2]. Sedimentation analysis of suspended particles is widely used to characterize the level of sewage pollution and assess the effectiveness of cleaning them [3].

Wastewater is a complex heterogeneous system consisting of aqueous solutions, colloidal mixtures, suspended solids, various forms of living organisms: viruses, bacteria, yeasts, filamentous fungi, micro-algae, protozoa, and their associates [3, 4].

The dispersed particles of wastewater are separated into groups according to the size:

– molecular dispersions with particle size less than 10^{-7} cm. They include homogeneous molecular and ionic solutions of organic and inorganic substances. Their content in the urban wastewater treatment facilities is 10–50 mg / l;

– colloidal systems with a particle size of 10^{-7}–10^{-5} cm as solutions of substances have kinetic stability and are not stratified in the water. Their content in the wastewater can reach hundreds of milligrams per liter;

– suspensions, emulsions (particles larger than 10^{-5}cm) (oil products: mazut, mineral oil, solvents, etc.) which are present in wastewater at a concentration of 50–300 mg / l;

– coarse dispersions with a particle size of more than 10^{-3} cm (fibers, sand, clay, etc.) may be in the waste waters at concentrations from 200–400 to 1000–3000 mg / l;

– microorganisms and parasites: their sizes are from 10^{-6} to 10^{-1} cm and by disperse characteristics they are referred to biological colloids and suspensions.

Total microbial count of microorganisms in wastewater is estimated in the range $10^6 – 10^8$ CFU/cm^3.

Pollution o wastewater with parasites is determined by the number of viable lamblia cysts and helminth per unit volume of water and changes in the interval 10^0–10^2 particles /dm^3 [4].

According to L. A. Kulski's classification [5], weighted components of waste water are divided into settling and not settling ones. Knowing the velocity sedimentation of suspended particles it is possible to determine their disperse and sorption properties, reactivity.

Since large particles oxidized slowly by microorganisms, it is better to eliminate them at the early stage of water purification.

Sedimentation is the easiest way to discharge from the wastewater particulate pollutants, which settle on the bottom of the settler under the influence of gravitation or float on its surface in for two-hour.

To examine the particulate composition of the wastewater gravimetric and optical methods of analysis are widely used [2].

The disadvantage of gravimetric method applies is its high complexity. Particle light scattering method is less labor intensive than the gravimetric method, but it requires special equipment and doesn't allow analyzing too turbid media.

Main part. This work aims at the development of not labor-intensive rapid method of the sedimentation rate analysis of particles in aqueous media using video and digital image processing.

Aqueous suspensions of bentonite and soil with concentration C = 1 – 10 g / l, and also wastewater with suspended solid concentration 0.1 – 0.5 g / l determined by weighing the dry residue were the objects of research.

Kinetics of particle sedimentation was studied by gravimetric method based on measuring the mass of sediment deposited on the scale in liquid [2], as well as by video recording of deposition process of particles in aqueous suspensions using a digital camera Canon Power Shot A3300 IS with further image processing by a computer program Adobe Photoshop CS3.

Digital image is a matrix of pixels having different brightness depending on the radiation fell on them.

Each pixel is a photosensitive element having specific dimensions depending on the method of

matrix preparation and has a minimum pixel value 10 × 10 μm [6–8].

This paper deals with the method of digital photography to analyze particle sedimentation velocity of wastewater and water model systems.

Black and white (achromatic) digital image is characterized by a number of parameters: lightness, brightness, etc. [7].

Lightness is determined by the proportion of white light in the image.

Image brightness of non-reflection objects from the physical point of view is characterized by the intensity of the reflected or scattered light fell on the photocell matrix camera from the object being analyzed.

Digital image histogram characterizes the dependence of the number of pixels on their level of brightness. It is determined by the values of a total number of pixels in the image, the average brightness, the percentage of the number of pixels of the selected brightness, etc.

Fig. 1 shows a digital image of the soil samples in aqueous suspension, depending on its settling time.

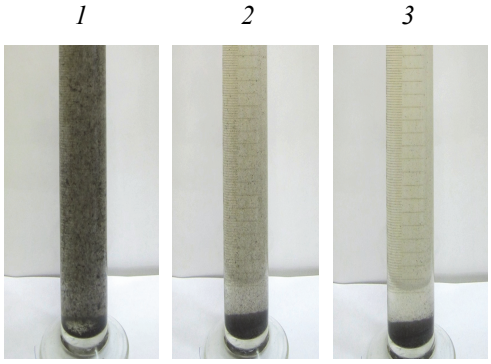

Fig. 1. Photos of the sedimentation of soil suspension particles in cylinder (C = 4 g / l): *1* – 0.5 min, *2* – 2 min.; 3 – 5 min.

As it can be seen, lightening of the suspension is observed when particles deposit.

The fundamental quantity to characterize images in sedimentation analysis can be pixel brightness, which reflects the change in the lightness image during the sedimentation of suspended particles.

Histograms of image brightness changes in soil suspension from the time of settling particles are shown in fig. 2.

As one can see from it, initially the pixels with brightness of black predominated in the image.

Then, during the sedimentation of suspended particles the proportion of pixels decreased and the maximum of the histogram shifted toward white.

As it can be seen, the brightness of light pixels in the image increases in the course of time.

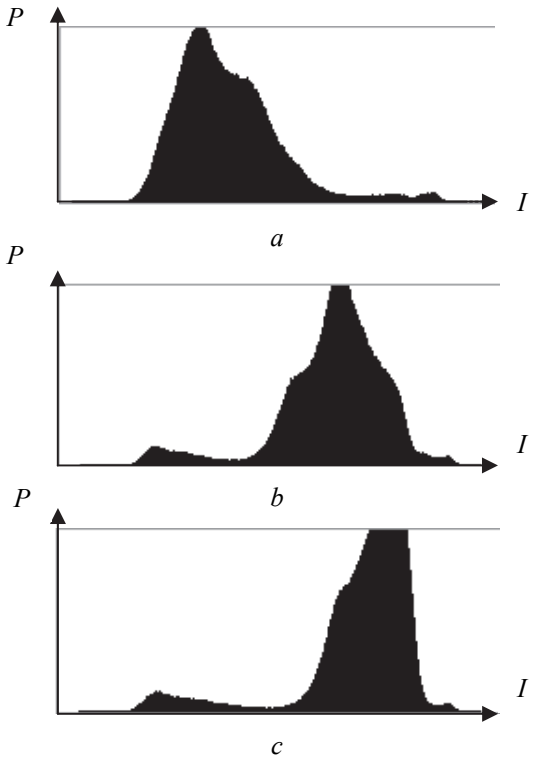

Fig. 2. Image brightness histogram of soil suspension from the sedimentation time: *a* – 0 ; *b* – 2 min ; *c* – 5 min; *P* – number of pixels of a certain level of brightness; *I* – brightness level

Fig. 3 shows changing kinetics of the image brightness in the deposition of soil suspension particles.

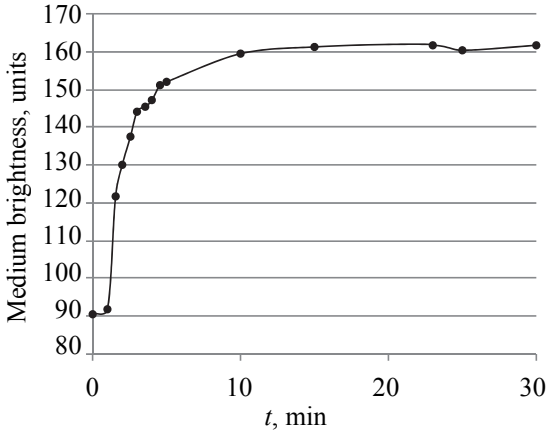

Fig. 3. Dependence of the brightness of soil suspension images (C = 0.4%) on settling time of the particles

This is due to the fact that the soil particles are black and readily absorb the emission of all colors. As a result, dark colors predominate in the histogram of the image at the initial time. The content of light colors increases with the deposition of suspended particles in the image.

The table shows the results of analysis of deposition rate of particles in an aqueous medium, de-

fined by the gravimetric method and according to changes in the brightness of digital images.

Table

Characteristic of particle sedimentation rate by gravimetric method and by analyzing the image brightness

Subject	Particle sedimentation rate, min^{-1}		Correlation coefficient
	gravimetric method	change in the bright-ness of digital images	
1. Soil suspension			
υ_1	0.180	0.709	0.966
υ_2	0.092	0.412	
υ_3	0.046	0.310	
υ_4	0.016	0.018	
2. Wastewater			
υ_1	0.044	0.022	0.955
υ_2	0.038	0.014	
υ_3	0.018	0.006	

The rate of change of image brightness was determined from the slope of the curves obtained for various fractions with different particle sedimentation rates.

As it can be seen from the table, there is a strong direct correlation between the indications of the gravimetric method and data analysis of image brightness, indicating the reliability of the results and the possibility of their use for the analysis of the sedimentation properties of suspended wastewater solids.

Conclusion. The digital image analysis of the sedimentation of suspended particles was carried out and rapid test is proposed for the rate estimation of deposition according to the change brightness of images. The method is characterized by high efficiency, low labor and accuracy matching with the gravimetric method of analysis.

The method can be used to control the level of pollution in wastewater, as well as evaluating the effectiveness of their purification from suspended particles.

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