Technical note

Significance and determination of fraction of non-separable particles of impurities in water purification

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ABSTRACT

The method to determine the quantity of non-separable particles in water, together with the calculations for the determination of the conditions of centrifugation under which the quantity of the non-separable particles can be determined, are dealt with in this paper. It is shown that for the determination of the quantity of non-separable particles it is beneficial to replace sedimentation in a gravity field with sedimentation in a centrifugal field. Reduction in the quantity of non-separable particles is characterised by the degree of destabilisation δ, which is proportional to the efficiency of the purification process. The development of separable aggregates is characterised by the degree of aggregation α_A which is proportional to the aggregation and separation efficiency of the system. The degree of destabilisation δ corresponds to the collision frequency factor α_p in the Smoluchowski equation for the perikinetic coagulation. The degree of aggregation α_A corresponds to the collision frequency factor α_O in the Smoluchowski equation for orthokinetic coagulation.

Keywords: non-separable particles, number of non-separable particles, degree of destabilisation, degree of aggregation, centrifugation, collision frequency factors

INTRODUCTION

The impurities which chemical water purification seeks to remove are present in water in the form of aggregately and kinetically stable dispersions. The prerequisite for removal of these particles is the removal of their aggregate stability, referred to as particle destabilisation. Particle destabilisation is achieved by addition of a destabilisation agent such as hydrolysing aluminium or iron salt. With a sufficient dosage of destabilisation agent, the energy barrier of particles is reduced to such an extent that the particles are brought into such close proximity that the influence of adhesion forces predominates and the particles combine into readily settleable aggregates.

The total number of particles of every pollutant in water is the sum of its two different particle size-fractions, namely:

- The separable (sedimentable) particles which can be removed from water by a suitable separation process such as sedimentation, flotation, centrifugation or deep bed filtration
- The non-separable particles which cannot be removed from water by any common separation method without appropriate chemical treatment

For the purpose of simplification of measurement, the number of particles is expressed by the concentration of determinant. The total number/concentration of particles on any pollutant is expressed as follows:

$$N_O = N_S + N_{NS} \qquad C_O = C_S + C_{NS} \tag{1}$$

where:

N_O (C_0) equals the total number (concentration) of particles of any determinant
N_S (C_S) is the fraction of the total number (concentration) of particles which is produced by the separable particles
N_{NS} (C_{NS}) is the remaining fraction of the total number (concentration) of particles which is produced by the non-separable particles.

Due to the variety of mechanisms that may be engaged in the transformation of particles of impurities present in water into separable aggregates using a hydrolysing coagulant, the term coagulation does not reflect all of the partial processes taking place during the transformation of colloidal impurities into readily separable flocs. It is more precise to call this process 'aggregation' and to call the flocs formed 'aggregates', as well as to call the hydrolysing coagulant 'destabilisation agent'. For this reason the terms aggregation, aggregates and destabilisation agent are used in this paper.

The objectives of this paper are to highlight the significance of the non-separable particles with regard to the quality of purified water and to provide a guide for determining the number of non-separable particles of impurities in water. Evidence of the impact of non-separable particles on the quality of purified water is also documented.

The kinetics of formation of separable aggregates

Particle aggregation proceeds gradually with random collisions between the destabilised particles producing kinetically unstable aggregates. The kinetics of the aggregation process is described by basic relationships developed by Smoluchowski (1917, 1918) as follows:

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