

Optimisation of reaction conditions of particle aggregation in water purification – back to basics

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Abstract

Basic types of pollutants in surface waters and methods for their removal are reviewed. Guidelines are provided for selecting the most effective hydrolysing destabilisation reagent (coagulant) for a particular quality surface water, which is polluted with different types of impurities, and optimising the reaction conditions under which its purification takes place.

Keywords: mineral impurities, natural organic matter (NOM), natural biological materials (NBM), aggregation stability, aggregation destabilisation, optimum dosage, optimised reaction conditions, optimised dosage and optimised reaction pH

Introduction

Until recently, in most English speaking countries, turbidity was considered to be the indicator of major pollutants used for monitoring the quality of purified water. In South Africa, turbidity is still considered to be the most important pollution indicator, which is used exclusively in most waterworks for monitoring their performance and for control of the required dosing rate of destabilisation reagent. Only very recently has the technological significance of organic pollution finally been recognised also in South Africa (Anonymous, 2000; Pryor and Freese, 1998), although not yet fully accepted as one of the most significant pollutants determining the quality drinking water. In contrast, Continental Europe has always considered natural organic matter (NOM) and other pollutants such as anion of destabilisation reagent (Me) and natural biological materials (NBM) to be equally or even more undesirable than turbidity alone. The aim in the purification of water in Continental Europe was always directed at the removal of all these pollutants to the highest possible extent by a simple coagulation process, which takes place under optimised reaction conditions.

The purification process by which dissolved natural organic matter (NOM), in addition to turbidity, is effectively removed is now being referred to as enhanced coagulation. Although this term cannot be substantiated in a physical chemistry meaning (Polasek and Mutl, 2000), it is now also adopted in South Africa (Pryor and Freese, 1998). It is claimed that NOM is effectively removed by the enhanced coagulation process at a dosage of destabilisation reagent by as much as eight times greater than that required for the removal of turbidity (Pryor and Freese, 1998). In this regard it should be pointed out that dosage of destabilisation reagent is a very important factor influencing the overall quality of the purified water as well as the economy of the purification process. Therefore, the dosage must be kept as low as possible but be sufficient to purify water to wholesome potable quality at all times. It will be evident from

practical examples of different waterworks shown in this paper that the dosage of destabilisation reagent is not eight times that required for turbidity removal as claimed, when purifying surface water from a source suitable for drinking water supply.

Due to the variety of mechanisms that may be engaged in the transformation of water impurities into separable suspensions, the term coagulation does not reflect the basis of all partial processes taking place during transformation of all kinds of colloidal impurities into readily separable flocs. It is more accurate to call this process aggregation and the flocs formed aggregates (Polasek and Mutl, 1995a; Polasek, 2003). In this context both terms, i.e. aggregation and aggregates are used in this paper.

The purpose of this paper is to review the basic types of impurities polluting surface waters and their influence on the determination of optimised reaction conditions under which water purification should take place, if all types of impurities are to be removed most effectively. It also introduces guidelines for selecting the most effective destabilisation reagent (coagulant). Furthermore, by using simplified models it explains how to determine the optimum dosage of destabilisation reagent for the removal of a single impurity and the optimised reaction conditions for the removal of a mixture of different types of impurities contained in surface waters.

Types of impurities in surface waters

Surface waters are dispersive systems containing particles of impurities of varying character with different degrees of dispersion. They are polluted by impurities which can be mineral, organic and biological by nature. According to their affinity to water the particles of impurities are either hydrophobic (turbidity producing dispersions and the anion of destabilisation reagent) or hydrophilic (dissolved organic matter of various types and nature). In some instances a hydrophobic colloid is surrounded by a hydrophilic colloid, which produces a protective colloid. The protective colloidal particles carry negative charges and are strongly hydrated. They appear as hydrophobic but behave as hydrophilic colloids and are the most difficult to aggregate. The quantities and the proportional presence of different types of impurities in water are determined by

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