

Aspects Regarding the Efficiency of Coagulation Process for Some Surface Waters

E. Zamfiroiu *, S. Masu **

* West University, Faculty of Chemistry-Biology-Geography, Timisoara, Pestalozzi st., no.16

** National R & D Institute for Industrial Ecology – ECOIND, Branch in Timisoara, P-ta Victoriei no.2, phone/fax : 0256 2202369, e-mail: andate@yahoo.com, Romania

Abstract: Coagulation is characterized through phenomenon of colloidal particles aggregation, settling and absorption onto formed aggregates of decayed natural organic matter, NOM. Fe and Al salts are coagulation reagents efficient in optimal doses, used in traditional coagulation based on stoichiometric relations and a mechanism of charge neutralization, respectively active sweep flocculation when coagulant excess act through absorption and charge neutralization mechanisms. Ferric chloride is more efficient than aluminum sulphate. Aluminum polymers (aluminum polychloride) are more efficient than monomeric species of Al and Fe, having higher efficiency on lower optimal doses. Choosing the coagulant must be based more on scientific information, than in Jar-Test performances.

Keywords: coagulation, NOM, Fe and Al salts

1. Introduction

In most of cases, surface water turbidity is caused by the clay particles and the color is owned to the decayed natural organic matter, NOM. Generally, the particles that determine the turbidity are not separated by settling or through traditional filtration. Colloidal suspension stability in surface water is also owned to electric charge of particles surface. NOM from surface water is mostly formed of humic and fulvic acids resulted from natural processes of vegetal and animal substances decomposing. Chlorine reaction with volatile organic matter form trihalomethanes (THM), and with non-volatile substances form compounds of haloacetic acid (HAA). These products are highly toxic. [1-4]

By applying the optimal dose of coagulation chemical reagent is realized the turbidity decrease. NOM decreasing is made with efficiencies that are depending of many factors: nature of organic matter, structure, dimension, functional groups, chemical species and others [2]

Among the control parameters of NOM removal efficiency, are organic matter load evaluated by chemical oxygen demand (COD), dissolved organic carbon (DOC), total organic carbon (TOC), absorbance in UV at $\lambda = 264\text{nm}$, and others [2].

Coagulant reagents are chemical agents that initiate the process, by destroying the stability forces between colloidal particles, bringing them together, simultaneously with NOM absorption. Aluminum and iron inorganic coagulants are including aluminum and iron salts and polynuclear compounds.

By aluminum salts addition in water their dissolving and dissociating take place, with producing of aluminum or iron aqua complexes, soluble species, monomers, like $\text{Al}(\text{H}_2\text{O})_6^{3+}$, $\text{Al}(\text{OH})^{2+}$, $\text{Al}(\text{OH})_4$, in equilibrium with metallic hydroxides [2-6].

Coagulants polymeric forms like aluminum polychloride, PCBA, are obtained through controlled and partial neutralization of aluminum salts. The predominated specie is a polymer, $\text{Al}_{13}\text{O}_4(\text{OH})_{24}(\text{H}_2\text{O})_{12}^{7+}$ (abbreviated Al_{13}). Polymeric species dimension is lower compared to hydrolyzed monomer species, so charge density of polymeric species is higher in comparison with the monomeric one [6-7].

The aim of the present paper is to establish the coagulation efficiency with different coagulation reagents of surface water.

2. Materials and methods

The surface water used in this study is a mixture of three samples, taken on one week interval between 10 and 28 march 2007. Average values of Danube water and of studied samples are presented in table 1.

Stock solutions of coagulant of coagulants: aluminum sulphate, respectively ferric chloride in concentration of 1 g Me^{3+}/l ., PCBA solution 0.17 M (0,46 g/l) $r = \text{OH}/\text{Al} = 2.3$.

TABLE I. Characteristics of the studied water

Parameter	NTPA values	Average values surface water	Average values of studied water
NTU turbidity	-	52.9 ± 2.5	26 ± 4
CCO(CCOMn) mgO_2/l	20 Cat.II	13.94 ± 2.0	13.5 ± 2.4
pH	5.5-9	7.54 ± 0.1	7.25 ± 0.1
UV ₂₅₄	-	-	0.17 ± 0.04

To determinate the optimal dose is used Jar-Test method effectuated with a SARTORIUS multiple arms shaker. The supernatant of coagulated samples is studied

with standardized analysis methods for turbidity, CCO and absorbance measuring at $\lambda = 264$ nm with UV-VIS Jasco spectrophotometer.

3. Results and discussions

Coagulants action onto colloidal particles take place through charge neutralization of negatively particles. If charge neutralization is the predominant mechanism, can be established a stoichiometric relation between particles concentration and coagulant optimal dose. Coagulation speed is very low on a low concentration of particles in water. To increase the speed are added higher doses, and in water is forming metallic hydroxide precipitate, the process being known as sweep flocculation, because through settling, the precipitate is carrying both particles and NOM. The NOM removal with coagulants is made through:

- binding of metal species to anionic sites, functional groups of humic dissolved matter and these sites charge neutralization when the solubility is reduced. This can lead to precipitation of the metal-humic complexes that can be removed by sedimentation or filtration;

- absorption of humic matter on amorphous metal hydroxide precipitate. At pH = 5-6, the humic substances are negatively charged and Al and Fe hydroxides are charged positively which will give strong absorption and charge neutralization. PCBA give a faster flocculation with large flocculants on aluminum optimal doses. The coagulants action must be understand in charge neutralization terms as well as in effects associated with precipitation with metallic hydroxide;

- optimal dose is determined using Jar-Test method for each coagulation agent. Through graphic representation of residual turbidity in function of tested coagulation reagent doses is determined the optimal doses, as in fig.1. In case of using the Al and Fe salts, are determinate two ranges for optimal doses for each coagulant: an optimal dose (OD - 1) for which turbidity is very low decreased but are obtained efficiencies under 50 % for organic removal, respectively 30 % for Al salts, 44.7 % for Fe salts and only 22.4 % for PCBA. At a three time higher dose (OD - 2) is obtained, near high decrease of turbidity, a reduction over 50 % of CCO. This correspond to the sweep coagulation aria with a advanced reduction of CCO that reach 51.9 % in Al salts case and 66.7 % in case of Fe salts, as shown in fig. 2.

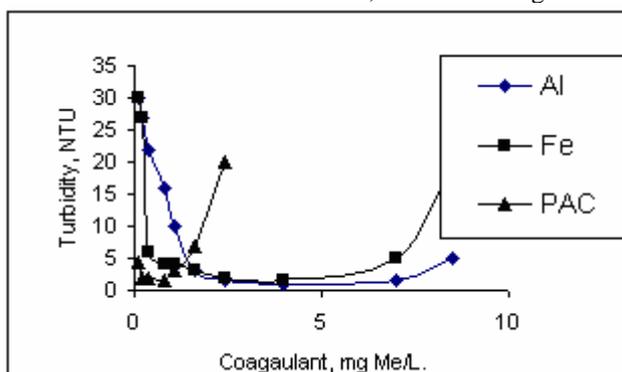


Figure 1. Turbidity evolution vs. coagulant doses (Al – aluminium sulphate; Fe – iron chloride; PAC – aluminium polychloride)

For the first range OD-1 can be observed that the iron optimal dose is lower than the one for aluminum for similar turbidity reductions, and in case of PCBA use as coagulation agent, optimal dose OD-1 for turbidity reduction is ten times lower than the iron optimal dose.

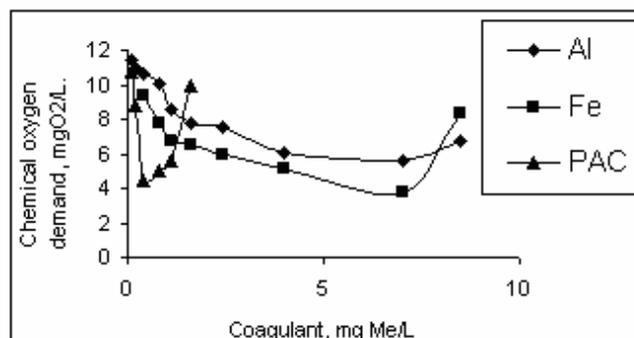


Figure 2. Variation of chemical oxygen demand for water samples vs. coagulant doses (Al – aluminium sulphate; Fe – iron chloride; PAC – aluminium polychloride)

In case of using PCBA, sweep coagulation aria is presented at 0.4 mg Al / dm^3 when dissolved organic matter reduction was higher than the one obtained in case of aluminum salts at DO-2, respectively of 60.5 %.

In fig.3 is presented UV₂₅₄ nm absorbance decreasing. This is similar to the one obtained in case of CCO parameter for Al and Fe salts. For PCBA are not obtained significant results, being known that PCBA has a strong UV signal that lead to their addition to ones of NOM.

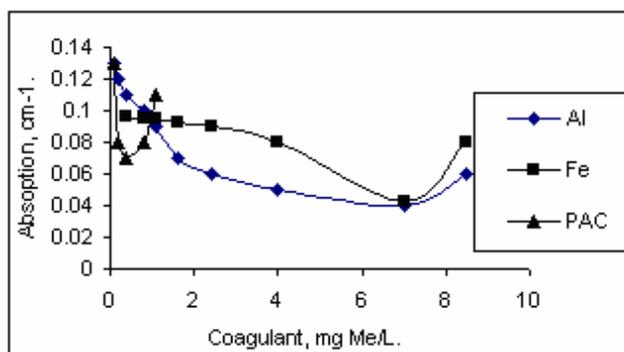


Figure 3. Evolution of specific absorbtion of water samples for 254 nm, vs. coagulant doses (Al – aluminium sulphate; Fe – iron chloride; PAC – aluminium polychloride)

4. Conclusions

In coagulation process, Fe and Al salts present two optimal doses: a lower one corresponding to charge neutralization mechanisms, and a three times bigger one corresponding to sweep coagulation. In Fe salts coagulation, the optimal dozes are lower then in case of aluminum. Fe salts have greater efficiencies in CCO reducing compared to those of aluminum.

Coagulation reagents based on aluminum polymers are more efficient, need 15 to 20 times lower doses than classic salts, to obtain similar results of turbidity and organic matter removal.

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