POLYALUMINUM CHLORIDE COAGULATION IN DRINKING WATER TREATMENT

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ABSTRACT

Dissolved organic matter, DOC [mg C/L], is a representative parameter for the content of organic matter in natural waters. Along the A254 absorbance as a measure of organic compounds determined at $\lambda = 254$nm UV [cm^{-1}], DOC underlies the calculation of SUVA (Specific Ultraviolet Absorbance) = A254/DOC x 100 [$L \cdot m^{-1} \cdot mg^{-1}$]. SUVA can be used to describe the composition of the water in terms of hydrophobic / hydrophilic character. The study results are presented in the coagulation process with pre-hydrolyzed aluminum salt, as a polyaluminum chloride (PACl), a simple salt of Al, as an Al sulfate (Alum), applied to surface water intended for drinking water. From SUVA values DOC removal efficiency in the coagulation process is estimated. SUVA = 2-4 estimated efficiencies of 25-50% removal in DOC. When using PACl, DOC removal efficiency is within the range of 27-53%, and slightly lower when using Alum. SUVA values <2 indicate DOC removal efficiencies <25%. DOC removal efficiencies obtained from the use of Alum are within the range 5.6-8.4% and those obtained when used as coagulation agent PACl are in the range 20.8-23.8%.

INTRODUCTION

Coagulant agents are those that govern the efficiency of coagulation and formation of sedimentary aggregates. It is known that multi-species metal ions, such as Al and Fe, can form dimers and trimers. After the addition of Al and Fe salts in water, they pass through a sequence of stages of hydrolysis, polymerization, aggregation and precipitation which results in a multitude of instable and transient species. This underlies the explanation that these forms are based on conversion of monomers into polymers that are present both in soluble form and precipitates and gels [1-3]. Hydrolysis of polymeric aluminum salts is different from that of simple salts such as aluminum sulphate (Alum). The degree of hydrolysis of polymeric salts can be controlled during manufacturing technology and the speed formation of precipitate after dilution polymer coagulant [4-6]. Polymeric aluminum species (Al_n) forming capacity increases with increasing the degree of neutralization Al polynuclear hydrolysis product has great practical importance, and it was designated Al_{13} ($Al_{13}O_4$)$(OH)_{24}^{+7}$). The proportion of polymer is 33% to 83% for a value of B increasing from 1 - 2.5 (B = OH/Al, molar ratio). Results were confirmed by other tests. The species is regarded as the best species for coagulation [5]. Two main mechanisms are considered that can be used to explain the phenomena of coagulation: compressing the electrical double layer of colloidal particles, adsorption, charge neutralization and precipitation, neutralization of charges,

including and sweeping of impurities by precipitation of hydrolyzed species. Actually, both mechanisms occur, but one predominates. Predominant mechanism depends on the type of coagulant, the source of water treated, the technique of adding coagulants etc. [3.6]. Hydrolysis / precipitation of the pre-hydrolyzed aluminum salt, as a polyaluminum chloride (PACl type), coagulating agents depend on the type of coagulant, water pH, the dose used, etc. [5-6]. The study presents the comparative effectiveness of removing dissolved organic matter (DOC) [mg C/L] in the coagulating process by hydrolyzed salt, PACl and simple salt, Alum, for sources of surface water intended for drinking water. Representative parameters to characterize organic matter content (NOM) of natural waters are the contents of dissolved organic carbon, DOC and UV absorbance at 254nm, A254 [cm^{-1}]. Also natural organic natter characterization of water is done using the Specific Ultra Violet Absorbance parameter, SUVA, introduced by Tobiason and Edzwald [7]. SUVA calculation is performed with the DOC and A254 ratio, SUVA = A254/DOC x 100 [$L \cdot m^{-1} \cdot mg^{-1}$]. SUVA can be used to describe the composition of the water within hydrophilic/hydrophobic character. Waters characterized by SUVA > 4 show a hydrophobic character with aromatic compounds, and those characterized by SUVA < 2 indicate a predominantly hydrophilic character [8].

MATERIALS and METHODS

For this study, 10 of the representative waters supplies used for drinking water were studied. The analyzed parameters are: DOC for filtrated water samples, trough 0.45 μm filter. Raw and coagulated samples were filtered through 0.45 μm pre-rinsed filter by type of SPARTAN 3D/0.45 RC, Whatman Inc. SUA. DOC was measured using a Multi C/N 2100S TOC analyzer (Analytik Jena); A254 are the values of ultraviolet absorbance at 254 nm, of the filtrate samples (0.45 μm). The absorbance was determined using a Specord 205 UV/VIS spectrophotometer Analytik Jena in a 1 cm^3 quartz cuvette. SUVA is a specific ultraviolet absorbance, determined as the absorbance at 254 nm (A254) [cm^{-1}], per unit of DOC [mg C/L] and SUVA= A254/DOC x 100 [$L \cdot m^{-1} \cdot mg^{-1}$]. The coagulant agents used are: Alum, $Al_2(SO_4)_3 * 18H_2O$ reagent, provided by Chimopar Bucuresti and poly-aluminum chloride, PACl are obtained by controlled reaction of aluminium salts with base under carefully controlled conditions [9]. PACl is characterized by B= 2.4 and was obtained by reaction of aluminum salts with a base under carefully controlled conditions. They are typically characterized by degree of neutralization expressed as “B” which is the ratio OH/Al total [6]. Jar Test method: coagulation experiments were carried out using Degremont Jar Test in 1L beakers. After the addition of the coagulants, the samples were subjected to rapid mixing for two minutes at 250 rpm, then flocculation 10 minutes at 25 rpm and the settling for 30 minutes.

RESULTS

Table 1 shows the values for DOC, A254 and SUVA of untreated water sources. DOC parameter values characteristic for water sources are studied within the range of 2.58-8.05 [mg C/L], A254 parameter values are within the range 0.063-0.206 [cm^{-1}]. The values of the water sources quality parameters covered very wide areas. Among the factors that influence the composition and concentration of DOC, present in water sources for drinking water, may be: the precipitation regime that leads to the formation of torrents that involve such large quantities of organic and

inorganic suspensions in hydrographic area; the amount of dead organic matter accumulated during the cold storage of the year, at different stages of humidification, thermal regime, topography, etc. As a result of fluctuations in composition and concentration of dissolved organic matter was necessary to introduce the SUVA parameter through which we can estimate the dissolved organic compounds character and their removal efficiencies when using coagulating agents. SUVA values for the studied water supplies are within the range 2.11-3.48 [$L \cdot m^{-1} \cdot mg^{-1}$]. The water supplies studied have values of SUVA = 2-4 [$L \cdot m^{-1} \cdot mg^{-1}$], which indicate the presence of a mixture of water compounds with hydrophilic and hydrophobic character. For this type of water sources there is an estimated removal efficiency between 25-50% in DOC. DOC removal efficiencies obtained from applying the optimal dose of coagulating agents, Alum and PACl, are shown in Figure 1. DOC removal efficiencies obtained from the use of PACl for water sources characterized by parameter SUVA=2-4 [$L \cdot m^{-1} \cdot mg^{-1}$], are shown in Figure 1. DOC removal efficiencies are within the range 27-53%. DOC removal efficiencies are in the range estimated by the SUVA values. The use of Alum determined lower reduction efficiencies of DOC vs. removal efficiencies obtained when using PACl coagulation agent. DOC removal efficiencies when using Alum as coagulation agent are within the 7-49% range. Note that for A_1 and A_4 water sources DOC reduction efficiencies at alum as coagulation agent are 7.0 and 15.2% respectively under the estimated level (see figure 1). The cause of this behavior is due firstly to the hydrophobic organic matter present in water sources and secondly to the Al species involved in the coagulation process. Species with coagulant action present in the pre-hydrolyzed agents, PACl have a greater capacity for removing DOC for optimal doses similar to the optimal doses of Alum.

Table 1 The values for DOC, A254 and SUVA of untreated water supplies

Nr. Crt.	Water supply	DOC [mgC/L]	Absorbance 254nm [cm^{-1}]	SUVA [$L \cdot m^{-1} \cdot mg^{-1}$]
1	A_1	2.58	0.063	2.44
2	A_3	3.22	0.082	2.49
3	A_4	3.29	0.089	2.70
4	A_6	2.22	0.068	3.06
5	A_7	6.33	0.174	2.74
6	A_8	5.93	0.155	2.61
7	A_9	7.53	0.159	2.11
8	A_10	8.04	0.162	2.36
9	A_12	3.01	0.105	3.48
10	A_13	8.05	0.206	2.56

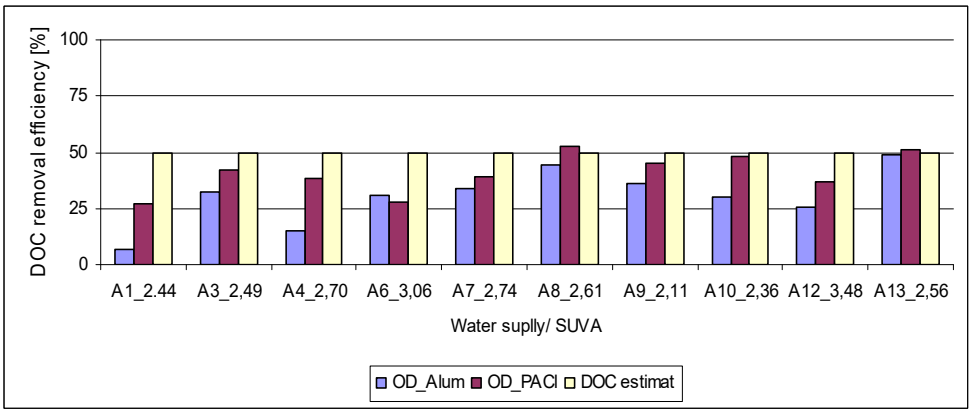

Figure 1. DOC removal efficiencies obtained from optimal doses of coagulant agents, Alum and PACl, water supplies with SUVA = 2-4

CONCLUSIONS

Natural factors influence the composition and concentration of DOC in raw waters. Water supplies studied have a variable content of DOC and different compositions of natural organic matter**.** SUVA parameter can be used to describe the composition of water within hydrophobic / hydrophilic character and therefore DOC removal efficiency is estimated. The hydrophilic/hydrophobic character determines reductions between 25-50%, confirming the SUVA estimates. The use of pre-hydrolyzed salts, PACl, leads to greater removal efficiencies vs. DOC removal efficiencies obtained when using Alum.

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