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USE OF QUICKLIME IN DRINKING WATER TREATMENT

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Abstract: A total of 99% of the population has access to drinking water throughout the year through different water treatment plants that OSE has, where raw water mainly obtained from surface sources is converted into **drinking water** through **conventional treatment**. It consists of two large stages: clarification whose objective is the elimination of particles that add turbidity to the water and disinfection to eliminate pathogenic microorganisms. Clarification is made up of different unit processes, coagulation being a crucial stage of the process. To achieve correct **coagulation**, raw water must reach adequate **alkalinity** and pH values, so it must generally be pre-conditioned through a chemical treatment. Currently, OSE uses sodium carbonate as an alkalizing agent in most of its plants, which is exported. The objective of this project is to determine the use of **quicklime** produced and marketed in our country by Cementos del Plata S.A., as an alternative to conventional alkalizing. For this, different tests were carried out, evaluating alkalinity and pH parameters, by simulating the clarification process and comparing them with the conventional alkalinizer. Based on the results obtained, it is concluded that quicklime is a promising alternative since it achieves a greater increase in these parameters compared to the conventional alkalizing agent. In addition, it indicates a competitive advantage since it may not require pH adjustments in stages prior to disinfection, where pH plays a fundamental role.

INTRODUCTION

The water purification process is a controlled process through which raw or raw water is transformed into drinking water. In Uruguay, the definition of drinking water and its characteristics are established in the National Bromatological Regulations. It defines it as water suitable for human consumption, which does not present a risk to health during the entire life of the consumer or which generates rejection by the consumer (2).

Currently, 99% of the country's population has access to drinking water throughout the year, through 77 water treatment plants that Obras Sanitarias del Estado (OSE) has, the most important being the Aguas Corrientes Water Treatment Plant, since it supplies the metropolitan area. Annually, 361 million m^3 of drinking water are produced (1).

The water to supply the water treatment plants can come from surface or underground sources. In OSE, 90% of the water produced comes from surface sources while the remaining 10% is from underground sources. When the source used is surface water, a treatment called conventional is used for its purification. This physicochemical treatment basically consists of two stages, the first one of clarification in which the particles that make the water less clear are eliminated and finally the disinfection that has the objective of inactivating the pathogenic microorganisms present. The unitary processes that are developed in conventional treatment are: pretreatment, coagulation, flocculation, sedimentation, filtration and disinfection (2).

Pretreatment may include physical and chemical conditioning. In the physical conditioning, the settleable material is removed, especially useful when the raw water contains an excess of sand that can affect the following stages of the treatment. On the other hand, chemical conditioning can consist of several stages: pre-oxidation, adsorption and pre-alkalization. The main objective of the first stage is the oxidation of organic matter and the removal of odor and taste. In the adsorption stage, substances dissolved in the raw water are removed, such as traces of organics, toxins and metabolites that generate odor and taste. The pre-alkalization stage is necessary when the alkalinity present in the raw water is not sufficient to achieve correct coagulation. For this, it is necessary to condition the raw water, achieving an adequate alkalinity that is provided by dosing soda ash (sodium carbonate, Na_2CO_3), caustic soda (sodium hydroxide NaOH) or hydrated lime ($Ca(OH)_2$). Currently, OSE mainly uses sodium carbonate in its water treatment plants. Another highly relevant parameter for the coagulation stage is the pH. The pH value at which maximum coagulation efficiency is obtained is called pH optimum and can be determined by jar tests. In this stage, the aluminum sulfate reacts with the alkalinity, producing a decrease in alkalinity, also accompanied by a decrease in pH. The **coagulation**, it consists of the neutralization of those particles that make up the turbidity by means of a product called coagulant (OSE uses aluminum sulfate). This way, there are no impediments and the particles join together, giving rise to larger and heavier particles called flocs. That process is called: **floculation**, and it must be done under controlled conditions, because a very violent agitation can cause the rupture of already formed flocs, while a very slow agitation can give rise to the formation of “spongy” and weak flocs, difficult to settle. **Sedimentation** or decantation is the first effective step in separating particles from water. It is at this stage that a reduction in turbidity and color is achieved with respect to the raw water. The **filtration**, this is the final stage of the water clarification process and the one that must be complied with in terms of quality parameters in terms of turbidity and color. The same consists of passing the water through a porous medium. The purpose is to retain those particles of lesser density (small flocs) and those that for some reason were not eliminated in the sedimenter. In addition to what is indicated, filtration is considered one of the main barriers for the retention of pathogenic microorganisms. Finally, at this stage, it may also be necessary to add an alkaline agent if the decrease in pH, a product of the coagulation stage, is lower than established in the quality specifications. The final product of this stage is called *filtered water*. The **disinfection** is the last stage of the water purification process, and consists of adding a chemical agent to eliminate pathogenic microorganisms that can transmit diseases. It is essential, that the parameters of turbiedity and color are complied with, since otherwise it hinders the action of the disinfectants (2 and 3).

Alongside the entire process of water purification, OSE performs operational controls in accordance with the OSE Internal Standard for Quality of Potable Water, monitoring the efficiency of the established control measures. The regulations establish that the water librated for consumption must have a maximum turbiedity of 1 NTU but it is recommended that it be less than 0,5 NTU at the outlet of the plant so that the disinfection process is carried out effectively. While the pH must be between 6,5 and 8,5 (3).

The objective of this project is to evaluate the use of quicklime produced in Cementos del Plata S.A as an alkalizing agent for the treatment of potable water.

RESULTS AND DISCUSSION

A series of tests will be carried out at the Potabilizadora de agua plant in the city of Treinta y Tres. Firstly, the process of pre-alkalinization of the raw water was simulated and the parameters turbidity, alkalinity and pH were evaluated, using different concentrations of quicklime and sodium carbonate. The results obtained are shown in Table I.

	Turbidity (NTU)	Alcalinity (p.p.m $CaCO_3$)	pH
Raw water	20,1	58	7,4
Raw water + 10 p.p.m. sodium carbonate	19,5	75	7,7
Raw water + 20 p.p.m. sodium carbonate	20,0	88	8,7
Raw water + 10 p.p.m. quicklime	19,9	78	8,9
Raw water + 20 p.p.m. quicklime	21,6	95	9,4

Table I: Turbidity, alkalinity and pH results using raw water and sodium carbonate or quicklime.

As it was mentioned earlier, in the pre-alkalinization stage, adequate alkalinity values are required to achieve a correct coagulation in the aluminum sulfate aggregate. As we can see in Table I, the same concentration of quicklime as sodium carbonate achieves a greater increase in alkalinity and pH parameters. This result indicates that our product can be used in the pre-treatment stage and that, in addition, it presents a strong competitive advantage compared to the alkaline agent most used in the water purification plants.

Secondly, the pH and turbidity parameters were evaluated in the filtered water from the quicklime aggregate and compared with the conventional pH corrector (sodium carbonate). The results obtained are shown in Table II.

	Turbidity (NTU)	Alcalinity (p.p.m $CaCO_3$)	pH
Filtered water	0,49	45	6,8
Filtered water + 10 p.p.m. sodium carbonate	0,47	55	7,1
Filtered water + 20 p.p.m. sodium carbonate	0,37	65	7,2
Filtered water + 10 p.p.m. quicklime	1	50	7,7
Filtered water + 20 p.p.m. quicklime	2,32	75	9,5

Table II: Results obtained from the turbidity, alkalinity and pH parameters of the jar test using filtered water and sodium carbonate or quicklime as a pH corrector.

As we can see, the same concentration of quicklime as that of sodium carbonate achieves a greater increase in the pH parameter. However, it causes a significant increase in turbidity. In this stage of the potabilization process, the filtered water must comply with the quality specifications where the pH must be in the range of 6,5 to 8,5 and the turbiedity must be less than or equal to 1 NTU. Therefore, our product is useful as a pH corrector with concentrations not exceeding 10 p.p.m.

In the final jar test, the complete process of pre-alkalinization, coagulation, flocculation and sedimentation was simulated, using lime as an alkalinizer and aluminum sulfate as a coagulant with the aim of determining the optimal coagulant concentration. Therefore, the dosage of quicklime (5 p.p.m) was maintained and different concentrations of aluminum sulphate were analyzed (30 p.p.m to 80 p.p.m). The parameters of turbidity, alkalinity and pH were evaluated. The results obtained are shown in Table III.

	Turbidity (NTU)	Alkalinity (p.p.m $CaCO_3$)	pH
Raw water	22	26	7,3
Raw water + 5 p.p.m. quicklime + 30 p.p.m aluminum sulfate	5,1	40	6,7
Raw water + 5 p.p.m. quicklime + 40 p.p.m aluminum sulfate	3,9	35	6,5
Raw water + 5 p.p.m. quicklime + 50 p.p.m aluminum sulfate	3,3	32	6,4
Raw water + 5 p.p.m. quicklime + 60 p.p.m aluminum sulfate	4,6	28	6,4
Raw water + 5 p.p.m. quicklime + 70 p.p.m aluminum sulfate	5,5	26	6,1
Raw water + 5 p.p.m. quicklime + 80 p.p.m aluminum sulfate	5,5	20	6,0

Table III: Results obtained from the turbidity, alkalinity and pH parameters of the jar test using a fixed quicklime concentration (5 p.p.m) and different aluminum sulfate concentrations (30 p.p.m – 80 p.p.m).

Based on the results obtained and what was observed during the test, it was determined that with 5 p.p.m of quicklime the optimal concentration of aluminum sulfate is 50 p.p.m due to the fact that the lowest value of turbidity and a very close pH are achieved. required by the standard. However, it is recommended to work with a slightly higher quicklime concentration (5 < p.p.m < 10) to comply with the pH range.

CONCLUSIONS

Based on the results obtained, it is concluded that quicklime has a significant potential to be used as an alkalizing agent in the pre-alkalinization stage. It is based on the substantial increase in alkalinity and pH of the raw water compared to the alkaline agent currently used in the Treinta and Tres water purification plant. On the other hand, it can also be used in the post-alkalinization stage as a pH corrector in filtered water using adequate concentrations of quicklime.

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