

A note on the use of chlorine dioxide vs. chlorine for potable water treatment

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Abstract

This paper deals with the results achieved by using ClO_2 in the treatment of raw water rich in Mn (more than 0,90 mg/l) during August and September 1991. Removal of Mn (II) by using the conventional process with Cl_2 yielded treated water in which the Mn residual levels were higher than those prescribed in the Spanish Drinking Water Law (50 u,g/l). The use of ClO_2 solved this problem and, at the same time, brought about a reduction in both the UV-absorbance values (at 254 nm) of the water, and the production of THM (trihalomethanes) during the potable water treatment processes. However, the real production cost of potable water increased from \$13,0/1 000 m³ (chlorine) to \$27,5 / 1 000 m³ (chlorine dioxide).

Introduction

Chlorine dioxide was first used as a water treatment process in the world at Niagara Falls, New York, in 1944 (Lykins et al., 1990). This substance can be effective in potable water treatment for controlling taste and odour, and for removing Fe and Mn, as well as for providing a lasting residual in water distribution systems (Masschelein, 1989). Likewise, it does not form chlorinated by-products (Beltrán et al., 1991; Craig Vogt, 1980).

Adverse tastes and odours may be caused (in drinking water) by a variety of industrial waters, and by metabolites of algae and bacteria. Furthermore, these may be aggravated through chlorine oxidation, which leads to the formation of chlorinated compounds.

Reactions between humic substances and chlorine lead to the formation of trihalomethanes (THM) in potable water (Beltrán, 1991); these can also be produced by reactions between algae (or their metabolites) and chlorine (Wardlaw et al., 1991). Due to their toxicity, THM concentrations in drinking water must be decreased (WHO, 1986).

Chlorine dioxide is very effective in reducing the THM levels in water, especially when the ClO_2 dosed has been produced without excess chlorine (Craig Vogt, 1980).

When the raw water which is to be treated shows high levels of Fe and especially Mn (associated with humic substances), the ClO_2 can be used as a substitute for Cl_2 with several advantages (Masschelein, 1989; Tirado et al., 1987).

Finally, for control of bacteria and viruses, ClO_2 is as effective as or superior to free Cl_2 (Lykins et al., 1990); this action could be due to a reaction between ClO_2 and the proteinic amino-acids of the cellular wall of the micro-organisms (Masschelein, 1989).

Summarising, ClO_2 is a suitable drinking-water disinfectant and estimates indicate that 300 to 400 utilities in the United States have ClO_2 treatment equipment. The situation in Europe shows an increasing trend in the use of this disinfectant (Masschelein, 1989).

Industrial-scale production of ClO_2 can be obtained in two forms: reaction between Cl_2 (strongly chlorinated water) and sodium chlorite, and through hydrochloric acid and sodium chlorite; the first method is probably the most used (Masschelein, 1989; Monscvitz and Rexing, 1980).

The aim of this paper was to compare the results (technical and economical) achieved in the treatment of water containing high concentrations of Mn, by using both Cl_2 and ClO_2 . At the same time, reduction in THM formation (total, chlorinated and brominated), and in the 254 nm UV-absorbance were observed with ClO_2 in comparison with Cl_2 .

Experimental

Drinking-water plant

Villa Azul Drinking-water Plant (Córdoba, Spain) currently produces 150 000 m³ (maximum) of potable water per day. The applied treatment scheme is as follows: pre-aeration of raw water (air, low pressure), pH correction with lime ($\text{Ca}(\text{OH})_2$) ozonisation (out of service during our study), pre-oxidation (Cl_2 gas, or ClO_2), decantation (one "floc recirculation settler" and two "lamella settlers"), filtration through 30 rapid sand filters, post-disinfection (Cl_2 or ClO_2), pH correction with lime, and fluoridation of treated water. (A complete description on the Drinking-water Plant of Villa Azul has been given in previous papers (Marin Galvín, 1991b and 1992a)).

Samples of water investigated corresponded to raw water before pre-aeration, decanted water in FRS (floc recirculation settler) and LS (lamella settlers), and filtered water before fluoridation (this was also considered as "treated water").

Data of water quality (untreated, decanted and filtered) oxidised with only Cl_2 corresponded to average values obtained between 13 and 19 August 1991. Data of water quality oxidised with ClO_2 dioxide corresponded to average values obtained between 20 August and 27 September 1991.

Chlorine dioxide production

Industrial ClO_2 generation was by means of the reaction between Cl_2 (2,0 g/l in water) and NaClO_2 (25 %), within a reactor of 1 100 l capacity, which contained 750 l of Rashing's rings (in

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Received 25 June 1992; accepted in revised form 24 December 1992.