Removal of iron from groundwater by ozonation-filtration aimed to potability water

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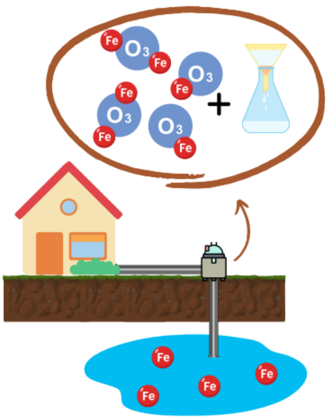

Groundwater can often contain high concentrations of iron, rendering it unsuitable for consumption as potable water. The aim of the project is to propose an ozone-filtration treatment for water sourced for a coastal city in southern Brazil. Laboratory tests were conducted to assess the influence of two controllable factors on iron concentration reduction at two levels each: contact time (10 and 20 minutes) and ozone flow rate (6 and 30 mg.L^{-1}). The tests showed efficiencies exceeding 98%, with no significant differences between them, resulting in iron concentrations below 0.3 mg/L.

Introduction

In certain localities where a public water supply network is absent, residents must seek alternatives to address the scarcity of water. One of the most efficient solutions, particularly in the southern region of Brazil, which allows for a quick and less costly resolution to this issue, is the drilling of artesian well [1]. Nevertheless, the groundwater often naturally contains elevated levels of iron surpassing potability standards due to the sediment's origin with which it's associated. It's known that consuming water with excess iron can pose health risks and impair human well-being, while also causing staining on clothing and sanitary fixtures, the World Health Organization (WHO) has set a guideline value of 0.3 mg.L^{-1}of iron in drinking water [2,3].

Ozone has the multi-function of oxidizing heavy metals, disinfection bactéria, color removal and oxidizing organic matter. Unlike other chemical purifying processes, ozone is an environmentally friendly chemical with no environmentally harmful residues. Removal of Fe consists of transforming the soluble form to insoluble that can be filtered out of the water; the ferrous iron is, therefore, easy to oxidize by ozone [4]

The objective of the project was to propose an easily accessible treatment that could be installed in households, based on commercial ozone generation equipment, followed by filtration, to achieve potable water standards.

Material and Methods

The groundwater was collected in the municipality of Osorio (-29°52'34.35", -50°4'27.12"), and the experiments and analysis were carried out at LACOURO/UFRGS. The ozone generator Ozonic C-10, Brazil, was used to carry out the experiments, using atmospheric air. Fine commercial sand was used as a filter medium, with a particle size of less than 0.2 mm.

The molecular absorption spectrophotometric method using orthophenanthroline was used to determine the amount of iron in the samples. The equipment used was a Genesys 30 visible spectrophotometer from Thermo Scientific, wavelengths from in 510 nm.

Ozonation-filtration experiments were carried out in the laboratory following a type 2^2 experimental design. Two factors were varied at two levels: low level (-1) and high level (+1): contact time, 10 and 20 minutes, and ozone flow rate, set between the minimum and maximum, 6 and 30 mg.L^{-1}, of the equipment's production. Then, the sample was filtered and analyzed.

The results were tabulated in Excel software and subjected to statistical analysis of variance. the four experiments are described in Table 1.

Results and Discussion

All the samples had a significant reduction in iron concentration, above 98%, reaching values suitable for human consumption according to the legislation, showed in Figure 1. The raw sample, at pH 5, enables for ozone reaction in its indirect form, generating hydroxyl ions (OH^{-}), which is a faster but less selective reaction.The contact times and flow rates were sufficient to oxidize a large part of the metal present in the sample and the filtration with fine sand was adequate to retain the compound. With the factors of flow rate and contact time, a statistical analysis of variance was carried out, proving that there was no statistical difference between the factors or the interaction between them ($p>0.05$).

A study using synthetic groundwater, with an initial iron concentration (2.6 $mg.L^{-1}$), when applying a dose of ozone 1.25 $mg.L^{-1}$ for 10 min, obtained a 90% reduction, and increasing the ozone to 3 $mg.L^{-1}$, the removal was over 96% [5] Corroborating the study that for groundwater with iron content higher than the limit indicated for consumption, small doses of ozone at short contact times are sufficient to achieve the standards.

Another study using ozonation/filtration treatment to remove iron analyzed three intensity of commercial ozonation equipment: minimum, medium and maximum. The levels showed no significant differences, and the lowest intensity was chosen. The total iron concentration of the sample does not change after ozonation, as ozonation does not remove iron, but converts it into a different form. Filtration was accomplish in in two different granular media: sand and granular activated carbon. While all of them reached the recommended value, sand was chosen because it has the lowest economic value [6].

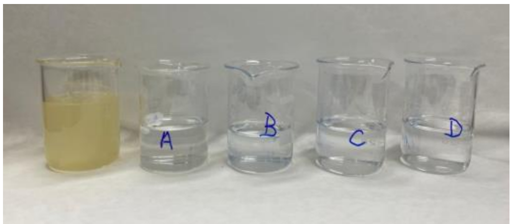

Figure 1. Raw water and after treatments.

Table 1. Experimental design and results[a]

Sample	Contact Time (minutes)	Ozone flow rate ($mg.L^{-1}$)	Iron Concentration ($mg.L^{-1}$)
Raw	-	-	3.04
A	10	6	0.04
B	10	30	0.01
C	20	6	0.04
D	20	30	0.05

Conclusions

Ozone proved to be an alternative for treating household water, and this technique is viable for applications aimed at removing soluble metals from water, since the ozonation process does not require any pre-treatment. The variations in flow rate and contact time were not significant, and the lowest flow rate can be used for the shortest time, which achieves the proposed objective and is better economically. The treatment of ozonation followed by filtration proved to be efficient in reducing iron in the samples, reaching the values permitted by law for human consumption. The next steps are to study the other water potability parameters, as well as the sizing and economic analysis of this treatment for implementation in homes.

Acknowledgments

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