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Sustainable water treatment for rural communities: technology selection

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Highlights:

- The water quality of 250 wells was assessed to address the challenge of freshwater in rural communities.
- The most promising water treatment technologies to meet water potability standards were identified.
- The water treatment technologies were evaluated in three dimensions of sustainability: technical, economic, and social.
- Zeolites/Activated carbon + Chlorination presented the lowest costs and higher operational simplicity.

Keywords: Decentralized water treatment; sustainability; rural communities.

INTRODUCTION

Developing more sustainable and resilient societies to climate change is a worldwide concern. According to the 18th Chapter of the 21 Agenda from the UN, strengthening water resources management with local participation is an important aspect of building such societies. Besides, it is also necessary to assist communities so they can sustainably manage their systems, stimulating them to act in local water management.

Considering this approach, access to water in adequate quantity and quality in rural communities poses an even higher challenge. This can be attributed to the unequal investment that centralized solutions to water treatment and distribution received over the last century worldwide. This governance model also contributed to unequal policies. In Brazil, for example, the legal framework – as well as investments – has always prioritized water infrastructure for urban centers (Brazil, 2020). Therefore, while 90 % of urban communities have access to treated water, only 33 % of the rural population retrieves water from secured sources (Funasa, 2017).

Water treatment in rural communities needs to overcome big challenges in all three dimensions of sustainability: social, techno-economic, and environmental. A possibility of this is to look for integrated solutions that can meet all these three dimensions and provide sustainability in the long term. In this context, a technology must be selected in terms of its technical performance, and economic and environmental feasibility, i.e., be seen as a social technology. To this, this work aimed to investigate, define and validate technologies able to treat water for rural communities, considering their long-term sustainability and the local realities.

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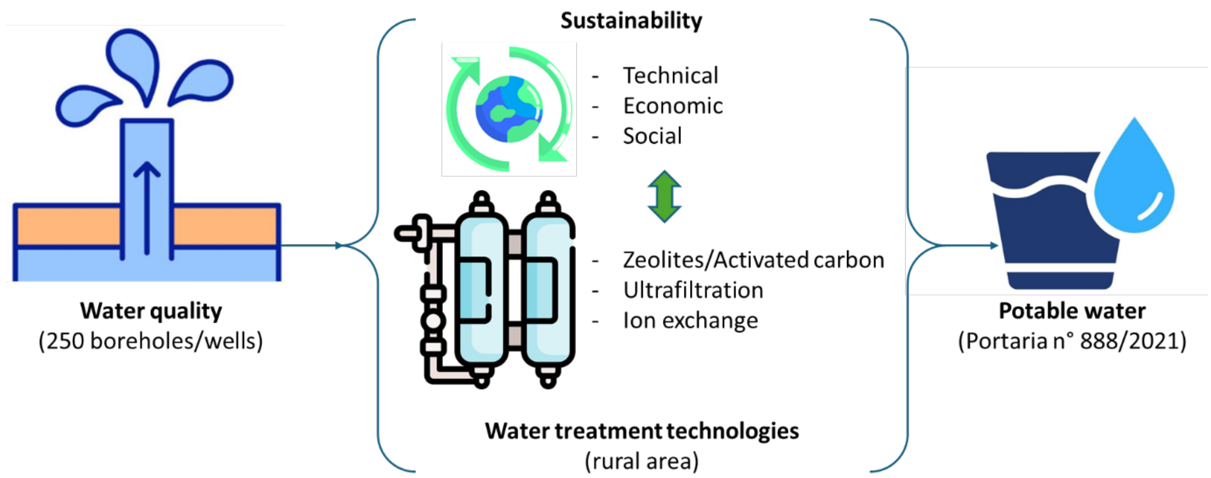
MATERIAL AND METHODS

To understand the most suitable technologies for rural water treatment, the water quality of 250 boreholes/wells was compared with the Brazilian directive to potable water, Portaria de Consolidação n° 5/2017, adapted to Portaria n° 888/2021. To this, more than 7,000 water samples were analysed.

After understanding the main water contaminants, research was performed to define which technologies were suitable for reaching potable water (Figure 1). They were then compared in terms of (a) cost of maintenance, (b) cost of operation, and (c) impact on the environment. After selection, the chosen technologies were installed, and their feasibility was proved.

Figure 1 - Graphical abstract of the work conducted



RESULTS AND CONCLUSIONS

The main contaminants found in the water samples analyzed are presented in Table 1, namely total aluminum, total arsenic, total barium, total lead, total iron, total manganese, turbidity and total zinc.

Table 1 - Main water contaminants from the assessed boreholes/wells.

Parameter	Unit	Minimum	Quartile 25	Media	Median	Quartile 75	Maximum
Aluminum Total	µg/L	1.00	1.37	181.72	20.00	135.00	177,000.00
Arsenic Total	µg/L	0.50	1.00	1.48	1.00	1.00	57.00
Barium Total	µg/L	1.00	11.90	58.41	29.70	70.10	2,230.00
Lead Total	µg/L	0.50	1.00	5.66	2.26	10.00	1,890.00
Color	CU	5.00	5.00	24.84	10.00	15.00	5,000.00
Iron Total	µg/L	1.00	35.25	1,376.23	100.00	908.75	95,600.00
Manganese Total	µg/L	1.00	4.35	81.71	20.00	71.10	11,400.00
Turbidity	NTU	0.10	0.39	16.31	1.83	12.98	6,050.00
Zinc Total	µg/L	1.00	5.40	276.84	20.00	104.50	37,600.00

Seeing these results, the following technologies were compared in terms of their socioeconomic performance: dead-end ultrafiltration (UF), zeolites, ion exchange, and activated carbon. They were chosen according to the contaminants in the water. For example, metals and particulate materials suggest the installation of zeolites combined with an activated carbon filter. Also, a major challenge meeting the bacteriological parameter, particularly due to the limitations of area for the implementation of the treatment system, which reduces the contact time with the disinfection agent. The final course of treatment consisted of combining these technologies with chlorination.

In order to compare these course treatments, the main operation costs and ease of operation related to the water treatment by zeolites and chlorination are presented in Table 2.

Table 2 - Costs and operation of the final course of treatments.

Water treatment technologies	**Operation and maintenance cost (R$/m³)**	**Ease operation**
Zeolites/Activated carbon + Chlorination	R$ 0,64	Fully automated, including backwash
Ultrafiltration + Chlorination	R$ 9,49	Partially automated, requires proper membrane storage and cleaning
Ion exchange + Chlorination	R$ 1,30	Fully automated, including backwash

From the results shown in Table 2, conventional treatment, composed of zeolites, activated carbon, and chlorination has the lowest operating and maintenance costs and is an easy-to-operate system. For this reason, this system was chosen as technically and economically more adherent for water treatment in rural communities.

REFERENCES

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