# Characterization of adsorbents obtained from sludge from a water treatment plant

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**Highlights:**

**Water quality depends on the physical, chemical, and biological properties of water sources, influenced by natural conditions and human activities**

- **Chemical coagulants, such as PAC, $Al_2(SO_4)_3$, and $FeCl_3$, have the drawback of producing non-biodegradable sludge.**
- **Brazilian regulations require proper disposal of sludge, but 50% is discharged into rivers and the rest is disposed in landfills.**
- **The obtained adsorbent proved to be effective in removing methylene blue as a model contaminant.**
- **Transforming water treatment sludge into adsorbents shows promise for sustainable waste management and environmental protection.**

**Keywords: Sludge; adsorbent; water treatment**

## INTRODUCTION

**The process of water treatment typically includes coagulation, flocculation, decantation, and filtration, which generate residues, particularly in the decanters and filters(1).**

**The coagulants used in this process, such as poly-aluminum chloride (PAC), aluminum sulfate, and ferric chloride, play a crucial role in removing suspended particles from the water by agglomerating them into larger flocs that can be easily separated. However, the use of chemical coagulants also has disadvantages, such as the generation of non-biodegradable sludge that requires specific disposal methods(2–4).**

**In Brazil, more than 50% of the sludge generated in water treatment plants is disposed of in bodies of water, while the rest is disposed of in landfills(2). The sludge generated in water treatment plants is classified as solid waste (Class II A - Non-inert) and must comply with Law 12,305/2010 and NBR 10,004/2004. This law considers reuse and recycling as priorities in waste**

**management, and sludge containing aluminum and iron can be used in the production of mortar and ceramic materials (2,5).**

**The use of waste from water treatment plants, such as sludge, has gained increasing interest in the search for sustainable and economically viable alternatives. The production of adsorbents from sludge has been identified as a promising alternative for sectors such as the textile industry and wastewater treatment stations, demonstrating significant potential for the sustainable management of waste (6–8).**

**In this sense, sludge can be effective in removing impurities, water treatment and the reduction of environmental pollution. Hence, application of sludge therefore presupposes that all drinking water quality standards are met. Studies have reported that adsorbents derived from sludge have been used to treat water samples and that monitoring of water quality parameters (hardness, alkalinity, pH, residual aluminum, and fecal and total coliform bacteria) did not raise health concerns. Regarding the possible release of heavy metals (Pb, Mn, Cr, Ni, Zn and Cd) from the sludge, which can contaminate the treated water, it was found that these levels are below those recommended in international standards. (9,10).**

**Finally, the cost of adsorbent preparation can be determined based on the cost of raw materials and the chemicals used to process them. Other cost factors include adsorption capacity, selectivity, operational cost, and adsorbent degradation rate. Due to the characteristics of composition, abundance and lack of acquisition cost, the use of WTS as an adsorbent for removing aqueous pollutants is a very promising alternative (11,12).**

## METHODOLOGY

**The study was conducted at the Water Treatment Station (ETA) of Maringá, Paraná, which treats approximately 1400 L/s of water from the Pirapó River for the city's supply. The treatment process includes coagulation, flocculation, decantation, filtration, disinfection, and fluoridation, with the use of poly aluminum chloride (PAC) All paragraphs are set with no indent but justified. This section should describe the crucial aspects of the material and methods.**

**The waste sludge was collected from the decantation tanks and subjected to various treatments, including drying, maceration, and sieving, to obtain a fine powder. The powder was then calcined in a muffle furnace at 550°C to produce the final adsorbent material, named R-ETA550. The study characterized the waste sludge and the obtained material in terms of total solids, fixed and volatile solids, and surface charge. The surface charge was determined by the point of zero charge (pHpzc) method, which involves preparing solutions with different initial pH values and measuring the final pH after 24 hours of agitation. The obtained material were also characterized by XRD.**

**The adsorption experiments were conducted in batch mode, with different concentrations of methylene blue and adsorbent mass. The nitrate adsorption capacity was also evaluated using 0.1 g of adsorbent, $NO_3$-N concentration of 20 mg/L at pH 4, 7, and 10. Furthermore, the manganese**

**ion adsorption capacity was assessed using a solution at 0.2 mg/L of Mn and 0.1 g of adsorbent at the natural pH of the mixture (around 8).**

**Leaching tests were carried out for the main components of the sludge (aluminium, iron and manganese) (13). 1 g of the adsorbent was added to 100 mL of water, placed in a stirred bath and stored at room temperature for 6 hours. The leached metals were determined by UV-Vis spectrophotometry.**

## RESULTS AND CONCLUSIONS

**The sludge collected from the Water Treatment Plant contained approximately 60% solid mass and 40% moisture. Within the solid fraction, 68.51% consisted of inorganic material, possibly composed of riverbed soil where the water originates, along with inorganic suspended solids and products used in water treatment processes such as coagulation and flocculation. Regarding the solid fraction of the sludge, 31.48% corresponded to organic matter present, originating from decomposing residues, organic pollutants, microorganisms, among others.**

**The R-ETA550 material showed a point of zero charge of 6.5, indicating that it has a positive charge at pH values below 6.5 and a negative charge at pH values above 6.5.**

**The parameter values, both for the Langmuir and Freundlich models, indicate that the data obtained for the methylene blue adsorption best fit the Freundlich isotherm. The calculated maximum adsorption of methylene blue on the R-ETA 500 adsorbent was qm = 2.917 mg/g. With a parameter RL = 0.5, it can be defined that the adsorption is favorable as the RL value is between 0 and 1. The parameter n represents the affinity of the adsorbent with the adsorbate, and the range of 2 to 10 is considered ideal. Therefore, the affinity between the adsorbent obtained from ETA residue and methylene blue (n=2.01) is considerably good. The surface area of the R-ETA550 material was found to be 27.78 mg/g, indicating its potential for water treatment applications. However, in order to adsorb nitrate and manganese, which are two contaminants found in groundwater in various regions of the planet, further studies are necessary, such as chemical activation of the adsorbent.**

**The leaching tests showed that, when properly prepared and used under optimal conditions, presented concentrations of leached metals that were within the levels permitted for drinking water**

**The study demonstrates the potential of using waste sludge from water treatment plants to produce adsorbent materials for water treatment. The R-ETA550 material showed good adsorption capacity for methylene blue, indicating its potential for removing pollutants from water. The study also highlights the importance of characterizing the waste sludge and the obtained material to understand their properties and behavior in water treatment applications.**

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