Mini Review

Open Access CrossMark

Evaluation of the use of biochar in the retention of textile effluents in alluvional soils

Volume 7 Issue 1 - 2024

Josielly Braz da Silva, Gisely Leite de Oliveira Silva, Luan Alves Furtad, Severino Martins dos Santos Neto, Artur Paiva Coutinho
Federal University of Pernambuco, Recife, Brazil

Correspondence: Josielly Braz da Silva, Federal University of Pernambuco, Recife, Brazil, Email josielly.bra@ufpe.br

Received: January 27, 2024 | **Published:** February 09, 2024

Introduction

Groundwater is the portion of water that remains underground, which can flow to the surface or be extracted through wells. This portion of water is essential for maintaining soil moisture and base flow in rivers, being responsible for perennialization during dry periods.[1]

One of the main humanitarian problems of the 21st century is water scarcity, even more so when it comes to semi-arid regions. Of all the water available in the world, 97% is salty, the remaining 3% is divided between atmospheric, surface, glacial and underground, however, the portion usable by the population is only 1%. Water availability corresponds to the portion of flow available for population use, being subject to temporal and spatial variations.[2,3,4]

The semi-arid regions of the Brazilian Northeast have climatic and geological characteristics that have direct impacts on the amount of freshwater available for human consumption.[5,6] The Alto Capibaribe region, located in Agreste Pernambucano, is characterized by long dry periods, low rainfall, low rainwater storage capacity and rivers with intermittent flow, having water during rainy periods and drying up during dry periods.[7] Therefore, the aquifers present in dry bed alluvium are an essential source of drinking supply for diffuse communities affected by drought.[8]

Combined with the climatic challenges of semi-arid regions, the uneven expansion of cities and the development of agriculture and industry have intensified the processes of environmental degradation, as emissions of large quantities of pollutants promote high rates of pollution.[8] Among these, it is worth highlighting textile effluents, which are characterized by highly toxic compounds that are difficult to degrade, which, if released into the environment, without due treatment, cause potential risks to human health.[9–11]

Wastewater treatment systems, before disposal into water bodies, are still a scarce practice in the Agreste region of Pernambuco, despite the fact that in the last two decades there has been greater awareness among local industries. According to,[12] in the mid-2000s, the Capibaribe River was known by the population as 'Blue River', due to the high concentration of dye in the water discarded, after dyeing in the jeans textile manufacturing process.

Textile effluents are responsible for a considerable portion of contamination of water bodies in the state of Pernambuco, mainly in the municipalities located in the region covered by the Textile Pole, which encompasses the cities of Caruaru, Toritama and Santa Cruz Capibaribe.[13] The indiscriminate release of these pollutants commonly occurs in dry riverbeds, which have mostly sandy soils, poor in nutrients and with low sorption capacity for these contaminants,[14,15] facilitating the transfer of these compounds to the alluvial aquifers.

The remediation of textile effluents is generally complex, essentially due to the presence of compounds such as dyes, whose high molecular weight structures, composed of groups such as carbonyl, methine, amine, sulfonate and hydroxyl, make the process of removing these pollutants difficult. Therefore, it is necessary to remove the color and break down these molecules in order to generate simpler compounds. Therefore, evaluating the appropriate remediation technique, taking into account aspects such as greater savings and less generation of secondary products, has great relevance in efficiency and environmental recovery.[10,4,16]

Several remediation technologies have been applied to remove contaminants from groundwater, among which the use of biochar stands out. This is a solid product, produced through the thermochemical conversion of biomass, through the pyrolysis process, with a limited supply of oxygen, at temperatures between 300ºC and 700°C.[3,7] The resulting product, rich in carbon, has a high specific surface area, a large number of active sorption sites and a porous structure. In addition to the low production cost, biochar can be reused through desorption treatment, which makes it a potentially competitive material in the field of bioremediation.[17,18]

Therefore, the need to find ways to mitigate environmental degradation, caused by inadequate disposal of textile effluents, makes the use of biochar, as an additive to improve the properties of sandy soils, an option to retain these pollutants leached through layers of alluvial soils, characteristic of the region, through the adsorption of these substances.

In the current context, where textile activities are developing more every day and are responsible for a considerable portion of the Gross Domestic Products (GDP) of the municipalities that make up the Clothing Hub of Agreste de Pernambuco, the problems resulting from this production chain must be mitigated through prevention and protection measures for ecosystems and quality of human life.

Therefore, the use of innovation from recent research, such as the use of biochar to maximize the adsorptive capacity of alluvial soils in order to adsorb effluents with high contaminant loads, such as heavy metals and textile pigments, presents itself as a possible alternative efficient, practical, low-cost and accessible for implementation in locations with high levels of contamination.

Therefore, there is a need for studies that analyze the retention and mobility of textile dyes, through characterization and qualitative-quantitative tests so that they can evaluate the behavior and effects of the deposition of textile contaminants in the soil, analyzing the effect of the natural adsorptive capacity. and the influence of the addition of biochar, thus evaluating the risk of contamination of underground aquifers by the leaching of textile contaminants. Since, in semi-arid regions, such as the upper Capibaribe in the Brazilian Northeast, they suffer from water shortages and require preservation and continuity of existing water sources.

Systematic review

From the perspective of groundwater management, the preservation and mitigation of impacts on underground aquifers is essential for the maintenance of these important reserves, essentially in semi-arid regions.[19] The northeastern semi-arid region is one of the most populous in the world, with only three rainy months per year, a temperature range of around 5ºC, with higher temperatures during the day and milder temperatures at night, with high rainfall variability, marked by heterogeneous landscapes is inhabited by around 23.5 million people.[2,5]

Semi-arid regions have high rates of surface water evaporation, around five times greater than precipitation, leading these locations to a considerable water deficit and vulnerability of local inhabitants.[2] Therefore, the use of low-cost strategies, such as biochar, capable of increasing the adsorptive capacity of sandy soils that store water reserves in depth is essential for maintaining these water sources. Furthermore, the production of biochar does not require high investments, as it is essentially produced from organic substrates coming from some type of biomass.

Biochar, when applied mixed into the soil, works as an additive that improves the properties of the material, but it can also be applied as a uniform layer, functioning as a filtering barrier that retains unwanted substances. Furthermore, it can be used in the manufacture of low-cost biofilters, enabling home use to filter water collected in wells, which are often consumed without adequate treatment, as they are the best quality water available in rural communities. Biochar is a low-cost adsorbent, which generally has characteristics capable of increasing the adsorption capacity of alluvial soils, promoting the retention of contaminants in soil layers, preventing underground water reserves from being contaminated.

According to,[7] biochar is a solid product of the thermochemical conversion of biomass carried out at temperatures above 300 °C in the absence of oxygen, defined as pyrolysis. Biochar is not pure carbon, but rather, it consists of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulfur (S) and ash.

Pyrolysis is the first stage of combustion, during this process the polymeric components of biomass go through processes of "crosslinking, depolymerization and fragmentation" according to the different temperature ranges to which they are subjected. Initially the process forms condensable volatiles, non-condensable volatiles and carbon. The characteristics and composition of biochar depend on density, particle size, humidity, pH and the pyrolysis reaction.[3,7]

It is worth noting that the production of biochar is distinct from the production of charcoal and charcoal, although they are all produced by heating carbon (C), pyrolysis. Biochar is produced from the thermal decomposition of biomass with a limited supply of oxygen (O_2) and at temperatures below 700 °C.[3]

According to ,3 biochar is derived from a variation of biological components, which, due to complex chemical reactions during the thermal production process, presents a heterogeneous structure even when analyzing a single product. Thus, biochar is a carbonaceous material produced with the specific purpose of being applied to the soil for agronomic or environmental purposes, presenting a unique chemical composition.

Currently, biochar has been widely requested due to its ability to retain nutrients in the soil, retain water and store carbon in a sustainable way. Several types of biomass are suggested for the production of biochar, such as: agricultural and forestry residues, the organic part of urban solid waste and animal manure. However, the choice of the appropriate type of biomass depends on the chemical composition, environmental, economic and logistical factors.[7]

The properties of biochar's chemical composition influence the sorption of aqueous materials, filtration of percolated water and changes soil properties. Understanding these changes is essential to guarantee the quality and integrity of the modified subsystem. Furthermore, biochar has the capacity to sequester carbon, which favors the reduction of greenhouse gas emissions from the soil.[3,7,11]

Thus, biochar is used in agriculture, mainly in soil improvement, contributing to carbon sequestration and also to improve the properties of poor sandy soils. Its properties depend mainly on the type of biomass used in the pyrolysis process of its production, and negative effects may occur in its use, it will not always act in increasing soil nutrients and CO_2 production , sometimes presenting unfavorable consequences in its application.[11]

Conclusion

With the development of careful studies, it is possible to produce a biochar so that its pyrolysis is adequate, resulting in a heterogeneous material with elemental groups capable of favoring the adsorption process. With the analysis of transmittance spectra, the functional groups that will compose the final product are identified and evaluated through FTIR and XRD tests. So, it is possible to pre-determine the satisfactory behavior, or not, of biochar when applied to the soil and placed in contact with the contaminating solution.

Through characterization tests, the properties of the evaluated soil are described, demonstrating its potential for retaining fluids percolated by soil masses. Furthermore, the development of a careful bibliographical review makes clear the water importance of alluvial aquifers for the semi-arid northeast, highlighting the need to preserve and maintain the quality for consumption of these water sources.

However, there is an evident need to mitigate the harmful impacts of inappropriate dumping of textile effluents from the industries that make up the Agreste de Pernambuco Clothing Hub, which, on the other hand, have a great economic representation for the Alto Capibaribe region. In this way, the addition of biochar as a retention layer or soil improvement additive promotes bioremediation of impacts caused to the region's waters and soils, promoting the maintenance and preservation of dry-bed alluvial reserves.

Furthermore, through the use of modeling software it is possible to determine the hydro dispersive parameters, with the injection of a non-reactive solution, and transport, the injection of a reacting solution, through the analysis of solute transport by testing in soil columns. In this way, it is feasible to define the intrinsic characteristics of the researched soil, its behavior when biochar is added and how it reacts to contact with the coloring solution.

Acknowledgments

None.

Conflicts of interest

Declare if any conflict of interest exists.

References

1. Manzione RL. Águas Underground. 1st Ed, Paco Editorial; 2015.
2. Pedde S, Kroeze C, Rodrigues. LN Water scarcity in South America: current situation and future perspectives. XX Brazilian Symposium on Water Resources. 2013.
3. Victorino CJA. Planet water dying of headquarters: an analytical view on the methodology of water resource use and abuse. Edipucrs.
4. Cruz JC, Tucci CEM. Estimation of water availability through the retention curve. *Brazilian Journal of Water Resources*. 2008; 13(1):111–124.
5. Marengo JA, Alves LM, Beserra EA. Climate variability and changes in the Brazilian semi-arid region. Water resources in arid and semi-arid regions. 2011;1:385–422.
6. Usman M, Liedl R, Kavousi A. Estimation of distrubuted seasonal net recharge by modern satellite data in irrigated agricultural regions of Pakistan. *Environmental Earth Science.* 2015;74:1463–1486.
7. Durigan MAB, Vaz SR, Peralta Zamora P. Degradation of emerging pollutants by fenton and photo- fenton processes. New Chemistry. 2012;35:1381–1387.
8. Maiti S, Sinh SS, Singh M. Microbial decolorization and detoxification of emerging environmental pollutant: Cosmetic hair dyes. *Journal of hazardous materials*. 2017;338:356–363.
9. Gadekar MR, Ahammed MM. Use of water treatment residuals for colour removal from real textile dye wastewater. *Applied Water Science*. 2020;10(7):1–8.
10. Araujo FVDF, Yokoyama L, Teixeira LAC. Color removal in reactive dye solutions by oxidation with H2O2/UV. *New chemistry*. 2006; 29(1),11–14.
11. Santos VL, Silva PT, Silva RF, et al. Evaluation of the Fenton solar process in the treatment of effluent generated by a jeans laundry in Pernambuco. In: Embrapa Semiarid-Article in conference proceedings (ALICE) . In: Brazilian Congress Of Chemical Engineering, 19., 2012, Búzios. Anais. São Paulo: Brazilian Association of Chemical Engineering, 2012.
12. Lima JRS, Silva WM, Medeiros EV, et al. Effect of biochar on physicochemical properties of a sandy soil and maize growth in a greenhouse experiment. *Geoderma*. 2018;319:14–23.
13. Rebouças AC. Water in the Northeast region: waste and scarcity. *Studies Advanced*. 1997;11(29):127–154.
14. Lim SL, Chu WL, Phang SM. Use of Chlorella vulgaris for bioremediation of textile wastewater. *Bioresource Technology*. 2010; 101:7314 – 7322.
15. Christie R. Color chemistry. 2nd Edition. Cambridge, UK: The Royal Society of Chemistry. 2015.
16. Tahir U, Yasmin A, Khan UH. Phytoremediation: Potential flora for synthetic dyestuff metabolism. *Journal of King Saud University Engineering Sciences*. 2016;28:119–130.
17. Brown R. Biochar production technology. In: Biochar for environmental management. Routledge, p. 159–178, 2012.
18. Duku MH, Gu S, Hagan EB. Biochar production potential in Ghana —a review. Renewable and Sustainable Energy Reviews.2011;15(8):3539–3551.
19. Prevot A, Ginepro M, Peracaciolo E, Zelano V, et al. Chemical vs bio-mediated reduction of hexavalent chromium . An in-vitro study for soil and deep waters remediation. *Geoderma.* 2018;312:17–23.
20. Liu C, Fiol N, Villaescusa I, et al. New approach in modeling Cr(VI) sorption onto biomass from metal binary mixtures solutions. *Sci Total Environ*. 2016;541:101–108.
21. Braga RAP; Silva S, Barbosa I, et al. Águas de Areias. Recife: ANE. 2016;277–303.
22. Cirilo JA, Cabral JJSP, Ferreira JPCL, et al. The sustainable use of Water Resources in Semi-Arid Regions. Recife-PE: UFPE University Press. 2007;508p.