Using Rice Husks in Water Purification in Brazil

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Abstract

Rice husk, which is considered a waste, has a high level of silicon. This paper investigates the use of carbonized rice husk in water purification. The carbonization was done using a handmade carbonizer. The preparation process starts with the production of a precursor that is rich in carbon through the pyrolysis of the rice husk in an inert atmosphere. The results show an important contribution of the use of carbonic materials, by giving a direct evidence of the permanence of sodium ion $\text{Na}^+$ in activated carbon. The results also show that the utilization of carbonized rice husks in the purification of water is quick, efficient and economically viable.

Keywords

Silicon, Carbonized, Inert Atmosphere, Precursor

1. Introduction

Brazil is in a privileged situation in relation to water availability; however, about 70% of the country’s fresh water is found in the Amazon region, which is inhabited by less than 5% of the population. The idea of abundance served for a long time as a support for the culture of wasting available water, the devaluing of it as a resource and putting off of the necessary investment for the optimizing of its use. The problems of water scarcity in Brazil fundamentally come from the combination of the exaggerated growth of localized demands and the degradation of water quality. This picture is the consequence of disordered urbanization processes, industrialization and agricultural expansion [7].

Analyzing public water supply quality is very important. The main indicators of water quality are segmented in its physical, chemical and biological characteristics. These indicators determine the level of treatment needed to be appropriate for consumption according to national standards.

The treatment of water, meanwhile, implies the use of chemical substances which may affect the health of the workers. These chemicals may pass through a series of physical and chemical changes, including the combination with other chemical compounds, being capable of intensifying or diminishing the toxicity for human beings and living organisms. Therefore, analyses are needed to determine the ideal concentration of these products such as the analyses of pH, conductivity, total dissolved solids, color, turbidity, and hardness are carried out.

All surface water varies in quality throughout time and rain regime. Every method of water treatment has a limited efficiency since each method assures a percentage of the reduction of existing pollution. The degree of pollution may, however, make a determined type of treatment unsatisfactory. One of the stages of water treatment is filtration by activated carbon, which has the capacity to selectively collect gases, liquids or impurities in the interior of its pores, presenting, therefore, an excellent power in clarifying, deodorizing and purifying liquids or gases. Activated carbon is obtained
through the controlled burning with a low level of oxygen of porous materials such as wood, corn cobs, coconut husks and rice husks, the latter the objective of our work in water treatment. According to [3], the husk and straw from rice are basic materials of low cost, normally considered to be difficult in reuse due to its negative characteristics, such as abrasiveness, resistance to degradation, the great volume occupied, low nutritive properties and high level of ash. 

Agriculture cultivation in Brazil uses controlled irrigation systems, where the culture is carried out in systematized floodplains. Planting starts in dry soil with irrigation, until the start of tilling, when it definitively enters the blocks. Cultivation may also be carried out without irrigation control in the humid floodplains. About 40% of the total area of cultivated areas in Brazil gives about 60% of the national production, which is due to its high level of productivity (around 5.5 ton/ha). The environmental question, with the necessity of minimizing the global emissions of CO$_2$, is a favorable point for the use of biomass, since when this is burned, CO$_2$ is released into the atmosphere; however, the plants absorb this gas during their photosynthesis.

Brazilian agricultural production has a large production of residues, and thus the reuse of these residues is presented as a relevant question in the Brazilian scenario. These residues have been studied to assess their potential in water treatment in order to lessen the environmental impact of these residues. Rice husks are used a filtration material after carbonization. This paper studies the utilization of carbonized rice husks (CRHs), which are rich in fixed carbon, like activated charcoal has that the capacity to purify water. The purification system and be done building a carbonizer to burn rice husks and installing a filter for the filtration system. The carbonized rice husks possess high-energy power, since they are composed of organic material and silica, which in its part eliminates color and odor, and removes dissolved organic substances. The main objective of this paper is to verify the viability of the energetic reuse of carbonized rice husks in water purification.

Rice husk is a biomass material formed of polymers identical to those of wood, whose abrasive hardness is a typical characteristic of materials with a higher quantity of lignin. This material possesses a quantity of inorganic material, around 15-20% of the material’s mass, where SiO$_2$ is responsible for around 95% of this total. Some oxides are also present in lesser quantities than 1% of the mass, such as Al$_2$O$_3$, CaO, AgO, K$_2$O, MnO, Na$_2$O and P$_2$O$_5$ [2, 11]. Black rice husk ash (BRHA) was used as an Adsorbent for Purification of Water Basins Polluted with Diesel Fuel [1]. It also has been used for the Purification of Oil-polluted Sea Water [12].

The rice husks are carbonized and used as a substrate in beds or recipients in the germination of seeds and formation of cuttings from higher vegetables, permitting the penetration and exchange of air at the base of the roots; and being sufficiently firm and dense to fix the seed or stake; it has a dark coloration, being opaque to the light at the base of the stake; it is light and porous, permitting good aeration and drainage; it has a constant volume whether dry or humid; it is free of weeds, nematodes and pathogens; it does not need chemical treatment for sterilization, the reason being that it has been sterilized by the carbonization. The substrate of carbonized rice husk presents the following physical and chemical characteristics: dry density 150g/L, capacity for water retention of 53.9%, capacity for exchange of cations of 5.5 meq/dL, pH in water of 7.4, level of soluble salts of 0.7 g/L, 0.7% of nitrogen, 0.2% of phosphorus and 0.32% potassium [10]. The calorific power of rice husk is approximately 16,720 kJ/kg. The physical and chemical properties of the carbonized rice husk vary with the increase in temperature; for example, on raising the temperature of the process, it becomes more friable and less hygroscopic [4]. Carbonization is a thermal decomposition which occurs at a temperature above 500°C and which eliminates non-carbon species, producing a fixed and porous mass of carbon, generally in an inert atmosphere (with the presence of nitrogen and the absence of oxygen) [9]. Activated carbon is that which is treated with oxygen to open thousands of tiny pores between the carbon atoms. “The use of special techniques of fabrication results in highly porous carbons with areas of from 300 to 2,000 m$^2$ of surface per gram. These so-called active or activated carbons are widely used to adsorb odiferous or colored substances in gases or liquids”. In adsorption, the molecules of one substance are fixed to the surface of another substance. The enormous surface area of activated carbon gives it various places for bonds. When certain chemical substances pass near to the carbon surface, they are united to this surface and imprisoned. The activated carbon is good in imprisoning other impurities, which have carbon as a base (chemical organic substances), as well as substances such as chlorine. Many other chemical substances are not attracted by carbon (sodium, nitrates, etc.), passing directly by it. This means that a filter of active carbon will remove certain impurities, but ignore others. Another manner of approaching this description is as made by [5, 6], in quoting that the activated carbon produced is known to be a porous material of high specific superficial area, representing one of the most important groups of adsorbents from the industrial point of view. This type of material possesses attractive adsorbent qualities which have been utilized for the purification and elimination of toxic components in the liquid and gaseous states, as well as used in reactions of catalysis. Due to the progressive degradation of the environment, it is
hoped that activated carbon comes to play an important role in the reduction of pollutants.

2. Material and Methods

Rice husks produced in the city of Russas, CE, were used in the research. For the carbonization of the husks, a carbonizer was created using a 3-litter tin, a drilling machine with a 4mm drill and a carbon steel tube of approximately 0.5m length and 1.5". Using a can opener, the edge of the tin where the lid rests is removed, and then a hole is made in the bottom of the tin the size of the internal diameter of the tube, which represents the chimney. Finally, using the drilling machine, hundreds of holes are made in the can (Figure 1).

![Figure 1. Carbonizer.](image1)

The carbonizer was allocated on top of cotton waste, which is impregnated with kerosene, and fire is lit on the same. Soon after, 2 kilos of rice husks were dumped on the carbonizer, covering it in a way in which no cracks remained. After about 20 minutes, the carbonization began. Afterwards, the husks were spread out to cool and stored in plastic bags. Figure 2 shows the rice husks during and after carbonization.

![Figure 2. Rice husks before and after carbonization.](image2)

In the preparation of the filter, a local filter was bought. In the middle of the same, a piece of 0.5" flexible hose of approximately 12cm was placed, going near to the bottom, substituting the original filter. Two nipples or beaks were threaded scaled in the entrance and the exit of the filter for the placing of the hoses (0.5" x 1.5mm). For safety, a clamp was placed on each hose (Figure 3).

![Figure 3. The preparation of the filter.](image3)

Then the filter was filled by sand (0.7-1.3mm) and carbonized rice husks in 1:1 proportion, where 125mL (217g) of fine sand (0.7 to 1.3mm) were mixed with 125mL (14g) of carbonized rice husks and placed in the filter. This quantity was sufficient for the flexible hose or the PVC tube to be in contact with the filtering material (around 5 to 7cm). The “exit” hose was connected to a water tap from untreated source (well). Figure 4 shows the filtering system in operation.

![Figure 4. Filtration system.](image4)
Waters coming from the well and from the filtration were collected and stored in PET bottles and analyzed physically and chemically in the laboratory. The parameters were estimated and analyzed by the following methods:

- **pH**: electrometric method;
- **Conductivity**: electrometric method;
- **Total dissolved solids**: electrometric method;
- **Color**: spectrophotometric method;
- **Turbidity**: spectrophotometric method;
- **Hardness**: titrimetric method.

### 3. Results and Discussions

According to this research, it was clearly observed that the removal of color and odor was directly after the passing through the filtration bed (sand + carbonized rice husks). Figure 5 shows the differences between water quality before and after filtration.

![Figure 5. Water quality before and after filtration.](image)

More analyses were carried out immediately after passing through the filtering bed. Analyses include physical and chemical parameters of the well water before and after filtration. Table 1 presents the main water parameters that had been analyzed.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Before filtration</th>
<th>After filtration</th>
<th>National standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>6.99</td>
<td>7.01</td>
<td>6.0-9.0</td>
</tr>
<tr>
<td>Conductivity</td>
<td>uS</td>
<td>780</td>
<td>793</td>
<td>1000</td>
</tr>
<tr>
<td>TDS</td>
<td>ppm</td>
<td>476</td>
<td>479</td>
<td>1000</td>
</tr>
<tr>
<td>Color</td>
<td>Pt/Co</td>
<td>&gt; 550</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>391</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Hardness</td>
<td>mg/L</td>
<td>82</td>
<td>72</td>
<td>500</td>
</tr>
</tbody>
</table>

According to the national standards, the Brazilian Ministry of Health [8], pH level has an acceptable level of water supply (6.0 - 9.0). The pH of water before the treatment presented a small variation due to the fact that pH in natural waters is near to neutrality if there is no direct contamination. The small increase in pH after treatment is due to the removal of fulvic and humic acids, which have an intense color and can be found in the soil. The electric conductivity of the water shows a small increase after the treatment. This parameter indicates the presence of salts dissolved in the water, which is proved by the small increase in the total dissolved salts parameters. As shown in Table 1, there was a considerable reduction in color and turbidity of the well’s water after treatment. The color in the water for human supply is generally due to the presence of colored organic material in the soils, which is principally composed of fulvic and humic acids. Table 1 shows that a considerable reduction of water color from 550 to 13 Pt/Co in the water treated by the filter. Levels below 15 Pt/Co are generally acceptable by consumers. The turbidity of the water is due to the presence of particulate material in suspension in the water, such as finely divided organic and inorganic material, phytoplankton and other microscopic organisms, passing from 391 NTU to 4 NTU. Turbidity values around 4 NTU are generally imperceptible visually. According to the national standards, the turbidity of 5 NTU is acceptable to consumers. However, according To WHO, 1 NTU is recommended.

To conclude, the treated well water by the carbonized rice husks is acceptable for drinking purposes according to national standards, the Brazilian Ministry of Health [8], Table 1.

### 4. Conclusion

In this paper, a new technique for using activated carbon that is embedded in rice husks was created and used. The created filter has shown good results regarding water purification process. The filter was quite successful, with the visible reduction of color and turbidity. It may be a substitute for industrial activated carbon. The use of this technique creates a possibility of offering a contribution to the current investigations on the mechanism of the use of carbonaceous materials. Moreover, the possible use of primary materials, which considered residuals and wastes in the agricultural industry, possesses implications of interest as much economic as environmental since it is already evident that its appropriate use will benefit the sustainability and the process of environmental conservation. Consequently, it would be a big mistake of a noble primary material to consider it a waste instead of a source, since it may be used in various industrial branches such as water purification.

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References


