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Wastewater Treatment Trial by Double Filtration on Granular Activated Carbon (GAC) Prepared from Peanut Shells

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Abstract

The aim of this work is the purification of wastewater by double filtration on granular activated carbon prepared from peanut shells. The samples of carbonized peanut shells were activated with 35% sulfuric acid and finally, we proceeded to the purification tests on double filtration of wastewater. Granular activated carbons (GAC) were very effective for the treatment of turbidity, dissolved oxygen, suspended solids, iron, COD and BOD5 but the best results were observed with nitrite, nitrate and phosphate. However, the second filtration was the most efficient while the lowest rates were observed for pH (17.91% on average), and conductivity (29.71% on average). In addition, this work has allowed increasing the dissolved oxygen by more than 50.16% at the exit of the first filter and more than 105.36% at the exit of the second filter. This study shows that granular activated carbon prepared from peanut shells could be a credible alternative for developing countries in the control of pollution and environmental protection.

Keywords

Wastewater Treatment, Activated Carbon

1. Introduction

Man's technical progress has an impact on the environment. The action of man on his environment is such that the life of man on our planet is under threat of extinction [1]. Chemistry, materials and the processes associated with them are sources of environmental damage and must innovate strongly with technical solutions and rational use of raw materials. Thus, the progress of chemical processes

brings enough negative consequences to the environment [2].

Disasters such as Seveso (1976), Jilin (2005), AZF France plant (2001), Metaleurop Nord (2003) and most recently in September 2019, LUBRIZOL (France) have contributed to the bad reputation of the chemical industry, which needs to forge a new ethic in the context of sustainable development. It is therefore urgent to design processes that take into account the issues related to the use of reasonable and balanced ways of natural resources that can be recycled, in order to ensure harmonious coexistence of man and nature, and also to adapt technological solutions that are more respectful of the environment by integrating recycling techniques for sustainable development, since the urgency of safeguarding the environment and sustainable development are at the origin of the rise of the concept of "green chemistry" [3].

In this increasingly restrictive environmental context marked by the production and diversification of waste, the control or reduction of wastewater pollutant discharges into nature through the recovery of more environmentally friendly materials is a current issue. The quality of water, whether it is intended for human consumption, for irrigation or simply discharged into nature, into rivers, oceans or the ground, has become a major problem and a major concern for public authorities, bodies and organizations [4].

The physico-chemical properties of water are certainly one of the main conditions that allowed the birth of life billions of years ago, but due to its irrational use by man, it is undergoing serious aggression with the degradation of its qualities, thus undermining its role as a guarantor of life [5].

The sudden and massive discharge of waste into the natural environment has led to the appearance of many risks for the balance of the natural environment and ecosystems, but also for man himself, who is the producer of this waste and instigator of this great imbalance [6].

This fact should therefore stimulate and encourage the improvement of de-pollution techniques and the development of new processes that allow meeting and complying with the increasingly restrictive international standards. Different techniques have been used for the elimination of certain soluble pollutants in industrial or domestic effluents. They are different from each other and include adsorption, electrolysis, flotation, precipitation, ion exchange, extraction and membrane filtration.

Of all these possibilities, adsorption with activated carbons can be a simple, selective and economically acceptable alternative for the treatment of wastewater pollution [7], especially for developing countries. Activated carbon is a material composed mainly of carbonaceous material with a porous structure. Due to this porosity, the surface developed by activated carbon is important and can reach more than 1500 m^2 per gram of activated carbon [8]. Activated carbon can be produced from different materials such as peanut shells.

Activated carbon is one of the most widely used adsorbents worldwide in the treatment of water and aqueous waste. It can be said that coal, without activation, was used by Scheele in 1773 in the treatment of gases. It was also used in

natural coal to decolorize aqueous solutions in 1786 and was responsible for carrying out the first quantification of the adsorptive power of coal in the liquid phase. Commercially viable activated carbon appeared in the early 20th century with the Swedish scientist von Ostreijko, who obtained two patents in 1900 and in 1901. These patents contained the basic concepts of chemical and physical activation, the latter also called thermal [9].

Peanuts are one of the most important crops in Guinea in terms of economy and food. It is one of the country's cash crops, occupying 16.41% (160,632 ha) of the sown food crop area (978,662 ha), and is one of the most important crops in terms of contribution to food security and agricultural income generated by sales [10]. As a consequence, this crop produces huge solid waste that pollutes the environment. Thus, the valorization of these agricultural wastes (especially groundnuts) through the use of activated carbons for wastewater treatment in the Singuedala River is the objective of this work.

Specifically, it will be a matter for us:

- To determine some physico-chemical parameters such as pH, conductivity, turbidity, suspended solids, iron, nitrites, nitrates, phosphates, dissolved oxygen, COD and BOD5 of the Singuedala River waters;
- To carry out filtration tests on a double filter.

This will allow us to observe the effectiveness of the use of double filtration from this vegetable activated carbon for the treatment of the physico-chemical pollution of wastewater.

2. Material and Methods

2.1. Description of the Study Area

This study takes place in the prefecture of Mamou located 270 km from the capital Conakry between 10˚22'39.93"N and 12˚5'2.57"W at an average altitude of 700 m, with a climate characterized by the alternation of two seasons of equal duration, the dry season from November to April and the rainy season from May to October. Rainfall varies between 1600 mm and 2000 mm, with an average annual temperature of 25˚C. It covers an area of 8000 km^2 with a population of 318,738 inhabitants (2014) [11].

2.2. Material

For the realization of this work, the following equipment was used: a pH meter HANA HI 1832, a conductivity meter HANA LF 330, a spectrophotometer DR 2800, Oximeter Model DO210, a turbidimeter Hach 2100p, an analytical balance with a precision of 0.0001 g ADAM—Model NBL124i, a filtration ramp with funnels and filter holders, a vacuum pump.

2.3. Methods

2.3.1. Sampling

In total, we took one (1) sample from the level where the pollution is higher [12].

The sample was double filtered through granular activated carbon (GAC) activated with 35% sulfuric acid. For the determination of the parameters, three (3) tests were performed for each parameter. The results for each parameter thus represent the average found.

2.3.2. Preparation and Characterization of Activated Carbon CA

The coals obtained come from peanut shells from the Mamou prefecture. The coals were obtained by carbonization. After cooling, the charcoal was crushed to obtain the Grain Activated Carbon (GAC) and chemical activation was done with 35% sulfuric acid. Some characteristics of the carbon (iodine value, Methylene Blue value, activation rate, yield) were determined [13].

2.3.3. Analysis of Physico-Chemical and Microbiological Parameters of Treated Water

The physico-chemical parameters were measured as follows:

- pH with the pH meter HANA HI: 1832, conductivity with the conductivity meter HANA LF 330;
- Nitrites, nitrates, phosphates, iron, lead and zinc were measured with the spectrophotometer DR 2800. Dissolved oxygen was measured with the Oximeter Model DO210;
- Turbidity was measured with the turbidimeter Hach 2100 p; The microbiological parameters studied were Total and Fecal coliforms which were determined by the membrane filtration method.

3. Results and Discussion

3.1. Results

The graphs (**Figure 1**) below represent the results of the analyses for the physico-chemical parameters studied.

3.2. Discussions

3.2.1. pH

The determination of the physico-chemical parameters of the Singuedala River water in the town of Mamou (Guinea) allowed us to know that these waters are acidic (6.03). The double purification of activated carbon allowed us to observe a decrease of this value of 7.13% after the first filtration compared to the initial value and of 28.69% after the second filtration compared to the initial value. The increase in this rate during the second filtration could be due to the fact that the wastewater is less loaded when arriving at the filter. These rates are lower than those found during the double filtration on powdered activated carbon which was 29.39% and 48.77% respectively for the first and second filtration.

3.2.2. Turbidity

Determination of the turbidity of the Singuedala River waters showed that these waters have a turbidity of 5.45 NTU higher than the norm. These waters could thus harbor microorganisms indicative of animal or human pollution [14]. The

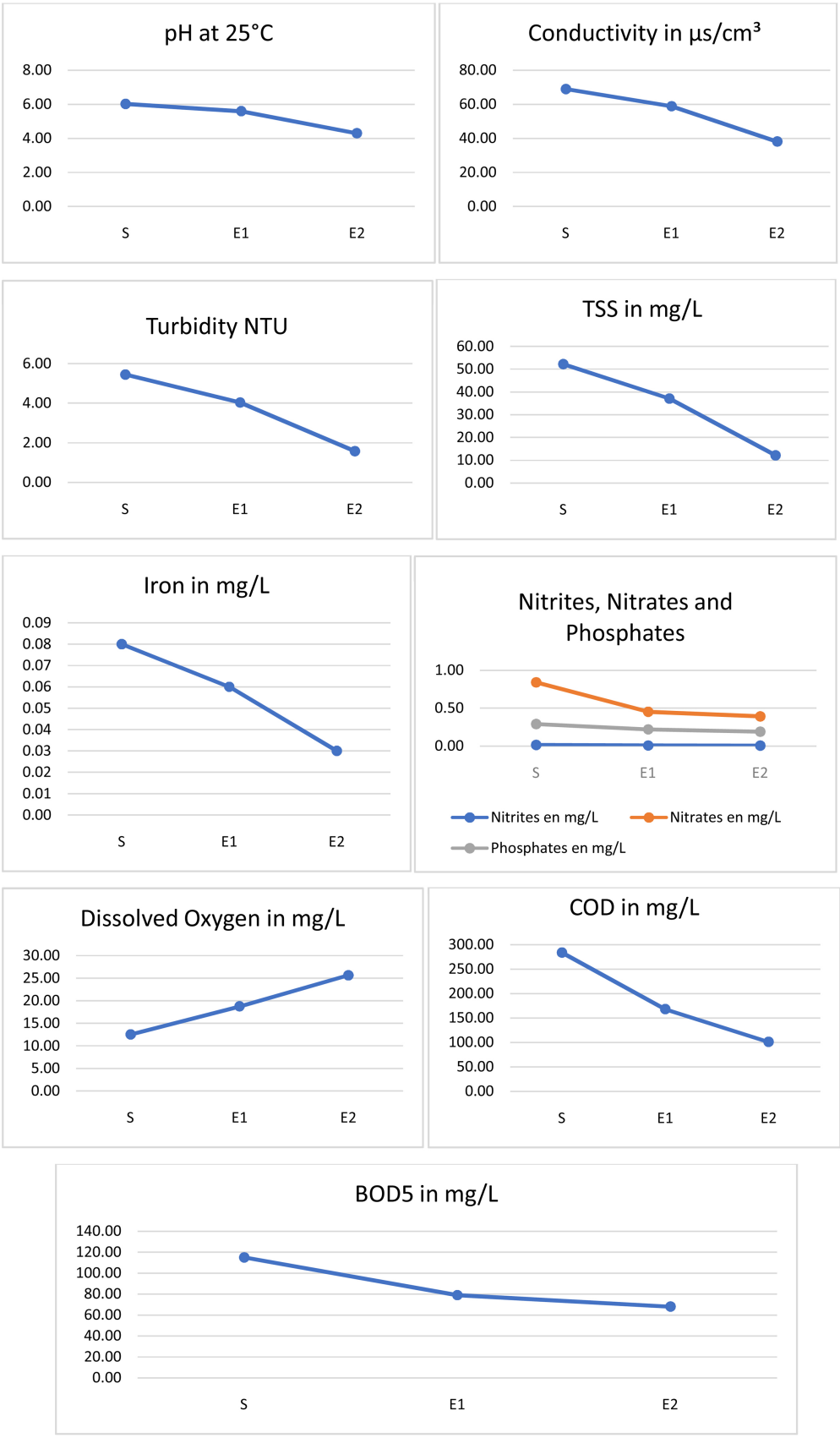

Figure 1. Results of physico-chemical parameters.

first filter reduced this turbidity by 25.97% and 71.01% for the second filter compared to the initial value, in contrast to the results obtained during the double filtration on powdered activated carbon of the Mamouwol River waters (66.89% and 80.81%).

3.2.3. Conductivity

The conductivity of the Singuedala River water was 69.00 mg/L. The double filtration of these waters on granular activated carbon allowed a lowering of this conductivity of 14.67% and 44.75% for the first and second filtration. These results thus confirm that wastewater treatment on activated carbon could be a credible alternative in wastewater management.

3.2.4. Suspended Solids (SS)

The determination of suspended solids in the Singuedala River shows that the water is very loaded (52.26 mg/L). The purification tests reduced this turbidity by 28.97% in the first filter and 76.75% in the second filter compared to the initial value of this turbidity.

The strong decrease (76.75%) observed at the second filter may be due to the fact that the impurity load decreased with the first filter.

However, these results are lower than those obtained during the double filtration of the Mamouwol River water on powdered activated carbon.

3.2.5. Nitrites, Nitrates and Phosphates

The analysis of samples before purification showed that the waters of the Singuedala River in the urban commune of Mamou are polluted by nitrites, nitrates and phosphates and those human activities are the main cause of this pollution [13].

Filtration on a double powdered activated carbon filter made it possible to obtain at the exit of the first filter a content decrease of 55.33% for nitrites, 46.43% for nitrates and 24.14% for phosphates. At the exit of the second filter, the water had a decrease of 64.00% in nitrites, 53.57% in nitrates and 34.48% in phosphates compared to the initial value.

3.2.6. Iron

The iron results for Singuedala River waters show that these waters are loaded with compliant iron (0.08 mg/l) and that this could be due to low erosion [14]. Double filtration on granular activated carbon resulted in a reduction of this value by 25.00% and 62.50% respectively for the first and second filter. These results are better than those found in the double filtration on powdered activated carbon of the Mamouwol River (12.50% at the outlet of the first filter and 62.50% at the outlet of the second filter).

3.2.7. Dissolved Oxygen

The quantity of dissolved oxygen (12.50 mg/l) shows a certain risk of pollution due to the oxidation reactions of mineral and/or organic matter. Thus, the waters of the Singuedala River are not suitable for aquatic life. The purification by

activated carbon has increased this quantity by 50.16% and 105.36% respectively for the first and second filtration. These rates are lower than those found during the double filtration of powdered activated carbon of the Mamouwol River (252.56% at the exit of the first filter and 426.49% at the exit of the second filter compared to the initial value).

3.2.8. COD and BOD5

The results of the determination of the chemical oxygen demand (COD) and the biological oxygen demand (BOD5) allow us to observe that the waters of the Singuedala River are polluted. The purification tests on granular activated carbon in double filtration allowed a reduction for COD of 40.85% and 64.44% respectively at the exit of the first and second filter. For BOD5, this reduction was 31.30% and 40.87% at the outlet of the first and second filter.

These results are consistent with those found in the study of adsorption and treatment of organic contaminants using activated carbon from bamboo waste in Nigeria [15] as well as those found by Catherine AYRAL for the Removal of aromatic pollutants by catalytic oxidation on activated carbon [16] and the results of Ibrahim Tchakala *et al*. The treatment of polluted natural water by adsorption on activated carbon (CAK) prepared from shea cake [17].

4. Conclusions

The results of the wastewater treatment trial by double filtration on granular activated carbon prepared from peanut shells allowed us to observe that:

- The waters of the Singuedala River in the urban commune of Mamou (Guinea) are polluted and the main source of this pollution is animal and human waste;
- GACs were very effective in treating turbidity, dissolved oxygen, suspended solids, iron, COD and BOD5, but the best results were observed with nitrites, nitrates and phosphates. However, the second filtration was the most efficient while the lowest rates were observed for pH (17.91% on average), and conductivity (29.71% on average).

This study allowed us to observe that powdered activated carbon (PAC) prepared from peanut shells would be a safe alternative for developing countries in the control of water pollution, and environmental protection by recycling agricultural waste. It has allowed us to obtain water that can be used for irrigation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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