

Research Article

Assessment of Sewage Water Treatment Using Grinded Bauxite Rock as a Robust and Low-Cost Adsorption

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The shortage of water resources in Saudi Arabia is becoming an increasingly serious problem. Management of sewage water is an attractive option to reduce the contamination of water resources such as ground water. This work aims to use bauxite rock as a low-cost adsorbent/coagulant for sewage water treatment in a simple and rapid technique. Different doses (1, 2, 3, 4 and 5 g/l) of the grinded bauxite was used as an adsorbent/coagulant. The results revealed that, at rock doses of 1, 2, 3, 4, and 5 g/l, the COD concentration was decreased from 326 to 134, 98, 83, 70, and 65 mg/l, respectively, while the BOD concentration was lowered from 243 to 196, 104, 71, 60, 51, and 47 for the same rock doses. This was reflected on the turbidity of the treated effluent from each treatment step. Also, the FC counts were reduced to 2 log units. Furthermore, the dose of 3 g/l of the grinded bauxite rock was found to be the least economic dose for the treatment of sewage water. Bauxite mineral has been used explicitly in a high-performance, very affordable method for wastewater treatment.

1. Introduction

As the population of the world grows and water resource problems keep making headlines, it has never been more essential to preserve water supplies to our maximum extent capacity and to make sure that the water at our disposal is clean and free from pollutants. Organic loads, nutrients, and pathogens contribute major threats in water resources. The removal of such contaminants in wastewater is one of the fundamental aims in waste management. A range of techniques were used for the treatment of various types of wastes to suitable standards [1, 2]. However, conventional waste treatment technologies are expensive. Consequently, several research efforts are running to develop low-cost treatment technologies appropriate in developing countries [2]. Furthermore, during the last few decades, stringent regulation of waste discharge into the environment is receiving wider attentions. To comply with these standards and preserve safe environment, it has become necessary to find some cost-effective treatment techniques. In order to achieve

cost-effective technologies, natural materials such as rocks and sands are widely applied in wastewater treatment for removing pollutants [3]. Several methods were established to remove hazardous substances from wastewater such as precipitation, reverse osmosis, ion exchange, and adsorption [4, 5].

Among all past strategies, adsorption using clay and other composite materials is regarded to be a particularly effective technique, mainly by using minimal-cost and economical methods to eliminate contaminants from industrialized wastewater and aqueous solutions [6–8].

Natural clay minerals and activated carbon with large removal capability are the most popular sorption approaches [9, 10]. Several studies centered on the use of low-cost, extremely efficient pollutant sorbents and also examined the sorption activities of several recycled materials and chemicals [11]. Most of these are clay composites [12], agricultural products, certain aquatic plants, and micro-organisms [11]. Many of these studies have already shown that natural materials are capable of acting as good adsorbents for hazardous contaminants like heavy metals [13, 14], while the kinds and quality of clay materials are also essential as they

are included in selecting which contaminants to address. Ali et al. [15] conducted the adsorption of harmful pollutants from wastewater applying natural zeolite. The results suggest that clinoptilolite removal for ammonium varied from 70 to 92 percent, whilst at different circumstances, it varied from 70 to 99 percent for heavy metals. Bhattacharya et al. [16] examined the adsorption performance of zinc from an aquatic environment with different adsorbents; the results obtained revealed that the percentage of zinc removal rised by raising the adsorbent dosage to achieve full adsorption at 98 percent and pH around 5 and 7 [17]. The adsorption of Cd^{+2} on the surface of nanomaterial based on wollastonite prepared with/without CuO was examined. The results showed that at optimum operating conditions (at pH 9), cadmium ions removal reached 98.88%.

Combined with the growing need for superior quality of water, a growing research for the use of low-cost materials as an adsorbent for water treatment will be an initiative that would be a serious environmental success. Therefore, the main aim of this study is intended to examine and evaluate the ability of certain metal ions to removal using bauxite rocks as natural and low-cost material for the treatment of water and sewage water in Saudi Arabia. The removal experiments were conducted and optimized in the laboratory using the original concentration of metal ions, solution pH, and contact time as variables.

2. Materials and Methods

2.1. Rock Samples. In the northeastern part of the city of Hail, 200 kilometers from the province of Baqa'a lies the village of Zubayra rich in bauxite ore, which is the basic raw material for the production of aluminum, where it is available in large quantities. Bauxite was collected from Zubayra city [18]. The rock was initially grinded to 0.5–1 mm particle diameter and dried. Scanning Electron Microscope (SEM) Model Quanta 250 FEG (Field Emission Gun) attached with EDX Unit (Energy Dispersive X-ray Analyses), with accelerating voltage 30 K.V., magnification 14x up to 1000000 and resolution for Gun.1n) has been performed.

2.2. Sewage Water Samples. Sewage water samples were brought from Sakaka wastewater treatment plant. Within 2 hours after collection, sewage water samples were analyzed [19].

2.3. Method of Jar Test. Jar testing is a process of observing a full-scale method of water purification, offering a sensible idea of how a chemical treatment will operate and perform with a specific type of raw water. Because it imitates full-scale service, process technicians could use jar analysis to identify which chemical treatment looks best with the raw water of their system. Sewage water samples were subjected to a jar test for application of grinded rock adsorption. Different doses of rock (1, 2, 3, 4, and 5 g/l) were tested for the treatment of sewage water. The flash mixing speed was 250 rpm for 1 minute followed by flocculation at 100 rpm for 30 minutes. The flocculation speed was chosen as 100 rpm

due to the precipitation of the grinded rocks and to be in contact with the sewage samples. The test was carried out in 1 liter beakers. The same procedures were carried out in a blank (sample without addition of grinded rock) [19].

2.4. Analysis. During the time of study, the efficiency of the treatment procedure was studied. For samples (raw and treated sewage water), physicochemical and biological analyzes were performed. PH, total suspended solids (TSS), chemical oxygen demand (COD), biological oxygen demand (BOD), and fecal coliform were included in the physicochemical analyzes. The analyses were performed in accordance with the American Public Health Association, Standard Water, and Wastewater Analysis Methods [19].

3. Results and Discussion

3.1. Material Characterization. The main composition of the ore is presented in Table 1. Based on multipoint EDX assessment, there are obviously noticeable round hematite particles with other elements in these regions that is supposed to be given a high bauxite content of Fe_2O_3 . The findings of these analyses that are provided are another evidence of the complicated structure of bauxite and support the data found in the literature suggesting that bauxite minerals are interconnected rather than separately occurring.

3.2. Sewage Water Characteristics. From the results depicted in Table 2 and Figure 1, it is clear that the sewage water used in this study is classified as a low-strength wastewater [20]. The average values for COD, BOD, and TSS were 326, 242.3, and 123.5 mg/l, respectively. The BOD/COD ratio shows the biodegradability of the used wastewater.

3.3. Efficiency of the Treatment Process. In an attempt to enhance the sedimentation of sewage water, the grinded bauxite rock was used. Figure 2 shows the variation of EC, TDS, and turbidity along with the different doses of rock. The levels of TDS and EC were inversely proportional with the turbidity of the raw sewage as well as the samples.

Figure 3 shows the depletion of the concentration of COD with various doses of the rock. It is clear that the concentration of COD reduced by increasing the dose of the rock. The concentration of COD was reduced from 326 to 134, 98, 83, 70, and 65 mg/l at rock doses of 1, 2, 3, 4, and 5 g/l, respectively. The same pattern was noted for both BOD and TSS reduction.

Figure 4 shows the performance of the treatment of sewage water with bauxite rocks. By applying bauxite as an adsorbent, the FC amount was decreased by two logs. The FC count was reduced from 5.5×10^7 to 4.2×10^5 , 3.4×10^5 , 2.8×10^5 , 2.4×10^5 , and 2×10^5 MPN/100 ml for raw sewage, 1, 2, 3, 4 and 5 g/l rock, respectively. Table 3 summarizes the performance of bauxite rock for the treatment of sewage water.

TABLE 1: The bauxite rock's main chemical composition.

Element	Weight (%)	Atomic (%)
O	30.52	49.61
Al	34.51	33.27
Si	1.69	1.56
Ca	0.27	0.17
Fe	33.02	15.38

TABLE 2: Physicochemical features of the wastewater*.

Parameter	Unit	Minimum	Maximum	Average
pH	—	7.3	8.0	
EC	mS	485.1	676.0	576.4
Turbidity	NTU	95	121	111.0
TDS	mg/l	325	406	66.4
COD	mg/l	274.0	370.0	326.0
BOD	mg/l	205	275	243.3
BOD/COD		0.74	0.75	0.745
TSS	mg/l	110	135	123.5
FC	MPN/100 ml	3.3×10^7	7.0×10^7	5.5×10^7

*number of samples = 13.

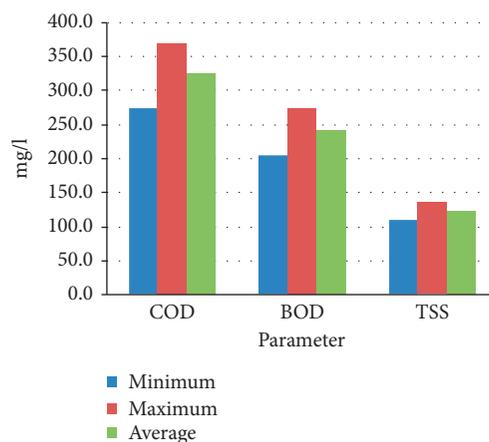


FIGURE 1: Characteristic of raw sewage water COD, BOD, and TSS.

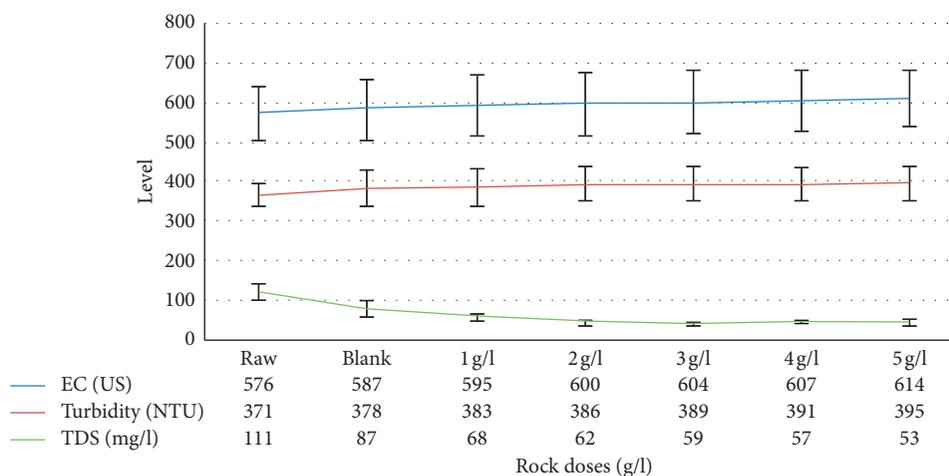


FIGURE 2: Variation of the levels of EC, Turbidity, and TDS along the treatment steps.

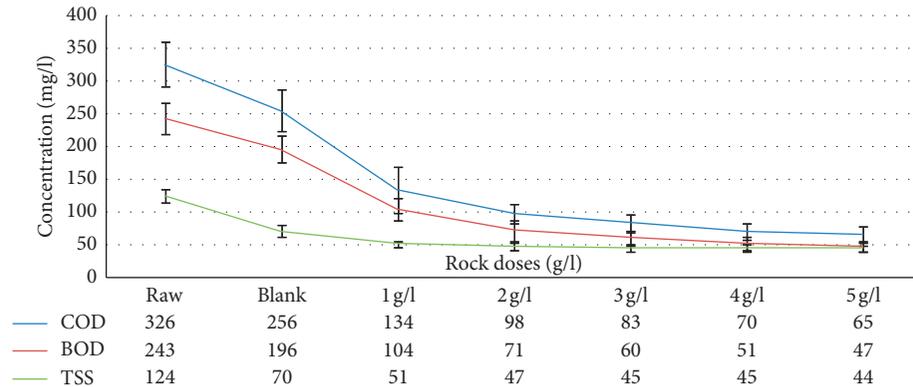


FIGURE 3: Depletion of the COD concentration with the rock dose.

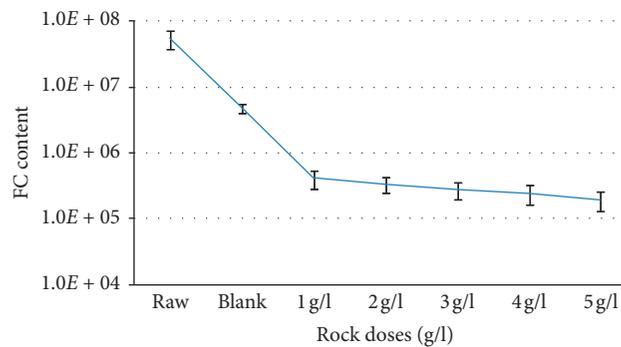


FIGURE 4: Variation of the FC count along with the treatment steps.

TABLE 3: Complete analysis of the raw waste water and different treated effluents.

Parameter	Raw	Blank	% R	1 g/l	%R 1 g/l	2 g/l	%R 2 g/l	3 g/l	%R 3 g/l	4 g/l	%R 4 g/l	5 g/l	%R 5 g/l
pH	7.5	7.9		8.0		8.0		7.8		7.7		7.5	
EC (μ S)	576	587		595		600		604		607		614	
TDS (mg/l)	371	378		383		386		389		391		395	
Turbidity (NTU)	111	87	22	68	21	62	28	59	32	57	34	53	39
COD	326	256	22	134	48	98	61	83	67	70	72	65	75
BOD	243	196	20	104	47	71	63	60	69	51	74	47	76
BOD/COD	0.75	0.74		0.72	0.73			0.72		0.72		0.72	
TSS	124	70	43	51	28	47	33	45	36	45	36	44	38
FC	5.5×10^7	4.9×10^6	90.26	4.2×10^5	91.30	3.4×10^5	93.00	2.8×10^5	94.33	2.4×10^5	94.99	2.0×10^5	95.99

3.4. Removal Mechanisms. There were two main mechanisms for removal of the organic loads from sewage water. The first was adsorption on the surface of the rock particles. The second was the coagulation that occurred due to the presence of Al and Fe in the rock composition. By increasing the rock dose, the surface area increased as well as the dissolution of some component of the rock. This was the reason for increasing the removal efficiency of the organic loads reflected by COD, BOD and TSS and in the consequence, increased the TDS of the treated samples. Raising the dose of rock has also enhanced the turbidity of the treated samples. It was observed that the adsorption capacity

was not significantly raised by raising the rock dose from 3 to 5 g/l. The FC count also decreased by using the grinded rock as the coagulant. The main mechanism for removal of FC bacteria was the adsorption on the surface of the rock. Since it has a positively charged surface (due the presence of Fe and Al), the FC bacteria had negatively charged functional groups. Grehs et al., [21] examined the removal of microorganisms by using aluminiumsulphate. They noticed that, as well as the bacterial numbers, turbidity and color were decreased by 1-2 logs. The removal of solid materials from water coagulation and flocculation methods are of major importance. Such methods could minimize color strength

and decrease turbidity levels, organic compounds [22]. Aboubaraka et al. [23] examined graphene oxide for the elimination of turbidity from water, and his results were found to be higher than those obtained in this study.

4. Conclusions

The Bauxite can be crushed to a certain particle size to create a material with high performance in decreasing the water pollution as indicated by COD and BOD values. The findings showed that the COD concentration reduced from 326 to 134, 98, 83, 70, and 65 mg/l while the BOD concentration decreased from 243 to 196, 104, 71, 60, 51, and 47 at rock doses of 1, 2, 3, 4, and 5 g/l for both parameters. In addition, the use of such approach is known to be a rapid strategy of treating sewage water in different areas to reduce the potential for drinking water supplies (such as groundwater).

Data Availability

The data (including the results and all the values of the physicochemical analysis of water before and after treatment) used to support the findings of this study are included within the article. The data are represented in Figures and Tables.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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