



An Experimental Investigation on Addition of Bentonite on Tannery Wastewater Characteristics

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Abstract: In this study, wastewater generated from Africa tannery in Khartoum North was investigated for removing of chromium from a wastewater by utilizing Bentonite. Experiments were carried out in order to obtain the optimum dose of Bentonite to be applied for the best removal of chromium and other wastewater parameters which include chemical oxygen demand, Oil and grease, total suspended solid, and chloride. For a 15mg/L dose of Bentonite removal rates of 99%, 44%, 94%, 75% and 53% of chromium(Cr), chemical oxygen demand (C.O.D), total suspended solid (T.S.S) and chloride (Cl) were respectively obtained. The Removal time for the above dose 15 mg/L was 6 hours. The results of the test were statistically analyzed by regression technique and a predication model was obtained after three trends of testing (linear, Exponential and polynomial). The exponential trend was the best ($R^2=0.9368$). The prediction model was validated by comparing predicted and measured data and good fit of data were obtained. Therefore, the use of Bentonite to remove chromium is considered as a very successful method, and it can be a solution to the problem of industrial waste resulting from the tanning industry.

Keywords: Wastewater, Tannery, Bentonite, Heavy Metals, Sudan

1. Introduction

Wastewater is the liquid waste resulting from private, public or commercial areas, or from industrial processes in addition to infiltration into sewers. Industry waste are commonly classified into three categories: liquid waste, solid wastes, and gaseous wastes [1]. Industrial wastewater are usually more polluted than the other sources of wastewater [2]. According to type and size of industry the wastewater characteristics vary in both flow and pollutional strength [1].

In tanneries based on chemical processes animal hides and skin transforms to useful materials which are used in manufacturing leather products [3, 4, 5]. The effluents of tanning industry comprises of organic and inorganic pollutants which is classified as the highest pollutants compared with the other industrial wastes [6, 7].

The modern sector of tanning industry in Sudan dated back to 1945. In 1965 the development in tanning industry with establishment of Khartoum tannery [8]. Numbers of techniques have been proposed to remove heavy metals from

tanning effluent such as chemical precipitation, ion exchange, and reverse osmosis. These methods are either needs high cost or the performance are low [9].

Bentonite is defined as clay rocks which is formed by the weathering of volcanic ash and have a wide range of applications in industry [10, 11].

Khartoum North is the major and biggest industrial area in Sudan, causing industrial hazards for human and environment. There are many factories such as: chemical, plastic, paints, oil mills and soap manufacturing plant, food processing, steel plating and pharmaceutical labs. Africa tannery is located in Khartoum North –NO: 26 –Block: 2 – Area: 400m². Africa tannery was established at 2005 with production capacity about 300 leathers/day for leather Export and internal production. Africa tannery waste treatment by using on-site disposal (sedimentation tank 6*4*3m). Amount of water consumption in industry about 300-400m³/ day.

Tannery effluent containing chromium is one of the most

obvious problems in leather industry. Africa tannery wastewater is discharged directly to the public sewer which may cause difficulties in the sewer system and to the wastewater treatment plants if not pretreated. The main objective of this study is to assess the effect of adding a cheap material such as Bentonite to remove chromium from Africa tannery wastewater.

2. Materials and Methods

The samples were collected in glass bottle (8 liters) and were corked immediately. All the samples were brought to the laboratory and stored at 4° C temperatures in refrigerator till the analyses were completed. All chemical analysis were done in evening or the following days. This sample was used for the tests given below. The sampling procedure according to “Standard Methods for Examination of Water and Wastewater” [12].

2.1. Samples Preparation

Sample collected from study area was divided into five groups in beakers with total capacity of 1 liter. Different doses of bentonite were added into each beaker (e.g. 5, 10, 15, and 20 gram.). The retention time of samples 6 hours after addition of doses before the applications. Table 1 lists the compositions of the samples.

Table 1. Samples compositions.

Sample Group	Bentonite (gram)
A	-
B	5
C	10
D	15
E	20



Figure (1). Samples Preparation.

2.2. Bentonite Properties

The chemical composition of Bentonite used in this study was investigated using ICP test.

3. Results and Discussions

Table (2) shows the chemical composition of bentonite used as heavy metal removal.

The addition of bentonite to the Africa tannery wastewater causes a huge reduction in chrome as shown in figure 2. At a concentration of 20 gram this reduction reaches 0.198 mg/L which is a high percentage of removal.

Also, Figures 3 and 4 shows that the increase in bentonite concentration decreases the values of BOD₅ and COD until reach concentration 15 gram of bentonite and then the values of BOD₅ and COD increases at 20 gram bentonite.

As far as the effect on chloride, O&G, T.SS are concerned, figures 5 to 7 show that the increasing of bentonite concentration decreases the chloride, O&G, T.SS in difference degree of removal efficiency.

As shown in figure 8 increasing of bentonite concentration decreases the pH values till the concentration of bentonite 15 gram, after this point any addition of bentonite increase the pH values.

Table 3 shows the removal percentage of different types of tests carried out.

Table 2. Chemical Composition and Loss on Ignition of Bentonite.

Elements	Unit	Result
Al ₂ O ₃		10.04
CaO		1.207
Fe ₂ O ₃	Wt%	18.30
K ₂ O		0.0111
MgO		0.8620
MnO	ppm	2617
Na ₂ O	Wt%	2.866
P ₂ O ₅		2.125
LiO ₂	ppm	33.89
TiO ₂		1.469
SiO ₂	Wt%	48.94
L.O.I		14.38

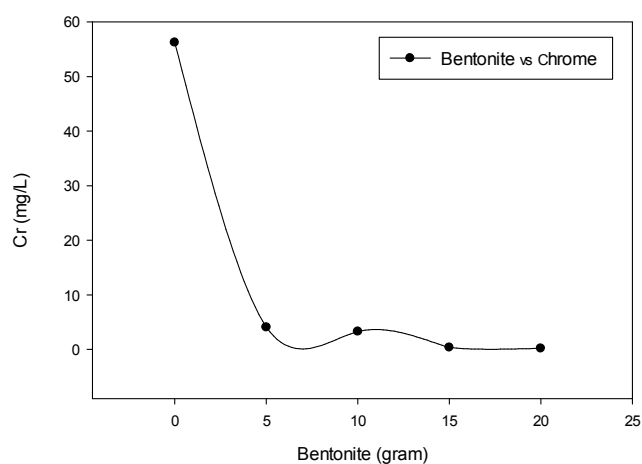


Figure (2). Bentonite additive vs. chrome.

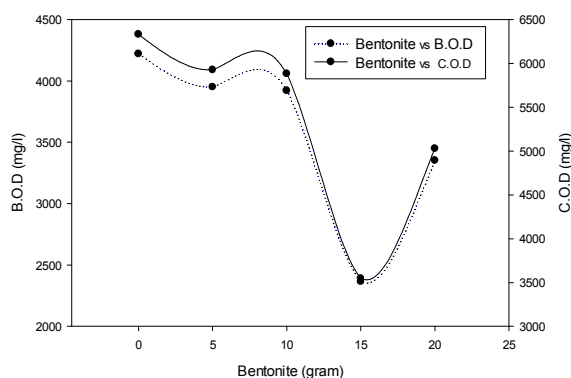


Figure (3). Bentonite additive vs. B.O.D. and C.O.D.

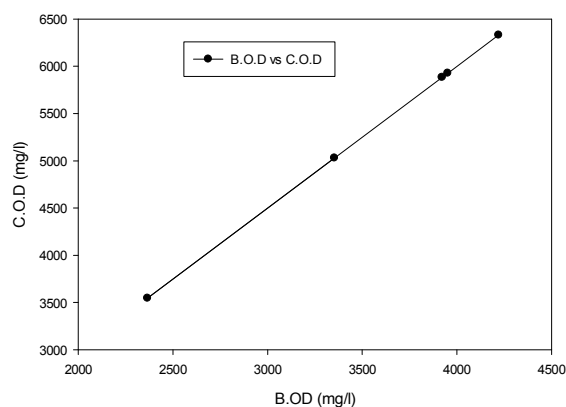


Figure (4). B.O.D. and C.O.D. Relationship.

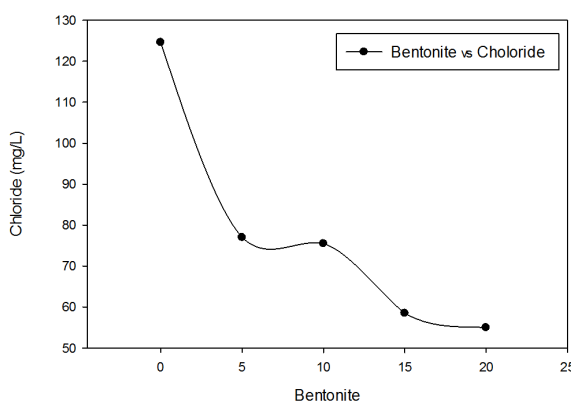


Figure (5). Bentonite additive vs. Chloride.

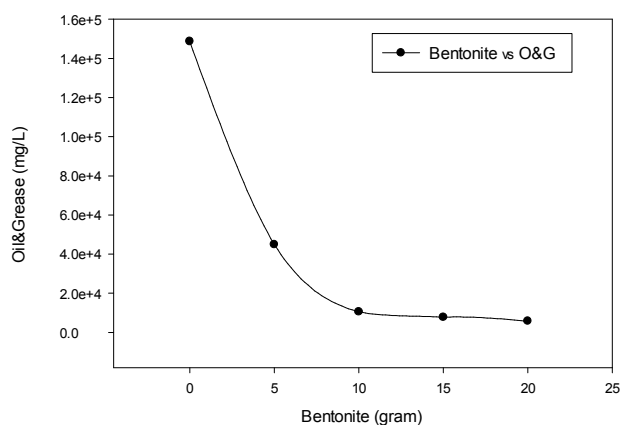


Figure (6). Bentonite additive vs. O&G.

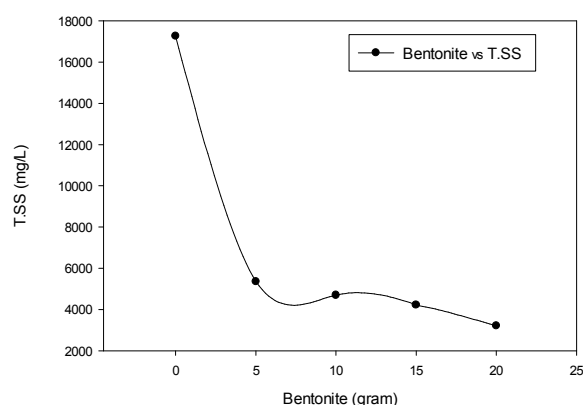


Figure (7). Bentonite additive vs. T.SS.

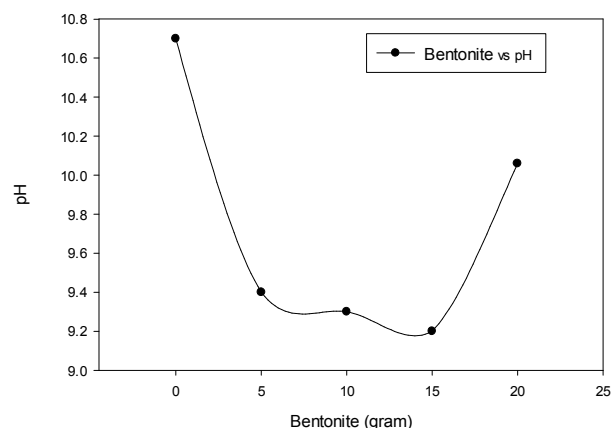


Figure (8). Bentonite additive vs. pH.

Table 3. Removal Percentage includes total Cr.

Bentonite Concentration	Removal %				
	Cr	C.O.D	O&G	T.SS	cl ⁻¹
5 gram	92	37	69	68	38
10 gram	94	39	92	72	39
15 gram	99	44	94	75	53
20 gram	99	50	96	81	55

Empirical Model

The Empirical Model was developed using Regression Analysis Techniques. Regression analysis is a statistical tool for the investigation of relationships between variables. The chrome Concentration (C) related to the amount of the bentonite (B). Figures 9 and 10 show the trend lines which represent the above relationship. The measured data was used to develop the empirical model to predict the effect of increasing bentonite amount on chrome removal. The Exponential trend line was the best Empirical model to predict the chrome as function of bentonite amount.

Fig 10 shows the relation between measured and predicted values of chrome. The empirical Equation 1 was found to predict satisfactorily the chrome with

$$R^2 = 0.9368$$

$$C = 34.574e^{-0.274B} \quad (1)$$

Table 4 shows the constants for various trend lines for the relationships between chrome and bentonite amount. Fig 11

shows the measured and predicted data.

Table 4. The empirical model constant to compute chrome.

Trend lines	a	b	c	d	R ²
Exponential	34.574	-0.274	-	-	0.9368
Polynomial Order 2	0.2926	- 8.1776	50.772	-	0.8794
Linear	-2.326	36.143	-	-	0.566

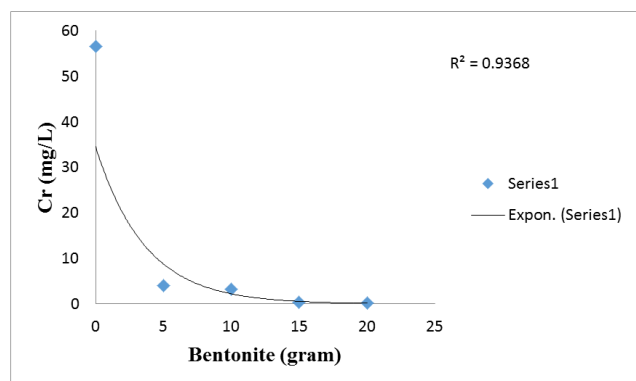


Figure (9). The change in chrome as a function of bentonite amount Expon trend line.

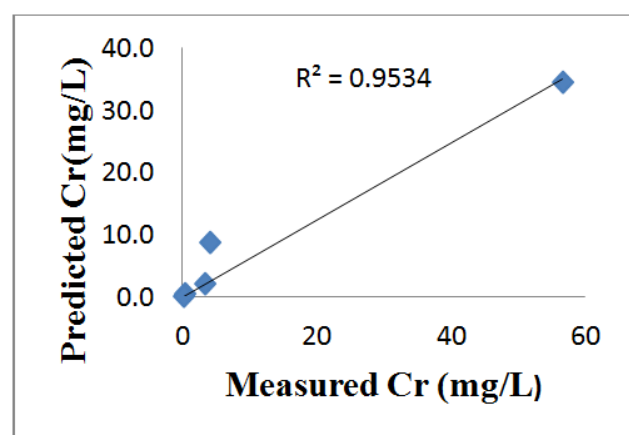


Figure (10). Predicted and measured values of chrome.

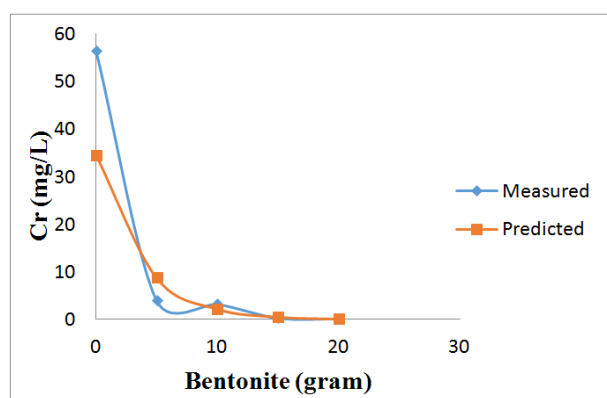


Figure (11). Measured and predicted data.

4. Conclusions and Recommendations

Based on the results of the tests performed, the following conclusions were drawn:

- The tannery effluent analyzed was found to contain excessively high amount of Cr hazardous if returned back to the environment untreated
- Adding Bentonite to Africa tannery wastewater remove chrome in different degrees of efficiency.
- Chloride, O&G and T.SS for wastewater collected from Africa tannery decreases with increase in Bentonite concentration.
- Addition of 15gram of Bentonite concentration for the selected samples gives the lowest values of BOD of 2365mg /l and COD of 3547 mg /l.
- Based on the above result of this study 15gram of Bentonite concentration is recommended as an optimum dose.
- The study recommends the use Bentonite in the field of tannery wastewater treatment.
- Developed models can be used to predict chrome values with different Bentonite concentration.

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