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Original Research

Evaluation of the performance of different filters for sewage treatment

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ABSTRACT:

The objective of this study, is to design two wastewater filtration system, by using corn cobs and red mud (bentonite), and to compare between their performance. Filter A (bentonite) and Filter B (corn cobs) were designed and each filter consists of three layers. To determine the most effective filter, four parameters were measured that is, pH chemical, Biochemical Oxygen Demand (BOD5), Oxygen Demand (COD), and Total Suspended Solid (TSS). The results showed that Filter A sowed the removal BOD5 up to 87%, TSS up to 8.6% and reduction of pH up to 4.3% whereas Filter B showed the removal of BOD_5 up to 91%, TSS up to 13%, COD up to 89% and pH up to 18.4%.

Keywords:

Corn cobs, Mud, Bentonite pH chemical, BOD5, COD, TSS.

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INTRODUCTION

The treatment of wastewater is one of the key aspects of protecting water resources. Wastewater treatment methods are intended to accomplish enhancements in the nature of the wastewater. Filters are engineered systems that have been designed and constructed to treat wastewater, with numerous processes, some of these operations are filtration, adsorption, coagulation (Bhatnagar *et al.,* 2011), foam flotation, ion exchange (Mayo and Abbas, 2014), solvent extraction aerobic and anaerobic treatment, advanced oxidation processes, microbial, activated sludge and reduction. However, these methods differ in its efficiency. The adsorption process is one of the most efficient methods, for the treatment and removal of organic and inorganic contaminants in wastewater. Adsorption is better than the other methods, due to simple design, that can include low interest in term of both, beginning expense and land required (Saleh *et al.,* 2016). Adsorption is a mass exchange process which incorporates the accumulation of substances, in the interface of two phases, for instance, liquid– solid, liquid– liquid, gas– liquid, and gas– solid, or interface. The substance being adsorbed is the adsorbate and the adsorbing material is to depict the adsorbent (Naseeruteen *et al.,* 2018). The main advantage of adsorption recently, became the use of low-cost materials, such as red mud (bentonite) (Shabiimam *et al.,* 2017) corn cobs, Palm tree wastes (Ahmed, 2010) etc. In this study corn cobs (Ali *et al.,* 2014) and red mud (bentonite) (Abdullah *et al*., 2013) were used for the treatment process. Studies have shown its performance in water treatment and received wide attention, as an effective adsorbent for water pollution control, corn cobs is one of the material that could be used. Corn cobs has a high porosity and high surface area also act as adsorbent and can effectively remove particles and organics from water (Foroughi *et al.,* 2013). The use of red mud has undoubtedly become more widely and popularly used as an adsorbent and ion exchange for wastewater treatment applications especially for removing BOD5 and COD, organic pollutants and heavy metals (Foroughi *et al*., 2010). Generally, there are two types of bentonite which are calcium bentonite and sodium bentonite. Calcium bentonite was used in this present examination. The utilization of natural clay minerals, for instance, bentonite for wastewater treatment are growing. An aftereffect of their negligible effect, high surface area, high porosity, clays are incredible contenders as adsorbents (Abdelaal, 2004). This study investigates the comparative suitability of bentonite and corn cobs as adsorbents for wastewater treatment based on the removal of efficiencies of COD, BOD5, TSS. The

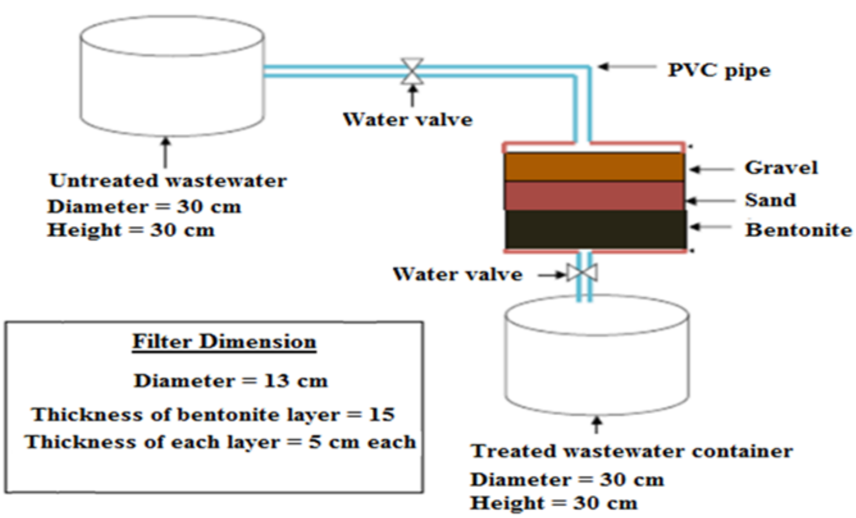

Figure 1. Illustration of the filter A

Table 1. Chemical properties of bentonite used in the experiment

S. No	Chemical characteristics	Value
1	SiO_2 (%)	56.0
2	Al_2O_3 (%)	17.0
3	Fe_2O_3 (%)	5.3
4	CaO (%)	5.0
5	MgO (%)	4.0
6	Na_2O (%)	3.0
7	CEC (cmol/kg)	21.0

effects of pH was also taken under consideration. This work is aimed to use low cost adsorbents, which consists of corn cobs as plant wastes and bentonite in the treatment of waste water for the removal of different pollutants from water by wastewater and comparing their performance.

MATERIALS AND METHODS

Waste water sample were collected in the period between 4^{th} and 20^{th} of March 2016, the tests were conducted to determine the characteristics of water, in the College of Agriculture-University of Sulaimania-Iraq. Four water parameter were estimated *viz*., pH, chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD5) and Total Suspended Solid (TSS). There were two different filter models designed in this study. Filter B contained corn cobs, sand and gravel and the filter A contained red mud (bentonite), sand and gravel. The sketched designs of two filters were illustrated in Figure 1 and 2.

Table 2. Chemical properties of organic waste decomposed by the filters

S. No	Chemical characteristics	Value
1	Organic carbon ($Gm.kgm^{-1}$)	372
2	Total nitrogen ($Gm.kgm^{-1}$)	21.6
3	Phosphorus ($Gm.kgm^{-1}$)	7.2
4	Potassium ($Gm.kgm^{-1}$)	1.5
5	C/N ($Gm.kgm^{-1}$)	17.2
6	Fulvic Acid (%)	13.71
7	Humic acid (%)	15.64

Red mud (bentonite) filter (A)

A flexible metal from within the group montmorillonite (Shabbiiman, 2017), characterized by the soft gray granules italics color to yellowish. It consists mainly of silica by (60-70%), aluminum (15-20%) with low percentages of iron, The bentonite were collected from Ahmed Ui area near the governorate of Sulaymaniyah. This filter consists of three layers, the first (surface layer) was filled with gravel at a thickness of 5 cm, the second layer was filled with sand at thickness of 5 cm and third layer was filled with red mud (bentonite), at thickness of 15 cm. Chemical properties of bentonite used in the experiment were shown in the Table 1.

Corn cobs filter (B)

The corn cobs were collected from local farmers and sun dried for one month. 20 kg of corn cobs was taken and subjected to the decomposition for a 60-day process, according to the proportion of carbon and nitrogen (C/N). This method is based on the principle of decomposition by providing an appropriate level of humidity. It has been added to the water plant organic waste and then urea fertilizer (N 46%) was added by1% (N) and fertilizer Super triphosphate (P_2O_5 21%) by 0.5% (P). Wastes were placed in a pile on a piece of nylon to keep the sap organic waste, which collects and restores the pile. A residue decomposition was left with the moistened and turned over every three days until the end of decomposition (AL-Hadithi, 2011) and (Guimarães *et al*., 2009). Chemical properties of organic waste decomposed were shown in the Table 2.

The adsorption test was used to check the performance of the corn cobs, this filter consists of three layers, the first (surface layer) was filled with gravel, a thickness of this layer at 5 cm. The second layer was filled with sand, a thickness of this layer at 5 cm and third layer was filled with organic corn cobs residues after decomposition with a thickness of this layer at 15 cm.

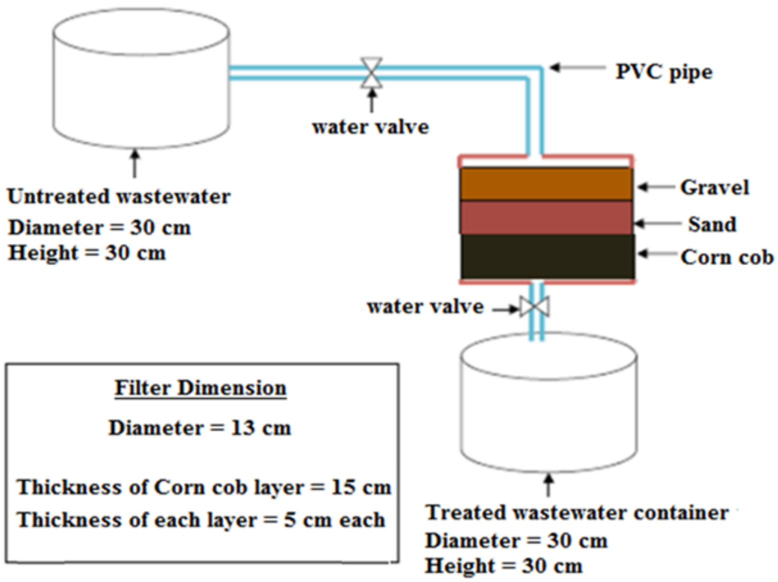

Figure 2. Illustration of the filter B

Four water parameter namely pH, BOD5, COD and TSS were used for the examination of water and wastewater. All methods were adapted from the standard methods (Ali *et al*., 2014). Experiments lasted over a month and a half where the sample was taken every three days. The samples were tested in the Central Laboratory/College of Agriculture at the University of sulaimania (CLCS). Temperature (°C), pH was measured in the field. BOD5, COD, TSS were measured in CLCS. Before the wastewater enters the filtration system, the initial characteristic of the domestic wastewater will be determined. Dissolved Oxygen Meter (HANNA-HI9146) within its properties measure the temperature of the wastewater within the bed and measurement of BOD5. Where the pH measurements were made with the help of portable CYBER SCAN pH- meter (model PC 300 series) while total suspended solids as known quantity of well blended sample was separated through a measured standard glass fiber filter and the residue held on the channel was dried to a steady weight at 103 to 105°C. The increase in weight of the filter represented total. Quantity in milligram per liter was calculated (EPA,1999).

Biological Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose the waste. If there is a large quantity of organic waste in the water supply, there will also be a large amount of bacteria exist to decompose this organic matters in wastewater. Thus, the demand or oxygen will be high and the BOD level will be high as well. The BOD test is done by taking a water sample and keeping it cool and dark for five days. Dissolved oxygen test was performed on both samples and subtracted the two results so as to ensure the used amount of oxygen was used during the time period (Xi, 2007).

The standard technique for indirect estimation of the proportion of contamination (that can't be oxidized biologically) in sample while the COD test methodology depends on the chemical deterioration of organic and inorganic contaminants, dissolved or suspended in water. The result of a COD test showed the measure of water dissolved oxygen (showed as parts per million or milligrams per liter of water) devoured by the contaminants, amid two hours of decomposition from a solution of boiling potassium dichromate. The higher the COD the higher the proportion of conformation in the test. For the contaminants that can be oxidized biologically, the Biological Oxygen Demand (BOD) meth-

Table 3. The value of pH in different filters for sewage treatment

S. No	Period / Treatment	P_1 (1-6 Weeks)	P_2 (6-12 Weeks)	P_3 (12-18 Weeks)	Mean
1	Raw wastewater	7.66 ± 0.067^a	7.68 ± 0.058^a	7.62 ± 0.066^a	7.65 ± 0.042^A
2	Biofilter (1)	5.92 ± 0.086^c	6.04 ± 0.180^b	6.76 ± 0.050^c	6.24 ± 0.091^C
3	Biofilter (2)	7.36 ± 0.107^b	7.34 ± 0.107^a	7.26 ± 0.092^b	7.32 ± 0.042^B

od is utilized (Business dictionary, 2005).

Statistical analysis

Statistical analysis was performed for the trial data using analysis of variance to study the effect of the corn cob and red mud (bentonite) for wastewater treatment, moral differences were compared between averages by polynomial test (Lawal, 2014). statistical program (SAS, 2004) was used in the statistical analysis according to the following mathematical model :

$Yij = \mu + Ti + eij$

where, Yij: observed value (j) belonging to the treatment of (i); μ: general average of the studied status; Ti: effect of treatment (i); Eij: random error, which is distributed naturally averaged zero and contrast of σ2e. (Lawal, 2014).

RESULTS AND DISCUSSION

Each filter showed different reading of reduction, depending on the design of filter itself. The values are the average values of three samples, that have been used for the experiment.

Hydrogen ion concentration (pH)

The pH level of the aqueous solution is an important variable which controls the adsorption of the organic constituents at the solid-water interfaces (Wehr *et al*., 2016). From Table 3, it was observed that the significant decrease of pH ($P \leq 0.05$) in the effluent as compared to its average values in the influent (Ahmed, 2010). Average pH values at first period was 7.66 mg/l in influent while filtered effluent was 7.36 mg/l and 5.92 mg/l respectively. The significant removal of pH was ($P \leq 0.05$) in the effluent as compared to its average values in the influent. Average pH value at second period was 7.68 mg/l in influent while in filters effluent was 7.34 mg/l and 6.04 mg/l respectively. Average pH values at third period was 7.62 mg/l in influent while in effluent (bentonite, corn cobs) filter was 7.26 mg/l 6.76 mg/l respectively. The significant removal of pH ($P \leq 0.05$) in effluent as compared to its average values in the influent and mean values of pH during the study period was 7.65 mg/l in influent while in filters effluent was 7.32 mg/l and 6.24 mg/l respectively. It was noted that there was also a change in the pH value of the effluent compared to the influent. Lower or higher pH value than its permitted limit is highly undesirable from environmental point of view as it leads to killing of microbiological population necessary for biodegradation and pollution control (Ass *et al*., 2018). From the result, it was observed that the decreasing in the values of pH in the filter (B) compared with filter (A) may be due to corn cobs (organic wastes resulted in decrease in pH) Because when humus (corn cobs) decomposes, acids such as humic acid will be released, resulting in reduced pH (AL-Hadithi, 2011).

Table 4. the value of TSS in different filters for sewage treatment

S. No	Period / Treatment	P_1 (1-6 Weeks)	P_2 (6-12 Weeks)	P_3 (12-18 Weeks)	Mean
1	Raw wastewater	2461 ± 20.2^A	2233 ± 35.9^a	2342 ± 35.1^a	2345 ± 28.6^A
2	Corn cob biofilter	2110 ± 32.5^C	1898 ± 22.2^c	2092 ± 28.7^b	2033 ± 21.3^C
3	Bentonite biofilter	2196 ± 9.79^B	2082 ± 36.4^b	2150 ± 15.8^b	2142 ± 9.80^B

Table 5. The value of BOD_5 in different filters for sewage treatment

S. No	Period / Treatment	P_1 (1-6 Weeks)	P_2 (6-12 Weeks)	P_3 (12-18 Weeks)	Mean
1	Raw wastewater	320.6 ± 11.6^a	384.4 ± 3.82^a	414.4 ± 4.00^A	373.1 ± 3.89^A
2	Corn cob biofilter	34.6 ± 1.32^b	24.6 ± 1.28^c	38.6 ± 1.02^C	32.6 ± 0.72^C
3	Bentonite biofilter	44.0 ± 1.26^b	37.0 ± 0.94^b	56.0 ± 0.89^B	45.6 ± 0.34^B

Total Suspended Solids (TSS)

The concentration of total suspended solids is also very important in designing the wastewater treatment plants (Manahan, 2011). Table 4 shows the significant removal of TSS ($P \leq 0.05$) in effluent as compared to its average values in the influent. Average TSS values at first period was 2461mg/l in influent while infiltrated effluent was 2196 mg/l and 2110mg/l respectively. Its average values in the influent. Average TSS values at second period was 2233 mg/l in influent while infiltrated effluent was 2082mg/l and 1898 mg/l respectively. The significant removal of TSS ($P \leq 0.05$) in effluent as compared to the average values in the influent. Average TSS values at third period was 2342 mg/l in influent while infiltrated effluent was 2150 mg/l and 2092mg/l respectively. The significant removal of TSS ($P \leq 0.05$) in effluent as compared to its average values in the influent. Mean value of TSS during the study period was 2345 mg/l in influent while infiltrated effluent was 2033 mg/l and 2142 mg/l respectively. It was noted that the difference was clear in the value of corn cobs which was the best treatment experience. These minimum TSS reduction values due to the low density that can't settle within the filtration (Liebl, 2009).

Biochemical Oxygen Demand (BOD5) Test

Is the most important parameter to estimate the pollution potential of wastewater. The BOD5 removal rate depends on organic matter content (Shabiimanm, 2017). The Table 5 shows the significant removal of BOD5 concentration ($P \leq 0.05$) in effluent as compared to its average values in the influent. Average BOD5 values at first period was 320.6 mg/l. in influent while in the filters effluent was 44 mg/l and 34.6 mg/l respectively.

The significant removal of BOD5 ($P \leq 0.05$) in effluent as compared to its average values in the influent. Average BOD5 values at the second period was 384.4 mg/l in influent while infiltrated effluent was 37 mg/l and 24.6 mg/l respectively. The removal of BOD5 ($P \leq 0.05$) in effluent was significant as compared to its average values in the influent. Average BOD5 values at third period was 414.4mg/l in the influent while infiltrated effluent was 56 mg/l and 38.6 mg/l respectively. The significant removal of BOD5 concentration ($P \leq 0.05$) in the effluent as compared to its average values in the influent. Mean value of BOD5 during the study period was 373.1 mg/l in influent while infiltrated effluent was 45.6 mg/l and 32.6 mg/l respectively, BOD5 value was decreased about in effluent as compared to its average value for the effluent which may be due to settling

Table 6. The value of COD in different filters for sewage treatment

S. No	Period / Treatment	P_1 (1-6 Weeks)	P_2 (6-12 Weeks)	P_3 (12-18 Weeks)	Mean
1	Raw wastewater	646.6 ± 9.63^a	682.6 ± 4.67^a	738.4 ± 4.61^A	689.2 ± 1.53^A
2	Corn cob biofilter	75.6 ± 0.92^b	66.0 ± 1.22^b	81.8 ± 0.86^C	74.4 ± 0.35^C
3	Bentonite biofilter	84.8 ± 0.58^b	74.2 ± 0.96^b	93.6 ± 0.81^B	84.2 ± 0.38^B

and degradation of organic matter. It was noted that the difference was clear in the value of corn cob which was the best treatments experience. The high BOD5 removal efficiency infiltrates might be caused by detention time. when the detention time increased then the removal efficiency of BOD5 is increased. It was noted that the low efficiency of the filter in the third period may be due to the aging of the filter (Ganesan and Namasivayam, 2015).

Chemical Oxygen Demand (COD) test

Organic matter is present in the sample which determines the quantity of oxygen to be used under specific conditions of oxidizing agent, temperature and time. Organic compounds are oxidized into carbon dioxide and water during their decomposition process (Manahan, 2011). The significant removal of COD ($P \leq 0.05$) in effluent as compared to its average values in the influent in Table 6. Average COD values at first period was 646.6 mg/l. in influent while in the filters effluent was 84.8 and 75.6 mg/l respectively. The significant removal of COD ($P \leq 0.05$) in effluent as compared to its average values in the influent. Average COD values at second period was 682.6 mg/l in the influent while in filters effluent was 74.2 and 66 mg/l. respectively. The significant removal of COD ($P \leq 0.05$) in effluent as compared to its average values in the influent. Average COD values at third period was 738.4 mg/l in the influent while in effluent filters was 93.6 and 81.8 mg/l respectively. The investigation demonstrated the low proficiency of the filter in the third period perhaps due to the aging of the filter. The significant removal of COD ($P \leq 0.05$) in effluent as compared to its average values in the influent. Mean value of COD during the study period was 689.2 mg/l. in influent while in the effluent filters was 84.2 and 74.4 mg/l respectively. The high COD removal efficiency in filtration system might be caused by detention time and sedimentation mechanisms (Tang *et al*., 2018).

CONCLUSION AND RECOMMENDATION

From the results of the present study, the following conclusions can be deduced:

- The investigation shows that the corn cobs and bentonite filtration system can provide high BOD5 and COD removals.
- Corn cobs filter was more efficiency in BOD5, COD and TSS removals than the bentonite filter in all the experimental tests.
- From the result, it was observed that the pH was within the allowable limits for best quality.
- Besides, the reduction of Biochemical Oxygen Demand (BOD) is higher. It means that, the corncobs is successfully treated the wastewater by removing the microorganism in the water.
- Use the corn cob to treat other types of water such as rainwater to help in removing the unwanted material in the water.
- Others water parameters test should be conducted.

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