Industrial Wastewater Purification Using Cow Bone and Saw Dust Filters

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ABSTRACT

Poorly treated wastewater can adversely affect the existence of plants and animals. There is a need to look for low-cost filters to address the scarcity of water in rural areas surrounded by industrial wastewater. The present study investigates the use of low-cost filter for purification of industrial wastewater. Filters made from cow bone (CBF) and saw dust (SDF) were used to remove some impurities in wastewater. Wastewater from Ore Industrial Estate, Ondo State, Nigeria, are collected and ran through the filter, the physicochemical parameters were determined using standard method while metal content were determined using Atomic Absorption Spectrophotometer. The filter content before and after use were analyzed using Fourier Transformed Infrared (FTIR) Spectrometer. CBF reduces Electrical Conductivity (EC), Chloride and chemical oxygen demand COD of the wastewater appreciably. It removed 74 %, 70 %, 65 %, 68 % and 81 % of Mn, Ni, Cd, Pb, and Zn respectively while SDF removed 8 %, 14 %, 26 %, 17 % and 28 % of the same elements respectively. The C = O stretch was recorded at wavelength of 1646.31cm^{-1} before filtration and broad at 1640.19 cm^{-1} after filtration in CBF. Broad OH peak was recorded at 3750.84 cm^{-1} before filtration and 3674.41 cm^{-1} after filtration for saw dust filter (SDF). It was concluded that the spectral showed that some materials are removed from the water. The cow bone filter is more efficient than the saw dust filter.

Key words: Bone, Cow, Filter, Industry, Water

INTRODUCTION

Water is an indispensable resource for life and is essential for the livelihood and socio-economic development of any community[1]. Adequate provision of safe drinking water remains a major challenge globally and more importantly in developing nations. Indiscriminate discharge of toxic substances into water bodies occur because of industrial activities and rapid urbanization[2]. The treatment and re-use of wastewater is compelling to increase water availability[3]. Different methods have been developed to treat polluted water. The methods include activated sludge process, phytoremediation, bioremediation, advanced oxidation process, adsorption, and membrane technologies. Drinking contaminated water without treatment portends danger to human health[4]. The source of wastewater may be purely domestic or industrial [5]. Domestic wastewater is a combination of excreta, flush water, kitchen water and bathroom water. It is more commonly known as sewage and much diluted[6]. In developing nations, there is need to look for inexpensive materials that can remove the waste efficiently for sustainable water reuse.

The interest by African countries to industrialize has resulted in the discharged of partially treated and untreated wastes into the surrounding water bodies[7]. In Nigeria, river runs through the town in most cases and industrial wastes are washed into them by erosion and flooding. This resulted in the contamination of the river water which affects aquatic plants and animals[8]. The industrial discharge, therefore, constitutes a large portion of the flow of the rivers during the dry season, which makes the quality of the rivers to be deteriorated. Separation of particulate matter from the liquid phase is one of the significant steps in wastewater treatment processes[9].

Among all the water contaminants, pesticides, radioactive materials, heavy metals, and toxic chemicals are considered as the contaminants of priority due to their toxicity [10]. Partially treated wastes from processing factories located in Cities are discharged into inland water bodies resulting in contamination, discoloration and a greasy oily nature of such water bodies [11]. River water situated closed to an industrial estate in Aba, Nigeria, was found to contained high concentration of Fe, Cu, Mn, and Cr due to industrial activities (Nwankwoala and Ekpewerechi, 2017)[12].

Intensive chemical treatment of wastewater such as chlorination, alum addition, ozonation, ion exchange and coagulation can add to the problem of contamination and scaling of fresh water sources (Shannon, 2008)[13]. Filter units which may consist of single media or mixed media are used to improve water quality without scaling. The added material must promote hydraulic and environment behavior of filter unit which should reflect on treatment cost reduction of wastewater and drinking water regardless of the source[14]. Filtration of wastewater is very important in assessing the suitability of water for different purposes. The most sustainable solutions to safe drinking water for the rural dwellers are point-of – use water filtration. The problem of water clarity in the filtration method by adopting additional material mixed with sand is circumvented by using activated bone char and cellulose extracted from saw dust. Boris *et al.*[15], used bone char filter to remove fluoride in water, and reported high fluoride uptake indicating the suitability of the filter in de-fluorination. There is a need to look for low-cost filters to address the scarcity of water in rural areas surrounded by industrial wastewater. This will assist in ensuring sustainable water use with minimal cost. The objective of the present study is to use bone char to reduce physicochemical parameters and metals in industrial waste water.

MATERIALS AND METHOD

Materials

Wastewater samples were collected from Ore Industrial Estate located in Ore, Odigbo Local Government area of Ondo State, Nigeria. Ore Industrial Estate is located in Omotosho between 6^o 28′ N – 6^o 35′ N and 4^o 19′ E – E 4 ^{o} 50′ E. Cow bone were collected from government certified butchers of Okitipupa, Ondo State. Saw dust from gmelina wood were collected from government registered Saw Millers in Okitipupa, Ondo State, Nigeria. All reagents used are pure and procured from Sigma-Aldrich Chemicals.

Method

Chloride concentration was determined using Mohr's method, Bench top digital pH meter was used to measure pH, Titration method was used to measure Alkalinity and hardness, TDS meter (Thermo-Scientific model) was used to measure Electrical Conductivity. Trace elements (Mn, Ni, Cd, Pb, Zn) were determined by using Atomic Absorption Spectrophotometer (AAS) Buck Scientific 210 Model), Winkler's method was used to determine Dissolved Oxygen [16]. The IR spectral of the filter material were measured before and after filtration using Nicolet (iS10) FT-IR Spectrometer.

Sampling and Analyses

Water samples were collected into a previously cleaned 2L plastic. A total of 10 water samples were collected from different points within the surroundings of the industrial estate in triplicates. Water samples used for the determination of trace element (Mn, Ni, Cd, Pb, Zn) were collected separately and preserved with 0.1M nitric acid while those meant for physicochemical analysis were preserve in ice chest before taking to the laboratory for immediate analysis.

Water samples meant for metal determination were digested by boiling in a mixture of hydrochloric acid (HCl) and nitric acid (HNO_3) at the ratio of 3:1.

Filter preparation:

The cow bones were washed in deionized water, sundried and placed in muffle furnace (400^0C) to carbonize for 1 hour and cooled in a desiccator. The carbonized bones were crushed and activated by spraying with 50 ml HCl. The filter used consists of a plastic frame support with polyethylene net on it. The surface of the net was coated with the slurry of activated cow bone. The filter made of saw dust that has been previously delignified, turns to powder, then slurry and spray of over the frame up to a layer of 2mm thickness. It was allowed to dry in an oven at 105^{0}C for 30 minutes.

RESULTS AND DISCUSSION

The pH recorded from wastewater collected from Ore Industrial Estate ranged from 5 to 6.9 with the mean value of 5.75 ± 0.685 while the temperature ranged from 26.2^{o}C to 28.5^{o}C with the mean value of 27.5 ± 0.422^{o}C (Table 1). EC recorded in the water ranged from 225 µSCm^{-1} to 361 µSCm^{-1} with the mean value of 255.6 ± 37.2 µSCm^{-1}. Alkalinity ranged from 120 mgCaCO$_3$L^{-1} to 330 mgCaCO$_3$ L^{-1}with the mean value of 208 ± 70.5 mg CaCO$_3$ L^{-1}.

Table 1: Range of Physicochemical parameters and metallic elements in river around Ore Industrial City

Parameters	Min	Max	Mean ± SD	WHO2011
pH	5	6.9	5.75 ± 0.685	6.5-8.5
Temperature(^{o}C)	26.2	28.5	27.5 ± 0.422	NA
EC (µSCm^{-1})	225	361	255.6 ± 37.2	250
Alkalinity (mgCaCO$_3$L^{-1})	120	330	208 ± 70.5	<120
Total Hardness (mgL^{-1})	20.0	150	92.1 ± 36.5	1150
Cl- (mgL^{-1})	230.3	480	324.6 ± 90.23	250
TDS (mgL^{-1})	120	303.1	140.1 ± 15.4	<500
DO (mgL^{-1})	1.6	4.4	3.1 ±0.34	6
BOD (mgL^{-1})	9.2	12.3	10.6 ± 0.96	10
COD (mgL^{-1})	1.2	2.6	1.34 ± 0.486	4
Mn(mgL^{-1})	ND	ND	ND	0.4
Ni(mgL^{-1})	0.1	0.6	0.311±0.15	0.02
Cd(mgL^{-1})	0.2	0.7	0.44±0.16	0.3
Pb(mgL^{-1})	0.10	0.4	0.21±0.09	0.01
Zn(mgL^{-1})	1.2	3	1.95±0.55	Nil

Key: ND - not detected, TDS - Total Dissolve Solid, DO –Dissolved Oxygen, BOD – Biochemical Oxygen Demand, COD – Chemical Oxygen Demand

Total hardness ranged from 20.0 mgL^{-1} to 150 $mgL^{-1}$with the mean value of 92.1 ± 36.5 mgL^{-1}. Chloride concentration ranged from 230.3 mgL^{-1} to 480 $mgL^{-1}$with the mean value of 324.6 ± 90.23 mgL^{-1}. TDS ranged from 120mgL^{-1} to 303.2 $mgL^{-1}$with the mean value of 140.1 ± 15.4mgL^{-1}. Ayedun *et al*.[17], reported TDS average of 244.7±278.7 mg L^{-1} in Lagos water while previous studies[6] reported TDS value below WHO limit in water of Owo, Ondo state, Nigeria. Based on TDS content, water can be classified into desirable for drinking (up to 500 mg L^{-1}), drinking (500–1000 mg L^{-1}), useful for agricultural purposes (up to 3000 mg L^{-1}), and unfit for drinking and irrigation (above 3000 mg L^{-1})[18].

DO ranged from 1.6 mgL^{-1} to 4.4 $mgL^{-1}$with the mean value of 3.1 ±0.34 mgL^{-1}. BOD ranged from 9.2 mgL^{-1} to 12.3 $mgL^{-1}$with the mean value of 10.6 ± 0.96 mgL^{-1}. COD ranged from 1.2 mgL^{-1} to 2.6 $mgL^{-1}$with the mean value of 1.34 ± 0.486 mgL^{-1}. The DO, BOD, and COD in Igbokoda river are in the range lower than the present study [19]. The low DO and BOD was attributed to growth of algae in some sampling points along the wastewater flow line which prevents oxygen from getting to the water surface. The reduction in light penetration prevents photosynthesis in aquatic plants and activities of phytoplankton in the water body.

Mn is not detected in the wastewater while Ni concentration ranged from 0.1 mgL^{-1} to 0.6 $mgL^{-1}$with the mean value of 0.311±0.15mgL^{-1}in the river water (Table 1). Nwankola *et al* [12], reported an appreciable concentration of Mn in Aba River, very close to an industrial estate. Cadmium concentration ranged from 0.2 mgL^{-1} to 0.7$mgL^{-1}$with the mean value of 0.44±0.16 mgL^{-1}. Pb concentration ranged from 0.01 mgL^{-1} to 0.4 $mgL^{-1}$with the mean value of 0.21±0.09 mgL^{-1}. Zn concentration ranged from 1.2 mgL^{-1} to 3 $mgL^{-1}$with the mean value of1.95 ±0.55 mgL^{-1}

The cow bone filters (CBF) were used to filter the wastewater and the physicochemical parameters were determined after filtration. The mean pH value before filtration was 5.75 while after filtration the pH was 6.1 (Figure 1). Nasr[20], reported pH between 4.5 and 7.5 during defluorination by bone char filtration. The pH of to be filtered can influence the efficiency of the filter. The EC which reduces from 271.3µSCm^{-1}. to 150 µSCm^{-1}., alkalinity reduces from 208 $mgL^{-1}$to 103 mgL^{-1}. Hardness reduced from 92.1 mgL^{-1} to 40 mgL^{-1}, chloride reduces from

324.6mgL^{-1} to 210mgL^{-1}. While TDS reduces from 162.7 mgL^{-1} to 117 mgL^{-1}.

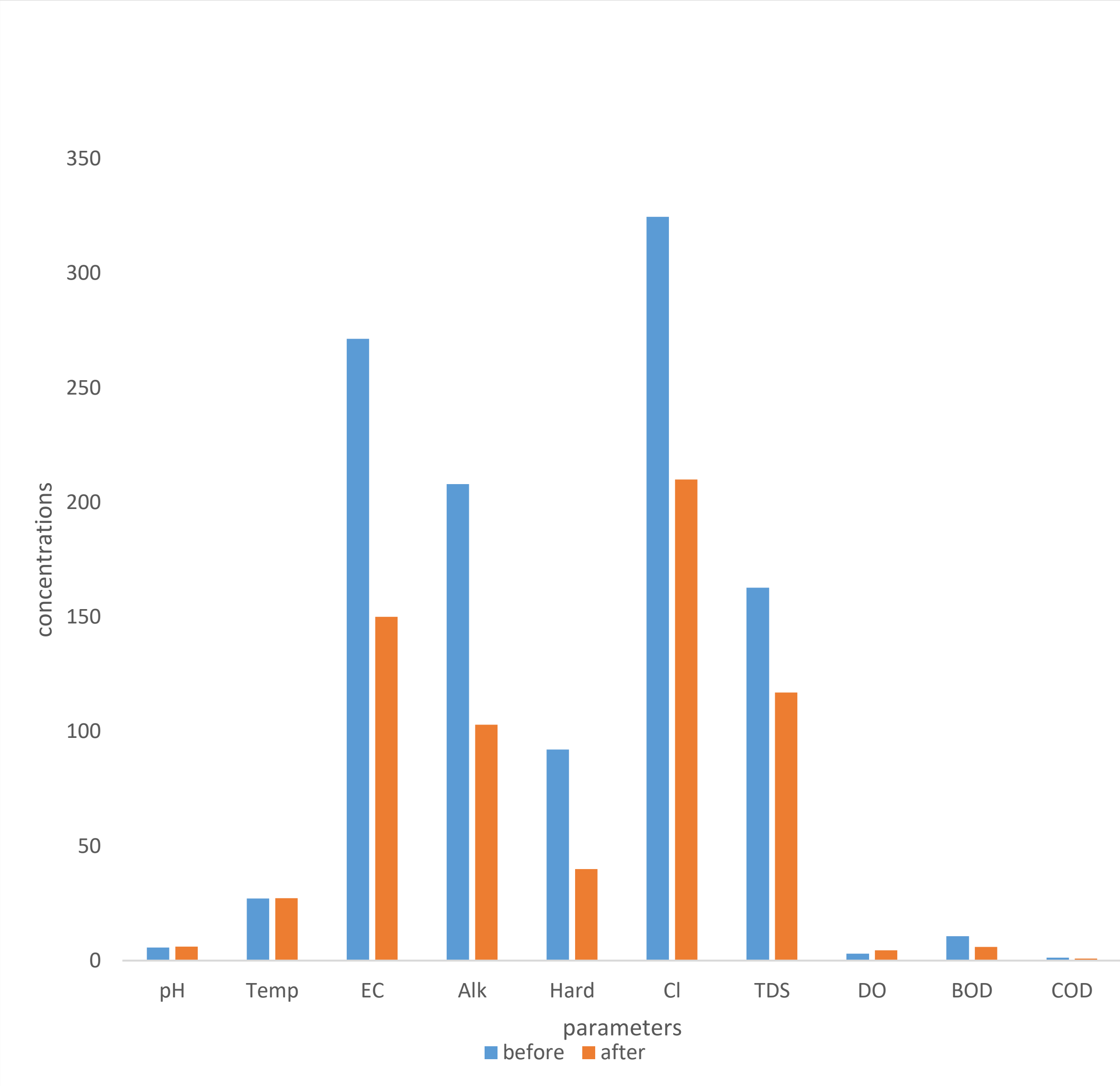

Figure 1: Results of filtration using cow bone filters (CBF)

DO increases. from 3.1 mgL^{-1} to 4.5 mgL^{-1} while BOD decreases from 10.6 mgL^{-1} to 6.0 mgL^{-1}. COD decreases from1.34 mgL^{-1} to 0.9 mgL^{-1}. The reduction of COD is in agreement with results from previous studies[21]. The chemical oxygen demand (COD) is the main indicator of wastewater treatment efficiency and capacity as it shows the degradation by oxidation of organic materials[22].

The saw dust filter (SDF) and cow bone filter (CBF) was used to filter solutions containing 500ppm each of Mn, Ni, Cd, Pb and Zn. The CBF reduces Mn, Ni, Cd, Pb and Zn to 100 ppm, 180.1 ppm, 195.3 ppm, 130 ppm, and 95 ppm respectively.

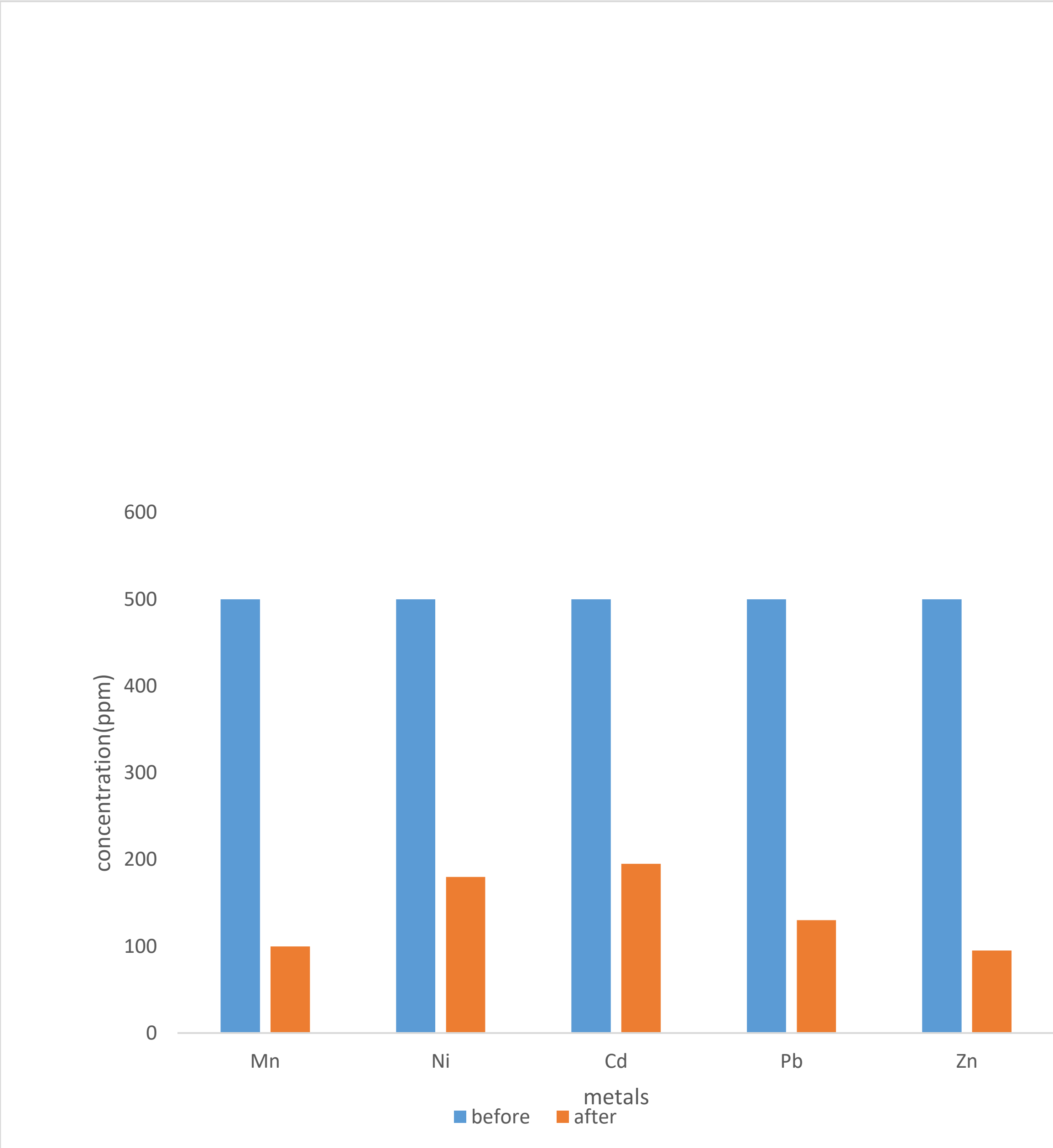

Figure 2: Removal of metals concentration by cow bone filters (CBF)

To confirm the removal of metals by filters made of saw dust (SDF), and cow bone filter CBF. A standard solution of each element containing 500 ppm were prepared and allowed to pass through the filter. The SDF removed 8 %, 14 %, 26 %, 17 % and 28 % of Mn, Ni, Cd, Pb, and Zn respectively (Fig 3). However, CBF removed 74 %, 70 %, 65 %, 68 % and 81 % of Mn, Ni, Cd, Pb, and Zn respectively. This agrees with previous studies[23], who reported filters that reduces concentration of metals in water from wells and boreholes

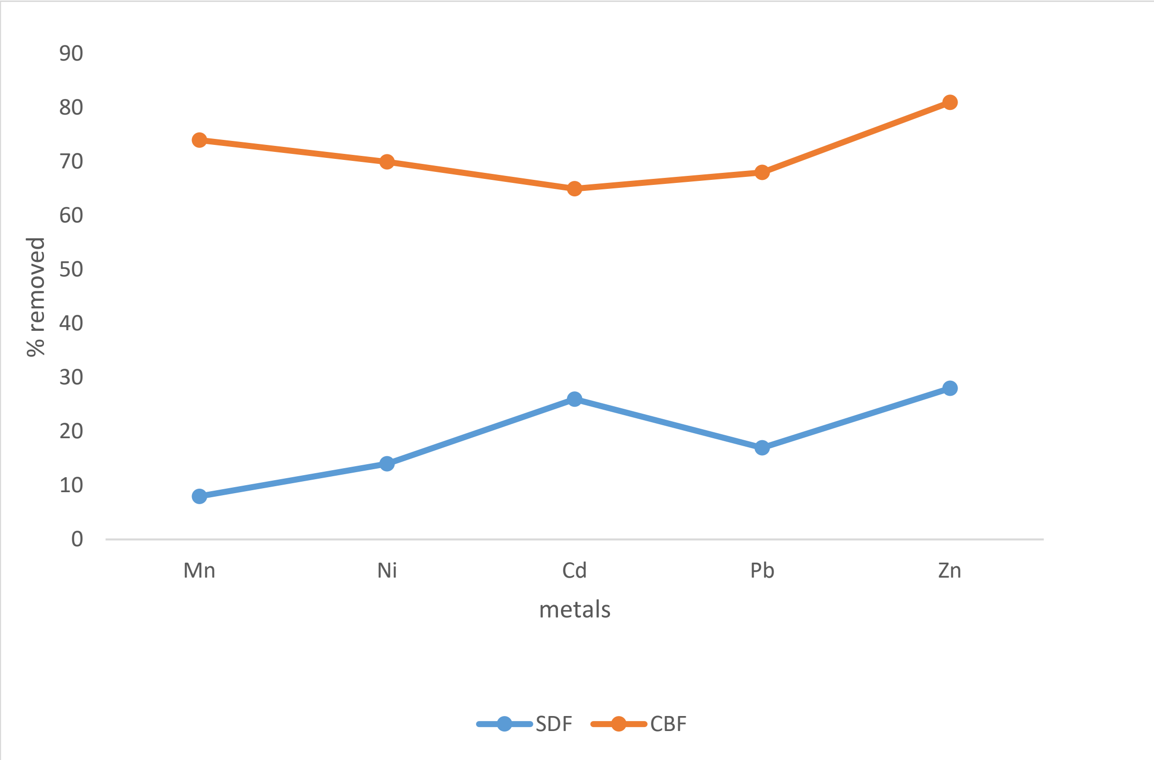

Figure 3: Comparison of % of metals removed by SDF and CBF

The FTIR spectral of CBF filter were recorded which showed that some bonds that are visible before filtration is either of low intensities or broad after filtration. The observed peaks at wave number 3838.42 cm^{-1} (Figure1) before filtration and 3750.93 cm^{-1} (Figure2) after filtration is characteristic for stretching vibration of O-H and C-H bonds in cellulosic material. This may occur as a result of possible contamination of the CBF during preparation. The broad peak recorded at 3449.76 cm^{-1} before filtration and 3447.55 cm^{-1} after filtration can be assigned to N - H bond. The C = O recorded at wavelength of 1646.31cm^{-1} before filtration was found to be broad at 1640.19 cm^{-1} after filtration. The sharp prominent peak at 2014.51 cm^{-1} before filtration was found at 2014.38 cm^{-1} after filtration. This confirmed that some substances are retained on the filter.

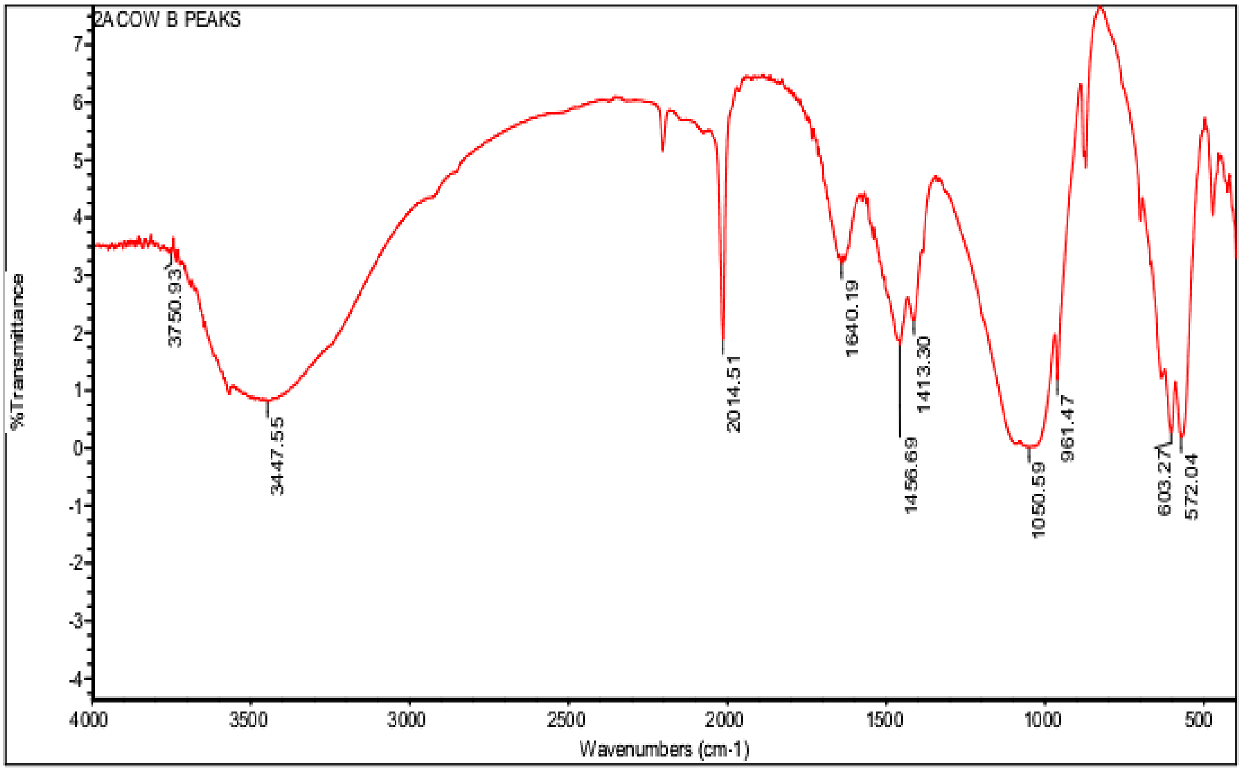

Figure 1: Spectral for cow-bone filter (before filtration)

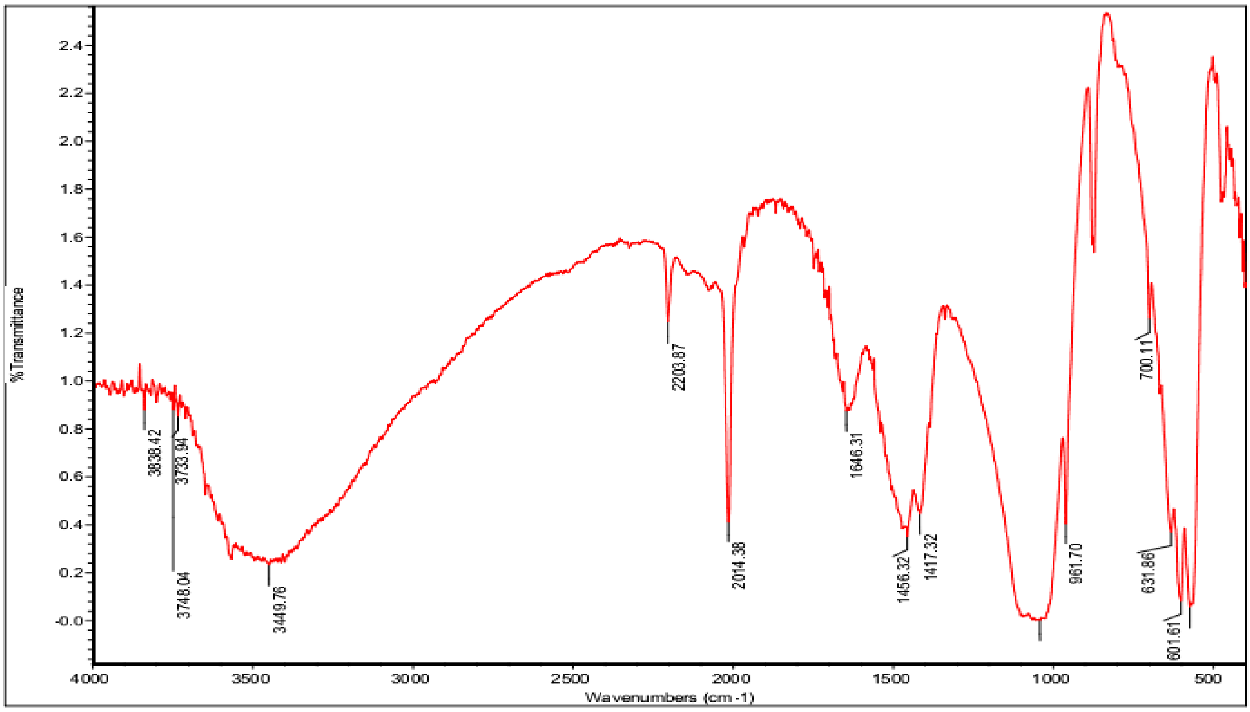

Figure 2: Spectral for cow-bone (After filtration)

The absorption bands at 1417.32 cm^{-1} and 1413.30 cm^{-1} belongs to stretching and bending vibrations of $-CH_2$ and -CH, -OH and C-O bonds in cellulose[24].

Similarly, the broad peak observed at 3750.84 cm^{-1} and 3674.41 cm^{-1} for saw dust filter (SDF) is characteristic for stretching vibration of the hydroxyl group in polysaccharide[25]. The SDF spectral before filtration showed that C-N bond appeared at 556.61 cm^{-1}, sharp, with intensity of 0.0465 while after filtration, it appeared at 572.43 cm^{-1}, broad with intensity of 0.411 while after filtration (Figures 3 and 4).

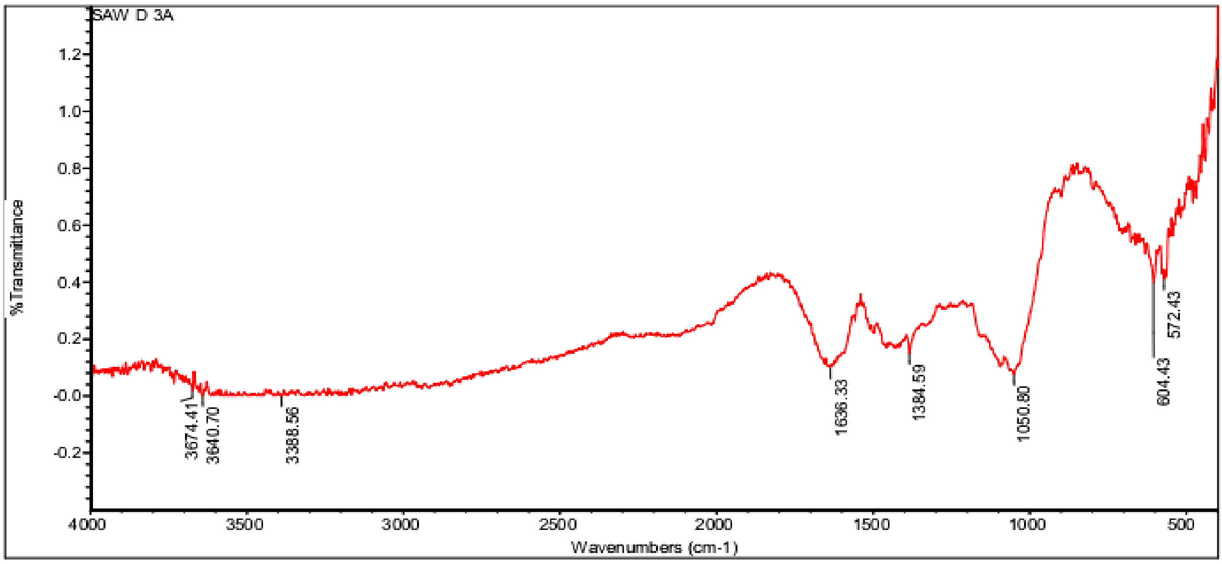

Figure 3: Spectral for saw dust (before filtration)

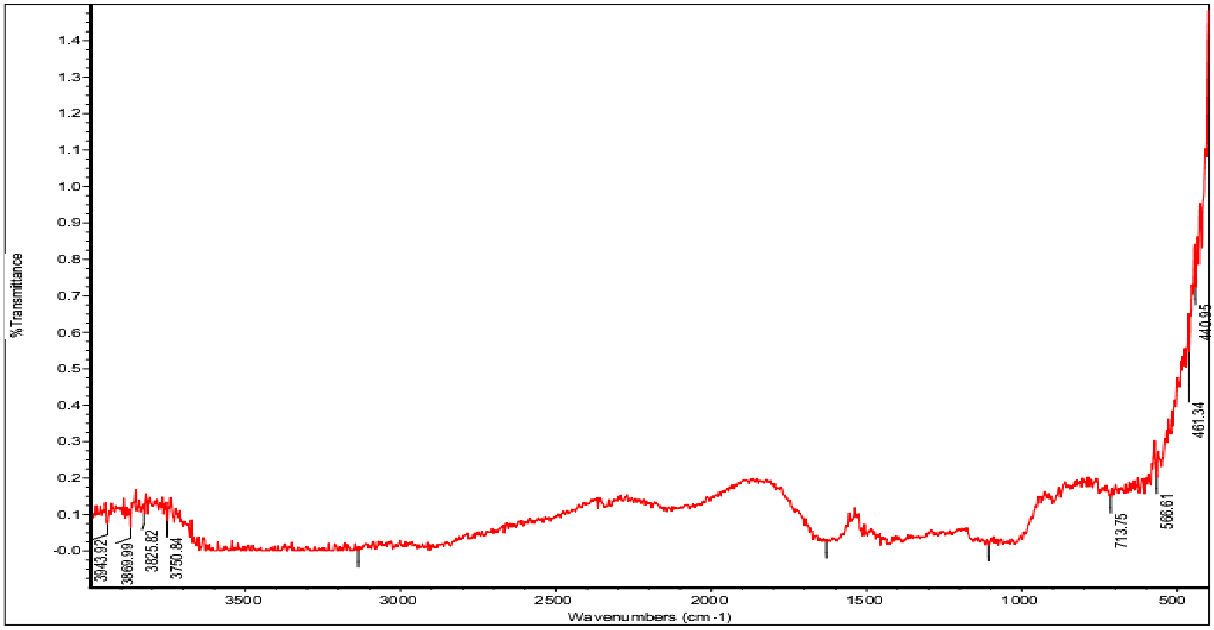

Figure 4: Spectral for saw dust (After filtration)

The sharp band at 713.75 cm^{-1} and 604. 43 cm^{-1} can be assigned to the amorphous region of cellulose [25]. The differences recorded in spectral before and after filtration established that some materials are retained on the surfaces of the filter.

CONCLUSION

The present study showed that Industrial wastewater can be purified using activated cow bone filter and saw dust filter. The CBF removed Chloride and metals better than SDF. The treatment given to wastewater generated reduces the physicochemical parameters appreciably. The IR showed that appreciable differences occur in the spectral before and after filtration. This further supports the fact that some materials are absorbed to the surfaces of the filter.

ACKNOWLEDGEMENT

The efforts of Mrs. A. O. Akomolafe is acknowledged for assisting in water sampling and laboratory analysis

ETHICS DECLARATION: There is no conflict of interest

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