THINK INDIA JOURNAL

ISSN:0971-1260
Vol-22- Issue-14-December-2019

Adsorption And Desorption Of Fe^{2+} Using Sugarcane Bagasse Activated Carbon In Remediating Metal Galvanizing Industrial Wastewater

[a]Samson O. Ojoawo, Seun E. Oyekanmi, [b]Pushparaj A. Naik

[a]Department of Civil Engineering,
Ladoke Akintola University of Technology,
P.M.B 4000,
Ogbomoso, Nigeria

[b]CivilEngineeringDepartment,
NMAMInstitute Technology,Nitte-574110,
Udupi District,Karnataka,India

e-mail: soojoawo@lautech.edu.ng,
Tel: +234-803-391-6883

Abstract

One of the world's current environmental pollution challenges is the rational use of water resources, the solution to which largely lies in treatment of industrial wastewater containing heavy metals, particularly iron. Excess iron in humans can be highly toxic, leading to a variety of serious conditions of liver, heart, and lung diseases, hormonal abnormalities, diabetes mellitus, and a dysfunctional immune system. There is therefore a need for urgent attention to remediate and recover iron from the studied metal galvanizing industrial wastewater. This study examined the application of Sugarcane Bagasse (SCB) activated carbon as an adsorbent in remediating Fe^{2+} from the metal galvanizing industrial wastewater, and its desorption for recovery.

Galvanizing industrial wastewater effluents were collected from the Electroplating Plant in the Coating Department of the Nigerian Machine Tools (NMT), Osogbo, Osun State, Nigeria, and subjected to Atomic Absorption Spectrophotometry (AAS) analysis to determine its Fe^{2+} concentration.Sugarcane (SC) stem was collected from LAUTECH Teaching and Research Farm, its juice was extracted, the soft edible fibre of the stem was cut into 5mm sizes and crushed inside mortar with pestle, rinsed inside clean water to completely remove ligneous, cellulose and trapped impurities in the bagasse. The filtration process was repeated and the final clean bagasse was collected in a stainless pan for oven drying. The sugarcane bagasse (SCB) was then oven dried for 24hrs at 40^0C after which it was grinded. The SCB powder obtained was graded in sieve No. 200 and the fines passing through the sieve were stored in airtight 0.75L PET bottles. Characterization of the adsorbent was done through FTIR and SEM analyses. Adsorption study was carried out by determining the effects of adsorbent dosage, contact time, and agitation speed on the process during the wastewater treatment. Desorption of the loaded adsorbent was done with 0.1 and 0.3M of HCl and residue subjected to SEM analysis after centrifugation and oven drying at 105^0C.

The SEM images of raw adsorbent before treatment are characterized by a heterogeneous, well developed structure for incorporation of particles. The FTIR result shows band of 3314.5 (3300 – 3500cm^{-1}) due to N – H stretching bond, Amines or Amides functional group or class with medium intensity of absorption. The shoulders observed at 2889.7 (2850 - 2970cm^{-1}) due to C – H stretching

ISSN:0971-1260
Vol-22- Issue-14-December-2019

bond, alkanes functional class and medium – strong intensity of absorptions. The band 1689.6 is due to C = C stretching bond, Alkenes group and variable intensity of absorption and near 1450cm^{-1} is due to aromatic rings with strong intensity of absorptions. The initial concentration of Fe^{2+} in the wastewater was 10.848 mg/l. The adsorption capacity was found as 0.200mg/l for $Fe^{2+}$with optimum adsorbent dose of 0.2 g/l. The maximum observed adsorption is about 95% for Fe^{2+}. The SEM analysis of the desorbed SCB shows smoother, compact materials which are uniformly distributed on the surface and interior pores believed to be Fe^{2+} filling the interstices of the adsorbent.

It is concluded that Sugarcane bagasse is very efficient in remediating Fe^{2+} from metal-galvanizing wastewater. Considering the cost, ease of preparation and regeneration capacity after treatment, Sugarcane bagasse application in remediating Fe^{2+} from metal-galvanizing industrial wastewater is hereby strongly recommended.

Keywords: Sugarcane bagasse, remediation, adsorption, desorption, industrial wastewater

1.0 Introduction

The essentiality of water to all creatures (man, animal and plants) cannot be overemphasized. Water is used in almost all activities of man on a daily basis. A good percentage of water is sea water, only a small percent is available as fresh water. Naturally, surface water contained all the fresh water available to human use which are inform of rivers, streams and lakes and in sub-surface as in rocks and soil called underground water (Gad *et al.,* 2011). Rational use of water resources appears to be one of the world's urgent environmental challenges, as it leads to water pollution, and the solution to which largely lies in treatment of wastewater that comes from anthropogenic activities in various fields: industries such as metal galvanizing, metallurgical, mining, chemical, tannery, battery and nuclear, agriculture, shipping and others. It is especially important to control contents of heavy metals (Roccaro*et al.*, 2013) which are one of the most biologically dangerous and toxic components of wastewater effluents.

Also, the increased flux of metallic substance in the aqueous environment was as a result of tremendous increase in the use of heavy metals over the past few decades. The persistency of heavy metals makes it of special concern. Pollution studies by toxic metal compounds assume considerable importance in chemical process industries. Due to their high toxicity for human health, a concentration of heavy metal in wastewater is strictly restricted by high standard (Kamal *et al.*, 2014).

Iron is one of the prominent metals in industrial wastewater, it is a toxic, bio-accumulative and persistent heavy metal which does not break down in the environment; it is not metabolized easily and dangerous to human health. The various potential sources of iron pollution are metallurgical and metal finishing (galvanizing), copper plating and pickling, drilling mud's catalysts, primer paints, fungicides, corrosion inhibitors in cooling and boiler systems (Thomas, *et al.*, 2008).Acute poisoning from ingestion of excessive iron can cause anorexia, oligura, diarrhoea, hypothermia, diphasic shock, metabolicacidosis and even death.Liver toxicity has been seen in doses high enough to cause death. High doses of iron are frequently associated with gastrointestinal effects, especially constipation, but also with nausea, diarrhoea and vomiting. Chronic iron exposure promotes gastric and esophageal ulceration in humans and animals. Excess iron deposition in human body is regulated by a complex mechanism for maintaining homeostasis (Gurzau *et al.*, 2003).

ISSN:0971-1260
Vol-22- Issue-14-December-2019

Excess iron in humans can be highly toxic. This toxicity involves many part of the body, lead to a variety of serious conditions, such as liver, heart, and lung diseases, as well as hormonal abnormalities, diabetes mellitus, and a dysfunctional immune system. The tissue damage associated with iron overload is believed to result primarily from free-radical reactions mediated by iron. The diseases associated with iron overload can be managed effectively or prevented. Therefore, there is a need for urgent attention to remediate industrial wastewater which is one of the major sources of Fe^{2+} ion in aqueous environment.

Majumdar*et al.,* (2004) carried out a study on the sources and physicochemical characteristics of galvanizing industry effluent. The pH value indicated extremely acidic nature of effluent due to presence of acids originated primarily from the cleaning units of the industry. The high conductivity value suggested the occurrence of large amount of inorganic compounds in the effluent. The elevated value of turbidity also indicated the presence of sizable amount of suspended solids derived from washing and bathing units of the industry. The concentration of$Fe^{2+}$was found to be between 21.00 and 32.5 mg/L which is beyond the permissible 10 mg/L of the EPA effluent standard, thereby causing pollution.

Wastewater containing heavy metals can be treated through conventional treatment techniques such as chemical precipitation, ion exchange, floatation, membrane filtration, electrochemical process, reverse osmosis, phytoremediation etc.(Rich and Cherry, 1987).
Hence the disadvantages like incomplete metal removal, high reagent and energy requirements, generation of toxic sludge or other waste products that require careful disposal has made it imperative for a cost-effective treatment method that is capable of removing heavy metals from aqueous effluents.These techniques were found to have some drawbacks, which includes incomplete metal removal, production of excess toxic sludge which requires special disposal method, high initial and operation cost, and demand for high energy (Salihi *et.al.,* 2017; Eccles, 1999).

The low-cost adsorbents obtained from plant wastes applied as a replacement for costly conventional methods of remediating heavy metal ions from wastewater has been reviewed. It is well known that cellulosic waste materials can be obtained and employed as cheap adsorbents and their performance to remediate heavy metal ions can be affected upon chemical treatment. Sugarcane bagasse, Fly ash, Peanut hulls, Banana peels, Neems leaves, Tea waste, Rise husk, Saw dust, Coconut husk, Soyabean hulls, Cotton seed hulls etc. are low cost adsorbents. (Zodape *et al.,* 2011)

Sugarcane bagasse (SCB) is obtained from the fibrous material left after cane stalk crushing and juice extraction. Sugarcane bagasse originates from the outer rind and inner pith, and has been used in the natural form as well as in a modified form (Renu, *et al.,* 2017).SCB is a by-product of agricultural wastes that consists of lignin (23%), polyoses (27%) and cellulose (50%).Its biological component polymers, makes SCB riches in phenolic and hydroxyl groups and these groups can be chemically altered to increase its adsorption capacity (Renu, *et al*., 2017; Ngah and Hanafiah, 2008).Chemicals used for modification of sugarcane bagasse are sulphuric acid, succinic anhydride, pyromellitic anhydride, citric acid, sodium bicarbonate, ethylenediamine, etc. These acids serve as good activating agents, they polymerized with SCB to increases the number of chelating sites and pore spaces (porosity) helps in heavy metal removal from wastewater (Renu, *et al*., 2017).

Thomas *et al*., (2008) have studied that use of agricultural and agro-processing industry waste (Sugarcane bagasse) as metal adsorbents from wastewater. Modified materials displayed better adsorption capacity of some was comparable with that of commercial activated carbons and synthetic resins. Agricultural wastes are low cost adsorbents and can be viable alternatives to activated carbon for treatment of metal contaminated wastewater. Adsorbents based on sugarcane bagasse activated carbons

ISSN:0971-1260
Vol-22- Issue-14-December-2019

(SBACs) are widely heavy metal contaminants removal due to their well-developed porous structure (large mesopores and micropore volumes) and a high specific surface area, as well as different surface functional groups (including carboxyl, carbonyl, phenol, quinone, lactone, and others) bound to the edges of the graphite-like layers (Burakov,*et al*, 2017).

Kamal et al, (2014), used sulphuric acid for modification of SBACs and reported 96.4% removal obtained at an optimum pH of 5. Akhila *et al.*, (2013), used synthetic treated SBACs and removal of above 93% copper was reported at an optimum pH of 5. Patil *et al.,* (2012) has studied the efficiency of removing metal ions from iron and zinc chloride using acid modified sugarcane bagasse. Iron adsorption by SBACs was affected by initial concentration and pH of the solution. The percentage removal of iron obtained was 85 - 97%. Thomas *et al.*, (2008) reported that batch adsorption of sugarcane bagasse reached equilibrium by 60 min of contact and 60% removal of iron was achieved at pH of 5.5.

The focus of this paper is to remove and recoverFe^{2+} ions from metal galvanizing industrial wastewater using raw sugarcane bagasse adsorbent. The objectives are to determine the initial concentration of Fe^{2+}ions in the wastewater;characterize the adsorbent for suitability; to determine the optimum conditions (such as effect of phase contact time, rotating speed and concentration dosage) of the adsorbent; to determine the removal efficiency of SCB in adsorbing Fe^{2+} from wastewater; to regenerate and recover the Fe^{2+} through a desorption process using HCl as agent.

2.0 Materials and Method

(a) Wastewater Sampling: The preliminary experiment study was conducted on the wastewater samples collected from Nigerian Machine Tools (NMT), Kilometer 8, Ikirun Road Osogbo, Osun State, Nigeria. The sample was collected from Coating Department (Electroplating Plant) of the company. The sample was collected in a clean airtight 10 litres keg, tightly corked after collection, the keg was rinsed with little sample in order to clear any impurities that may be present inside the keg, the sample was stirred together to avoid sedimentation of wastewater sludges, finally the keg was filled up with stirred sample with a scoop.

(b) Material and Adsorbent Preparation: Sugarcane (SC) stem was collected from LAUTECH University Research farm, sugarcane juice of the (SC) stem collected from research farm was extracted by a pestle and mortar. The sugarcane (SC) stem collected from the research farm was peeled with knife to remove the hard bark of the sugarcane. The soft edible fibre of the stem was cut into 5mm sizes and it was crushed inside mortar with pestle. The crushing sugarcane stem was filtered with a clean towel handkerchief to remove the juice from the bagasse. After the remover of juice, the sugarcane bagasse (SCB) was rinsed inside clean water to completely remove ligneous, cellulose and trapped impurities in the bagasse. The filtration process was repeated and the final clean bagasse was collected in a stainless pan for oven dry. SCB was then oven dry for 24hrs at 40^0C after which it was grinded. The SCB powder obtained was graded in sieve No. 200 and the fines passing through the sieve were stored in airtight 0.75L PET bottles (Ojoawo *et al.*, 2016).

(c) Characterization of Agrowaste material and wastewater: The agrowaste material wascharacterized using Fourier Transform Infra Red (FTIR) and Scanning Electron Microscopy (SEM). The analysis of wastewater was by Atomic Absorption Spectrophotometry (AAS). The digestion of wastewater samples was carried out and its characteristics determined through physico-chemical laboratory analysis, with special focus on Fe^{2+} concentration determined by using AAS.

ISSN:0971-1260
Vol-22- Issue-14-December-2019

(i) Fourier Transform Infrared (FITR) analysis: Fourier Transform Infrared analysis was carried out on the prepared SCB sampleusing Infrared Spectrophotometer model: BUCK M530 series at the LAUTECH Central Research Laboratory to determine its functional group in other to evaluate its rate of absorption. Infrared spectroscopy is a powerful tool for identifying the presences of functionalities such as Hydroxyl, Carbonyl, alkane, aromatic compounds, amino compounds, among others. The vibration spectrum of a molecule is considered to be a unique physical property and is characteristics of the molecule. The most useful region of the infrared radiation extends from above 2.5 to 16 microns (1 micron = 1 micrometer = 10^{-6} meter). However, to use wavenumbers to specify the positions of absorptions. The wavenumber of a particular radiation is the number of waves per centimeter, which is simply one divided by the wavelength (λ) in centimeter

$$\text{Wavenumber} = \frac{1}{Wavelenghtincm}.$$

In this study a 0.05g portion of the 0.2g sample taken to the Laboratory was mixed with KBR before subjected to FTIR equipment for analysis. The emerging spectrum being produced by the FTIR equipment for the sample was noted.

(ii) Scanning Electron Microscopic (SEM) analysis: Specimens for Scanning Electron Microscopy were prepared by carbon taping. They were stuck on the carbon tape plate and subjected to detail-obscuring conducive coating, gold coating using Auto-fine coater equipment JEOL, JEC-1600 to improve the conductivity of specimen since it is a non-conductive sample. The carbon-taped sample was transferred into JEOL fine-coater at pressure of 30Pa and allowed to be pressurized to a value <5Pa, creating a vacuum inside. After which certain rays were displayed, coating the specimen and the timing count-down was from 60 to 0 sec. Coated specimens were immediately transferred into the Specimen Stage of the SEM (Model: JEOL JSM-6380LA, Analytical Scanning Electron Microscope) after its cooling system has been topped with liquid nitrogen coolant.

(iii) Atomic Absorption Spectrophotometry (AAS) analysis: AAS analysis was carried out to determine the concentration of the untreated wastewater, the final concentration after treatment and the control sample. The instrument used is the atomic absorption spectrophotometer (AAS) with model number PG6990. Prior to the AAS analysis the wastewater sample was subjected to digestion. This was carried out with the aim of breaking down the complexity of the samples. In the process, 10mL of the wastewater was measured into a 50mL beaker and a 5mL of concentrated nitric acid, acting as a catalyst was carefully added to it. The beaker was placed inside the fume cupboard and heated with the heating mantle for 30 minutes at 100^0C. The cooled mixture was removed from the fume cupboard and then topped with distilled water to make it up to 100mL before beingfiltered for AAS analysis.

The AAS machine consists of three (3) main components which are the main equipment, the compressor and the computer. The digested wastewater was sucked by the compressor on the main machine and which later sends signal to the computer.

ISSN:0971-1260
Vol-22- Issue-14-December-2019

The wavelengths of the metals to be analyzed were adjusted and the monochromator then measure the quantities of the absorbed metals, the flame used in the analysis is air-acetylene. The temperature formed in the air-acetylene flame is around 2300^0C. The FAAS technique made use of the fact that neutral or ground state atoms of element can absorb electromagnetic radiation over series of very narrow, sharply defined wavelengths (Ojoawo *et. al.*, 2014).

(d) Adsorption Batch Experiments: The batch experiments with One Factor at A Time (OFAT) were conducted on the wastewater samples varying the factors of adsorbent dosage, contact time and rotating speed of rotary incubator as follows:

(i) **Adsorption Study**: This was carried out with 50ml of wastewater sample poured into 250ml conical flask and 0.2g of prepared SCB adsorbent was added, placed on a rotary shaker at 150 revolutions per minute (rpm) at room temperature for one hour. The suspension was filtered and the filtrate was subjected to AAS analysis.

(ii) **Effect of Adsorbent Dosage**: this was studied with the varying dosages of 0.2, 0.4, 0.6, 0.8, 1.0g into 50ml of the wastewater sample in a conical flask respectively and agitated at 150 rpm for 60mins and the suspension was filtered and the filtrate was subjected to AAS analysis.

(iii) **Effect of Contact Time**: This was performed as 0.2g of adsorbent was added to 50ml of wastewater samples in different conical flasks , placed on a rotary shaker and agitated at 150 rpm for each of the different contact times chosen as 20, 40, 60, 80 and 100mins respectively.

(iv) **Effect of Rotating Speed:** 0.2g of the adsorbent was measured into 50ml of wastewater sample into different conical flasks and subjected to various agitation rpm from 50 to 200 at 50 rpm intervals. The filtrate from each batch was then subjected to AAS analysis.

(v) **Percentage removal of adsorbate/biosorption:** the percentage biosorption of heavy metal for the experiment, (Ojoawo *et al.,*2018).

Calculation: $$\% \text{ Biosorption} = \frac{Ic - If}{Ic} \text{ X } 100\% \quad \text{.....} \quad 1$$

Ic = Initial concentration

I_f = Final concentration

(e) Desorption Study: Desorption of metal ions from the adsorbents was carried out by washing loaded sorbents (initial concentration of iron, 10.871 mg/L, dosage 0.2g, shaking speed 150 rpm, at room temperature) with 20ml of HCl eluent in a glass petri dish at different concentrations of 0.1 and 0.3M, in accordance with the report of Kołodyn´ska *et al.*, (2017). In order to determine the time at which the highest percentage of desorption (D %) can be achieved, the phase contact time in the range 300–360mins. was applied. In this study iron concentration was determined in the samples removed after 360mins. It is important to note thatwith the increase in the acids concentration, the desorption efficiency

ISSN:0971-1260
Vol-22- Issue-14-December-2019

also increases. However, higher acid concentration may damage the structure of the adsorbent or reduce the adsorption and desorption efficiency of the adsorbent.

(f) Centrifugation: Centrifugation is a technique which involves the application of centrifugal force to separate particles from a solution according to their size, shape, density, viscosity, of the medium and rotor speed. The desorbed solution was subjected to centrifugation process in order to separate the desorbed metals ions from the adsorbent. The solution was poured into a test tube and loaded inside the centrifuge machine test tube hanger; the machine was powered, and set at 1500 revolutions per minute for 30minutes. The acid filtrate was decanted, left only pure metals ion and adsorbent at the bottom test tube, which was picked by scoop and oven dried at 105^0C for Scanning Electron Microscope (SEM) analysis.

3. 0 Results and Discussion

(a) Heavy Metals Concentration of the Sample before Treatment

Table I: Concentration of heavy metals in the wastewater sample prior to Treatment compared with Quality Guidelines and Standards.

Metals	*Present Study mg/l*	*WHO Standards MPL*	*Nigeria Standard MPL*
Cd^{2+}	ND	0.005	0.003
Mn^{2+}	0.185	0.50	0.20
Pb^{2+}	0.079	0.015	0.01
Zn^{2+}	31.859	5.00	3.0
Fe^{2+}	10.848	0.30	0.30
Cr^{2+}	0.270	0.05	0.05
Co^{2+}	0.403	None	0.05
Cu^{2+}	0.328	1.00	1.00

N.B

**MPL = Maximum Permissible Limits*
***mg/l = milligram per liter*
****ND = Analyzed for but not detected/value is below reportable limits*

Table I shows the initial concentration of heavy metals present in the effluent from the electroplating department of Nigeria Machine Tools, Osogbo. Eight heavy metals were analyzed for in the wastewater, the results revealed that seven metals were presents which are Manganese (Mn), Lead (Pb), Zinc (Zn), Iron (Fe), Chromium (Cr), Cobalt (Co) and Copper (Cu). Only Cadmium (Cd) was not present in the effluents. From Table 1 and Figure 1, it is shown that Zinc (Zn) has the highest concentration of 31.859ppm (72%), confirming it as the major content of metals used in the electroplating process. This is

ISSN:0971-1260
Vol-22- Issue-14-December-2019

followed by Iron (Fe) with about a quarter of the total metal concentration, 10.848ppm. That formed the basis of the focus on Fe^{2+} in this study. Copper, manganese, lead, and chromium have insignificant concentrations; less than 1% in each case while Cadmium was not detected. When compared with the WHO and Nigerian standards, both copper and manganese were found not to be constituting pollution in the sample.

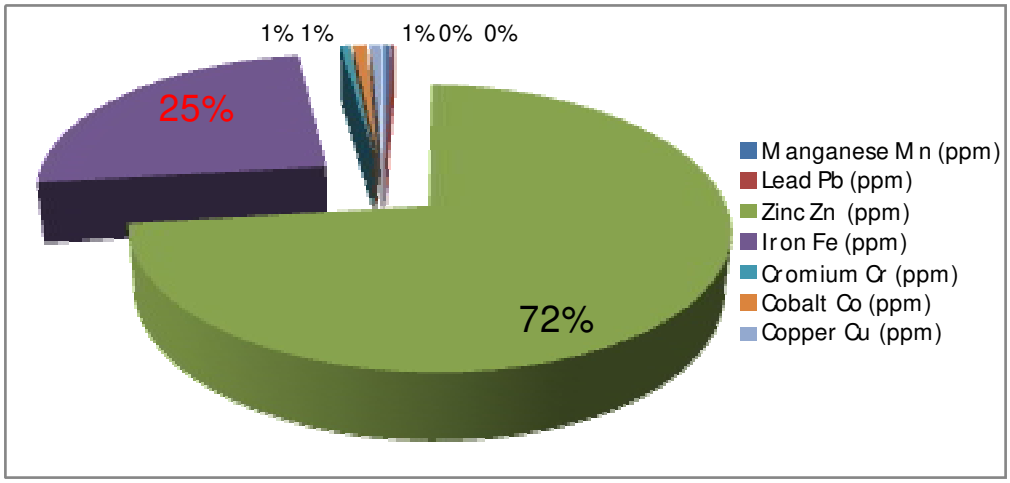
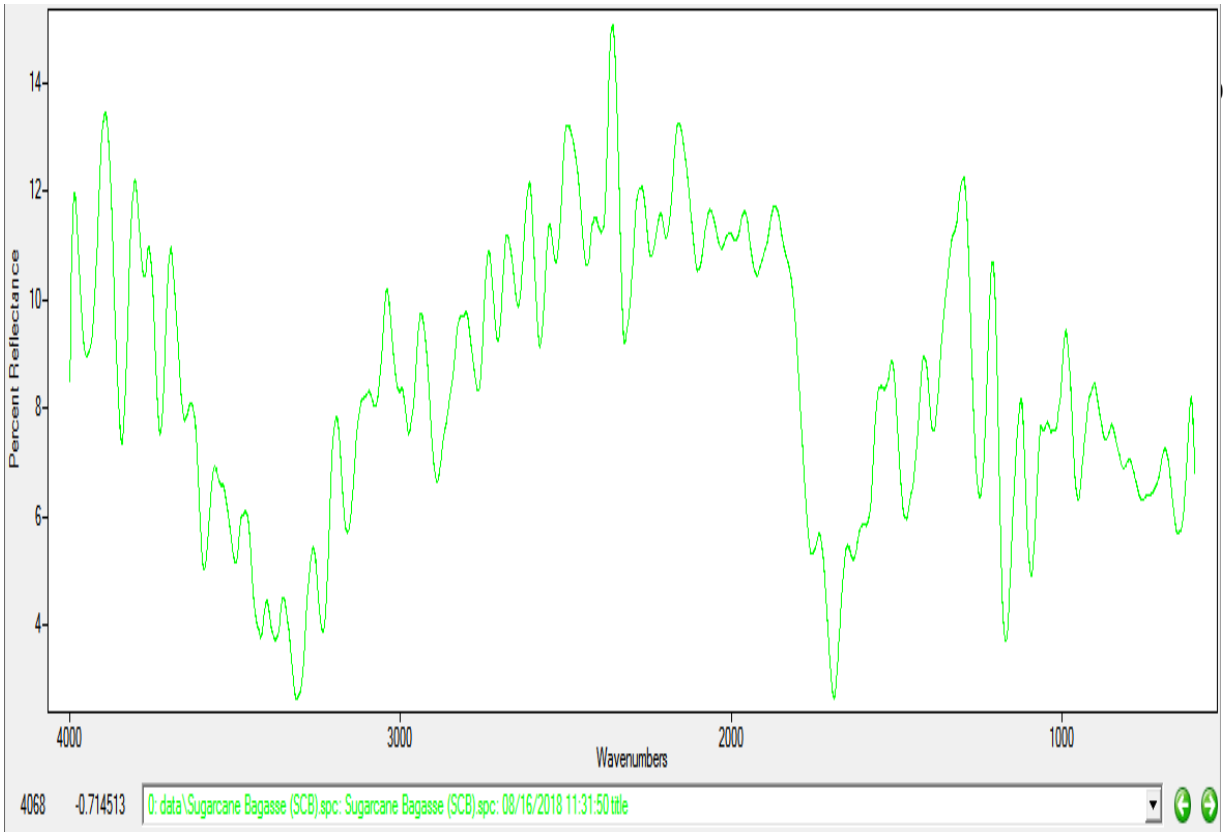


Figure I: Initial metals concentration in the wastewater prior to treatment

(b) FTIR Spectrum characterization results

The surface functional groups of SCB were determined by FTIR, the results of which are summarized in Figure II.



ISSN:0971-1260
Vol-22- Issue-14-December-2019

Figure II: FTIR Spectrum for SCB Sample

Figure II shows band of 3314.5 (3300 – 3500cm^{-1}) due to N – H stretching bond, Amines or Amides functional group or class with medium intensity of absorption. The shoulders observed at 2889.7 (2850 - 2970cm^{-1}) due to C – H stretching bond, alkanes functional class and medium – strong intensity of absorptions. The band 1689.6 is due to C = C stretching bond, Alkenes group and variable intensity of absorption and near 1450cm^{-1} is due to aromatic rings with strong intensity of absorptions.With the N – H stretching bond it shows characteristic absorption in their IR spectra, and which are soluble in organic solvents regardless of size.The bond is capable of intermolecular hydrogen bonding, because nitrogen is less electronegative than oxygen; however, intermolecular hydrogen bonds between N and H are weaker than those between O and H. The C-H is a covalent bond meaning that carbon shares its outer valence electrons with up to four hydrogen atoms, completing both of their outer shells making them stable. They have a bond length of about 1.09 Å (1.09 × 10−10 m) and bond energy of about 413 kJ/mol.Unlike a C-C single bond, the double C = C bond does not permit rotation.It is formed with a sp^2-hybridized orbital and a p-orbital that is not involved in the hybridization.

(c) Batch adsorption experiments results

Tables II to IV show the results of AAS analysis after the adsorption studies with the varied factors of dosage concentration, contact time and agitation speed. The percentage removal of the adsorbent was presented alongside each factor. Table II indicates thatthe metal was completely removed by the SCB right from the dosage of 0.2g, which is observed as the optimum dosage.Table III shows the effect of rotating speed on the adsorption of the iron. At 100 rpm was the optimum speed found with removal efficiency of 98.2%. The adsorption capacity thereafter reduces with further increase of the rotating speed.

Table II: Results of Adsorbent Dosage

Adsorbent Dosage (g)	*Fe^{2+} (ppm)*	*(% removal)*
0.2	0	100
0.4	0	100
0.6	0.003	99.97
0.8	0	100
1.0	0	100

Table III: Effect of Rotating Speed

ISSN:0971-1260
Vol-22- Issue-14-December-2019

Speed (rpm)	*Fe^{2+}(ppm)*	*(% removal)*
50	1.077	90.07
100	0.200	98.16
150	0.466	95.7
200	0.728	93.27

Table IV: Effect of contact time on the adsorbent

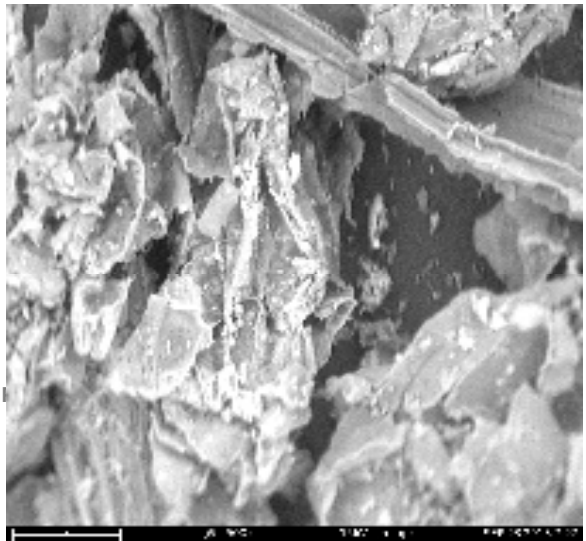
Contact time (mins)	*Fe^{2+} (ppm)*	*(% removal)*
20	0.374	96.55
40	0.371	96.58
60	1.349	87.56
80	1.994	81.62
100	0.863	92.04

From Table IV the effect of contact time on the adsorption of Fe^{2+} in the wastewater sample was noted to have largely decreased with increasing contact time. The adsorbent gave optimum removal at 40mins contact time with 96.58% and thereafter practically slides downward in efficiency.

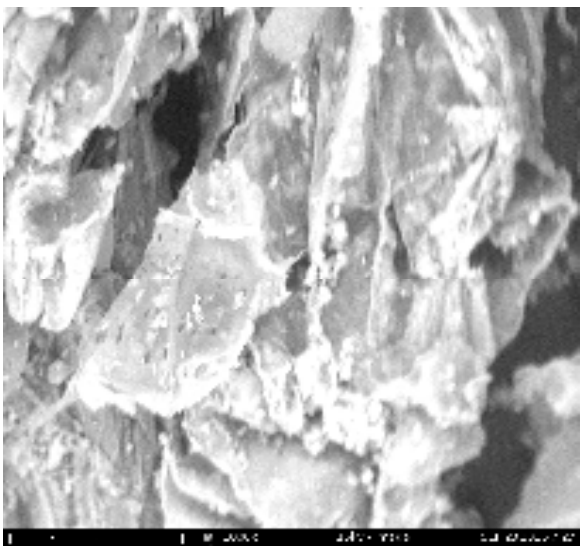
(c) SEM Results and the desorption studies

In Figures III to V, the Scanning Electron Microscope (SEM) images of raw adsorbent before treatment, after the adsorption study and then after the desorption experiment at different magnifications are presented. The raw adsorbent in Figures III and b has a heterogeneous, well-developed porous structure, highly receptive to the adsorbate, which is Fe^{2+}, the heavy metal under study.

(a)



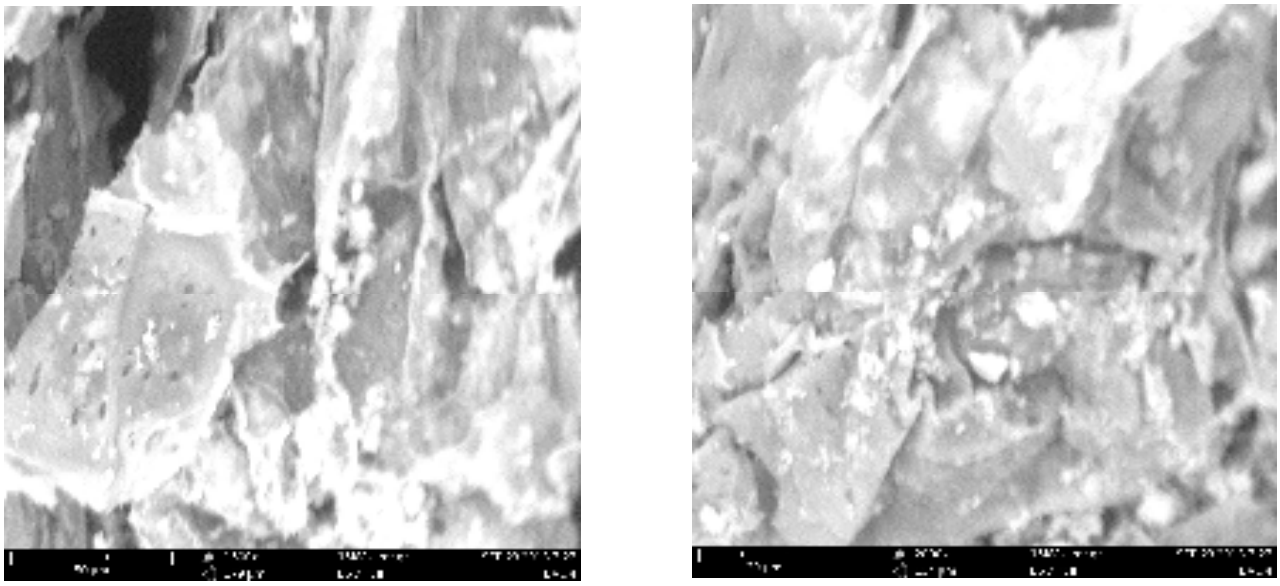
(b)



ISSN:0971-1260
Vol-22- Issue-14-December-2019

Figures III a-b: SEM images of SCB sample before treatment at (a) 500x, (b) 1000x magnification

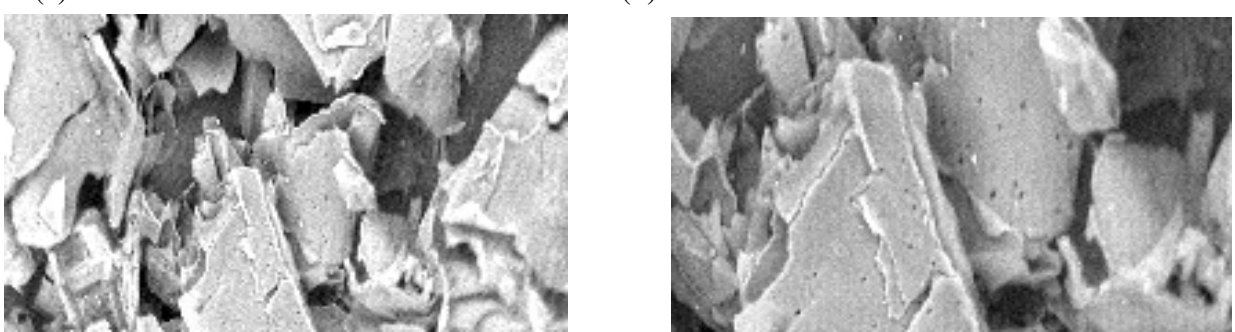
(a) (b)



Figures IV a-b: SEM images immediately after the adsorption studies at (a) 1500x and (b) 2000x magnifications.

In Figures IV a and b, certain accumulation of substances were observed all over the structures of the adsorbent, suggesting the adsorption of Fe^{2+}. Furthermore, based on the magnified images in figures IV, the sorbed metal ions are uniformly distributed on the surface and interior pores of the SCB adsorbent and they are characterized by a smoother compact and uniform structure, this finding corroborates an earlier report of Kołodyn´ska *et al.*, (2017). From Figures V a to d, it is observed that the desorbed metal created certain spots on the structures of the adsorbent. The initial clogging observed in figures IV a and b are no longer in the desorbed structure. This suggests that the organic activities were terminated with the acid and Fe^{2+} components are now dissociated from the adsorbent, from where it can be regenerated and recovered.The images generated confirmed the recovery of the metal ions on the surface pores of the SCB adsorbent.

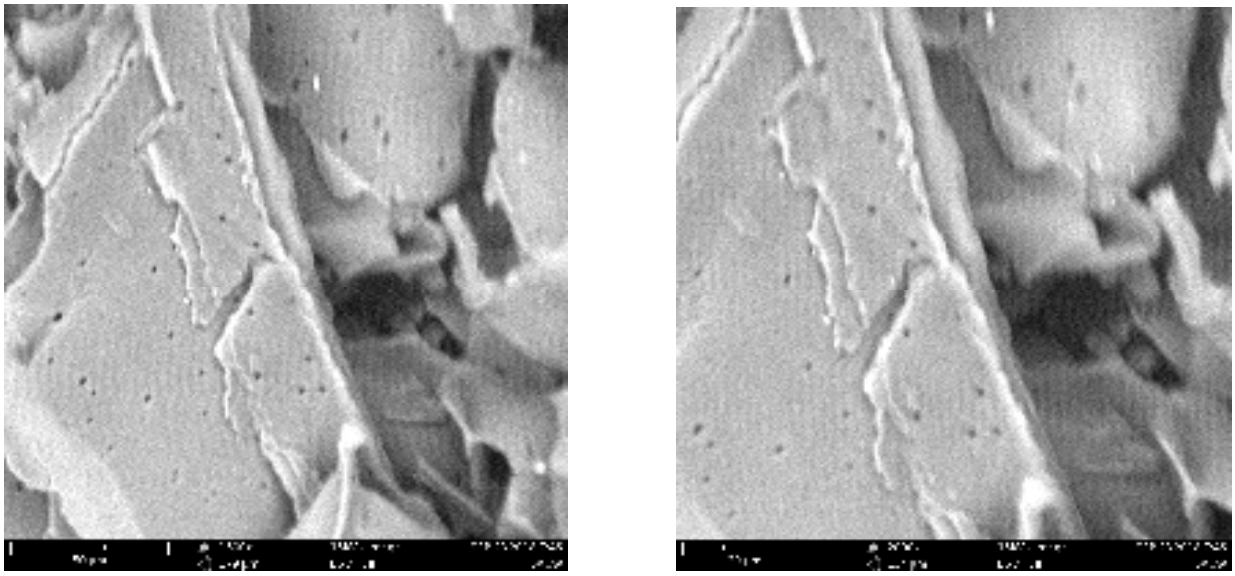
(a) (b)



ISSN:0971-1260
Vol-22- Issue-14-December-2019

(c)

(c) (d)



Figures V a-d: SEM images of loaded adsorbent after the desorption process at (a) 500x, (b) 1000x, (c) 1500x and (d) 2000x magnifications.

5.0 Conclusion

This research works shows that sugarcane bagasse is a good low cost, abundantly available and can be used as an effective biosorbent for removal of Fe^{2+} ions in aqueous solution. The adsorption process is a function of the metal ion concentrations, contact time, rotating speed and adsorbent dosage. The maximum percentage removal of Fe^{2+} ions from aqueous solution was found to be 95.11% with the raw sugarcane bagasse adsorbent. Sorption capacity reduces with the increasing dosage concentration and phase contact time. Desorption studies presented a good basis for the regeneration and recovery of both adsorbent and heavy metal ions. Sugarcane baggase ash is therefore recommended for use as an adsorbent for Fe2+ in the metal galvanizing industrial wastewater.

ISSN:0971-1260
Vol-22- Issue-14-December-2019

6.0 References

Akhila P., Swathanthra, S.B, Babu, S.M, Srinivasa, M.R., Basava V.V. (2013)*"Removal of Copper from Aqueous Solutions by Using Sugarcane Bagasse"* ISSN: 2320 - 1932

Burakov, A.E., Alexander E., Evgeny V. Galunin, Irina V. Burakova, A.E. Kucherova, S.A., Alexey G.T., Vinod K.G (2017*) "Adsorption of heavy metals on conventional and nanostructured materials for wastewater treatment purposes: A review"*. Ecotoxicology and Environmental Safety, 148: 702–712

Eccles H. (1999)*"Treatment of metal-contaminated wastes: why select a biological process?"* .Trends inbiotechnology, 17: 462-465.

Gad, A., Ali R., and El-zeiny, A. (2011)*"Negative impacts of man-made activities on water quality, Egypt"*, researchgate.net/publication/276935702

Kamal, R., Mitali, S., Nilesh, L.A. (2014*)"Adsorption of copper Cu^{2+} metal ion from wastewater using sulphuric acid treated sugarcane bagasse as adsorbent*".International Journal of Advanced Engineering Research and Science (IJAERS): 1(1), June 2014: ISSN: 2349-6495

Kołodyn´ska D., Krukowska J., Thomas P. (2017)*"Comparison of sorption and desorption studies of heavy metal ions from biochar and commercial active carbon"*. Chemical Engineering Journal, 307: 353–363

Majumdar J., Baruah, B.K., and Dutta K. (2004)*"Sources and Characteristics of Galvanizing Industry Effluent"*, Journal of Industrial Pollution Control.

Ojoawo, S.Oand Udayakumar, G. (2014*) "Susceptibility of Some Selected Nitte Municipal Wastewater Sources to Trace Metals Pollution"*. Journal of Computational Water, Energy, and Environmental Engineering, 3 (3): 93-101.

Ojoawo, S.O., Rao, C.V., and Goveas, L.C. (2016) *"Bioremediation of Zn, Cu, Mg and Pb in fresh domestic sewage by Brevibacterium sp"*. International Journal of Environmental Research, 10 (1): 139-148.

Ojoawo, S.O., Udayakumar, G., Adegoke, A.A, Adewale, A.T. (2016) *"Adsorption Potentials of Carica Papaya in Remediating Pb^{4+} and Cr^{3+} from Metal – Galvanizing Industrial wastewater adsorption"*.International Journal of Innovative Trends in Engineering (IJITE).

Ojoawo,S.O.,Adegbola, A.A, Olaniyan, O.S, Olaoye, R.A, Oluremi, J.R, Ajamu, S.O, Ademola, A.A and Ademola, I.A (2018) *"Performance evaluation of Azardirachta Indica (Neem Tree) bark in the remediation of Pb^{4+} and Cr^{3+} from galvanizing industrial wastewater"*. The Advances in Multidisciplinary and Scientific (AIMS) Research Journal, 4 (2): 73-88.

Patil K.P., Patil V.S., Nilesh P., Motiraya, V.(2012)*"Adsorption of Copper (Cu^{2+}) & Zinc (Zn^{2+}) Metal Ion from Waste Water by Using Soybean Hulls and Sugarcane Bagasse as Adsorbent"*. ISSN: 2279-0543

Rich, G. and Cherry, K. (1987)*"Hazardous Waste Treatment Technologies"*, Pudvan Publishers, New York.

Roccaro, P., Sgro, I.M., Vagliasindi, F.G.A. (2013)*"Removal of xenobiotic compounds from wastewater for environment Protection: treatment processes and costs"*. Chem. Eng. Trans. 32, 505–510.

Salihi, I. U., Kutty S.R.M., Isa, M. H. (2017)*"Adsorption of Lead ions onto Activated Carbon derived from Sugarcane bagasse"*,7th International Conference on Key Engineering Materials (ICKEM 2017).

ISSN:0971-1260
Vol-22- Issue-14-December-2019

Thomas A.J., Niveta J., Joshi, H.C., and Shiv, P. (2008)*"Agricultural and agroprocessing wastes as low cost adsorbents for metal removal from wastewater"*. Journal of Scientific and industrial research, 9: 647-658

Zodepe.G.V, Dhawan.V.L, Wagh.R.R, Sawant.A.S (2011)*"Contamination of heavy metals in seafood marketed from Vile Parle and Dadar markets of suburban areas of Mumbai (west coast of) India"*. International Journal of Environmental Sciences, 1: 6.

