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Decontamination of Zinc, Lead and Nickel from Aqueous Media by Untreated and Chemically Treated Sugarcane Bagasse: A Comparative Study

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Abstract

Heavy metal pollution is a major problem in the environment due to its extreme toxicity towards aquatic life and humans. Hence, there is a need for controlling its emission into the environment. Among the different technologies for heavy metals removal, adsorption was found to be a common and very efficient due to its availability,Iow cost, easy of operation and efficiency. Sugarcane bagasse (SB) is available in abundant quantity and is widely used as an adsorbent. SB was used in different metal detoxifications in water and wastewater such as the sorption of Zn(II), Pb(II) and Ni(II) ions from their aqueous solution. SB was characterized and has been used in two directions for heavy metals removal; before and after modification by H_2SO_4 . In this study, Variety parameters like pH, contact time, adsorbent dose and the initial metal ions concentration were studied in batch experiments. The maximum removal capacities for Zn(II) were 92% for untreated SB and 96% for treated SB with H_2SO_4, for Pb(II) were found 86% for untreated SB and 92% for treated SB with H_2SO_4 while for Ni(II) were found 78% for untreated SB and 90% for treated SB with H_2SO_4 at optimum conditions. The maximum removal of Zn(II), Pb(II) and Ni(II) was obtained at 5 µg/ml initial concentration. It was noted that the metal ion removal capacity for SB-H_2SO_4 more than SB-native, which indicated that the chemical treatment enhanced the biosorption of metal ions. To describe the adsorption isotherms, langmuir and freundlich models were used where langmuir isotherm was found to be more fitted (R^2= 0.99) than freundlich isotherm(R^2=0.91-0.97). The biosorption process obeyed pseudo-second-order kinetics. This study showed that SB is a suitable and low cost-effective adsorbent for Zn(II), Pb(II) and Ni(II) ions removal from their aqueous solutions.

, Adsorption, sugarcane bagasse, Chemical modification

Keywords: Heavy metals, Adsorption, sugarcane bagasse, Chemical modification

1. Introduction

Heavy metals are metallic elements which are very toxic and have a high atomic weight and relatively high density [1]. It has been found that dissolved heavy metals leaked to the environment having a serious health hazards. Heavy metal cations could be introduced into agricultural soils by application of fertilizers, limiting materials, sewage sludge, composts and other industrial and urban waste materials [2]. The toxicity of heavy metals occurs also at low concentrations of about 0.01-3mg/L. Heavy metals include cadmium (Cd), copper (Cu), zinc (Zn), lead (Pb), mercury (Hg), arsenic (As),silver (Ag), chromium (Cr), iron (Fe), selenium (Se), Nickel(Ni), Manganese(Mn) and the platinum group elements [3, 4]. It is important to learn about heavy metals and take protective measures against excessive exposure. According to World Health Organization, the permissible levels for the studied metal ions Zn, Pb and Ni in drinking water are 3mgL^{-1}, 0.01 mgL^{-1} and 0.07 mgL^{-1} respectively [5].

Zinc is an essential and beneficial element for human bodies and plants. High zinc levels proceed health problems and the prolonged zinc exposure results in copper deficiency [6]. Lead is an important pollutant and considered one of the priority metals from the point of view of potential health hazards to human even at low concentration. Lead toxicity in humans causes severe damage to kidney, liver , brain, reproductive and nervous systems [7]. Acute poisoning of Ni (II) causes headache, dizziness, rapid

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respiration, cyanosis and extreme weakness and perturbations in the male reproductive system [8]

There are many general techniques for removing the metal ions from surface water as well as ground water or any water contaminated with heavy metals such as ion exchange, membrane filtration, chemical precipitation, electro dialysis, Flotation, Flocculation and Coagulation which are called the conventional methods [9, 10]. The Conventional techniques are ineffectual for the removal of low concentrations of metal ions and they are non-selective and of high capital cost [11].

Adsorption could be a potential alternative to traditional treatment processes of metal ions removal due to its considerable advantages such as low cost, profitability, ease of operation, availability, and efficiency [12]. Also adsorption has distinct advantages over the conventional methods: the process does not produce sludges requiring further disposal, it could be highly selective, more efficient, can handle large volumes of wastewaters containing low metal concentrations. Adsorption using biological matter such as plant wastes or microbes is termed biosorption. Biosorption is relatively suitable technique, which could be used to reduce the load of toxic metal ions in the wastewater since various biological materials had metal binding capacities [13]. Several agricultural biomasses had been studied for adsorption such as rice straw, sugarcane bagasse (SB), palm kernel shell, maize stalks, wheat straw …etc [14-18].

Sugarcane is one of the largest products of agricultural crops in the world. It was mainly used in the form of raw material in alcohol and sugar manufacturing. The by-product sugarcane bagasse is mainly composed of cellulose (45% to 55%), hemicellulose (20% to 25%), and lignin (18% to 24%) [19,20]. Sugarcane bagasse had its utility in many industries like pulp and paper industriesand also as a fuel[21]. Bagasse had been also used effectively as an adsorbent for removal of different pollutants such as dyes, heavy metals, sulfonamide antibiotics and motor oil from aqueous solutions [22-26]. There were many functional groups on its surface, such as -COOH and -OH, where the adsorption process takes place [27]. These groups increased its adsorption capacity when they were chemically altered. Examples of chemicals used for the modification of sugarcane bagasse include sulphuric acid, Zinc Sulphate, citric acid, tartaric acid , sodium hydroxide, phosphoric acid, ethylenediaminetetraacetic acid, etc. These chemicals are particularly used as activating agents, which polymerized with SB to increase the number of chelating sites and pore spaces (porosity) for effective heavy metal removal from wastewater [28-33]. This work aimed to study the removal of Zinc, Lead and Nickel ions from aquatic solution using SB as a low-cost biosorbent before and after modification by sulphuric acid.

Throughout the preliminary experiments; pH, contact time and dosage of adsorbent with SB was selected for Zinc, lead and Nickel. The results of the optimum pH ,contact time and dose that were obtained with the unmodified materials and then were applied to study the effect of initial metal ion concentration to compare between unmodified and modified adsorbent materials. The fourier transmission infrared (FTIR) examination of untreated and treated adsorbent materials were conducted to clarify the types of functional groups in it. Also, a scanning electron microscopy (SEM) of the adsorbent was carried out before and after treatment and after the adsorption of the element onto its surface. Two isotherm models involving two-parameters had been designed to enable the prediction of procedures for contaminant removal in a large-scale scenario, Langmuir and Freundlich isotherms, that were commonly used in equilibrium studies. Also kinetic models were implemented to examine the experimental data.

2.1 Apparatus

Orbital shaker (BTC Model BT4010, made in Egypt), pH meter (Adwa model AD110, Romania), and magnetic stirrer (IDL GMBH model ME1, Germany), drying oven (bender, Germany), shaking standard testing sieves (model: RX-29-10, USA), grinding (food processor), balance Sartorius (model ED224S, Germany) were used for sample preparation. Infrared spectrometer (FTIR, Nicolet model 7199 (170 SX) TR infrared spectrometer, China) was used to illustrate the functional groups existing in the adsorbents. CHNS/O analyzer (Perkin-Elmer model CHNS/O 2400 II, USA) was used for elemental analysis, SEM (model JEOL JSM-5500 LV, made in Japan), Mortar for grinding, Glassware flasks (Volumetric and Conical), Glassware (beakers, cylinders, Pipettes, Clear glass bottles and funnels), polypropylene bottles and filter paper GVS (made in Italy) were used in working experiments.

2.2 Chemicals and reagents

All used reagents and chemicals which of certified analytical category were $ZnSO_4.7H_2O$ (1000 mg/L), $Pb(NO3)_2$.anhydrous (1000 mg/L), $NiCl_2.6H_2O$(1000 mg/L), muroxide indicator, EBT indicator, NaOH, H_2SO_4, HNO_3, NH_4Cl, NH_4OH, EDTA, $MgCl_2$.6H2O, $CaCO_3$, HCl, tartaric acid, and NaCl, which were purchased from Fluka chemicals in addition to first distilled water for washing and second distilled water that was used for all solutions preparation.

2.3 Adsorbent

The sample of SB produced and was collected from a shop of fruit selling sugarcane juice located at Dar Elsalam town, Sohag, Egypt. The SB was made up mainly by natural polymers (biopolymers) such as the cellulose whose monomer is the glucose, the hemicellulose, which is a copolymer composed of xylose connected with glucose and arabinose [34].

2.4 Preparation of adsorbent

The collected bagasse was washed with tap water to remove the coloration and dirts, then washed by first distilled water and naturally dried. The dried SB was crushed into small size and was grinded by food processor into a powder, then was boiled with second distilled water for 10 min to remove and eliminate soluble sugars present in it. SB was washed with hot second distilled water several times with using a magnetic stirrer until removal of color, and the washing water becomes clear and was separated by decantation and single filtration. SB was dried at 70 °C for 7 hours, was weighed and then was re-dried at the same degree for two hours. It was observed that the weight was stable. Therefore, this degree was considered suitable for drying and ensuring that the material was not combusted. Then the dried SB had been sieved for particle size 125 µm then was packed in a clean plastic polypropylene air tightly bottles. The adsorbent was designated as SB for Zn(II), Pb(II) and Ni(II) sorption capacity, study characterization and also used for modification.

2.5 Chemical treatment of sugarcane bagasse

For the modification process, H_2SO_4 was used at laboratory temperature to increase the proportion of active surfaces, produce an adsorbent, increase the surface area and microporosity and also to eliminate soluble components such as reducing sugars, colouring agents, tannins, resins and content of anions & cations. For these treatment, SB was settled during 30 min in 0.1 M H_2SO_4 with a liquid-solid relation of 0.003g/0.1 mL till it ultimately precipitated in the sulphuric acid at ambient temperature and then the solution was Shaked on a shaker at 100 rpm for 2hrs to become the complete impregnation time 150 min. Then the biomass was separated and was washed by decantation with first distilled water followed by second distilled water till the neutrality (pH 7) of the washing water. The filtration was then applied, and the biomass (H_2SO_4-SB) was dried in a hot air forced oven at 70 °C until reaching a fixed mass and was sifted to the particle size 125 µm then was packed in a clean polypropylene air tightly bottles. The adsorbent was designated as modified (msb) and was used for Zn(II), Pb(II) and Ni(II) sorption capacity and studying characterization.

2.6. Zinc, Lead and Nickel adsorption study

There were several factors that affect the metal ions sorption (Zn(II), Pb(II) and Ni(II)) by the active sites on the adsorbent surface such as pH of the solution, contact time, the amount of the adsorbent and the initial concentration of the metal ion. These factors were studied at fixed circumstances; room temperature, particle size 125 µm, and agitation speed 100 rpm [35]. Erlenmeyer flasks and orbital shakers were used to carry out the tests. From the results of preliminary experiments; pH, contact time and the dosage of the adsorbent were selected as 6.5, 60 min and 12 g/L respectively for Zn(II) and, 6, 100 min and 4 g/L respectively for Pb(II) and 6.5, 60 min and 8 g/L respectively for Ni(II) and these data were kept constant throughout the study. After 60, 100 and 60 min of contact time for Zn(II), Pb(II) and Ni(II) respectively, the suspension was filtered and the concentration of the metal in the filtrate was analyzed by complexometric EDTA titration [36, 37]. The amount of Zn(II), Pb(II) and Ni(II) adsorbed onto biosorbent was calculated using Eq. (1) [38]: $q_t= (C_i−C_f)V/m$ (1) for calculating the percentage uptake (Removal), and the following Eq. (2) is used [39]:

$$\text{Removal (\%)} = ((C_i\text{-}C_f)/C_i) \times 100 \qquad (2)$$

Where q_e is the amount of the adsorbed metal ion (mg/g), C_i and C_f (mg/L) are the initial and final concentrations of Zn(II), Pb(II) and Ni(II) in the solution respectively, V(L) is the solution volume, and m(g) is the adsorbent mass.

3. Results and Discussion

3.1 Characterization of the adsorbent

3.1.1 Elemental analysis study

The elemental analyses of SB and mSB illustrated that there was some similarity in their composition except for the existence of a small amount of nitrogen only in SB as shown in Table 1.

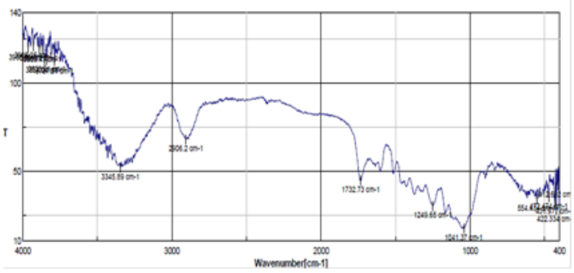
Table 1 Elemental analysis of SB and mSB.

Sample	Elemental results(% dry basis)				
	H%	C%	S%	O%	N%
SB	5.74	44.76	-	48.95	0.55
mSB	5.93	46.75	-	47.32	-

3.1.2 FTIR discussion

FTIR spectra define the major functional groups that the adsorption process of heavy metals took place. The IR spectrum in Fig.1 (a, b) show that IR bands for SB were comprised of four classes; the stretching bands of carbonyl groups (1604–1732 cm^{-1}), the stretching bands of CH, $CH_2$and CH_3(2906 cm^{-1}), the broad hydroxyl bands (3345-3430 cm^{-1}), and the fingerprint region (below 1550 cm^{-1}) in which there was a complex interaction of the IR vibration systems [40, 41]. The results showed that the wave number of the absorption band of both carboxyl acid and ester groups in SB was approximately 1732 cm^{-1}, whereas that of the carboxylate ion groups was about

1604 cm^{-1}. Also the intense peak recorded at 1041 cm^{-1}, the weak peak at 1249 cm^{-1} and the shoulder peak at 1164 cm^{-1} is C–O stretching vibrations of ethers and alcohols. The FTIR spectrum of SB that was chemically modified by H_2SO_4 indicates only a fractional modulation of functional features. Significant wave numbers and peaks noticed for SB were kept the same, while there were respectable alterations in the intensities of the peaks. Precisely, a reduction in the broad hydroxyl bands from (3345-3430 cm^{-1}) to (3336-3419 cm^{-1}), also the decrease C—O stretching vibrations of alcohols and ethers from 1041 cm^{-1} to 1033 cm^{-1} proved the partial oxidation of these functional groups [42].



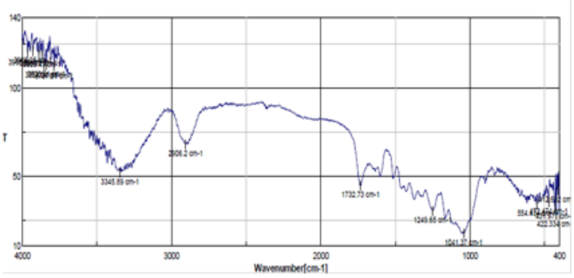
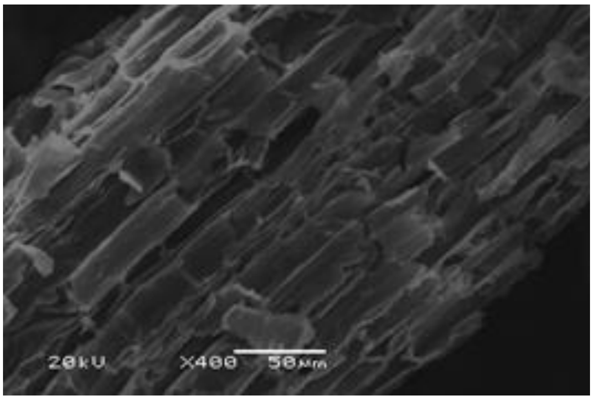


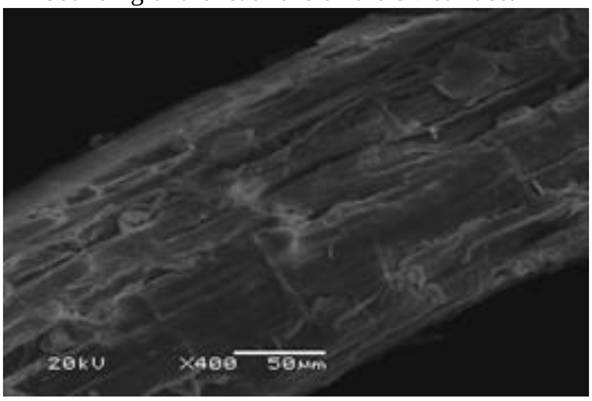
Figure1: IR spectra analysis (a): SB (b): mSB

3.1.3 Scanning electron microscopy

The surface morphology of the solids were analyzed using a Jeol Jsm-5500 LVSEM at an accelerating voltage of 20 kV and a working distance of 50 µm.Fig. 2 showed the SEM of (a) SB, (b) H_2SO_4–SB and (c)SB-Pb samples. There was a little difference in the surface morphology of the samples (a) and (b) except for some apparent of pore widening on H_2SO_4–SB that had occurred from the oxidation process. This is due to the splitting of C–O bridging bonds on the SB surface during H_2SO_4 treatment. Also there was difference in the surface morphology of the samples (a) and (c) due to the bounding of the lead ions on the SB surface.



(a)



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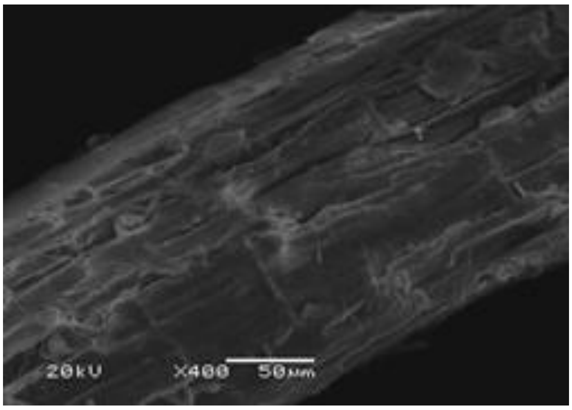
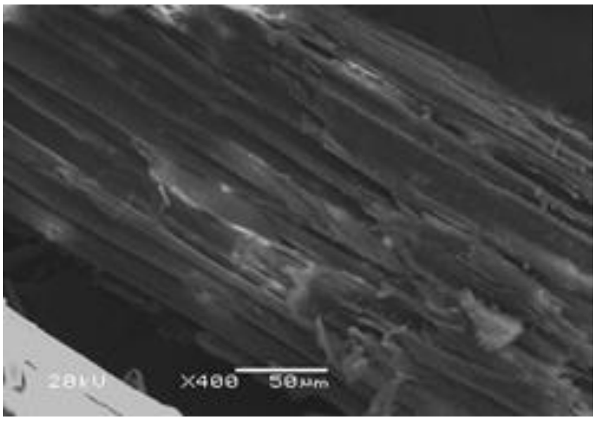


(C)



(D)

Figure 2: SEM (a) SB,(b) mSB by H_2SO_4 and (c) SB-Pb

3.2 Effect of pH on adsorption

The effect of pH of the aqueous solution on the removal percentage of Zn(II), Pb(II) and Ni(II) for SB were shown in Fig.3. The results generally showed that the maximum metal adsorption behavior occurring at high pH values. The other parameters were kept constant. The initial pH values of the solutions were detected by adding 0.01M HNO_3 and 0.01M NaOH solutions to reach the desired value. The figure displayed that the removal percentage of SB for Zn(II) and Ni(II) increased with increasing of pH, achieving a somewhat constancy at the range 6.5– 10.At the other side, the removal percentage of Pb(II) by SB increased with increasing pH up to 6 and then decreased with more increasing in pH. The increase of removal percentage with increasing of pH could be demonstrated due to the surface charge of the adsorbent and the degree of ionization. At low pH, the highly movable H^+ would vie with the metal ions for the active binding sites. So, the binding sites may be protonated causing the decrease of the metal sorption on the adsorbent surface. At higher pH, H^+ concentration and also the solubility of metals decreased which enhanced the sorption of metals on the adsorbent surface. Further increase in pH upon 7 caused precipitation of metals as their hydroxide. This precipitation is unpreferred as adsorption process will not occur [43].

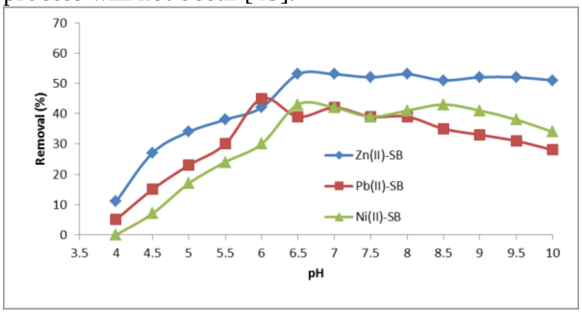


Figure 3:Effect of pH on Zn(II), Pb(II) and Ni(II) removal on SB (initial conc. 15 ppm, time 60 min for Zn(II) and Ni(II) and 100 min for Pb(II), dose 0.3 g for Zn(II), 0.1g for Pb(II) and 0.2 g for Ni(II))

3.3. Effect of contact time

The effect of different adsorption times on the removal percentage of Zn(II), Pb(II) and Ni(II) using SB were shown in Fig. 4 where the optimum times for the metal ions were 60, 100 and 60 min for Zn(II), Pb(II) and Ni(II) respectively. The other adsorption conditions were kept constant during the study. The removal percentage gradually increased, then slowed down, and eventually reached the equilibrium state with time. This was because the functional groups of the SB gradually reacted with the metal ions and the adsorption sites became gradually occupied. The removal percentage of the heavy metal ions reached its limit under the current adsorption conditions when the adsorption sites and functional groups of SB were close to saturation [44].

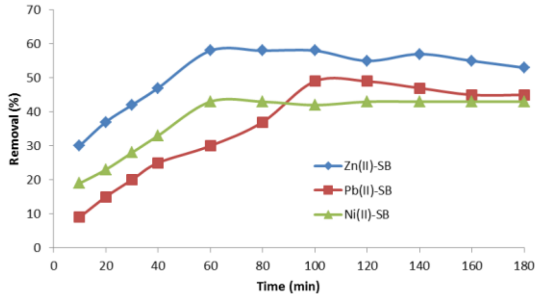


Figure4: Effect of contact time on Zn(II), Pb(II) and Ni(II) removal on SB (initial conc. 15 ppm, pH 6.5 for Zn(II) and Ni(II) and 6 for Pb(II), dose 0.3 g for Zn(II), 0.1g for Pb(II) and 0.2 g for Ni(II))

3.4 Effect of the amount of the adsorbent

The effect of adsorbent dose on the removal percentage of Zn(II), Pb(II) and Ni(II) metal ions from synthetic wastewater were shown in Fig.5 where the optimum dose for the metal ions were 0.3, 0.1 and 0.2g for Zn(II), Pb(II) and Ni(II) respectively. It was observed that as the weight of biomass increased, gradual increase in the removal percentage was obtained for metal ions. This referred to the increase in the sorptive surface area and the active binding sites was more available on the adsorbent surface with increasing of the adsorbent dose. Further increase in dose of adsorbent will not have any major changes [45].

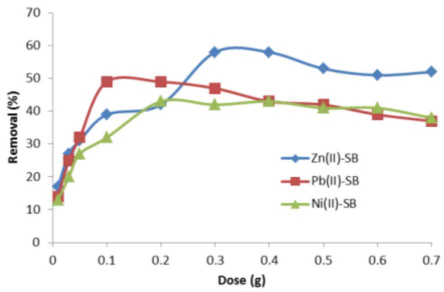


Figure 5: Effect of dose on Zn(II), Pb(II) and Ni(II) removal on SB (initial conc. 15 ppm, time 60 min for Zn(II) and Ni(II) and 100 min for Pb(II), pH 6.5 for Zn(II) and Ni(II) and 6 for Pb(II)).

3.5Effect of metal ions concentrations

The comparative sorption study was accomplished with modified and non-modified sugarcane bagasse to deduce sorption efficiency of the sorbents. The effect of modification of SB on the biosorption of Zn(II), Pb(II) and Ni(II) were shown in Fig.6 where the results of zinc, lead and nickel biosorption tests with SB before and after modification with H_2SO_4 solution were shown. Metal ions concentrations were studied at the range of 5 to 50 mg/L with a fixed optimum parameters of pH, contact time and dose as illustrated before. The removal capacity of the metal ions were decreased by increasing concentrations from 92% to 21% for SB and 96% to 30% for

H_2SO_4–SB with Zn(II), 86% to 19% for SB and 92% to 28% for H_2SO_4–SB with Pb(II) and for Ni(II) the removal efficiencies decreased from 78% to 17% for SB and 90% to 27% for H_2SO_4–SB. Thus, the removal efficiency was decreased by increasing metal ions concentrations in the solutions. By increasing the metal ion concentration, the number of sorption sites in a certain mass of an adsorbent substance became saturated.

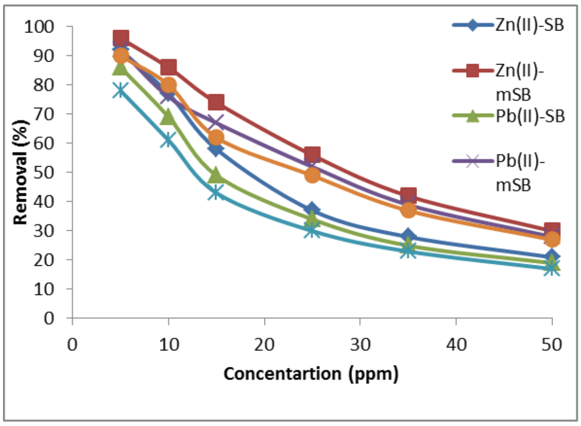


Figure 6: Effect of concentration on Zn(II), Pb(II) and Ni(II) removal on SB and mSB (time 60 min for Zn(II) and Ni(II) and 100 min for Pb(II), pH 6.5 for Zn(II) and Ni(II) and 6 for Pb(II), dose 0.3 g for Zn(II), 0.1g for Pb(II) and 0.2 g for Ni(II)).

3.6 Adsorption isotherms

Zinc, lead and nickel sorption data were correlated with Langmuir [46] and Freundlich [47] models [Eqs. (3) and (4)].

$C_e/q_e = 1/(q_{max} * b) + (1/q_{max}) * C_e$

Langmuir equation (3)

$Lnq_e = LnK_f + (1/n_f)\, LnC_e$

Freundlich equation (4)

Where C_e is the metal solution concentration at equilibrium (mg/L), q_e the metal amount sorbed at equilibrium (mg/g), q_{max} the maximum sorption capacity, q_{max} and b is Langmuir constants, K_f and n_f are Freundlich constants.

Langmuir and Freundlich isotherms equilibrium models of the biosorption of Zn(II), Pb(II) and Ni(II) onto unmodified SB and modified SB by H_2SO_4 at (30±5)°C were reported in Table 2. The correlation coefficient values (R^2) illustrated that the Langmuir isotherm model was more propered for the biosorption of heavy metal ions on SB and mSB as shown in Fig.7:(a, b) [48].

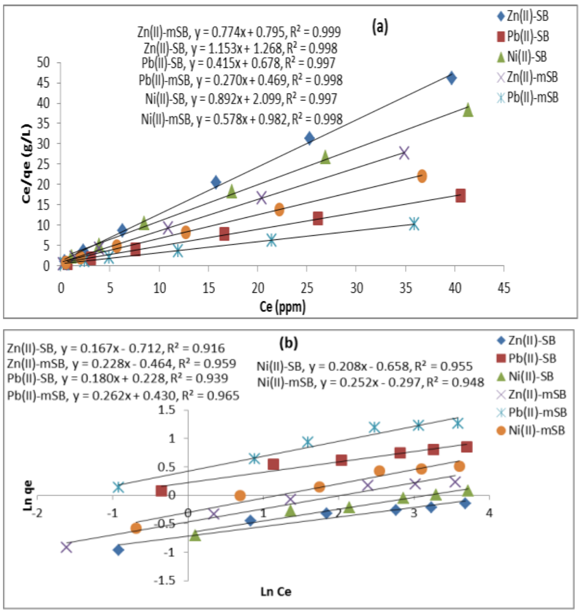


Figure 7: Langmuir (a) and Freundlich (b) models of Zn(II), Pb(II) and Ni(II) adsorption on SB and mSB.

3.7 Adsorption kinetics

In this study the pseudo-first and pseudo-second order kinetic models were applied to study and describe the adsorption kinetics of the metal ions [49, 50]. The pseudo-first equation that represented the adsorption of a solute from liquid solution was shown in equation 5. In addition, the pseudo-second-order equation that depended on the adsorption equilibrium capacity could be expressed in equation 6.

$Ln(q_e - q_t) = Ln\, q_e - K_1 * t$ (5)

$t/q_t = 1/k_2 q_e^2 + t/q_e$ (6)

Where q_e is the adsorbed metal ion mass at equilibrium (mg/g), q_t is the adsorbed metal ion mass at time t (mg/g), K_1 is the pseudo-first order reaction rate constant (l/min) and K_2 is a constant that represents the pseudo second-order reaction rate equilibrium (g/mg min).

In this study, the pseudo-first and pseudo-second order models were reported in Table 3. The estimated models for zinc, lead and nickel and the related statistic parameters that depended on linear regression data (R^2), the adsorption kinetics of the metal ions onto the adsorbent could be well represented by the pseudo second-order equation as shown in Fig.8 [51]. Table 3: show Kinetic model's parameters of Zn(II), Pb(II) and Ni(II) adsorption on SB and mSB.

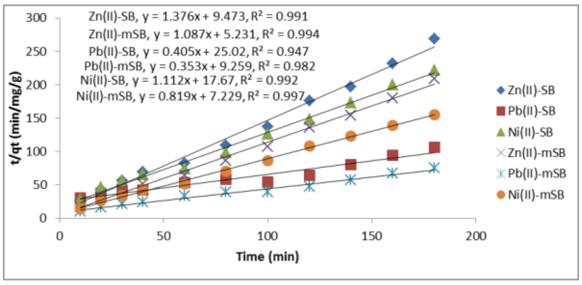


Figure 8: Pseudo-second-order kinetic model of Zn(II), Pb(II) and Ni(II) adsorption onSB and mSB.

3.8 Comparison Sorption Capacity between the Adsorbents in this Work and other Adsorbents

At the end, the sorption capacities data of zinc, lead, and nickel that reported in this work were compared with other reported adsorbents as shown in Tables 4, 5 and 6.

Table 2: Langmuir and Freundlich models parameters of Zn(II), Pb(II) and Ni(II) adsorption on SB and mSB.

Metal ion	Adsorbent	Langmuir			Freundlich		
		q_{max}, mg/g	b, L/mg	R^2	K_f, (mg/g)·(L/mg)1/n	n_f	R^2
Zn(II)	SB	0.867	0.910	0.998	0.491	5.988	0.916
	mSB	1.292	0.974	0.999	0.629	4.386	0.959
Pb(II)	SB	2.410	0.612	0.997	1.256	5.556	0.939
	mSB	3.704	0.576	0.998	1.537	3.817	0.965
Ni(II)	SB	1.121	0.425	0.997	0.518	4.808	0.955
	mSB	1.730	0.589	0.998	0.743	3.968	0.948

Table 3: Kinetic model's parameters of Zn(II), Pb(II) and Ni(II) adsorption on SB and mSB.

Heavy metal	Type of adsorbent	1st order		2nd order	
		R^2	K_1	R^2	K_2
Zn(II)	SB	0.740	0.012	0.991	0.199
	mSB	0.702	0.012	0.994	0.226
Pb(II)	SB	0.920	0.015	0.947	0.007
	mSB	0.922	0.015	0.982	0.013
Ni(II)	SB	0.961	0.027	0.992	0.070
	mSB	0.870	0.024	0.997	0.093

Table 4: Comparison sorption capacity of SB and mSB with other adsorbents for Zn(II) were reported in the following table

Heavy metal	Type of adsorbent	**Conditions**			References
		q_{max} mg/g	**pH**	**Dose** g/L	
Zn(II)	SB	0.867	6.5	12	In this work
	mSB	1.292	6.5	12	In this work
	Iron-ore-sludge	0.745	5.5	20	[52]
	Tea waste	0.2789	-	20	[53]
	Sawdust of deciduous trees	2.17	5.2	20	[54]
	Natural zeolite	1.3189	6	5	[55]
	Activated sugarcane bagasse	0.3762	6	0.5	[56]
	Plantain Peels	0.9766	6	40	[57]
	Wheat straw	3.6	6.8	20	[58]

Table 5: Comparison sorption capacity of SB and mSB with other adsorbents for Pb(II) were reported in the following table:

Heavy metal	Type of adsorbent	**Conditions**			References
		q_{max} mg/g	**pH**	**Dose** g/L	
Pb(II)	SB	2.410	6	4	In this work
	mSB	3.704	6	4	In this work
	Iron-ore-sludge	1.305	5.5	20	[52]
	Coconut shell AC	4.151	-	10	[59]
	Corn Cob AC	4.739	-	10	
	peels of banana	2.18	5	40	[60]
	SB	6.366	5	10	[61]
	H2SO4–SB	7.297	5	10	
	sugarcane bagasse	3.32	5.5	8	[62]
	Bean husk	0.9895	7	4	[63]
	Fish scale	0.858	6	4	
	cell-o-PDAm	2.3873	8.6	2	[64]

Table 6: Comparison sorption capacity of SB and mSB with other adsorbents for Ni(II) are reported in the following table

Heavy metal	Type of adsorbent	Conditions			References
		q_{max} mg/g	**pH**	**Dose** g/L	
Ni(II)	SB	1.121	6.5	8	In this work
	mSB	1.730	6.5	8	In this work
	Kaolinite	1.669	-	10	[65]
		2.790	-	10	
	Sawdust of deciduous trees	4.6	5.2	20	[54]
	Coconut shell AC	6.792	-	10	[59]
	CornCob AC	5.094	-	10	
	Granularactivated carbon (GAC)	1.49	6.5	12	[66]
	Fly ash	0.03	8	10	[67]
	Bagasse	0.001	8	10	
	bagasse fly ash	1.70	6.5	10	[68]
	Sugarcane bagasse	2.234	5	10	[69]
	Wheat straw	2.5	6.8	8	[58]

4. Conclusion:

Removal of heavy metal ions from wastewater is essential due to their extreme toxicity towards aquatic life and humans. Adsorption has been proved to be an excellent way for heavy metal removal offering significant advantages like the low-cost, availability, easy of operation and efficiency. This work aimed to use the abundantly low-cost agricultural waste sugarcane bagasse, unmodified and modified by sulphuric acid, as a biosorbent material through studding its characterization and its removal of Zn(II), Pb(II) and Ni(II) metal ions from their aqueous media.The pH, contact time, dosage of adsorbent and concentration of the adsorbate were determined. Through the study, both the freundlich and langmuir adsorption isotherms models were tested to describe the adsorption behavior. Langmuir adsorption isotherm model was found to be more fitted for the best description of the adsorption behaviour of Zn(II), Pb(II) and Ni(II) metal ions. The experimental data showed that the pseudo second-order model provides the best description. IR spectra Characterization of the biosorbent performed that the modified SB supported well for the adsorption capacity efficiency for the metal ions removal. Thus the biomass SB could be enhanced by chemical modification for heavy metals removal from aqueous system.

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