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Removal of Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} from Aqueous Solution by Selected Activated Carbons Derived from Date Pits.

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ABSTRACT

Date pits, DP as a huge solid waste in Egypt is of little or no economic value and in fact present a disposal problem. The quantity of DP has been estimated to million tons per year. DP was used for preparation of physically and chemically activated carbons. The raw materials were physically activated with pure steam, steam with flow of nitrogen gas or steam with current of air, while the chemically activated samples were prepared by impregnation of 10% ferric chloride or 10% calcium acetate. The effect of various factors, e.g., carbon type, carbon dosage, pH, initial concentration, temperature, and various inorganic ions on the adsorption capacity, were quantitatively determined. The two-parameters equilibrium models Langmuir and Freundlich equations were discussed. In this work, analyses and batch adsorption experiments have been carried out to characterize and to understand adsorption mechanism by modeling the adsorption kinetics. The present study deals with the factors affecting the uptake of Pb^{2+} , Cd^{2+} , Fe^{3+} , and Sr^{2+} ions from aqueous solution using activated carbon developed from locally available material DP, by one-step steam pyrolysis in a batch mode. Concurrently removal of these cations from aqueous medium are affected by the presence of other ions e.g. NO_3^- , CO_3^- , SO_4^- and masking agents e.g. oxalic acid and EDTA in solution. Uptake values are decreased with increasing the concentration of these ions in solution.

Key Words: Activated carbons; Steam activation; Chemical activation; Adsorption; Heavy metals.

INTRODUCTION

Heavy metals are the most important pollutants in surface and groundwater. They are extremely toxic elements, which can seriously affect plants and animals and have been involved in causing a large number of affections⁽¹⁾. Levels of heavy metals in the environment have increased due to pollution caused by industries. Therefore, the elimination of heavy metals from water is important to protect public health. Treatment processes for metals contaminated water include chemical precipitation, membrane filtration, ion exchange, carbon adsorption and co-precipitation/adsorption⁽¹⁾. Over the last years, adsorption has been shown to be an economically feasible alternative method for removing metal ions in water⁽²⁾. Activated carbon has been an effective adsorbent. The adsorption of metal ions on carbon containing materials such as lignite, wood bark and charcoal has been thoroughly studied over the past two decades⁽³⁾. Many studies have appeared on the development of activated carbon from cheaper and readily available materials. Throughout the world agricultural by-products, such as rice husks or coconut shell⁽⁴⁾ are some of the raw materials used in activated carbon production. Lead ions found in fresh water usually indicates contamination from metallurgical wastes or from lead-containing industrial processes. Lead in drinking water is primarily from the corrosion of the lead solder used to put together the copper piping. Lead in the body can cause serious damage to the brain, kidneys, nervous system, and red blood cells. The US Environmental Protection Agency EPA, considers lead to be a highly toxic metal and a major health threat. The current level of lead allowable in drinking water is 0.05 mg/L⁽⁴⁾. Heavy metals are non-degradable and can accumulate in living tissues, so they must be removed from polluted water⁽⁵⁻⁶⁾. Currently there is increasingly interest in removing cadmium from drinking water due to its supreme toxicity to human health in small concentration. According to the World Health Organization guidelines, the permit Table concentration of cadmium in drinking water is less than 5 $\mu\text{g/L}$ ⁽⁷⁾. Long term drinking water containing cadmium higher than this level can cause nausea, salivation, diarrhea, muscular cramps, renal degradation, lung

insufficiency, bone lesions, cancer and hypertension in humans⁽⁸⁾. Therefore, the elimination of the Cd^{2+} ions from water is important to protect public health. Activated carbon is one of the most popular adsorbents for the removal of metal ions from aqueous solution⁽⁹⁻¹¹⁾. Inexpensive, effective, readily available materials can be used in place of activated carbon or ion exchange resin for the removal of heavy metals Cd^{2+} from solution. Because of chemical similarity to Ca, ^{90}Sr can easily replace Ca in the human body and cause chronic illnesses such as anemia and leukemia, so they must be removed from polluted water⁽¹²⁾.

DP was chosen due to their granular structure, insolubility in water, chemical stability, high mechanical strength, and their local availability at almost no cost. Natural DP used in this work was obtained from the food industry wastes in Egypt⁽¹³⁾. In this work, analysis and batch adsorption experiments have been carried out to characterize and to understand adsorption mechanism by modeling the adsorption kinetics. The present study deals with the factors affecting the uptake of Pb^{2+} , Cd^{2+} , Fe^{3+} , and Sr^{2+} ions respectively from aqueous solution using activated carbon developed from locally available material DP, by one-step steam pyrolysis in a batch mode.

EXPERIMENTAL

Activated carbons

Sixty grams of the roasted, crushed, date pits screened (1-3mm) were admitted into a stainless steel(SS) reactor (400 x 40 mm) fitted with a perforated disc from the inside, and screw caps either inlet and outlet tubes (10 mm diameter) at both ends. A cylindrical electric furnace surrounded the slightly tilted SS reactor, then temperature was raised at 5 °C/min up to 350 °C and steam, generated from a side device, introduced. This was followed by a slower temperature rise (50°C/10min) up to either 700-800 °C, to hold for various durations. These samples were thus prepared, in addition to two more derived under additional concurrent flow of N_2 , passing through the boiling water in steam-generating device, at soak temperatures of 700 and 800°C. In addition to two samples were prepared with chemical treated by 10% calcium acetate or ferric chloride at 700°C. Also one sample was prepared by steam with concurrent flow of air at 700°C. The outlet tube was connected to a cooled condenser and trap to collect condensates, and a side tube to vent non-condensable gases.

Adsorption capacity

Experiments were performed to evaluate the relative amenability of some water metal pollutants Pb^{+2} , Cd^{+2} , Fe^{+3} and Sr^{+2} to the prepared activated carbons. A known volume 25 ml aliquots of the stock solutions 100 mg/L of each metal were contacted with carbon 5 mg carbon in glass bottles. The bottles were shaken using a thermostatic shaker, for 24h. to achieve equilibration. Each mixture was filtered throughout a 11-cm Whatman filter paper No.40 under gravity, allowing all the solution to filter. The samples were analyzed by an atomic absorption.

The factors affecting the adsorption rates such as carbon type, carbon dosage, pH, initial concentration, temperature, and various inorganic ions were studied. The conditions of each solution were adjusted and the mixtures were shaken for different time intervals. Each mixture was filtered and the difference between the initial concentration (C_0) and the equilibrium concentration (C_e) was calculated to determine the adsorptive capacity (q_e) as follows :

$$q_e = V (C_0 - C_e) / M \dots\dots\dots(1)$$

Where V : is the total volume of solute solution (L), M : is the weight of adsorbent used (gm), C_0 : is the initial concentration of the solute (mg/L), and C_e : is the residual equilibrium concentration of the solute (mg/L).

Langmuir adsorption isotherm

The Langmuir isotherm is valid for monolayer adsorption onto a surface containing a finite number of identical sites. The model assumes uniform energies of adsorption onto the surface and no transmigration of adsorbate in the plane of the surface. The Langmuir isotherm is represented by the following equation ⁽¹⁴⁾.

$$q_e = \frac{q^0 b C_e}{(1 + b C_e)} \dots\dots\dots(2)$$

Where : q_e is the amount adsorbed at equilibrium time (mg/g), C_e is the equilibrium concentration (mg/l) and q^0 and b are Langmuir constants related to adsorption capacity and energy of adsorption, respectively⁽¹⁵⁾, which can be calculated from the $1/q_e$ vs. $1/C_e$ plot by the relationships: $q^0 = \text{intercept}^{-1}$ and $b = \text{slope}^{-1} \times \text{intercept}$.

The Freundlich equation

This equation is a special case for heterogeneous surface energies in which the energy term, b , in the Langmuir equation varies as a function of q_e , strictly due to variations in the heat of adsorption ⁽¹⁶⁾. The Freundlich equation has the general form:

$$q_e = K_f \cdot C^{1/n} \dots\dots\dots(3)$$

Where K_f and n are constants, and $n > 1$ ($k_f \propto RT_n b e^{\Delta H/RT}$).

The Freundlich equation is basically empirical but is often useful as a means for data description. Data are usually fitted to the logarithmic form of the equation:

$$\text{Log } q_e = \text{log } K_f + 1/n \text{ log } C \dots\dots\dots(4)$$

which gives a straight line with a slope of 1/n and an intercept giving the value of log K_f. The intercept is roughly an indicator of sorption capacity and the slope is an indication of adsorption intensity. The Freundlich equation generally agrees quite well with the Langmuir equation and experimental data over moderate ranges of concentration. The Freundlich equation is commonly used for comparison of powdered carbons used in water treatment. The amount adsorbed, q_e is equal to (C₀-C)/D⁰, C₀ being the initial concentration of the organic component in wastewater and D⁰ the dosage of carbon, that is weight per unit volume. Substitution into Equation (4) gives:

$$\text{Log } \frac{C_0 - C}{D^0} = \text{log } K_f + 1/n \text{ log } C \dots\dots\dots(5)$$

RESULTS AND DISCUSSION

Carbon type

A series of activated carbons were prepared from DP by one-step steam activation procedure in presence of nitrogen, 10% calcium acetate, 10% ferric chloride or pure air, where the preliminary study was conducted to choose the best adsorbent which gives high uptake for heavy metals under studies. Using standard solutions of Pb²⁺, Cd²⁺, and Fe³⁺, containing 100 mg/L, vol.=25ml and known amounts 10 mg of carbons were added and 24h shaking time. In case of Sr²⁺ ions the initial concentration is 8.76 mg/L, volume of solution is 10 ml and known amount of carbon =5 mg, with the same shaking time 24h. The adsorbability and removal percent of Pb²⁺, Cd²⁺, Fe³⁺ and Sr²⁺ ions from aqueous medium using the various types of activated carbons obtained from DP are listed in Table (1).

As shown in Table (1), the medium of steam activation at 700 °C N₂ and Air has slightly effect on the uptake of Pb²⁺, Cd²⁺, Fe³⁺ and Sr²⁺ ions from aqueous solution. Thus the steam is efficient and enough, taking into account the uptake of Pb²⁺, Cd²⁺, Fe³⁺ and Sr²⁺ ions from aqueous solution. The uptake of Pb²⁺ ions increases from 134 to 151 mg/g, i.e. 12.7%, 66 to 127 mg/g, i.e. 92.4% for Cd²⁺, 132 to 216 mg/g, i.e. 63.6% for Fe³⁺, and reached from 0.96 to 13 mg/g for Sr²⁺ by increasing temperature of activation from 700 °C to 800 °C. Moreover the hold time using more steam 1h. as activant only increases the uptake of Pb²⁺ by 11.9 %. Similar results of Pb²⁺ and Cd²⁺ uptake are obtained by using steam in N₂-medium and Air at temperature 700 °C. But Fe³⁺ uptake is increased by increasing temperature from 700 °C to 800 °C using steam in N₂-medium. The catalyzed gasification, in presence of calcium or iron, affects on the uptake of Pb²⁺, Cd²⁺ and it was found that the capacity of DPS71-Ca-carbon for the removal of Pb²⁺ is nearly twice than that of DPS71-Fe-carbon due to its S_{BET} = 290 m²/g, V_p = 0.25 ml/g and r = 17 °A and calcium catalyzed, meanwhile, raises porosity and widenes pore size, whereas iron reduces considerably total porosity without affecting the very narrow porosity character. Therefore, the DPS71-Ca-carbon was the best adsorbent for the removal of Pb²⁺ from aqueous medium. On the other hand, the capacity of DPS71-Fe-carbon toward the uptake of Cd²⁺ is also nearly twice than that of DPS71-Ca-carbon due to its surface area, S_{BET} = 217.5 m²/g,

total pore volume $V_p = 0.10$ ml/g and mean pore radius $r^- = 9.1$ Å. However, the atomic weight of Pb^{2+} is larger than that of Cd^{2+} 207.2 and 112.4, respectively. Thus, DPS71Fe-carbon is good adsorbent for the removal of Cd^{2+} from aqueous medium. While it was found that DPS81-carbon which has good physical properties $S_{BET} = 701.6$ m²/g, $V_p = 0.33$ ml/g and $r^- = 9.4$ Å, gives good affinity toward the uptake of Fe^{3+} and Sr^{2+} ions from aqueous medium.

Table (1): Adsorbability of Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} onto various types of activated carbons derived from DP.

Adsorbent Type	Adsorbability Pb^{2+}		Adsorbability Cd^{2+}		Adsorbability Fe^{3+}		Adsorbability Sr^{2+}	
	q_e mg/g	%R	q_e mg/g	%R	q_e mg/g	%R	q_e mg/g	%R
DPS71	134	53.8	66	26.5	132	26.6	---	---
DPS81	151	60.6	127	51.0	216	43.3	13.8	79.2
	169	67.7	61	24.5	168	33.8	---	---
DPS82	131	52.5	115	46.0	118	23.6	---	---
DPSN71	148	59.2	88	35.5	161	32.2	---	---
	249	99.8	78	31.5	66	13.2	0.9	5.5
DPSN81	124	49.8	135	54.0	65	13.1	6.9	39.8
DPS71-Ca	131	52.4	120	48.0	65	13.1	---	---
DPS71-Fe								
DPSA71								
	Initial concentration $C_0 = 100$ mg/L, vol.=25ml, amounts of adsorbents = 10 mg and 24h shaking time						$C_0 = 8.76$ mg/L vol.=10ml, 5mg ACs and 24h shaking time	

Where the bold means the selected types of adsorbents, and (---) means not studied

Effect of carbon dosage

Fig.(1-a), show the relationship between amounts of Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} ions remaining in solution C_e (mg/L), versus carbon dosage using investigated activated carbons. The mass used from these adsorbent types are in the range of 1-30 mg. Results showed that the remaining ions concentration in aqueous solution decrease with increasing the carbon mass, this may be due to the availability of more surface functional groups at higher carbon masses⁽¹⁷⁻¹⁸⁾. While the decrease in residual concentration, C_e (mg/L), becomes insignificant when the amount of adsorbent is increased further from 20 to 30 mg, this may be due to saturation of active sites.

Fig.(1-b): represents the relationship between the % removal of metal ions versus carbon mass using the various carbons. Data show that the % removal of metal ions are increased with increasing

the adsorbent mass. However, the adsorption values are not affected by increasing the amount of adsorbent mass more than 20 mg. The maximum % removal values are 91.7, 99.5, 71.8 and 81.8 for Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} ions by using the tested activated carbons.

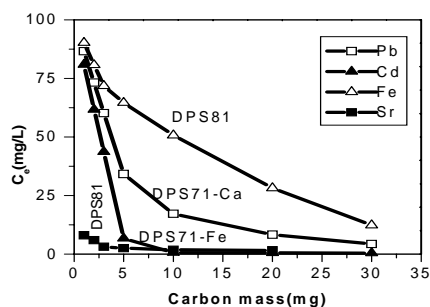


Fig. (1-a): Effect of carbon mass on the residual concentration of Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} ions by DPS71-Ca, DPS71-Fe and DPS81 activated carbons.

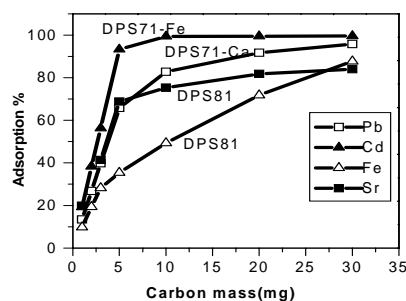
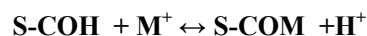


Fig. (1-b): Effect of carbon mass on the % R of Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} ions on DPS71-Ca, DPS71-Fe and DPS81 carbons. $C_o = 100$ mg/L for Pb^{2+} , Cd^{2+} , Fe^{3+} and 10 mg/L for Sr^{2+} .

Effect of pH

The adsorption of heavy metals on activated carbon is known to be pH dependent. Therefore, the pH dependence of metal ion adsorption is a complex phenomenon and influences the metal uptake on solids⁽¹⁹⁾. The ion exchange mechanism between H^+ ions at the surface of activated carbons with metal ions may follow this reaction:



Where S is the adsorbent surface .

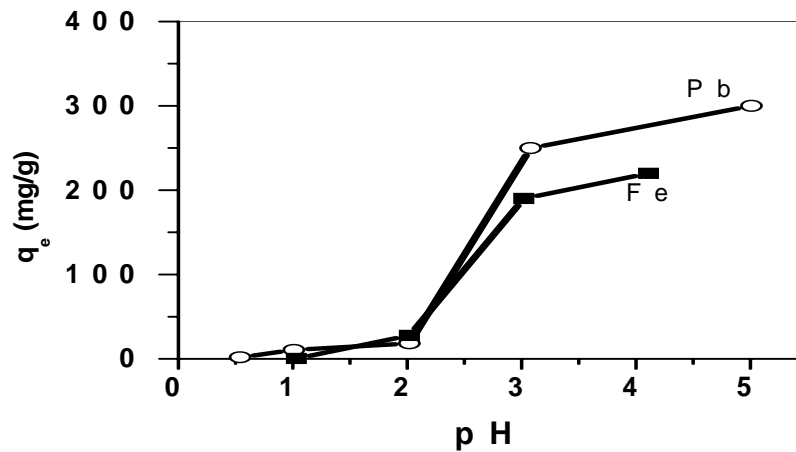


Fig. (2): Effect of pH on adsorption of Pb^{2+} and Fe^{3+} ions using DPS71-Ca and DPS81 activated carbons $C_0=100$ mg/L, Mass = 5 mg, Volume = 25 ml and Time = 3h.

Fig.(2) and 3(a,b): show the effect of pH on adsorption of Pb^{2+} , Fe^{3+} and Cd^{2+} , Sr^{2+} ions using DPS71-Ca, DPS81 and DPS71-Fe, DPS81 activated carbons respectively. The pH data show that the adsorption of studied ions are markedly influenced by the solution pH as shown in Fig.(2) and 3(a,b). The results obtained shows that the uptake values are very small at lower pH range (in acidic range) < 2 . This may be due to excess protons released, which surround the surface of the adsorbent, thus, adsorption of both Pb^{2+} and $PbOH^+$ and Fe^{3+} and $FeOH^+$ species on the surface of activated carbons are not favoured. On the contrary as the pH increases pH = 2 to 5, the adsorbent surface becomes more and more negatively charged and the uptake of Pb^{2+} and $PbOH^+$ species on the surface of DPS71-Ca-carbon becomes favoured and reaches its maximum adsorption value around pH = 5. While the uptake of Fe^{3+} and $FeOH^+$ species on the surface of DPS81-carbon reaches its maximum adsorption value around pH ≈ 4 . Since electrostatic attraction are not possible between positive charges on the adsorbents surfaces and positive charges on the metal ion, it seems that some non-electrostatic forces are involved in adsorption. There are various species of lead in the solution, such as Pb^{2+} , $Pb(OH)^+$, $Pb(OH)_{2(s)}$, $Pb(OH)^{-1}_3$, and $Pb(OH)^{2-}_4$ ⁽¹⁹⁾. At pH values more than 5 the uptake of Pb^{2+} ions are rapidly increased due to the combined role of adsorption and precipitation attributed to the formation of metal hydroxide precipitation of $Pb(OH)_{2(s)}$ ⁽¹⁹⁾. Thus, also at pH values more than 4 the uptake of Fe^{3+} ions is rapidly increased, this is attributed to the formation of the precipitation of ferric hydroxide.

As shown in Fig.3(a,b), the adsorption of Cd^{2+} and Sr^{2+} ions onto activated carbons increases as the pH increases pH = 2 to 11. Uptake values of Cd^{2+} and $CdOH^+$ species are favoured and reaches its maximum adsorption value around pH ≈ 7 . At pH values more than 7 the precipitation of $Cd(OH)_{2(s)}$ is obtained, this is attributed to distribution species diagrams of cadmium ⁽¹⁹⁾. While the uptake of Sr^{2+} ions is favoured by pH and reaches its maximum adsorption value around pH ≈ 8 .

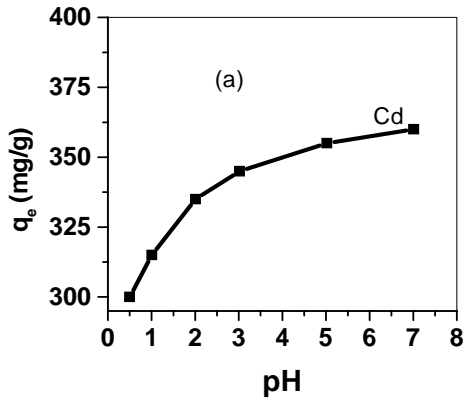


Fig. 3(a): Effect of pH on adsorption of Cd²⁺ using DPS71-Fe-carbon. C₀=100 mg/L, Mass=5mg, V = 25ml and Time=3h.

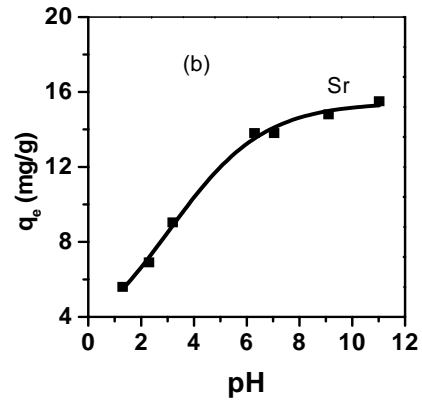


Fig. 3 (b): Effect of pH on adsorption of Sr²⁺ using DPS81-Carbon. C₀=10 mg/L, Mass=5 mg, V=10ml, Time=3h.

Contact time

Kinetic adsorption experiments were carried out in order to determine the effect of time on the adsorption and to identify the reaction rate. In this concern, Fig (4) shows the effect of shaking time on the removal of Pb²⁺, Cd²⁺, Fe³⁺ and Sr²⁺ ions by selected adsorbents obtained from DP. The removal curves are single, smooth, and continues leading to saturation, suggesting possible monolayer coverage of metal ions on the surface of the adsorbents. As shown in Fig(4) equilibrium was attained completely after 150 min. of contact between Pb²⁺, Cd²⁺ and Fe³⁺ solute while 90 min, for Sr²⁺ using DPS71-Ca, DPS71-Fe and DPS81 activated carbons respectively. The contact time required for these metal ions are very short. This result is interesting because equilibrium time is one of the important considerations for economical wastewater treatment applications⁽²⁰⁾. Also, it can be noted that more than 80, 90, 40 and 77 % respectively of the uptake of Pb²⁺, Cd²⁺, Fe³⁺ and Sr²⁺, occurred in the first 150, 120, 220 and 90 min., while the complete recovery was only achieved after further 50, 30, 80 and 90 min continually.

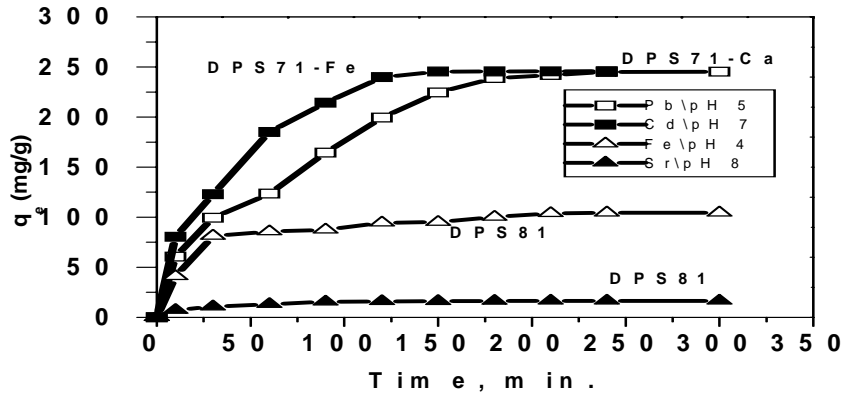


Fig. (4): Equilibrium uptake of Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} ions by selected adsorbent obtained from DP.

Effect of temperature

Variations in temperature cause rearrangements of the adsorbent and also changes in the adsorption/desorption equilibrium. The influence of temperature on the adsorption of Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} ions onto activated carbons were studied at various temperatures 25, 35, 45 and 55 °C. The shaking time 180 min, volume of solution 25 ml and weight of activated carbon 5 mg were kept constant for Pb^{2+} , Cd^{2+} and Fe^{3+} ions, while in case of Sr^{2+} ion, volume of solution was 10 ml only. Results showed that the uptake amounts remained constant with increasing temperature, i.e. temperature has no effect on the adsorption process of Pb^{2+} , Cd^{2+} and Fe^{3+} ions onto activated carbons so that $\Delta H = 0$. Such adsorption process is called "athermic"⁽²¹⁻²²⁾. Conversely as shown in Fig.(5) in case of Sr^{2+} :DPS81 adsorption system, it was found that the adsorbent exhibits the normal trend associated with physical adsorption i.e. a decrease occurs in the amount adsorbed with increasing temperature i.e. exothermic process.

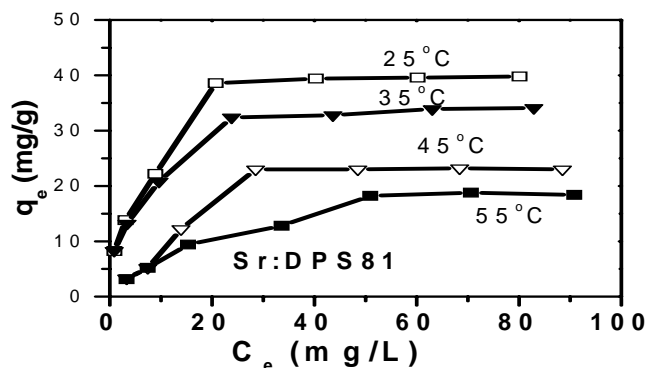


Fig. (5): Effect of temperature on the removal of Sr^{2+} ions from aqueous solution onto DPS81-carbons.

Effect of isotherm shape

The effect of isotherm shape has been considered by Weber and Chakravorti⁽²³⁾ with a view to predict if an adsorption system is favorable or unfavorable. In this concern, the essential features of the

Langmuir isotherm can be expressed in terms of a dimensionless constant separation factor or equilibrium parameter “ R_L ” which is defined by the following relationship giving by Hall et al.⁽²⁴⁾. $R_L = 1/(1+bC_0)$, where b is the Langmuir constant and C_0 is the highest initial concentration of Pb^{2+} , Cd^{2+} , Fe^{3+} or Sr^{2+} ions. The equilibrium parameter “ R_L ” indicates the shape of the isotherm as shown from Table(2), the values of R_L are less than one indicating that these activated carbons are favorable for the removal of Pb^{2+} , Cd^{2+} , Fe^{3+} or Sr^{2+} ions respectively from aqueous medium.

Table (2): Langmuir and Freundlich adsorption parameters for Pb^{2+} , Cd^{2+} , Fe^{3+} and Sr^{2+} ions in single-component system by various carbons, at room temperature.

Adsorption system	Langmuir constants				Freundlich constants		
	b mg/L ⁻¹	q ⁰ mg/g	R _L	r	K _f mg/g	n	r
DPS71-Ca : Pb^{2+}	1.18	341.3	0.008	0.999	130.3	2.99	0.978
DPS71-Fe : Cd^{2+}	0.15	432.9	0.060	0.997	52.40	1.50	0.985
DPS81 : Fe^{3+}	1.10	222.2	0.009	0.998	83.10	2.90	0.946
DPS81 : Sr^{2+}	0.19	43.50	0.001	0.999	9.30	2.70	0.979

$R_L =$

Dimensionless constant separation factor., $r =$ Correlation coefficient.

Effect of interfering ions

Generally, the adsorption capacity for heavy metals by activated carbon is reduced with presence of more than one metal ion in solution⁽²⁵⁾. Thus, Table 3(a,b), show the effect of different concentrations 0-1 M of various anions e.g. CO_3^{-2} , NO_3^- and SO_4^{-2} and complexing agents e.g. oxalic acid and EDTA on the uptake of metal ions from aqueous medium by using the selected carbons. It is worth to mention that if the concentration of interfering ions causes unsteady state conditions and exceeds its K_{sp} (solubility product constant), the precipitation will occur immediately.

As shown in Table(3-a), %R of Pb^{2+} influenced significantly by the presence of any interfering ions. Whereas in the case of Cd^{2+} the interfering anion may has slight or insignificant effect even at concentration level 0.001M. This can be referred to the nature of the slightly soluble salt formed and its affinity to the carbon surface. The presence of CO_3^{-2} anions can also adversely affect the efficiency of the adsorption of Pb^{2+} and Cd^{2+} ions, where, chemical precipitation has been occurred at concentration level 0.01M or more. This should be due to the formation of lead and cadmium carbonate precipitates⁽²⁶⁾.

Table (3-a): Effect of various anions and complexing agents on the uptake of Pb^{2+} and Cd^{2+} ions using DPS71-Ca and DPS71-Fe- carbons.

Interfering type	%R of Pb ²⁺ ions using DPS71-Ca carbon at various concentrations of interfering anions.								
	0	2E-4	5E-4	1E-3	0.01	0.1	0.5	1	
CO ₃ ⁻²	65.8	62.8	44.8	30.0	ppt	ppt	ppt	ppt	
NO ₃ ⁻	65.8		65.8	65.6	42.8	29.9	21.4	10.8	
SO ₄ ⁻²	65.8		65.8	65.8	65.9	74.4	77.6	ppt	ppt
Oxalic	65.8		65.8	65.8	65.9	61.8	50.5	30.3	20.1
EDTA	65.8		65.8	49.3	28.3	ppt	ppt	ppt	ppt
	%R of Cd ²⁺ ions using DPS71-Fe carbon at various concentrations of interfering anions.								
CO ₃ ⁻²	93.3	93.2	92.3	90.8	ppt	ppt	ppt	ppt	
NO ₃ ⁻	93.3	93.3	93.3	93.3	92.9	92.9	92.8	92.7	
SO ₄ ⁻²	93.3	93.3	93.3	93.3	94.3	94.8	96.0	97.3	
Oxalic	93.3	93.3	93.3	93.4	93.1	93.0	91.8	90.7	
EDTA	93.3		93.1	91.7	ppt	ppt	ppt	ppt	

Where (ppt) means precipitation.

A gradual decrease in %R of Pb²⁺ ions with increasing the concentration of NO₃⁻ ion. This may be attributed to the affinity of nitrate ion to be adsorbed on the carbon surface as well as the common ion effect. Conversely the %R of Cd²⁺ is not affected at all by NO₃⁻ at levels from 0 up to 1M. The %R of Pb²⁺ ion is not affected by presence different concentrations of SO₄⁻² ion up to 0.1M, and the precipitation was occurred only at higher concentration of sulfate, due to the formation of lead sulfate. In the presence of complexing agents e.g. oxalic acid and EDTA, the adsorption of Pb²⁺ ion is decreased with increasing the concentration of oxalic acid. This may be due to the high acid concentration suppresses the hydrolysis of Pb²⁺ ion⁽²⁷⁾. The presence of EDTA at concentration levels 5 x 10⁻⁴ and 1 x 10⁻³ M showed a significant reduction in the %R of Pb²⁺ whereas no effects occur in the %R of Cd²⁺ at these concentration levels. At higher concentration of EDTA ≥ 0.01M, both Pb²⁺ and Cd²⁺ were precipitated due to formation of Pb-EDTA or Cd-EDTA complexes⁽²⁷⁾.

As shown in Table (3-b): the percent removal %R of Fe³⁺ was reduced to various extends at concentration level of 0.0005M for CO₃²⁻. However, precipitation occurs at higher concentration due to the formation of insoluble ferric salt. On the other hand, the efficiency of DPS81-carbon was reduced in presence of NO₃⁻ up to their concentration level 0.1M. Then precipitation occurs at higher concentration due to the insoluble metal hydroxide formation. %R of Fe³⁺ ion was nearly stable by increasing SO₄⁻² concentration up to concentration level 0.1M. Whereas precipitation occurs at higher concentration due to the insoluble metal sulfate formation. Similar trend was observed using various concentration of oxalic acid, whereas precipitation occurs at 1x 10⁻³M or more due to insoluble metal oxalate formation. %R –values of Fe³⁺ ion was reduced in presence of EDTA up to concentration level 5 x10⁻⁴ M. Higher concentration of EDTA lead to precipitation of Fe-EDTA complex⁽²⁸⁾. As shown in Table (3-b), the presence of either cations e.g. Na⁺, Ca²⁺ or anions e.g. CO₃²⁻, NO₃⁻, SO₄²⁻ with Sr²⁺ ions showed a slight influence only on the %R of Sr²⁺ ions even at high concentration of any interfering type. The predominant effect of interference may be appeared in case of oxalic where the %R of Sr²⁺ ions was reduced by amount 72% at concentration range 0.1M-1M oxalic acid. However,

%R of Sr^{2+} ions was decreased in the presence of EDTA up to concentration level 1×10^{-3} M. A further increase in EDTA concentration causes precipitation due to the formation of Sr-EDTA complex ⁽²⁸⁾.

Table (3-b): Effect of various anions and complexing agents on the uptake of Fe^{3+} and Sr^{2+} ions using DPS81-carbon.

type	%R of Fe^{3+} ions using DPS81-carbon at various concentrations of interfering anions.								
	0	2E-4	5E-4	1E-3	0.01	0.1	0.5	1	
CO_3^{-2}	35.3	35.1	24.0	ppt	ppt	ppt	ppt	ppt	
NO_3^-	35.3		35.3	26.2	11.0	7.8	ppt	ppt	
SO_4^{-2}	35.3		35.3	35.3	35.8	35.9	36.0	ppt	ppt
Oxalic	35.3		33.1	23.3	ppt	ppt.	ppt.	ppt.	ppt.
EDTA	35.3		34.7	28.2	ppt	ppt	ppt.	ppt.	ppt.
	%R of Sr^{2+} ions using DPS81-carbon at various concentrations of interfering anions.								
	0	2E-4	5E-4	1E-3	0.01	0.1	0.5	1	
CO_3^{-2}	68.8	68.8	68.8	64.9	64.0	61.3	60.7	60.2	
NO_3^-	68.8	68.8	68.8	66.0	64.0	51.9	51.0	50.5	
SO_4^{-2}	68.8	68.8	68.8	65.5	61.0	58.0	57.5	57.0	
Oxalic	68.8	68.8	68.8	61.2	32.2	19.5	19.5	19.5	
EDTA	68.8	68.8	19.9	18.7	ppt	ppt	ppt	ppt	

Where (ppt) means precipitation.

CONCLUSION

DP was demonstrated to be feasible raw materials for the production of valuable adsorbents. Many categories of adsorbents were derived from the raw biomass. Adsorbents of varying physico-chemical properties were thus obtained: low and high density, low and high ash content, low, moderate and high developed porosity, and good to high adsorbing capacity.

The selected activated carbons obtained from date pits gives a good adsorbents for Pb^{2+} , Cd^{2+} , Fe^{3+} , and Sr^{2+} ions from aqueous solutions. Where, uptake amounts of Pb^{2+} ion by using DPS71-Ca-carbon is 341mg/g. While uptake amounts of Cd^{2+} ion by using DPS71-Fe-carbon is 432 mg/g. DPS81-carbon gives higher uptake amounts of Fe^{3+} ion 222 mg/g. But also uptake amounts of Sr^{2+} ion reaches to 44 mg/g by using DPS81-carbon.

As shown in Table (2), q^0 monolayer capacity for Pb^{2+} , Cd^{2+} , Fe^{3+} , and Sr^{2+} ions indicated that the adsorption follow Langmuir equation.

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