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Research Article

Equilibrium, Kinetics and Thermodynamics Studies of Cadmium (II) Ion Adsorption on to Anchote Peel (Coccinia abyssinica Peel) Activated Carbon Adsorbent

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Abstract

Powdered Activated Carbon Adsorbent produced from Anchote peel (Coccinia abyssinica peel). Powdered Activated Carbon Adsorbent was investigated for its adsorption capacity for Cadmium (II) ion. Effects of parameters: pH, contact time, adsorbent dose, initial metal ion concentration, and temperature on adsorption of Cadmium (II) ion were investigated. The best adsorption of Cadmium (II) ion occurred at pH 5, where the adsorption reached equilibrium within 210 min. for the optimum 0.025 mg/l initial Cadmium (II) ion concentration. Kinetic studies of the data showed that the adsorption follows the pseudo second order kinetic model where equilibrium adsorption capacities and adsorption rate increased at optimum level for all parameter. Fourier Transform Infra Red spectra of activated carbon adsorbent & Cadmium (II) ion loaded adsorbent were obtained. The enthalpy of Cadmium (II) ion adsorption was -71.986 J/mol. The negative enthalpy of adsorption indicated an exothermic nature of the adsorption. The equilibrium data better fitted Freundlich isotherm models within the temperature range 20 ℃ – 45 ℃. Maximum adsorption efficiency of adsorbent was 98.3% of Cadmium (II) ion at pH 5 and optimum contact time 210 min., adsorbent dose 0.25 g and initial conc. 0.025 mg/l respectively. The maximum adsorption capacity of Anchote (Coccinia abyssinica) peel activated carbon adsorbent was observed to 89.273 mg/g of Cadmium (II) ion at 30 ℃ and 5 mg/l.

Keywords

Equilibrium, Kinetics, Thermodynamics, Adsorbent, Anchote Peel, Carbonization, Cadmium (II) Ion, Isotherm, Sorption

1. Introduction

Cadmium is malleable, ductile, silvery white commonly divalent metal. The severity of the toxicity of Cadmium(II) metal ion on health is highly variable and depends on varying parameters and cause health impact eventually pose significant hazards to the ecosystem health especially human and living Organism. Heavy metal toxicity is the term for the toxic effect of certain metals in certain forms and doses on life. The use of Cadmium metal ion in the different Production over the past few decades has eventually contributed to a rise in the flow of cadmium metal ion into waste water, natural water sources and can raise significant ecological and health threats to living things because it is highly toxic at trace level. Cadmium (II) ion is non degradable and very toxic at trace levels (parts per billion). The metal ion can bio-accumulate in the main systems of living things and cause hazardous impacts to plants, animals, and humans [1]. Extensive use of heavy metal

in the manufacturing and production industry results in Cadmium (II) ion reaching living Organisms through disposing wastes and discharging effluents into the water sources cause the accumulation of Cadmium (II) ion. Cadmium(II) ion possibly released into the surface water due to environmental changes, such as sediment suspension and reduction–oxidation reaction that will extensively increase the Cadmium (II) ion concentrations. Ultimately, Cadmium(II)metal ion possibly absorbed and biomagnified in food chains, threatening the aquatic life and human health.

Apart from human and living Organism, plants commonly affected by heavy metal pollution [2]. Irrigation is the main sources of heavy metal intake by plants; whereby, 27% of national and international vegetables or plants are being irrigated with wastewater, which includes sewage and industrial effluents. A pilot study determines the interaction of cadmium on growth and leaf morpho physiological characteristics of European hackberry (Celtis australis) seedlings [3]. The results shows that the Cadmium ion concentration (5 mg l^{-1}) significantly reduced new shoot growth, plant leaf area, Soil Plant Analysis Development value, leaf water conductance and leaf photosynthesis. Researchers employ different efforts and approaches to show the efficacy of the process/method of wastewater treatment. Over the years, different approaches have been developed to remove the toxic heavy metal from different medium by prioritizing simple, efficient and cost effective techniques as a fundamental concept [4]. Common methods include: chemical precipitation, ion exchange, coagulation and flocculation, and membrane processes [5, 6]. Coagulation using aluminium sulphate ($Al_2(SO_4)_3$) was among popular treatment techniques that are utilized for wastewater treatment [7]. However, the drawbacks of these methods include their high cost, introduction of chemicals to the wastewater during treatment that caused secondary pollution and generated toxic sludge, and lower adsorption capacity in the low concentration [8, 9]. The selection method to be used in the treatment system usually depends on the medium characteristics.

Meanwhile, membrane separation is widely used as an advanced technology in wastewater treatment due to its lenient operational conditions. However, the high operational costs and low efficiency has restricted the use of this treatment processes, especially in small and medium scales of the industrial sector [10]. Out of the mentioned methods, adsorption has been effectively applied in recent decades [11]. Continuous research has been conducted since adsorption is considered as a cost effective and efficient technology as many adsorbents could be produced from biomass as one method of pollution control [12, 13]. In order to ensure the treatment process, the bonding process, the bonding interactions between adsorbent and adsorbate should eventuate [14]. The exact nature of the bonding depends on the details on the species of adsorbent and adsorbate involved, but the adsorption process is generally classified as physisorption or chemisorption [15]. The equilibrium behaviour is characterized by expressing the amount of adsorbate adsorbed as a function of partial concentration at a fixed temperature. Such equilibrium

model was called isotherm. Therefore, extensive removal of toxic heavy metals from the contaminated environment has become an important challenge among researchers. Each treatment has its own constraints, not only in terms of cost but also in relation to feasibility, efficiency, practicability, reliability, environmental impact, sludge production, operation difficulty, pre-treatment requirements and the formation of chemical residues [16, 17]. Adsorption is method of choice in terms of cost, efficient and suitability of raw materials of activated carbon [18, 19]. There is also a green improvement in this method by turning the biomass waste into commercial adsorbent. According to Research and market (2018) the top producer of Activated Carbon which is China shows an increasing demand of Activated Carbon starting from 2011. The market is booming further under the propulsion of national policy and demand growth, and the output of an average annual growth rate is estimated to maintain at least 5.0% during 2018 to 2023. In order to solve this problem, and pollution control, many researchers have attempted the adsorption method by changing the utilization of biomass waste to useful adsorbent [20, 21]. Because, it is an excellent way to treat toxic heavy metal ion, offering significant benefits such as affordability, profitability, ease of operation and efficiency. In this study, the powdered activated carbon adsorbent was well be produced from Anchote Peel (Coccinia abyssinica peel). The dynamic behaviors of the adsorption of Cadmium (II) ion from aqueous solution were investigated to examine the effects of initial metal ion concentration, contact time, adsorbent dose, pH, and temperature. The obtained activated carbon adsorbent exhibited high efficiency and high capacity.

2. Experimental Section

2.1. Materials and Method

The following are list of Chemicals, Apparatus, Instruments, and method used in this research work.

2.2. Chemicals

Analytical reagent grade chemicals were used. Potassium hydroxide solution (KOH) (25%W/V), Hydrochloric acid aqueous solution (HCl) (5% V/V), Nitric acid (HNO_3), Glacial Acetic acid (CH_3COOH), Sodium acetate ($NaCH_3COO^-$), Concentrated Ammonia (NH_3), Ammonium chloride (NH_4Cl), and Cadmium Chloride ($CdCl_2$).

2.2.1. Apparatus

Thermometer, Volumetric flask, Measuring cylinder, Crucible, Mortar and pestle, Sieve.

2.2.2. Instruments

Atomic Absorption spectrometry (AAS) (Model analytic jena nov AA 300, Germany), Electrical furnace (Model Naber

therm(R), Germany), pH meter (HANNA instruments, pH 211), Electronic balance (Model AFP-110L, ADAM, China), Thermostatic water bath (Model Grant GLS 400, England), Oven (Model GENLAB WIDNES, England), Fourier Transform Infrared Spectrometry.

3. Adsorption Studies

3.1. Preparation of Activated Carbon

Adsorbent Anchote Peel (Coccinia abyssinica peel) a raw material was collected and cut in to small sizes, allowed to be air dried. The raw material was repeatedly washed with tap water, air dried and further oven dried at 105 ℃ for 4 hr. The well dried sample was grinded and then sieved; activated with potassium hydroxide solution (25% W/V). Then oven dried for 12 hr at 105℃. The dried sample was carbonized in a muffle furnace at 700℃ for three hour. The carbonized sample was cooled. The activated carbon product was treated with 5% Hydrochloric acid solution followed by washing with distilled water until the P^H of the washing solution become neutral. Then the carbonization product "activated carbon" was kept in plastic container and from which applied for adsorption study. [22]

3.2. Proximate Analysis of Anchote Peel (Coccinia Abyssinica Peel) Activated Carbon Adsorbent

Anchote peel (Coccinia abyssinica peel) activated carbon

sample was determined using standard test method for moisture and total ash contents of activated carbon [23, 24].

The lower volatile matter and ash content are attributed to higher fixed carbon and lower inorganic content.

Table 1. Shows% yield of each parameter.

Parameter	Moisture content	Ash content	Volatile matter	Fixed carbon	pH
% Yield	2.23	8.7	5.5	83.57	7

Fourier Transform Infra Red spectrometry (Fourier Transform Infra Red spectra) of Anchote peel (Coccinia abyssinica peel) activated carbon adsorbent and Cadmium (II) sorbed activated carbon adsorbent were obtained using Fourier Transform Infra Red Spectrophotometry in the range of 4000–400 cm^{-1}. The Fourier Transform Infra Red spectrum showed multi functionalized nature of the adsorbent which meant that presence of a large number of peaks. Functional group: Hydroxyl group, Alcohol, Ethers, Esters group, Alkenes found in activated carbon adsorbent. The presence of these functional group in the activated carbon adsorbent enhances adsorption for different heavy metal from aqueous solution. These functional groups could act as chemical binding agents where hydroxyl, Ether, and Esters groups could dissociate negatively charged active surface. This meant that these functional groups could attract the positively charge objects such as heavy metal ions [25].

4. Characterization of Activated Carbon Adsorbent

4.1. Fourier Transform Infra Red Analysis

Table 2. Fourier Transform Infra Red results of Anchote Peel (Coccinia abyssinica Peel) Activated Carbon Adsorbent and Cadmium (II) ion Sorbed Anchote (Coccinia abyssinica) Peel Activated Carbon Adsorbent.

S. No	Absorption Before Adsorption	bands(cm^{-1}) Cd(II) laden AC	Difference	Assignment
1	3355	3367	12	Intermolecular Hydrogen bonded OH (OH stretching)
2	2915	2919	4	C-H Stretching
3	1559	1578	19	C=H Stretching
4	1047	1078	31	Esters, Ethers, primary alcohols, C-O Stretching
5	959	965	6	Alkene bonded group(trans), C=C Stretching

4.2. Preparation of Stock Solution

Stock solution of Cadmium (II) with a concentration of 100 mg/l were prepared from Cadmium Chloride, by dissolving 1.834 g of Cadmium Chloride in 100 ml volumetric flask. From 100 mg/l of Cadmium Chloride solution, cadmium (II) solutions with a concentration of 5 mg/l were prepared and by dilution method solutions of less concentrations were prepared.

5. Adsorption and Study of Parameters Influence Adsorption

5.1. Adsorption Batch Experiments

Study of the adsorption of Cadmium (II) metal ion on to Anchote peel (coccinia abyssinica Peel) activated carbon adsorbent have been performed. Adsorption parameter: pH, contact time, initial metal ion concentration, adsorbent dosage, and temperature were studied.

5.2. Effects of pH

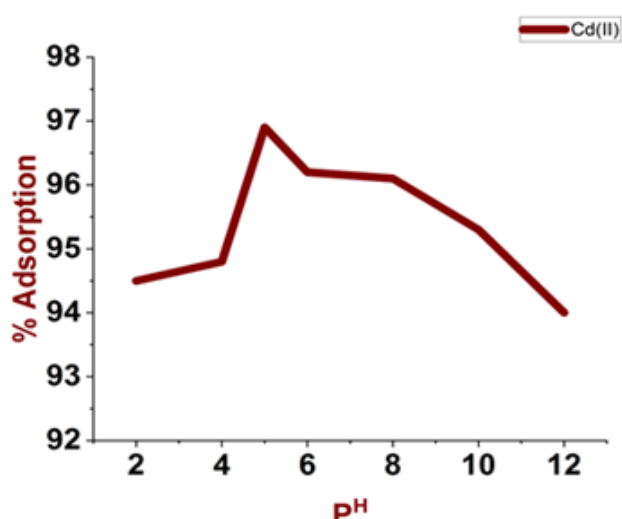P^H is an important parameter on which the adsorption of Cadmium (II) ion were strongly depended.

Figure 1. *Effect of P^H on adsorption of Cadmium (II) ion on to Anchote Peel(Coccinia abyssinica Peel)Activated carbon adsorbent.*

It was carried out by varying a pH between (1-12) and by contacting 0.25 g of adsorbent with 0.025 mg/l Cadmium chloride solutions keeping other variables constant. Then the mixture was shaken for 210 min. Then was filtered using whatman No 42 filter paper. The filtrate was analyzed using Atomic Absorption Spectrometry. Then the optimum pH was determined as the pH with the highest adsorption efficiency of Cadmium(II) ion. As it is shown in Figure 1, maximum adsorption was observed at P^H 5 for Cadmium (II) ion. However

at higher pH range, the formation of insoluble hydrolyzed species Cadmium hydroxide might also take place, and this condition is often not desirable as the metal precipitation could lead to a decreasement for the sorption capacity. The solution pH affects the adsorbate surface charge and the degree of ionization of the adsorbate speciation, metal ion and the active site.

At moderate pH (3–6), linked H^+ was released from the active sites allowing more metal ions to be adsorbed to the vacant sites [26]. pH values (<6) generally increase the electrostatic attraction between cations and the negatively charged surface, which promotes higher adsorption capacity. Therefore, maximum adsorption often occurs at low P^H level. The adsorption efficiencies of adsorbents were slightly decreased from lower pH values to higher p^H. Low pH causes surface OH^- groups to accept adsorbate ions, this facilitates the sorption process. Therefore, from the point of view of kinetics as well as equilibrium thermodynamics, low pH promotes anions and cations sorption.

5.3. Effects of Contact Time

The adsorption of Cadmium (II) ion was studied at various adsorption times (35, 70, 105, 140, 175, 210 and 245 min) at optimum pH and keeping other variables constant. After adsorption time was completed the activated carbon was removed from the solution and the solutions were filtered and analyzed; the final concentration of metal ion in each solution & optimum time was determined using Atomic Absorption Spectrometry.
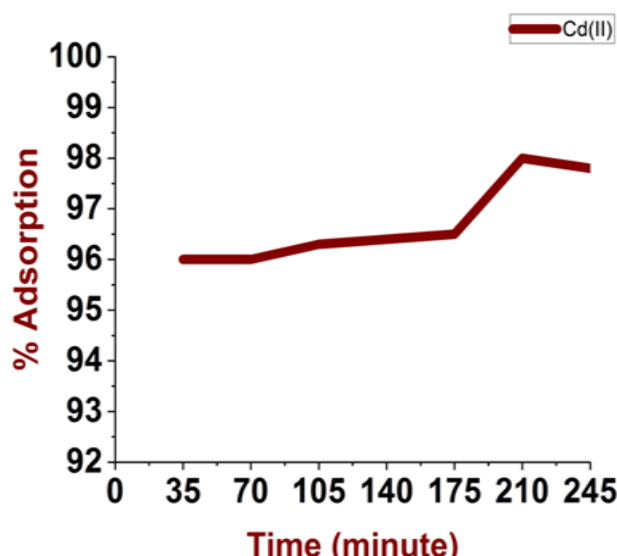

Figure 2. *Effect of contact time on the Cadmium(II) ion adsorption.*

As shown in Figure 2, Cadmium (II) ion uptake rate was rapid within the first 210 min of contact time. This could be due to the large number of Vacant spaces on the adsorbent surface and the initial strong attraction between adsorbent

negative sites and the negatively and positively charged Cadmium (II) ion. Above 210 min. a relatively slower adsorption was observed until it appeared to reach constant state. Further increase in contact time did not show an increase in adsorption. After 210 min. of shaking time, most of the adsorption sites on the surface of the Anchote Peel activated carbon adsorbent are occupied by adsorbate ion and repulsion between adsorbed Cadmium(II) ion and those approaching to occupy the remaining vacant surface sites from the bulk solution increases. As a result, the rate at which Cadmium(II) ion get adsorbed will decrease.

5.4. Effect of Temperature on Metal Ion Uptake

Cadmium (II) ion adsorption onto activated carbon adsorbent were favored at higher temperatures. This indicated that chemical adsorption could potentially be the nature of the adsorption of Cadmium (II) onto the adsorbent. The results demonstrated that an increase in the temperature from 20 ℃ to 40 ℃ led to an increase in the adsorption capacity from 88.143 mg/g to 89.273 mg/g for Cadmium(II) ion. Adsorption capacities of the adsorbent increased rapidly at optimum initial concentrations 0.025 mg/l of Cadmium (II) ion. Greater sorption levels of Cadmium(II) was observed at higher temperature range. These were due to the increasing tendency of adsorbate ions to adsorb from the solution to the interface with increasing temperature. The increase of the equilibrium uptake at increased temperature indicated that the sorption of Cadmium(II) ion on to adsorbent was exothermic. Adsorption efficiency increased with increasing temperature commonly 20 $^{\circ}$C – 40 $^{\circ}$C But, it was shown decreasing after 40 $^{\circ}$C because the increase in adsorption efficiencies of the Anchote Peel(Coccinia abyssinica peel) activated carbon adsorbent with temperature and the subsequent decrease, can be explained in terms of surface area. With an increase in temperature during thermal treatment process, increase Porous structures in their place which result in an increase in the surface areas of the Coccinia abyssinica peel activated carbon adsorbent. Temperatures above a certain optimum will destory Anchote peel(Coccinia abyssinica peel) activated carbon adsorbent structure and cause a decrease in surface area.

5.5. Study of Effect of Initial Concentration and Adsorbent Dose

Adsorbent dose is another important parameter in adsorption studies because it determines the capacity of an adsorbent for a given initial concentration of the metal ion at the operating conditions. Were done by introducing Cadmium(II) ion concentration ((0.00625, 0.0125, 0.025, 0.05, 0.1) mg/L) and then mixed with 0.15 g – 0.55 g absorbent and shaken for 210 min. at optimum temperature 30 ℃ keeping other variables constant. After adsorption time was completed, the solutions were filtered and Concentration of residual metal ions in each Solution was determined using Atomic Absorption Spec-

trometry. The adsorption of Cadmium(II) ion at different adsorbent doses in the range of 0.15 – 0.55 g were investigated. The effect of adsorbent dose on the adsorption of adsorbate ion are shown in Figure 3 below. It is clearly shown in Figure 3 that the adsorption of Cadmium(II) increased with an increase in the quantity of the adsorbent from 0.1 g to 0.25 g and remained nearly constant at adsorbent quantities higher than 0.25 g. The maximum adsorption of Cadmium(II) ion on adsorbent were found to be 98%. The observed initial increase in the sorption of Cadmium (II) ion from the solution with an increase in adsorbent dose could be due to an increase in the available active sites for binding Cadmium (II) ion. An increase in the amount of adsorbent above a quantity that can completely adsorb the available Cadmium (II) ion had no effect on sorption of metal ion.
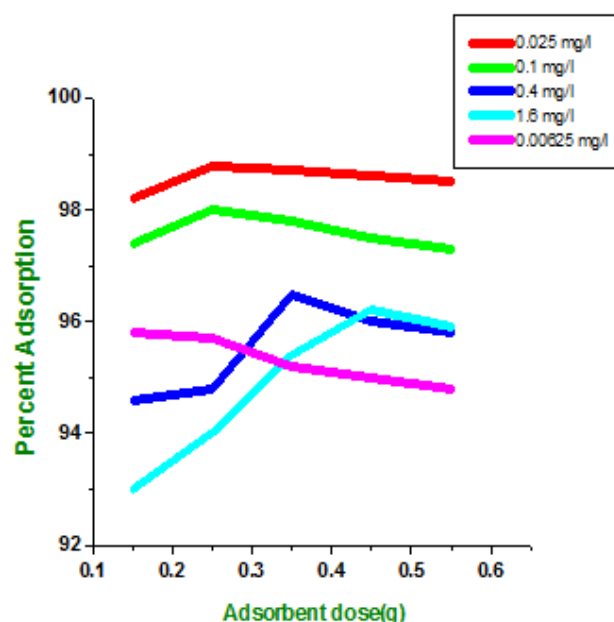

Figure 3. *Effect of initial concentration & adsorbent dosage on the adsorption of Cadmium(II) ion.*

Adsorption of Cadmium (II) ion increases at lower initial concentration. At high initial metal ion concentration, mg/L; the adsorption effeciency was observed to remain nearly constant. The initial sharp rise observed in adsorption followed by the relatively slow increase may be explained as follows: at lower equilibrium Cadmium (II) ion concentrations, surface coverage could be low and the availability of sites that are not occupied by Cadmium (II) ion cannot be a limiting factor. As a result, incremental adsorption is expected to be independent of adsorption capacity. With an increase in the equilibrium Cadmium (II) ion concentration, the linearity of the increase in adsorption efficiency with the equilibrium Cadmium (II) ion decreases due to an increase in the Surface coverage. The ratio of adsorbed to equilibrium Cadmium(II) ion concentration, however, generally decreases as the equilibrium concentration increases after only a small percentage of the adsorption capacity has been used.

6. Adsorption Isotherms

Adsorption isotherm is basic for the design of an adsorption system. It provides information on the capacity of the adsorbent or the amount required for removing a unit mass of Contaminant under the operating conditions. Adsorption isotherm is the relationship between adsorption capacity and concentration of the adsorbate at constant temperature. Generally, common isotherms used to describe the isotherm of the adsorption are Langmuir and Fruendlich isotherms. The Freundlich and Langmuir isotherms are the most commonly used isotherms for the application of activated carbon in water, aqueous solution and wastewater treatment. Freundlich isotherm is an empirical equation. Langmuir isotherm has a rational basis. High temperatures increased the kinetic energy of the metal and, hence, enhanced the mobility of the metal ions. This led to a higher chance of the metal being adsorbed onto the adsorbent and an increase in its adsorption capacity. Adsorbent of this type that exhibit the Langmuir isotherm behavior are supposed to contain fixed individual sites, each of which equally adsorbs only one molecule, thus forming a monolayer. The Freundlich isotherm model is considered to be appropriate for describing both multilayer adsorption and adsorption on heterogeneous surfaces. It has been shown that n values between 1 and 10 values indicate favorable adsorption. Therefore, the n values obtained in the current study indicate that the sorptive of Cadmium(II) ion on the adsorbent was feasible. In this work, the experimental data was fitted to both isotherms. However, it well fitted to the Freundlich isotherm as indicated by the higher R^2 values (Table 2). This show the heterogeneity of the adsorbent surface.
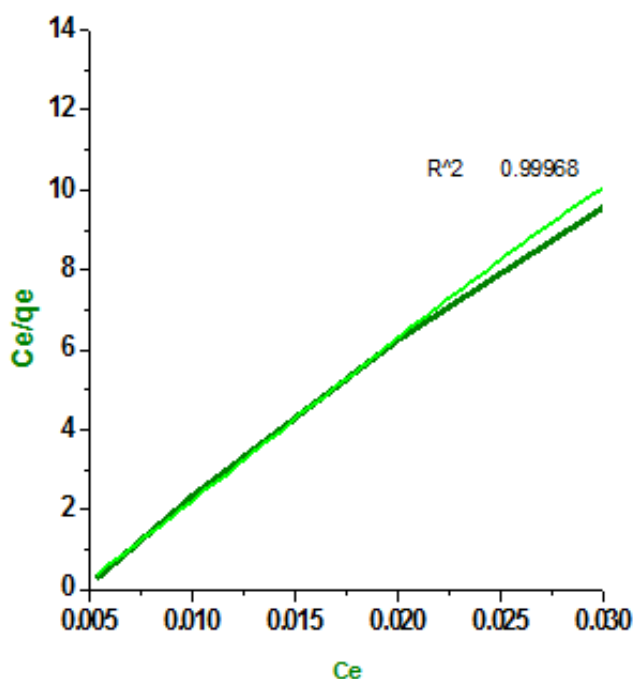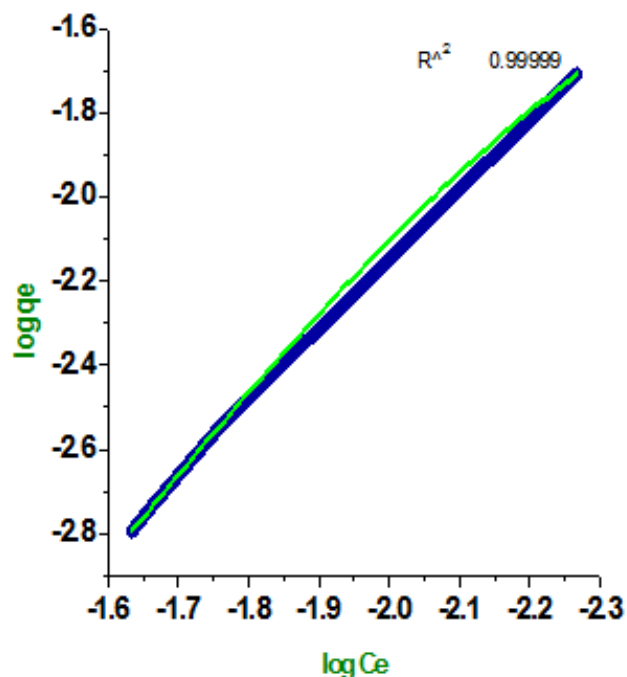

Figure 5. Freundlich plots of the adsorption of Cadmium(II) ion.

Table 3. Results of isotherm models for the adsorption of Cadmium(II) ion onto adsorbent at 298 K.

Isotherm Models	Values for Cadmium(II) ion
Langmuir constants	
q_m (mg/g)	0.31676
b_L (mg/g)	12.00
R^2	0.99968
R_L at 0.025 mg/L	0.9999
Freundlich constants	
K_f	0.34636
n	1.4204
R^2	0.99999

The adsorption is favorable since n values are more than unity and the values of R_L are between zero and one.

7. Adsorption Kinetic Studies

Adsorption kinetics describes the metal ions uptake rate, which governs time of adsorption reaction and is important in defining the efficiency of adsorption. Generally, the adsorption capacity increased with time until the equilibrium was attained between the amounts of metals sorbed on the adsorbent and the remaining in the solution. The adsorption took place more rapidly at initial stages and gradually slowed down in reaching its equilibrium state. This behavior is quite common due to the

Figure 4. Langmuir plot of adsorption of Cadmium (II) ion.

saturation of the available adsorption sites. The time to reach equilibrium varied with the initial concentration, i.e., the solution with a higher initial concentration required a slightly longer time than the solution with a lower initial concentration. The experiments revealed that the equilibrium was reached within 210 min for all cases investigated in this work. Figure (6 & 7) demonstrates that the kinetic curves were generally smooth and continuous. In order to evaluate the kinetic parameters, Pseudo first order, and Pseudo second order models were applied to analyze the experimental data. For pseudo first order kinetics R^2 was 0.9984 Cadmium (II) adsorption but qe (mg/g) values obtained from Pseudo first order kinetics did not agree well with the experimental (mg/g) values. Therefore it is not appropriate to use the Pseudo first order kinetic model to predict the sorption kinetics for Cadmium(II) ion onto adsorbent. Correlation coefficient, R^2 for the pseudo second order kinetic model were almost equal to unity and the values of qe (mg/g) obtained were in excellent agreement with the experimental (mg/g) values.
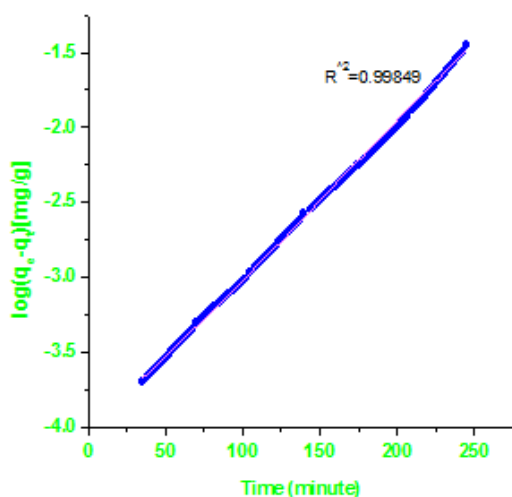
Therefore pseudo second order kinetic was appropriate model in interpreting data for sorption of metal ion on to adsorbent. In reaction kinetics, it was common to determine how the rate of reaction varied as the reaction progressed. Most widely used kinetic expression is the pseudo-second order rate expression where adsorption capacity was assumed to be proportional to the number of active sites occupied on the sorbent. Extremely Excellent agreements between the results and the model were obtained as illustrated by the high R^2 for the whole range of initial metal concentrations which by large confirmed the applicability of the pseudo-second order kinetics. Hence, it was concluded at this point that the adsorption here could be better represented by the pseudo-second order rate kinetics. In addition, the results indicated that at optimum initial metal concentration, the rate constant (pseudo-second order rate constant) increased. High pseudo-second order rate constant suggested that the metal could be rapidly sequestered by the adsorbent functional groups, resulting in the system quickly reaching equilibrium.

This was because optimum initial metal concentration enhanced the concentration gradient of metal ion between aqueous and solid phases. Consequently, the mass transfer of adsorbate into adsorbent increased. This finding supported the fact that pseudo-second order model that the sorption process was due to chemisorption. In this case, chemical sorption could have occurred by the interaction between polar functional groups on the adsorbent surface and metal ion. Experimental results showed rapid initial adsorption rate followed by a slower rate because initially, adsorption sites are open and metal ions interact easily with the sites. Slow adsorption was due to slower diffusion of adsorbate into the interior of the adsorbent. [27]

Figure 6. Pseudo- first order kinetics plot for the adsorption of Cadmium (II) on to adsorbent.

Figure 7. Pseudo second order kinetic plot for Cadmium (II) ion on to adsorbent.

Table 4. Kinetics parameters for the adsorption of Cadmium (II) ion onto Anchote Peel (Coccinia abyssinica Peel) Activated Carbon Adsorbent at 298 K.

Kinetic parameters	Values
Pseudo-first order constants	Cadmium(II) ion
q_e (mg/g)	83.35275
$K_1(min^{-1})$	0.006448
R^2	0.99849
Pseudo-second order constants	Cadmium(II) ion
q_e (mg/g)	89.2732
K_2 (g/mg. min)	4.0646
R^2	0.999

8. Adsorption Thermodynamic Study

Adsorption thermodynamic is important in order to estab-

lish the spontaneity and feasibility of such process. Thermodynamic parameters of adsorption process are temperature dependent process and were calculated. Experimental data obtained from adsorption procedures were employed to determine thermodynamic parameters: Gibbs free energy change (ΔG), change in enthalpy (ΔH) and change in entropy (ΔS). The thermodynamic parameters that help us to understand the nature of the adsorption are Gibbs free energy change, change in enthalpy and change in entropy and their calculated results are indicated in (Table 5) below.

Table 5. Thermodynamic Parameters for the adsorption of Cadmium (II) ion onto Anchote (Coccinia abyssinica) peel Activated carbon ad sorbent.

Heavy metal ion	ΔH(J/mol)	ΔS(J/mol.K)	ΔG(kJ/mol)				
			293 K	298 K	303 K	308K	313K
Cadmium(II)	-71.98616	0.225582	-3.3086	-5.0593	-2.1051	-3.2558	-6.1417

Negative values of Gibbs free energy change and Enthalpy change indicate the feasibility, spontaneous and exothermic nature of the adsorption process. Positive values of Entropy change show the increased randomness at solid-liquid interfaces during the adsorption. Negative values of Gibbs free energy change confirm the adsorption process is spontaneous, which becomes more negative with an increase in temperature. This indicates that a higher sorption is actually occurred at higher temperatures. At higher temperature, ions are readily desolvated and thereby their adsorption becomes more favorable.

9. Application of Developed Method to Real Sample

Cadmium (II) metal ion concentration in drinking water samples were investigated. Concentration levels of Cadmium (II) ion in drinking water samples were very small (less than maximum permissible limit in analyzed water samples) as determined using Atomic Absorption Spectrometry. Thus adsorption study was carried out using stock solution; by preparing aqueous solution of less concentrations from stock solution using dilution method as depicted above.

10. Conclusion

In this study, the powdered activated carbon adsorbent was well be produced from Anchote Peel (Coccinia abyssinica peel). The dynamic behaviors of the adsorption of Cadmium (II) ion from aqueous solution were investigated using locally available, less costly and environmentally friendly Anchote Peel (*Coccinia abyssinica peel) activated carbon* adsorbent for its efficiency and suitability in removing Cadmium (II) ion at low concentrations to examine the effects of initial metal ion concentration, contact time, adsorbent dose, pH, and temperature. The obtained activated carbon adsorbent exhibited high efficiency and high capacity. Maximum adsorption efficiencies was 98.3% for Cadmium(II) ion at pH 5, and optimum contact time 210 min., adsorbent dose 0.25 g and initial conc. 0.025 mg/l respectively. Maximum adsorption capacity of Anchote peel (Coccinia abyssinica peel) activated carbon adsorbent was observed to 89.273 mg/g of Cadmium(II) ion at 30 ℃ and 5 mg/L. The adsorption was found to be strongly influenced by contact time and pH, and initial metal ion concentration. The adsorption kinetic data were modeled using the pseudo-first order and pseudo- second order kinetic equations. Pseudo second order model gave better R^2 values confirming suitability of the model for describing the sorption system. Both Freundlich and Langmuir models can be used to fit the data and estimate model parameters, but the overall data is slightly better fitted by Freundlich isotherm reflecting surface heterogeneity of Anchote peel (Coccinia abyssinica peel) Activated Carbon adsorbent. Thermodynamic parameters Enthalpy change, Entropy change and Gibbs free energy change at 293 k, 298 k, 303 k, 308 K and 313 K) have also been calculated and it has been found that the adsorption was favorable, spontaneous and exothermic in nature. The positive values of the entropy change suggest that the increased randomness at solid-liquid interfaces during the adsorption of Cadmium (II) ion onto adsorbent. The Fourier Transform Infra Red spectrum showed multi functionalized nature of the adsorbent which meant that presence of a large number of peaks. The method was simple, cost effective and environmental friendly. Therefore, it will be necessary and aid us to choose adsorbent with highest carbon content for efficient use of the adsorbent for removal of toxic heavy metal ion.

Acknowledgments

Author Contributions

Leta Shifera is the sole author. The author read and ap-

proved the final manuscript.

Conflicts of Interest

The author declares no conflict of interest.

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