Arsenic (III) Removal from Contaminated Water using Low-Cost Adsorbents: A Batch Adsorption Study

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Abstract

Natural materials named as waste and lime (CaO) has been used as a potential low-cost adsorbent for the removal of As (III) from contaminated water in batch studies. Results showed that Corncobs, pine cones and olive pomas didn't effectively absorb As (III). The absorbtion capacity of lime (CaO) was 4.986 mg As (III) / g lime (CaO)/ hour, at the temperature of 20 o C and pH of 12.3. An adsorbent dose of 0.5 g could effectively remove 99.48% of As (III) from initial concentration of 50 mg L-1 within 1 h. As (III) removal depended on variations in pH and temperature. High adsorption of As (III) was observed at the pH of 12.3 at 20°C. The adsorption equilibrium data could be fit to Langmuir or Freundlich isotherms with similar accuracy. The Langmuir isotherm provided the best correlation for the adsorption of As (III) onto the lime (CaO). The maximum capacity of adsorption was 4.986 mg g -1 at 0.5g fixed adsorption dosage. The results suggest that lime (CaO) is a potential adsorbent for effective removal of As (III) ions from contaminated water.

Key words - Adsorption, arsenic, batch studies, contaminated water, lime (CaO)

1 Introduction

Arsenic (atomic number 33) is ubiquitous and ranks 20th in natural abundance, comprising about 0.00005% of in the earth's crust, ranks 14th in the seawater, and ranks 12th in the human body among other elements [1].Arsenic is mobilized by natural weathering reactions, biological activity, geochemical reactions, volcanic emissions and other anthropogenic activities. Soil erosion and leaching contribute to 612×10^8 and 2380×10^8 g/year of arsenic, respectively, in dissolved and suspended forms in the oceans [2]. Most environmental arsenic problems are the result of mobilization under natural conditions. However, mining activities, combustion of fossil fuels, use of arsenic pesticides, herbicides, and crop desiccants and use of arsenic additives in livestock feeds create additional impacts. Most environmental arsenic problems are the result of mobilization under natural conditions.

Arsenic exists in the −3, 0, +3 and +5 oxidation states [3]. Environmental forms include arsenious acids (H_3AsO_3, $H_2AsO_3^-$, $HAsO_3^{2-}$), arsenic acids (H_3AsO_4, $H_2AsO_4^-$, $HAsO_4^{2-}$), arsenites, arsenates, methylarsenic acid, dimethylarsinic acid, arsine, etc. Arsenic (III) is a strong acid and preferentially complexes with oxides and nitrogen. Conversely, arsenic (V) behaves like a weak acid, forming complexes with sulfides [4]. Inorganic forms of arsenic most often exist in water supplies [4]. Arsenic is uniquely sensitive to mobilization in the pH range of 6.5 to 8.5 under both oxidizing and reducing conditions among heavy metalloids [5]. Two forms are common in natural waters: arsenite

(AsO_3^{3-}) and arsenate (AsO_4^{3-}), referred to as arsenic (III) and arsenic (V). Pentavalent (+5) or arsenate species are AsO_4^{3-}, $HAsO_4^{2-}$, H_2AsO^{4-} while trivalent (+3) arsenites include As $(OH)_3$, $As(OH)^{4-}$, AsO_2OH^{2-} and AsO_3^{3-}. Pentavalent species predominate and are stable in oxygen rich aerobic environments. Trivalent arsenites predominate in moderately reducing anaerobic environments such as groundwater [6].

Arsenic occurrence in the environment, its toxicity, health hazards, and the techniques used for speciation analysis are well known and have been extensively reviewed [4, 6, 7, 8, 9, 10, 11, 12]. Longterm exposure of humans to drinking water containing arsenic causes skin, lung, bladder, and kidney cancer as well as pigmentation changes, skin thickening (hyperkeratosis) neurological disorders, muscular weakness, loss of appetite, and nausea [1,13,14,15,]. This differs from acute poisoning, which typically causes vomiting, oesophageal and abdominal pain, and bloody "rice water" diarrhea [13, 16, 17, 18]. The contamination of drinking water with As is an increasing environmental issue and has been extensively discussed especially during recent years because of its widespread occurrence in many parts of the world. High As concentrations (>50 lg/L) in natural groundwater sources, which provide drinking water for millions of people, have been found, for example, in parts of Bangladesh [19,20], West Bengal [21,22,23], Argentina [24], China [25,26,27], Mexico[28], the upper Midwest and the western United States [29, 30,31,32], Chile [33] and Japan [34]. Arsenic is ranked among the top 20 most hazardous, high priority substances by the Agency for Toxic Substances and Disease Registry [35]. It is of particular concern due to its chronic toxicity even at relatively low concentrations (<100 lg/L), a level that has been widely detected in drinking water. The World Health Organization set a provisional guideline limit of 10 lg/L for As in drinking water [36], which was subsequently adopted by the European Union [37] and the United States [38]. This low As drinking water standard requires the development of simple, cost effective methods for As removal from drinking water. Arsenic occurs in both inorganic and organic forms in natural water [39]. Inorganic As compounds are about 100 times more toxic than organic As compounds [40, 41]. However, more recent research has shown that methylation of As does not always mean that it is non-toxic, and the organic As species may be even more toxic than inorganic arsenicals [42, 43, 44]. Therefore, technologies for removing both inorganic and organic As species are urgently needed.

Solute–surface interactions complicate arsenic adsorption in multicomponent systems. Solute–solute competition occurs at the active adsorption sites. Solid–liquid phase equilibrium will emerge with a different capacity for single metal ions and a new set of isotherms occurs when competitive ions are present. The interpretation of the multicomponent systems has been proven to be complex and can be a function of ionic radii, electronegativity, pH, and the availability of the active sites. Most adsorption studies were carried out using deionized water in single ion systems. Multi-ion systems have received less attention. However, environmental arsenic is always accompanied in contaminated water by other ions, thus source water's effects on the adsorbent efficiency must be explored. Adsorption behavior of arsenic in presence of multicomponent impurities has been studied [45,46,47,48,49,50,51,52,53,54]. For example, groundwater in Bangladesh contains high concentrations of phosphates (0.2–3.0 mg P/L), silicate (6–28 mg Si/L) and bicarbonate (50–671 mg/L) [55]. More study is needed to establishe mechanistic guidelines for arsenic sorption in multicomponent systems. The adsorption of As (III) and As (V) onto hydrous ferric oxide (HFO in presence of sulfate and calcium ions as cooccurring solutes) was examined [49]. Decreased adsorption of both As(III) and As(V) was observed in the presence of sulfate.

The effect of sulfate was greatest at lower pH. Calcium enhanced the adsorption of As(V) at high pH. This enhancement was attributed to favorable electrostatic effects arising from calcium adsorption. NO^{3-}, SO_4^{2-}, Cl^-, Br^- anions did not significantly affect the adsorption of As(III) [45].

Cl^-, and HCO^{3-} interfered with arsenate removal using Bauxol by competing for surface sites [53] but Ca^{2+} did not. The suppression of arsenic sorption caused by HCO^{3-} was much higher than that by Cl^- [53]. The presence of Ca^{2+}, however, improved arsenic removal due to favorable electrostatic effects, as it increased the number of positively charged surface adsorption sites. Other dissolved substances present in source water (ground or drinking) have also been reported to interfere with arenate and arsenite mobility. The presence of natural organic matter in water may delay attainment of sorption equilibrium and suppress the extent of arsenite and arsenate adsorption. This was reported for alumina, goethite and hematite [56, 57, 58, 59]. Anion competition for the available sorption sites occurs but some other factors cannot be ruled out. Other anions may slow down the time to reach the equilibrium. Optimum times for single component arsenate, or arsenite solutions may not be sufficient for binary or multicomponent systems [53,60]. Clearly, studies must be conducted to see the interference behavior of various ions on the adsorption of arsenic in addition to single ion adsorption systems. Multicomponent sorption models should be applied to determine the adsorption capacities [61] in multicomponent systems.

Sorption capacities were evaluated at different pHs, temperatures, different concentration ranges, adsorbent doses and As (III)/As (V) ratios. The adsorbents were used to process ground water, drinking water, synthetic industrial wastewater, and actual wastewater, etc. The types and concentrations of interfering ions are different and seldom documented. Some adsorption capacities were reported in batch experiments and others in column modes. These cannot be compared with each other. In batch sorption experiments, the sorption capacities were computed by the Langmuir isotherm or the Freundlich isotherm or experimentally. This makes comparisons more complicated to pursue. In other words, direct comparisons of the tested adsorbents are almost impossible [62].

Obviously, some low-cost adsorbents developed from agricultural wastes or industrial wastes have outstanding capacities. These include treated slags, carbons developed from agricultural waste (char carbons and coconut husk carbons), biosorbents (immobilized biomass, orange juice residue), goethite, etc. Some commercial adsorbents, which include resins, gels, silica, treated silica tested for arsenic removal also performed well. Comparing sorbents by surface area alone is difficult. Adsorption of organics is usually dependent on adsorbents' surface area. The higher the surface area is the greater the adsorption is. But, this is often not true for metal ions/inorganics adsorption. Factors such as exchange and precipitation may contribute or dominate the adsorption process [62].

The cost of arsenic removal adsorbents developed from waste materials has not been extensively studied. The cost of individual adsorbents depends on local availability, processing requirements and treatment conditions [62].

Adsorption is a useful tool for controlling the extent of aqueous arsenic pollution. Activated carbon was studied extensively for arsenic removal. However, carbon only removes a few milligrams of metal ions per gram of activated carbon. Morever, regeneration problems are common. Thus, activated carbon use is not very feasible. Activated carbon use in developing countries is more problematic due to its high cost. Therefore, there is a definite need for low-cost adsorbents, which exhibit superior adsorption capacities and are locally available [62].

Selection of a suitable sorbent media to supply arsenic free drinking water depends on (1) the range of initial arsenic concentrations, (2) other elements and their concentration in water, (3) optimization of adsorbent dose, (4) filtration of treated water, (5) adjustment of pH in water, (6) post treatment difficulties, (7) handling of waste and (8) proper operation and maintenance. The adsorbents' active sites may be occupied by other contaminants based on its selectivity, thereby reducing the effective adsorption capacity for the target contaminant. Understanding the sorbent's selectivity sequence and knowing the water quality profile will help avoid competitive adsorption [62].

In this study, the removal of As (III) from water by using natural waste material and CaO was planned. To accomplish this plan, corncobi, pine cones, olive pomas and lime (CaO) were used as absorbants.Adsorption processes have been carried out with a batch process. The concentration of As (III) left in solution after adsorption has been determined with AAS using N2O acetilen flame.

Corncobs, pine cones and olive pomas didn’t effectively absorb As (III). However the absorbtion capacity of lime (CaO) was 36,5389 mg As(III) / g lime (CaO) in 1 hour, at 20 ^{o}C and pH=12.3.

The main objectives of this study were to (i) select the best materials from a set of different natural wastes and lime (CaO) samples for removal of As species; (ii) investigate the potential for using the target natural organic wastes (Corncobs, pine cones and olive pomas) and lime (CaO) as adsorbant material to remediate drinking water contaminated with As; and (iii) detemine low- cost effective methods for As removal from drinking water.

2 Material and methods

2.1. Adsorbents

Corncobs, pine cones, olive pomas and lime (CaO) were used as adsorbents.Lime (CaO) were provided from the limekiln (Öztüre Kireççilik)

Table 1 Molecular weight values and resolution of lime

molecular weight	56,08 g/mol
resolution	1,64 g/l

Table 2. Chemical analysis values of lime

CaO total	@	93,14 %
CaO active	TS EN 459-2	90,30 %
H_2O humidity	TS EN 459-2	0,10 %
CO_2	PF 1000 ^{o}C – PF 600 ^{o}C	1,65 %
MgO	TS EN 459-2	1,80 %
SiO_2	TS EN 459-2	0,24 %
Al_2O_3	LAB	0,18 %
Fe_2O_3	LAB	0,22 %
S	TS EN 459-2	0,21 %
$CaCO_3$	TS EN 459-2	3,75 %

Table 3. Physical characterization values of lime

Bulk density	ISO 787-11	1,1 / 0,9 g/ml
reactivity T_{60}	TSE	1’ 20’’ min

2.2. Reagents

All reagents were of analytical grade. A synthetic solution of As (III) was made using standard 1000 mg L^{-1} arsenite [As (III)] solutions and deionized (DW) water without further purification. Standard acid and base solutions (0.1N HC1 and 0.1N NaOH) were used for pH adjustments. The other solutions needed in the study were freshly prepared from stock solution for each experimental run.

2.3. Equipment

Arsenic concentration measurements were carried out using Varian 220 FS AAS. Atomic absorption spectrophotometer equipped with a arsenic hollow cathode lamp at the wavelength 253. 7 nm was used for the determination of arsenic in sample solutions. The instrument was calibrated by using As III) standard solution of 60,50,40 and 30 mg L^{-1}, which was prepared in diluted HCl. The pH of solution was measured with a Hanna P211 microprocessor pH-meter using a combined glass electrode. Conduct measurements were applied with model Hanna Instruments EC 215 conductmeter. For seperation of the selected adsorbents in view of specific grain was used model Retuch AS 200 micro sieve instrument. Temperatüre measurements were made with model Nüve BM 101 water bath instrument. The drying was carried out in a Nüve EN 400 drying oven.

2.4. Batch adsorption studies

First, the parameters affecting the performance of adsorbtion contact time were determined.

Lime (CaO) weighing 0.5 (± 0.0002) g were mixed with 25 mL standard As (III) solution (50 mg / L) and has been contacted by mixing for 0.5, 1, 2, 4, 8, 12 and 24 at room temperature.

In each experiment, the beakers were sealed with airtight cap and samples were shaken on the mechanical shaker at 300 rpm. Parameters including adsorbent dosage, contact time, pH and various initial concentration, temperature were optimized for maximum adsorption by the method of continuous variation following batch adsorption experiments mentioned above.

The quantity of adsorbed arsenic was calculated by the difference of the initial and residual amounts of arsenic in solution divided by the weight of the adsorbent by the following equation:

$$q_e = \frac{C_0 - Ce}{M} \times V \qquad (2.1)$$

Where q_e (mg g^{-1}) is the amount of As (III) anion adsorbed per gram of the ceramic, C_0 (mg L^{-1}) the initial concentrationof the solution of As (III), C_e (mg L^{-1}) the equilibrium concentration of the solution of As (III), V (L) the volume of the solution and M (g) the mass of the adsorbent.

The percentage of As (III) removed by the silica ceramic shows the efficacy of removal. It is determined from the ratio of concentration of As (III) present in the solution and particulate phases using the equation:

$$R_e = \frac{C_0 - Ce}{C_0} \times 100 \qquad (2.2)$$

Where R_e is the percentage (%) of As (III) adsorbed, C_0 and C_e are the initial and equilibrium concentration of As(III) respectively.

3. Results and Discussion

3.1. Effect of pH

In order to determine the most favorable pH for adsorption of As (III) (to corncob, pine cone and olive pomas), the study was carried out with different pH values as presented in Figure.1. In this experiment, the duration of arsenic adsorption was chosen to be an hour. Adsorption isotherms have been prepared from pH 4.0 to 10.8. The maximum adsorption was achieved in the pH of 10.8 for initial As(III) concentration of 50 mg L^{-1} Figure 1. This implies that favorable adsorption took place at pH 10.8, therefore all further experiments were carried out at pH of 10.8. Low adsorption was observed at lower pH values. For lime (CaO) solutions, the duration of arsenic adsorption was chosen as 1h. Adsorption was run at pH 12.3. From it is clear that maximum adsorption was achieved in the pH of 12.3 for initial As (III) concentration of 50 mg L^{-1} (Table 1).

The pH of the solution determines the concentrations distribution of the ionic forms of As (III). In the removal of As (III) by iron-coated sand [64, 65], amorphous ferric hydroxide [66], similar trends were reported.

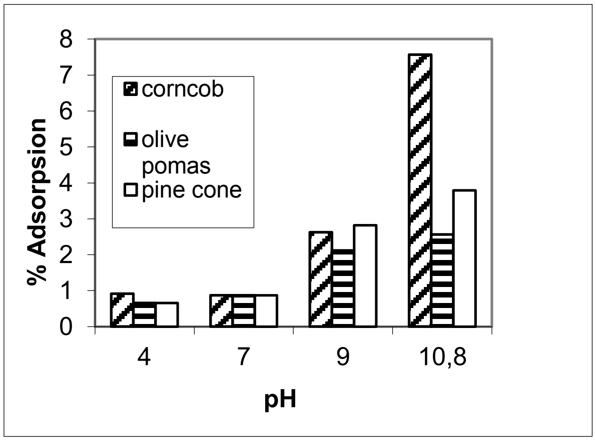

Figure1. Effect of pH on As(III) adsorption.

Table 4. Effect of pH Lime (CaO) As (III) ions adsorption performance

pH	After adsorption process, the amount of As (III) remaining in solition (mg/25ml)	the amount of As (III) adsorbed (mg/0,5g)	%adsorption
12,3	0,007	1,244	99,48

3.2 .Effect of contact time and initial As(III) concentration

To evaluate the effect of initial As (III) concentration (C_0) on adsorption, studies were conducted with initial As (III) concentration (C_0) of 50 mg L^{-1} with corncob, pine cone, olive pomas, lime (CaO) and modified corncob as the adsorbent materials.

First, the parameters affecting the performance of adsorption contact time were determined. For this purpose, based on the data, graphics were prepared between the adsorbed amount of As (III) vs time. The values found for the optimum contact time of 1 h can be seen in figure 2 and figure 3.

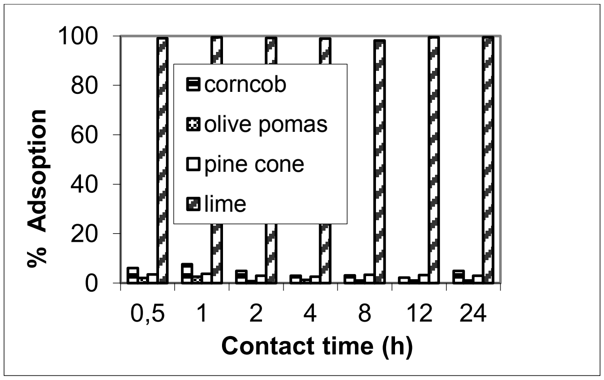

Figure 2. Effect of contact time on As(III) adsorption.

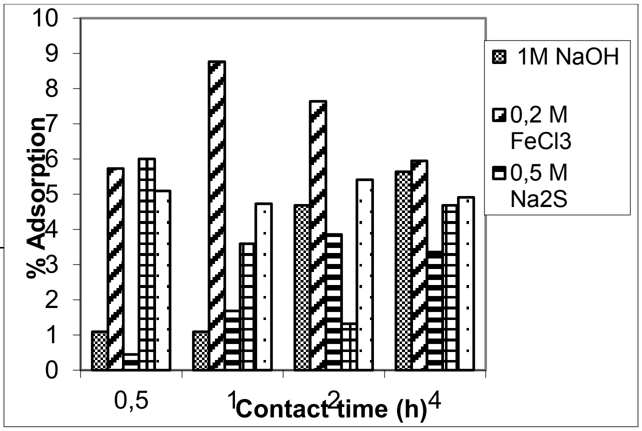

Figure 3. Effect of contact time on As (III) adsorption (modified corncob)

3.5. Effect of temperatüre

The temperature used for experiment varied from 20 to 40°C. No significant change with temperature for As (III) removal is seen Figure 4. The adsorption of arsenic on corncob, pine cone, olive pomas, lime (CaO) was highest at 20°C. Therefore other experiments were conducted at 20°C.

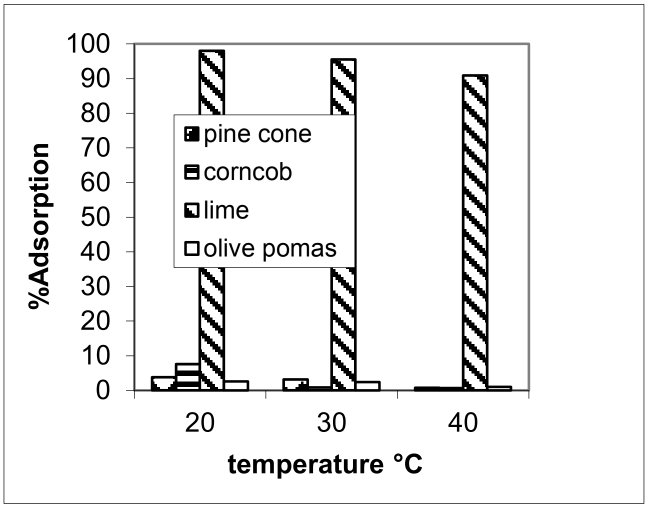

Figure 4. Effect of temperature on As (III) adsorption

For lime (CaO), temperature-dependent diffusion coefficient Kd of As (III) adsorption was found using the following equation:

$$K_d = \frac{C_0 - Ce}{Ce} \times \frac{V}{m} \qquad (3.1)$$

Where C_0 is the initial amount of As (III) (mg),C_e is the amount of As (III) (mg) remaining in solution,V is solution volume (mL),m is the adsorbent amount (g).After evaluating adsorption peformans criteria of As (III) in lime (CaO), enthalpy of adsorption (ΔH), Gibbs free energy (ΔG) and entropy of adsorption (ΔS) with the help of the following equations can be found.

$$\Delta G = RT \ln K_d \qquad (3.2)$$

As the equality of both sides of the equation -RT is divided, the following equation is obtained.

$$\ln K_d = \frac{\Delta S}{R} - \frac{\Delta H_{ads}}{RT} \qquad (3.3)$$

$$\Delta G = \Delta H - T\,\Delta S \qquad (3.4)$$

If 1/T versus ln Kd is drawn, ΔS and ΔH can be found from the slope of the graph. If we put these values in the equation of ΔG =ΔH - TΔS, we can find then ΔG Gibbs free energy.

Where K_d is adsorption diffusion coefficient (mL/g), R gas constant (8,314 J. mol/ K), T temperature (K).

Table.5 For As (III) adsorption of lime (CaO) Kd the optional temperature coefficient of dispersion data

temperature (^{0}C)	1/T (K)	Kd	In K
20	0,0034	2475,252	7,81
30	0,0033	1054,240	6,96
40	0,0032	497,765	6,21

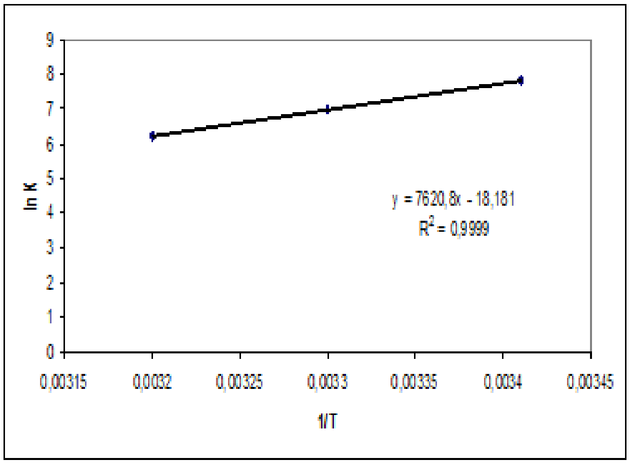

Figure 5. For As (III) adsorption of lime (CaO) 1 / T against Ink graphic.

Adsorption enthalpy (ΔH) As (III) of Lime (CaO) can be found using the following equations:

$$\ln\frac{K_1}{K_2} = -\frac{\Delta H}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$
(3.5)

Where K_1 is adsorption diffusion coefficient at 20 ^{o}C (mL/g), K_2 is adsorption diffusion coefficient in 40^{o}C (mL/g), R is universal gas constant (8,314 Jmol/K), T_1 is temperature (K), T_2 is temperature (K).

$$\ln\frac{2475{,}252}{497{,}765} = -\frac{\Delta H}{8{,}314}\left(\frac{1}{293} - \frac{1}{313}\right)$$
(3.6)

$$\Delta H = -61149{,}984\,J\,mol^{-1} = -61{,}149\,k\,J\,mol^{-1}$$
(3.7)

Adsorption entropy (ΔS) As (III) of Lime (CaO) can be found with the following equations:

$$\ln K_d = \frac{\Delta S}{R} - \frac{\Delta H}{RT}$$
(3.7)

$$\ln 2475{,}252 = \frac{\Delta S}{8{,}314} - \frac{-61149{,}984}{8{,}314 \times 293}$$
(3.8)

$$\Delta S = -143{,}737\, JK^{-1}\, mol^{-1}$$
(3.9)

Adsorption Gibbs free energy (ΔG) As (III) of Lime (CaO) can be found using the following equations.

$$\Delta G = \Delta H - T\,\Delta S$$
(3.10)

$$\Delta G = -61149{,}984 - [293 \times (-143{,}737)]$$
(3.11)

$$\Delta G = -190035{,}043\, J\, mol^{-1}$$
(3.12)

Therefore, the process was ekzothermic.

3.6. Adsorption isotherms

The plots of arsenic uptake against equilibrium concentration (Figure 6) indicate that adsorption increased initially with concentration but then reached the saturation point. Langmuir and Freundlich isotherms were applied to study the adsorption equilibrium. The Langmuir isotherm is based on assumption that **(i)** maximum adsorption corresponds to a saturated monolayer of adsorbate molecules on the adsorbent surface, (ii) that the energy of adsorption is constant and (iii) that there is no transmigration of adsorbate molecules in the plane of adsorbent surface.

The Langmuir isotherm is expressed as:

$$q_e = q_m \frac{bC_e}{(1 + bC_e)}$$
(3.13)

and its linearized form is

$$\frac{C_e}{q_e} = \frac{1}{q_m} + \frac{C_e}{q_m}$$
(3.14)

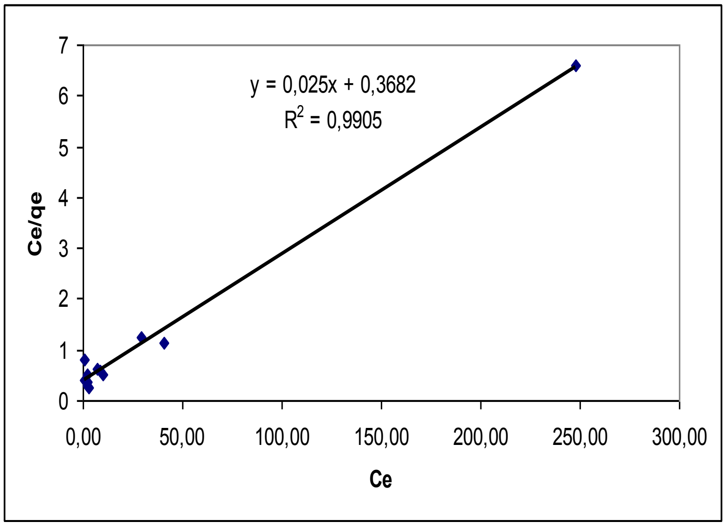

Figure 6. For As (III) adsorption on Lime (CaO), the Langmuir graphic

Where q_e is adsorbed amount (mg g^{-1}), C_e is equilibrium arsenic concentration in solution (mg L^{-1}), q_m is monolayer capacity of the adsorbent (mg g^{-1}) and b is adsorption constant or energy of adsorption (L mg^{-1}). The Freundlich isotherm equation is expressed as:

$$q_e = K_F + C_e^{\frac{1}{n}}$$
(3.15)

$$\log q_e = \log K_F + \frac{1}{n}\log C_e$$

(3.16)

Where q_e is adsorbed amount (mg g^{-1}), C_e is equilibrium arsenic concentration on in solution (mg L^{-1}), K $_f$ (mg g^{-1}) is the Freundlich constant related to adsorption capacity and n (dimensionless) is constant related to energy of intensity of adsorption.

Adsorption isotherms were obtained in terms of Eq. 17 and 19 by using experimental adsorption results in these equations. The Langmuir and Freundlich exponents q_m, b, K_f and n are determined from the linear plots of C_e / q_e vs C_e and log q_e vs log C_e which are shown in Figure 6 and 7, respectively and respective data are shown in Table 3.

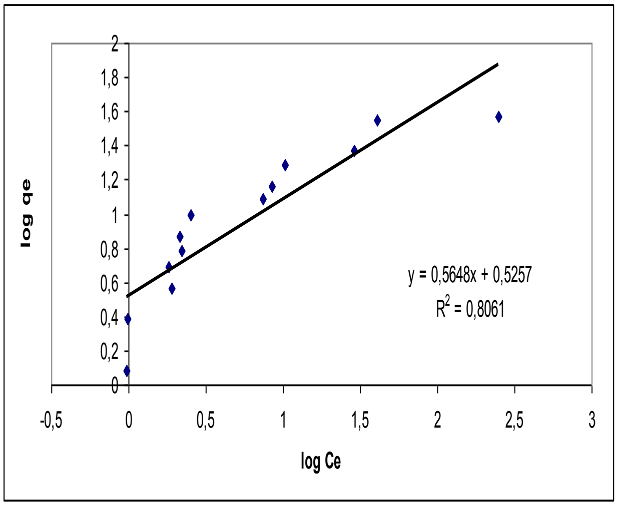

Figure 7. For As (III) adsorption on Lime (CaO), the Freundlich graphic

As shown Figure 6, the Langmuir equation represents the adsorption process very well; the determination coefficient, R^2, is higher for the Langmuir isotherm than the Freundlich isotherm, indicating a very good mathematical fit. The fact that the Langmuir isotherm fits the experimental data very well Figure 6 may be due to homogeneous distribution of active sites on the lime surface. The maximum adsorption capacity obtained from Langmuir model was found 4.986 mg g^{-1}. Previously, some studies have investigated other adsorbents such as activated red mud, iron oxide coated sand, calcined bauxite, activated alumina and Silica ceramic (S-K) for the removal As(III) aqueous solution. A comparison of the results obtained in this study with those in the previously reported works are given Table 6, which shows the adsorption capacities of various low-cost adsorbents in aqueous solution for As (III) removal.

It can be stated that the findings of this study is quite satisfactory as compared to those in the other studies.

Table 6. Comparison of As (III) adsorption of Lime (CaO) with other adsorbents

Adsorbent	Adsorption capacity (mg g^{-1})	Adsorbent Dose (g L^{-1})	Initial As(III) concentration (mg L^{-1})	References
Activated red mud	0.8838	20	25-30	Altundogan *et al.* (2002)[67]
Calcined bauxite	1.3620	-	0.5-8	Ayoob *et al.* (2007) [68]
Iron oxide coated sand	0.0286	20	0.1-08	Gupta *et al.* (2005) [64]
Activated alumina	0.2249	1-13	1	Singh and Pant (2004) [69]
Silica ceramic (S-K)	1.1041	40	2-44	Salim *et al.* (2007) [70]

Lime (CaO)	4.986	0.5	50	Present study

4.Summary

Results showed that corncobs, pine cones and olive pomas could not absorb As (III) effectively. However, Lime (CaO) can be used as an efficient adsorbent for As(III) removal in contaminated water treatment. The adsorption was found to be dependent on pH, temperature and contact time. Better results were obtained at higher pH values.

The amount of As (III) uptake (mg g^{-1}) was found to increase with contact time. The maximum adsorption occurred when the temperature was 20°C.

The adsorption isotherm followed Langmuir isotherm. The findings of the study have revealed that Lime (CaO) has high potential for use the in the removal of arsenit from contaminated water, but further work is needed to increase the arsenit adsorption capacity of Lime (CaO).

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5.References

5.References

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