Removal of Arsenic from prepared Synthethic Sample by Adsorption on Laterite Soil

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Abstract— This work focus on removal of arsenic from prepared synthetic sample using laterite soil as an adsorbent. Effects of pH, adsorbent dose and contact time on arsenic removal were found out. Laterite soil was found to be very effective for arsenic adsorption. It was found that 70 min contact time at pH 6.4 and temperature 32±1º C was sufficient for approximately 90.2% removal. Batch adsorption study were conducted by varying the contact time, adsorbent dosage & pH.

Key words: Arsenic, Laterite soil and Adsorption

I. Introduction

Clean environment and beautiful nature is a gift of god to mankind. But due to rapid growth of industrialization, urbanization, all over the world coupled with population explosion have resulted in pollution of environment. The air we breathe, the water we drink, the food we consume have been polluted remarkably by the pollutants, which are the byproduct of various industries. Process waste streams from the mining operations, metal plating facilities, power generation facilities, electronic manufacturing units, Organic chemicals and petrochemicals, Basic non-ferrous metal waste foundries, Basic steel works etc may contain heavy metals at concentration exceeding the local discharge limits. These waste streams contain toxic heavy metals such as arsenic, cadmium, lead, mercury, nickel, copper and Arsenic. They are not easily removed without specialized or advanced treatment[1].

"Arsenic" is a common pollutant introduced into newly water due to discharge of variety of industrial wastewater. According to world health Organization (W.H.O) drinking water guidelines, the maximum allowable limit for arsenic is 0.05 mg/L. Arsenic is a chemical element with symbol As and atomic number 33. Arsenic occurs in many minerals, usually in conjunction with sulfur and metals, and also as a pure elemental crystal. Arsenic is a metalloid. It can exist in various allotropes, although only the gray form has important use in industry. The main use of metallic arsenic is for strengthening alloys of copper and especially lead (for example, in car batteries). Arsenic is a common n-type dopant in semiconductor electronic devices and the opto electronic compound gallium arsenide is the most common semiconductor in use after doped silicon. Arsenic and its compounds, especially the trioxide, are used in the production of pesticides, treated wood products, herbicides, and insecticides[2].

The three most common arsenic allotropes are metallic gray, yellow, and black arsenic, with gray being the most common. Gray arsenic adopts a double-layered structure consisting of many interlocked, ruffled, six-membered rings. Because of weak bonding between the layers, gray arsenic is brittle and has a relatively low Mohs hardness of 3.5.This relatively close packing leads to a high density of 5.73 g/cm^3.Gray arsenic is a semimetal, but becomes a semiconductor with a bandgap of 1.2–1.4 eV if amorphized. Gray arsenic is also the most stable form. Yellow arsenic is soft and waxy, and somewhat similar to tetra phosphorus (P4). Both have four atoms arranged in a tetrahedral structure in which each atom is bound to each of the other three atoms by a single bond. This unstable allotrope, being molecular, is the most volatile, least dense, and most toxic. Solid yellow arsenic is produced by rapid cooling of arsenic vapor, As4. It is rapidly transformed into gray arsenic by light. The yellow form has a density of 1.97 g/cm^3. Black arsenic is similar in structure to red phosphorus. Black arsenic can also be formed by cooling vapor at around 100–220 °C. It is glassy and brittle. It is also a poor electrical conductor. The major industries contributing to Arsenic are shown in Table 1.

Sl. NO	Industries	Metals found
1.	Basic non-ferrous metal waste foundries	Al, Ag, As, Cd, Cr, Cu, pb,Zn
2.	Basic steel works	As, Cd, Cu, Fe, Hg, pb, Ni,Zn
3.	Organic chemicals and petrochemicals	Al, As, Cd, Cr, Hg, Fe, pb,Zn

Table 1: Major industries contributing to arsenic

A. *OBJECTIVES:*

To evaluate a feasible and economical low cost treatment of heavy metal, as present in synthetic sample by laterite soil which is naturally available as an adsorbent.

The present study has been carried out according to the guidelines as follows

1) To study the physical properties of laterite soil.
2) Removal efficiency of a adsorbent as a function of contact time, adsorbent dosage and pH.
3) To study sorption kinetics.
4) To study column tracer experiment and isothermal pattern.

II. Literature review

The determination of arsenic has been of importance to public health agencies for many years because of the toxicity of arsenic compounds. Several incidents have demonstrated that arsenic in water may be carcinogenic. The toxicity of arsenic compounds depends on the chemical and physical form of the compounds and the route by which it enters the body. Acute poisoning by arsenic involves the central nervous system leading to coma and for doses of 70-80 mg to death. The gastrointestinal tract, nervous system, the respiratory tract, and the skin can be severely affected. Adequate evaluation of toxicity hazards requires arsenic estimation in the micro-gram range. It is recommended that, when water is found to contain arsenic at level of 0.05 mg/l, an attempt should be made to ascertain the valence and chemical forms of the elements.

Mohammad Yaseen Farrukh (2016) his study deals with removal of colour from wastewater of silk filature using a low cost activated carbon prepared from Ziziphus Mauritiana shell powder of size 150µ. The chemically activated carbon is prepared with Impregnation Ratio of 0.75 A series of column tracer experiments have been performed with colour on the physically and chemically activated carbons for obtaining the breakthrough and retardation co-efficients. The values of Coefficient of Freundlich Isotherm (KF), Distribution coefficient (KdF), Coefficient of Freundlich Isotherm (1/n) and Retardation coefficients (R) are 1, 0.997, 0.993 and 1.549 for CaCl2 activated carbon are 1,0.992,0.982 and 1.542 and for MgCl2 activated carbon are1,0.999, 0.998 and 1.552 respectively. Adsorption capacity for physically and chemically activated carbon are 0.326mg/g, 0.579 mg/g and 0.627 mg/g respectively[4].

Annapurna (2014) has done attempt to study Arsenic content in groundwater imposes a great threat to people worldwide. As (III) which is toxic element and creates adverse effect to the human health .The present study deals with removal of arsenic from aqueous solution using low cost activated carbon prepared from Delonix regia (gulmohar seed pods).In adsorption solute present in dilute concentration in liquid or gas phase is removed by contacting with suitable solid adsorbent so that the transfer of component first takes place on the surface of the solid and then into pore of the solid. Batch adsorption study were conducted by varying the contact time, adsorbent dosage & pH[5].

III. MATERIAL AND METHODOLOGY

Laterite soil: Laterites are soil rich in iron and aluminum, formed in hot and wet tropical areas. Naturally all laterites are rusty red as shown in the fig 1 and fig 2 in solid form and in powdered form respectively. It's mainly because of iron oxides. They develop by intensive and long lasting weathering of the underlying parent rock. Tropical weathering (laterization) is a prolonged process of mechanical and chemical weathering which produces a wide variety in the thickness, grade, chemistry and ore mineralogy of the resulting soils. Laterites cover about one-third of the earth's continental land area, with the majority of that in the land areas between the tropics of cancer and Capricorn. Characteristics of laterite soil is shown in table 2. below

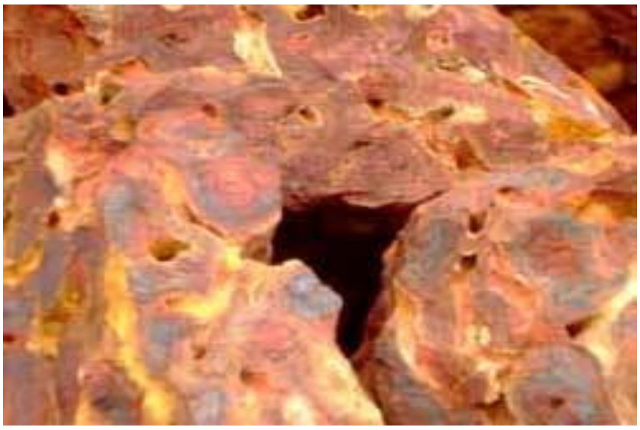

Fig. 1: Laterite in solid form

Fig. 2: Laterite in powder

Sl.no	Characteristics	Values
1.	pH	6.4
2.	Specific gravity	2.52
3.	Moisture content	16%
4.	Decolorizing power	14
5.	Bulk Density	1.46

Table 2: Characteristics of Laterite soil

A. *Preaparation of Synthetic Arsenic Solution:*

Stock Arsenic Solution was prepared by dissolving 1.320gm Arsenic trioxide (As_2O_3) in 10ml distilled water containing 4gms of NaoH and diluted to 1000ml distilled water; such that 1.00ml=1.00mg As.

Intermediate Arsenic solution was prepared by diluting 5.00 stock solution to 500ml with distilled water such that 1.00ml =10.00µg As.

Standard arsenic solution was prepared by diluting 1.00mL of intermediate Arsenic solution with 100mL distilled water, Such that concentration was 10 µg/L of Arsenic.

B. *Apparatus:*

A glass assembly has been designed and fabricated by NEERI for arsenic estimation. That is modified gutzeit apparatus as shown in fig 3.

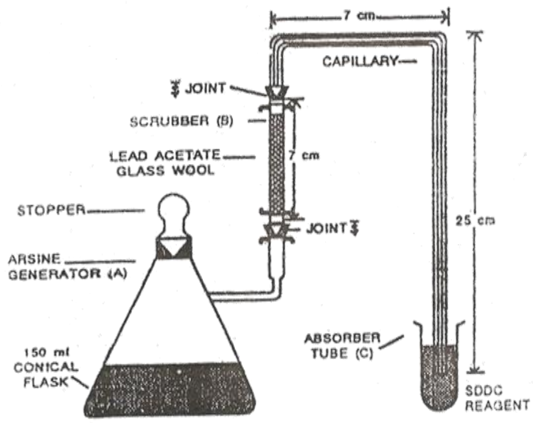

Fig. 3: Modified Gutzeit apparatus

C. *Procedure:*

Arsine generation and Measurement:

1) 50 ml of sample was taken in an arsine generator (A). 3g of zinc powder and 2 ml potassium iodide solution was added to the generator.
2) The glass wool in the scrubber (B) was impregnated with lead acetate solution.

3) 4.0 ml of silver diethyl dithiocarbamate (SDDC) reagent was taken in the absorber tube (C).
4) 5.0 ml conc. HCl and 1 ml stannous chloride reagent was taken in a measuring cylinder.
5) The generator scrubber absorber assembly was connected, and all connections were tightly fitted.
6) The stopper of arsine generator was removed, the solution of the measuring cylinder was added to the generator and the generator was closed immediately by the stopper.
7) 30 minutes was allowed for complete evolution of arsine.
8) The solution from the absorber tube was poured directly into 1 cm cell and the absorbance of the solution at 535 nm was measured spectrophoto-metrically.

D. *Batch sorption experiment:*

In batch sorption, a pre-determined amount of adsorbent is mixed with the sample, stirred for a given contact time and subsequently separated by filtration. Powder adsorbent is more suitable for the batch type contact process.

E. *Selection of optimum contact time:*

The adsorption is strongly influenced by the contact time. To study the effect of contact time, 100mL of 10µg/L arsenic solution was mixed with 200mg of different soils, stirred at different contact times varying from (10mins, 20mins, 30mins up to 120mins). Then filtrate was analyzed for arsenic concentration using spectrophotometer.

F. *Determination of optimum dosage of adsorbent:*

To determine the optimum dosage of different soils, it was added to the conical flask in different dosage varying from (200mg, 400mg, up to 2400mg), containing 100mL concentration of arsenic solution (10µg/L). The solution in the conical flask was subjected to stirring for optimum contact time, filtered and analyzed for residual arsenic concentration. The dosage which gives minimum residual concentration is chosen as optimum dosage.

G. *Selection of optimum ph on arsenic:*

The extent of adsorption is strongly influenced by the pH at which adsorption is carried out. The effect of pH on arsenic adsorption was studied by performing equilibrium adsorption tests at different initial pH values. i.e. from 6.0 to 8.75. The pH of solution was adjusted by using 0.1N H_2SO_4 or 0.1N NaOH. The pH which gives minimum residual concentration is chosen as optimum pH.

IV. RESULTS AND DISCUSSION

With the following Arsenic removal study gas been carried out with respect to the following parameters
1) Effect of contact time
2) Effect of dosage
3) Effect of pH

A. *Effect of contact time:*

Contact time has greater influence in the adsorption process. The effect of contact time on removal of arsenic from synthetic sample's by using laterite soil. Model values are tabulated in the table 3 and the resulting graph is plotted as shown in the below fig 4. From the graph it is evident that the extent of Arsenic adsorption increases with increase in time. After equilibrium further increase in time, adsorption is not changing. Hence, the removal efficiency on 'As' by using laterite soil was found to be 90.20 % with an optimum contact time of 70 mins respectively.

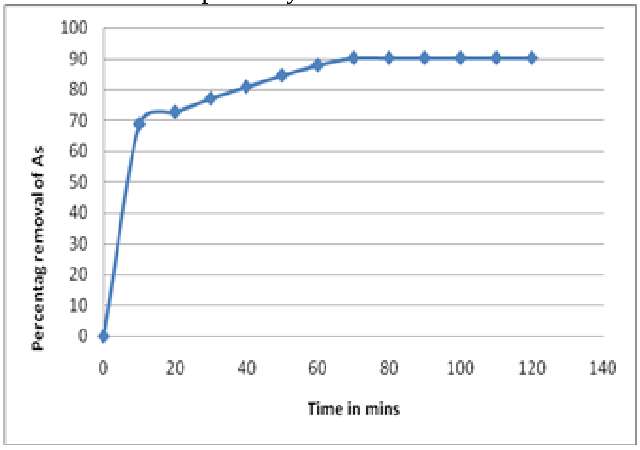

Fig. 4: Effect of Contact time on Laterite soil

B. *Effect of Adsorbent Dosage:*

Adsorption is a process in which continuous transfer of solute from solution to adsorbent occur, until residual concentration of solution maintains an equilibrium with that adsorbed by the surface of adsorbent at constant contact time. Effect of adsorbent dosage is studied and graph of percentage of arsenic versus dosage is plotted as shown in fig.5. It is observed from the graph that as dosage increases amount of As increases, sharply in the beginning and attains maximum latter. The point where maximum is attained is taken as optimum dosage. After attending optimum dosage, change in laterite soil dosage alter much in the beginning and remain constant after attending optimum dosage. Hence, the removal efficiency on As by using laterite soil was found to 89.40 % with an Optimum dosage of 1400 mg respectively.

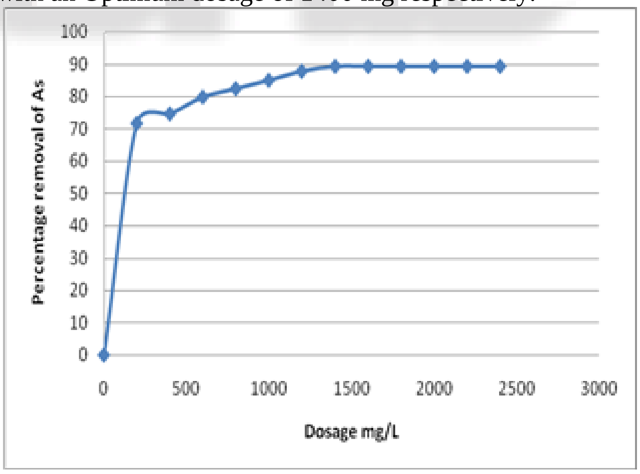

Fig. 5: Effect of Adsorbant dosage on Laterite soil

C. *Effect of pH:*

The impact of As removal mainly depends upon the pH of the medium. The graph of pH against As removal is plotted by not altering the optimum contact time and optimum dosage as shown in the fig 6. The amount of As not only depends on optimum time and optimum dosage but also depends on pH..From the graph it is evident that the As is removed more effectively in acidic range. As pH increases the removal efficiency of As increases appreciably. Hence, the removal efficiency on As by using laterite soil was found to be 84.8% around pH 6.25 respectively.

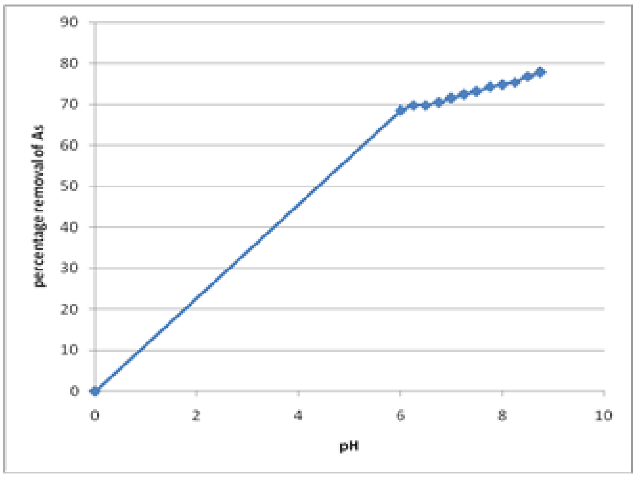

Fig. 6: Effect of pH on Laterite soil

V. CONCLUSIONS

Based on the experimental study following conclusions can be drawn

1) The statistical analysis by using laterite soil shows good removal efficiency of Arsenic from synthetic solution.
2) The adsorption of Arsenic is mainly pH dependent. The removal efficiency of adsorbent increases with decrease in pH value. It has been observed that maximum adsorption takes place in the acidic medium around pH 6.25.
3) The result of experiment on optimization of dosage of adsorbent reveals that, increase in amount of dosage added, increases the removal of Arsenic from the solution and almost becomes constant after saturation dose.

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