Comparison study on lead and arsenic removal using groundnut shell and tamarind seed by adsorption and nano-sorption

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Abstract

Toxic heavy metal contamination of industrial wastewater is an important environmental problem. Many industries such as electroplating, pigments, metallurgical processes, and mining and leather industries release various concentrations of heavy metals. Metal ions such as cadmium, nickel, chromium, copper, lead, zinc, manganese and iron are commonly detected in both natural and industrial effluents. An experimental investigation was carried out for the treatment of synthetic solution containing Lead an Arsenic using low cost adsorbents suchas ground nut shells and tamarind seed. This work focuses on the utilisation of activated carbon prepared from groundnut shell and tamarind shell for the removal of lead and arsenic from synthetic solution prepared. A laboratory scale setup was used to remove lead and arsenic from synthetic solution using Cu coated nanoparticle on activated carbon. The effects of temperature, contact time of lead and arsenic on the adsorption process have been investigated separately with respect to activated carbon and Cu nanoparticle coated on activated carbon. SEM and EDX analysis confirmed Cu nanoparticle successfully coated/decorated on activated carbon of size ~0.3-0.5 mm. AAS instrument was used To check the removal efficiencies of activated carbon and nanoparticle from synthetic solution and showed reasonably good potential for reducing heavy metals from synthetic solution.

Keywords: *Lead, Arsenic, Groundnut shell, Tamarind seed, activated carbon, nano particle, Adsorption, Nano-sorption.*

I. INTRODUCTION

Nowadays various toxins are released into water leading to a great deal of water pollution. Many heavy metals from various industries like battery plants, metal processing industries, pharmaceuticals, hospitals, mining fields etc. are being released into the water bodies leading to unsafe water for normal consumption. The most common heavy metals found are copper(Cu), lead(Pb), arsenic (As), chromium (Cr), oils and grease, pesticides , etc., which when present in very small amounts like ppb (parts per billion range)may be very fatal to the health and the surrounding environment as well.

In order to obtain clean and safe water it is required that these toxic chemicals and metals should be removed. The methods that is employed in this experimental study is purely by keeping in mind environmental sustainability using house hold wastes such as groundnut shell and tamarind seed, which are cheap, easily available and very effective adsorbents as indicated in few literature regarding removal of heavy metals. Groundnut shell and tamarind seeds have adsorbent properties and may be a successful method in purification of water due to the compounds in the groundnut shell and tamarind seed that contain cellulose, hemi cellulose, lignin and carbohydrates, protein, crude fibre, calcium, phosphorous, magnesium and potassium respectively. These elements are charged such that their negatively charged electron pairs are exposed, meaning they can bind with metals in the water that usually have a positive charge.

Nanotechnology is engineering at the molecular (groups of atoms) level. It is the collective term for a range of technologies, techniques and processes that involve the manipulation of matter at the smallest scale (from 1 to 100 nm^2). Nano coating is the one main part. It is nothing but paint or coating the nano particles to the destination material.

Adsorption is an effective process for removal of heavy metals. Agricultural by-product waste tamarind seeds and groundnut shell were tested for the removal of heavy metal ions. All the adsorbents were collected, washed with distilled water, dried, powdered, sieved and converted into activated carbon. They were characterised by SEM images. Batch studies confirm that both materials used as low cost adsorbent can be used as a substitute for high cost adsorbents.

The study on ground nut shell as adsorbent has been successfully approved it to act as a potential low cost adsorbent for removal of heavy metals from synthetic solution. About 85% removal is obtained for lead whereas the % of removal is 67% for arsenic.Tamarind shell act as a good adsorbent for heavy metal removal. The maximum adsorption percentage is 67% for lead and 38% for arsenic respectively.
The adsorption of metal ions increased with the increase of initial concentration of stock solution, contact time and adsorbent dosage. The results of the experimental study show that natural adsorbents has a suitable adsorption capacity for the removal of heavy metals from synthetic solution.
In cities with a sewage collection system, it is possible to dispose the industrial waste water to the networks, however, if a city has no sewage collection system, complete industrial waste-water must be treated. Conventional waste-water treatment plants are not able to meet the effluent quality standards for the industrial waste-water effluent. Although the adsorption and nano-sorption process has been used for the treatment of many waste-water, so far this method has not been used for the treatment of synthetic waste-water. Furthermore, the effect of interfering compounds present in the real waste-water has been intensively studied using the adsorption and nano-sorption methods. Therefore, the objectives this study was to

1. To check the feasibility of use of groundnut shell and tamarind seeds as adsorbents in activated state for purification of water containing Lead and Arsenic using synthetic solution.

2. To check the efficiency of use of groundnut shell and tamarind seed as adsorbents in activated state with Copper coated Nano particles in removal Lead and Arsenic.

3. To compare the efficiencies of the adsorbents in the removal of Lead and Arsenic before and after nano particle coating.

II. MATERIALS AND METHODS

Raw materials

The groundnut shell and tamarind seed were collected from the agricultural field. Prior to use the materials were washed with water to remove mud and other impurities present on the surface and dried in sunlight until complete evaporation of moisture.

Activated carbon

The dried groundnut shell and tamarind seed were physical activated at 200°Cfor 5 min and 700°Cfor 15 min in Crucible furnace respectively. Later the raw materials were cooled to room temperature, crushed and sieved with 2 mm sieve size.

Preparation of synthetic solution

Lead

Synthetic Lead sample was prepared by dissolving Lead Nitrate of 0.4 g in 100ml of distilled water and made up to 250 mL of 1000ppm with distilled water in a standard flask.

Arsenic

Similarly synthetic Arsenic sample was prepared by dissolving Arsenic trioxide of 0.6 g with 2N of dilute sulphuric acid in 100ml of distilled water and made up to 250 mL of 1000ppm with distilled water in a standard flask.

Copper coated activated carbon

Copper nanoparticles were coated on activated carbon by the method of top down approach. The top-down approach is a process of miniaturising or breaking down bulk materials (macro-crystalline) structures while retaining the original integrity. The Copper coated activated carbon was prepared by taking 10 g of AC in Mortars (round bottom flask) with 10 mL of Acetone (pH ~7) and was kept in a rotary hand movement using pestles. Further, almost 90% of the moisture was removed by slowly applying the vacuum. The slurry was taken out in a beaker and kept in a drying at room temperature to dry it completely.
All the test was conducted in a laboratory scale at room temperature using pH, SEM and AAS instrument. Data regarding the pH of the synthetic solution prepared and the test samples are summarised in the table below.

Table 1: pH of respective sample

Particulars	Lead Sample			Arsenic Sample		
	Synthetic solution	After addition of AC-G	After addition of AC-T	Synthetic solution	After addition of AC-G	After addition of AC-T
pH	4.8	7.8	7.6	4.5	7.3	6.8

III. RESULTS AND DISCUSSION

Characterisation of the adsorbent
Groundnut shell

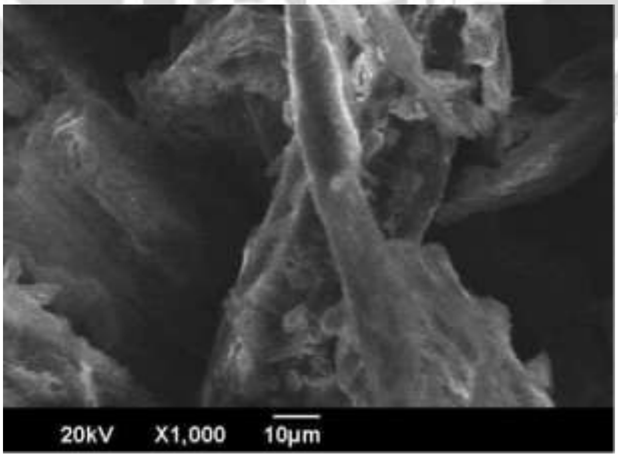

Fig. 3.1 SEM image of ground nut shell activated carbon

Scanning Electron Micrograph show the SEM image of groundnut shell activated carbon. From Fig. 4.1 it can be seen that the groundnut shell surface consists of strands of fibres which are randomly arranged. Such arrangement could enhance the accessibility of the surface to the metal ions easily. Apart from these fibres, the surface is also very rough and uneven in nature, with pores and cavities and provides a large surface area for the adsorption of metals.

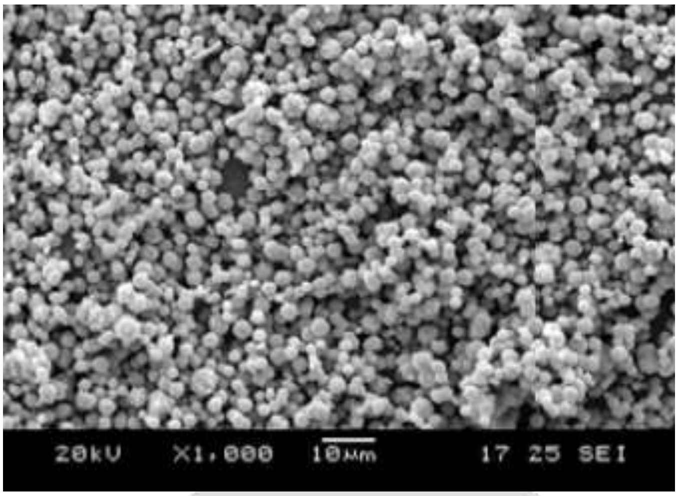

Fig.3.2 SEM image of Copper nano-particles

The SEM image (Fig.4.2) at 10000X magnification shows surface morphology with particle attached forming agglomerates because of high temperature exposure during combustion. The product so formed is porous and composed of large void spaces as interpreted from the SEM image.

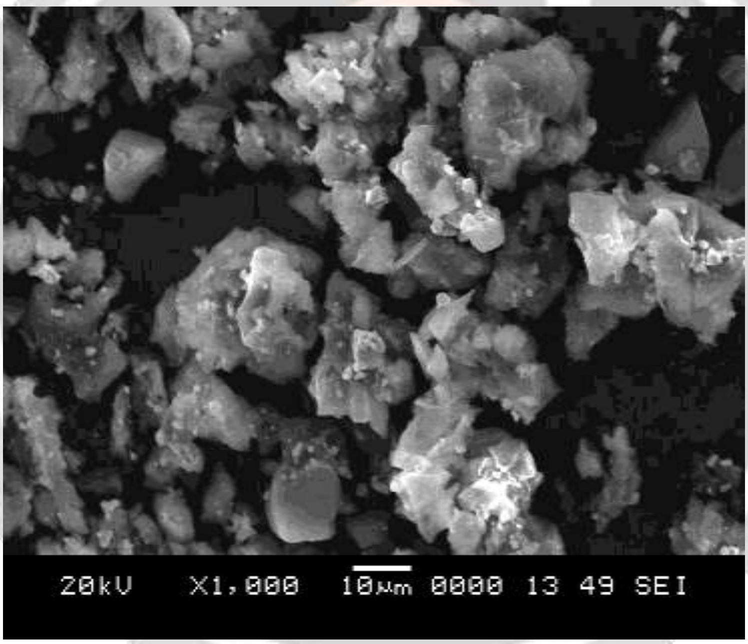

Fig.3.3 SEM image of Copper coated activated carbon

The surface of the activated carbon substrates is shown in Fig. 4.1.To confirm the coating of Cu nano-particles on the activated carbon, morphological analysis is carried out on these coated substrates using SEM. The SEM images clearly indicated that the surface structure of copper coated activated carbons is greatly changed from the activated carbon samples. Surface morphology of activated carbon showed a porous surface structure, whereas copper coated activated carbons possessed newly born copper particles on its surface. The presence of small sized copper particles may ultimately enhance the specific surface area of the solid samples which may increase the adsorption capacity of the material.

EDX Analysis in SEM

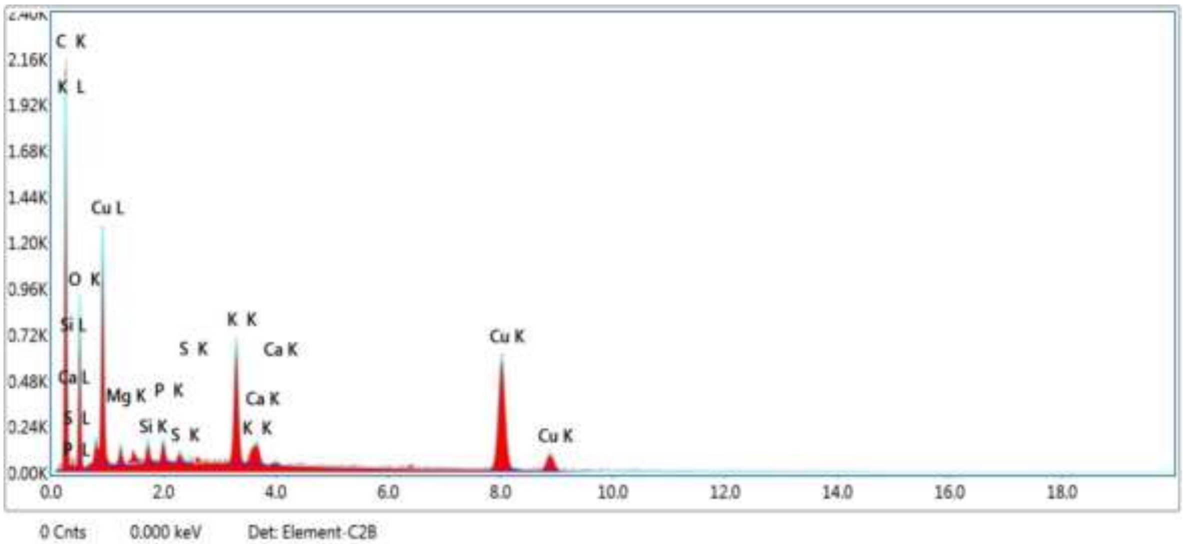

Fig. 3.4 Energy dispersive X-ray spectroscopy analytical results for copper coated activated carbon.

The EDX data, shown in Fig. 4.4 indicates the composition of the sample CCAC-G which contains a reasonable weight percent of copper, i.e., 21.6%. This result indicate that the copper particles were significantly immobilised on the surface of AC-G moreover the copper particles were almost uniformly distributed onto the surface of the AC as also shown in the SEM images.

Tamarind Seed

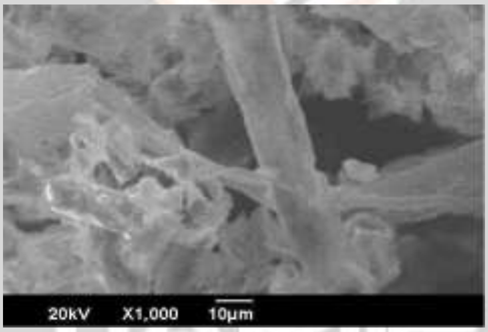

Fig. 3.5 SEM image of tamarind seed activated carbon

SEM images of tamarind seed based activated carbon with an activation temperature of 700^{o}C is shown in fig 4.9. It can be seen from the micrographs that the external surface of the activated carbon particles has cracks, crevices and some crystals of various sizes in large holes. The crystals in the macro pores are most likely the potassium compounds as it is hinted by the results of EDS.

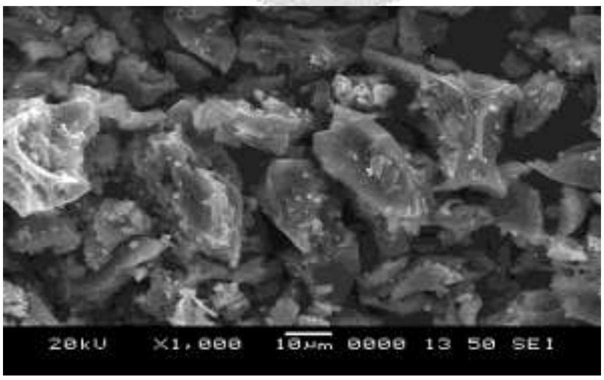

Fig.3.6 SEM image of Copper coated activated carbon

The surface of the activated carbon substrates is shown in Fig. 3.5.To confirm the coating of Cu nano-particles on the Activated carbon morphological analysis is carried out on these coated substrates using SEM.

AAS (Atomic Adsorption Spectroscopy)

Table 3.1- Efficiency of tamarind seed in lead removal

Contact time in hrs	Concentration in ppm	Remaining concentration after Adsorption in ppm	Removal in %	Remaining concentration after Nano-sorption in ppm	Removal in %
6	959.51	24.84	97.52	28.27	97.17
24		51.99	94.80	35.57	96.44
48		64.79	93.52	79.30	92.07

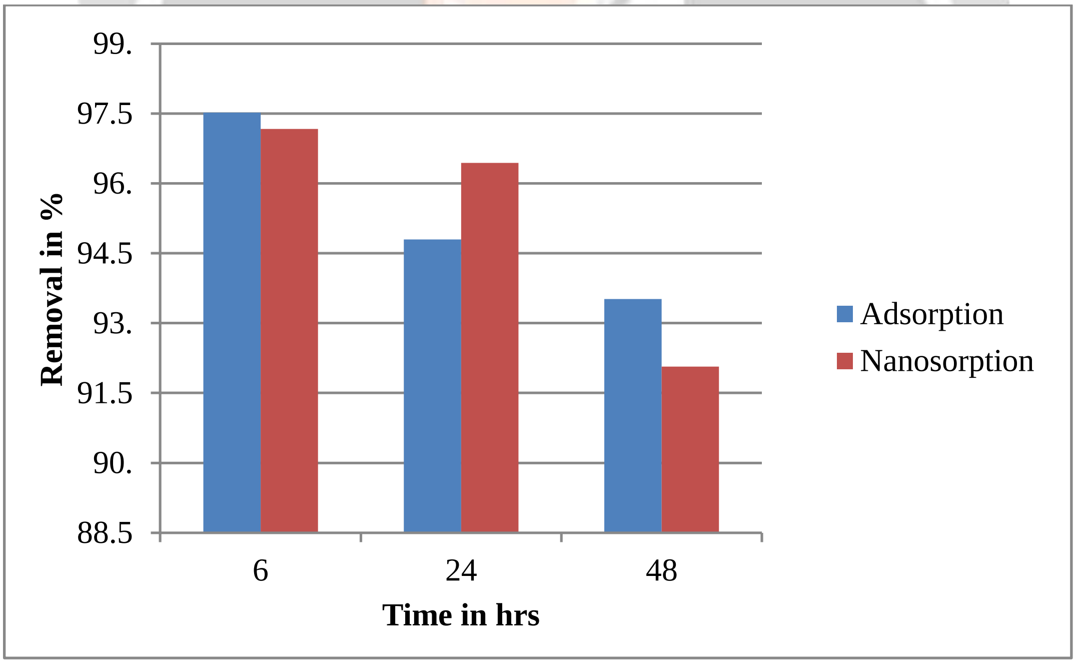

Fig.3.7 Efficiency of tamarind seed in lead removal

The above results (Figure 3.7) showed the effect of contact time on the treatment of lead ions from synthetic solutions. It was observed that the percentage removal of lead metal ions decreased with increasing contact time. The percentage removal is 97.52% for adsorption and 97.14% for nano-sorption at 6 hrs. It is clear that at the beginning, percentage removal decreased in few hours, by increasing the contact time; the percentage removal increased slowly till it reached the maximum value. These results indicate that tamarind seed has a good capacity for adsorption and nano-sorption of lead ions in solutions.

Table 4.8- Efficiency of tamarind seed in arsenic removal

Contact time in hrs	Concentration in ppm	Remaining concentration after Adsorption in ppm	Removal in %	Remaining concentration after Nanosoprtion in ppm	Removal in %
6	1142	115.29	89.91	129.03	88.70
24		140.76	87.67	141.34	87.62
48		36.93	96.77	31.38	97.25

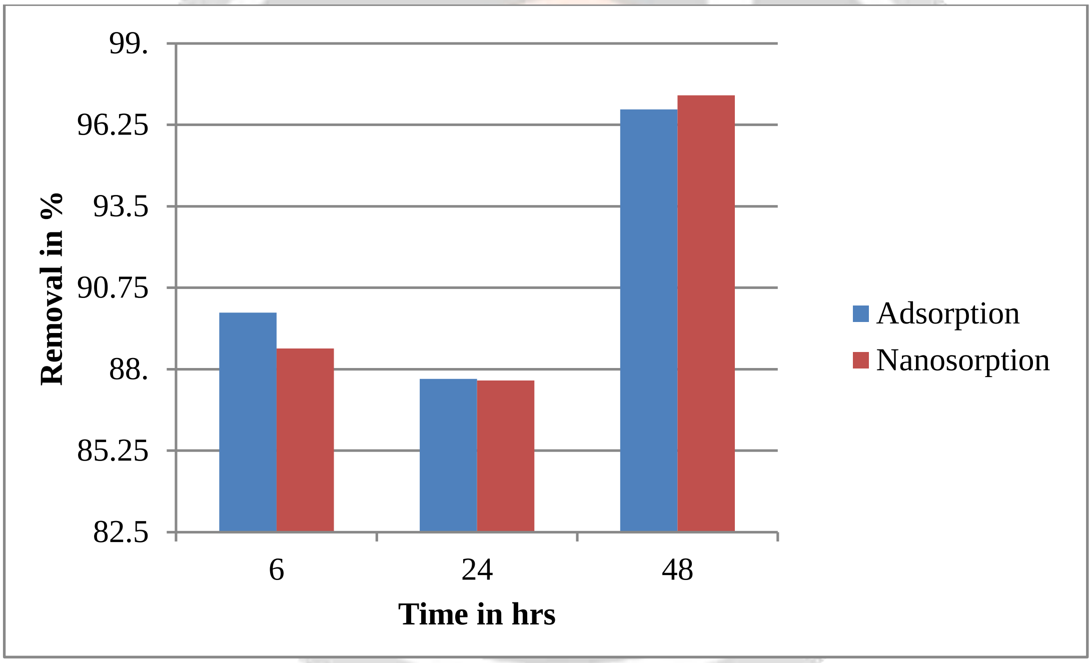

Fig.3.8 Efficiency of tamarind seed in arsenic removal

The above results (Figure 4.16) showed the effect of contact time on the treatment of arsenic ions from synthetic solutions. It was observed that the percentage removal of lead metal ions increased with increasing contact time. The percentage removal is 96.77% for adsorption and 97.25% for nano-sorption at 48 hrs. It is clear that at the beginning, percentage removal increased in few hours, by increasing the contact time; the percentage removal increased slowly till it reached the maximum value. These results indicate that tamarind seed has a good capacity for adsorption and nano-sorption of arsenic ions in solutions.

CONCLUSION

Groundnut shell showed with increase in contact time percentage of removal of heavy metals also increases. By adsorption method % of removal of lead and arsenic is 95.82% and 96.38% respectively. Similarly by nano-sorption method, percentage of removal of lead and arsenic is 96.24% and 96.27% respectively. By above experimental analysis it can be determined that there is no much difference in adsorption and nano-sorption methods in heavy metal removal.

Tamarind shell shows maximum efficiency in short interval of contact time for removal of lead. Whereas for removal of arsenic efficiency increases with increase in contact time. By adsorption method percentage of removal of lead is 97.52% for 6 hrs and for arsenic is 96.77% for 48 hrs. Similarly by nano-sorption method % of removal of lead is 97.17% for 6 hrs and for arsenic is 97.25% for 48 hrs.

The presents work employs the study of using two different waste materials as low cost adsorbent for removal of heavy metals. Adsorbents prepared from domestic and agricultural waste, can successfully be used to remove heavy metals from synthetic solution. Copper coated activated carbon exceeds the efficiency by 1-2% over activated carbon. Due to economical consideration nano-particle are expensive, hence adsorption method can be economical since there is no much difference in removal efficiency. The present study concludes that they could be employed as low-cost adsorbents, activated carbon as alternatives to other costly adsorbents for the removal of heavy metals from wastewater over a wide range of concentrations. The adsorbents are inexpensive and readily available, thus this study provide a cost effective means for removing metal ions from contaminated water or effluents.

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