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Examination Of Powdered Coconut Shell Carbon as An Eco-Friendly Water Treatment Technique to Eliminate Heavy Metals from Underground

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Abstract:

The study focusedto improve the removal of heavy metals from groundwater through bio-absorbent made from powdered coconut shell carbon.Coconut shells were processed using the green synthesis method to create inexpensive absorbent carbon. The study looks at how well synthetic bio-absorbent works to remove heavy metals from groundwater, such as copper (Cu), iron (Fe), zinc (Zn), and chromium (Cr). It has been established that recognising functional groups like Hydroxyl (OH), C-H of alkenes, C=C of alkenes, and C-O from carboxylic acids is crucial for extracting metals from groundwater through FT-IR spectroscopy.The images of the coconut shell showed the existence of sporadic, tiny flakes grouped together to form a sheet.The main goal of the study was to identify the main contaminants in the groundwater because of steadily declining quality of the groundwater in Vijayawada due to industrial growth, urbanisation and large-scale infrastructural projects.Water samples were exposed to bio-absorption utilizing powdered carbon from coconut shells.We utilized Atomic Absorption Spectroscopy to examine the decrease in concentrations of heavy metals.The results showed that the bio-absorption of heavy metals was more pronounced by coconut shells powdered carbon. The maximum percentages of adsorption for iron, zinc, and copper were 99.5%, 99.5%, and 98.4%, respectively.

Keywords: Carbon from coconut shells, Heavy metals, Optimization.

Introduction

The most vital element in all of existence is water. Water contaminated by heavy metals is a serious problem and growing worldwide resource concern.Fu and Wang (2011) highlighted the ongoing global increase in heavy metal pollution of ecosystems, especially in developing countries.Therefore, the development of a highly effective and cost-effective water filtration method that can eliminate even traces of metals is essential.Water bodies that were contaminated by heavy metals had negative consequences on both aquatic and terrestrial ecosystems, as well as human health.Millions of people in India depend on groundwater for their drinking water, whether they live in the country or in cities. All of India's states have worrying levels of groundwater pollution with trace substances, according to research findings.A healthy drinking water supply is a prerequisite for living a sustainable existence.

Because heavy metals cluster in food chains and contaminate aquatic bodies, their inherent toxicity poses a threat. Heavy metals have gained notoriety in recent years due to their ability to accumulate in living creatures' tissues. According to Aminet al. (2006), the pigment, electroplating, plastic, and metal finishing industries are the primary contributors of heavy metals found in water, which can harm kidney function by causing hypertension, bone loss, renal illness, and apoptosis in red blood cells.Many expensive procedures, such as ion exchange, chemical precipitation, membrane separation, adsorption etc, can be used to remove heavy metals from aqueous solutions.Some of these techniques have limitations, including low heavy metal concentrations, ineffectiveness, and high costs.Therefore, it is crucial to explore for alternative viable solutions.The natural alternatives have been the subject of research lately.

Study Area

Situated on the banks of the Krishna River in the NTR district of Andhra Pradesh, Vijayawada is a commercial city in a booming capital region surrounded by lush, green agricultural countryside. The three main irrigation canals that the Krishna River passes through on the south side of the city are the Bandar, Eluru, and Ryves canals. The main supplies of drinking water, industrial water, irrigation, and groundwater replenishment come from these three canal networks of the Krishna River.According to claims of contamination, these three waterways travel through areas that receive significant amounts of wastewater from the agricultural and industrial sectors. There are significant levels of pollutants and total dissolved solids in the groundwater in the southern parts of Vijayawada's central groundwater board. Kanuru in Vijayawada, the current experimental area, is a growing domestication region from agricultural areas. According to literature assessments, there have been instances of agricultural and industrial sources contaminating the groundwater in Kanuru panchayath. To make plans on how to get safe drinking water, it is essential to know how much of it is safe to consume. To determine whether groundwater bodies were contaminated with heavy metals, water samples were first taken from 16 bore wells and analysed.

Heavy metals that beyond the ISI limits, such as copper, cadmium, iron, lead, chromium, and zinc, have been found in laboratory analysis reports.Heavy metal levels in result reports were found to be greater than BIS limits.Water containing trace elements needs to be treated because they can be dangerous. There aren't many researches that discuss how carbon absorbents and naturally occurring plant sources can remove some heavy metals from water.

Objectives of the study

- To identify low-cost, locally available, simple economical and eco-friendly sustainable house hold material to remove metals from water.
- To identify the heavy metals removal efficiency of coconut shell carbon powder.

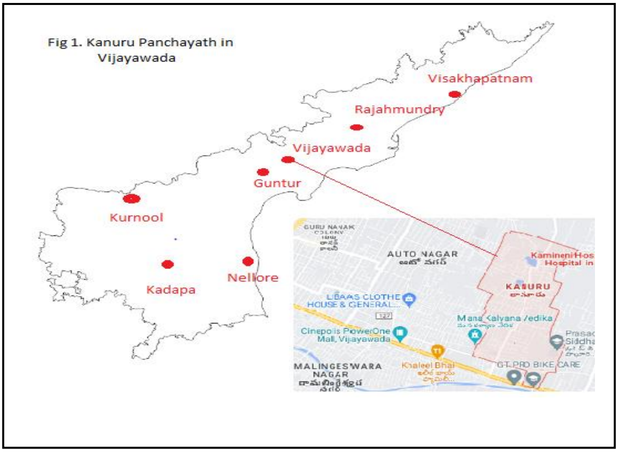
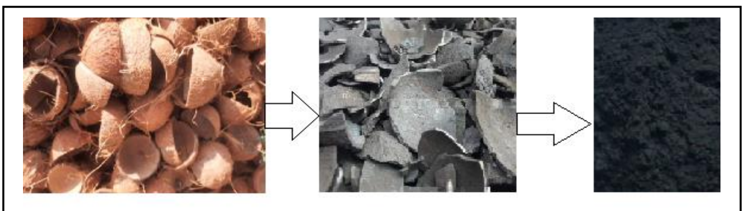


Fig 1. Kanuru Panchayath in Vijayawada

Materials and Methods

Preparation of carbon powder from Coconut shells

After cleaning and washing the coconuts to get rid of the husk, they were left to dry for a week in the sun. To make carbon coconut shell charcoal, the shells were ground into 2 mm to 3 mm granules and carbonised for 3 hours at 450 ^{0}C. After being ground, the charcoal samples were run through a 600-micrometer stainless steel sieve. 4N nitric acid was used to wash the charcoal that had been finely ground. It was heated to 450C for almost three hours. It was then repeatedly cleaned with distilled water to remove the acid and any other impurities. The sample was dried for six hours at 120°C in an air oven. For use in experiments, the dried material was kept in an airtight container.



Water Samples

Samples of groundwater were taken from bore wells in KanuruPanchayath and analysed to determine the presence of heavy metals. The amounts of copper, iron, zinc and chromium in the water samples ranged from 0.5 mg/L to 8 mg/L. Table 1 is a list of the observed values. The FASSAI (Manual_Water_Analysis, 2017), the Bureau of Indian Standards, and the Government of India's 1999 water quality handbook were followed in the execution of each sampling analysis.

Table 1. Heavy metals concentrations in Groundwater samples.

Parameter	IS10500Max Limit mg/L	Observed values mg/L
Copper	0.15	0.23
Iron	0.8	2.4
Zinc	5.0	8.2
Chromium	0.5	0.83

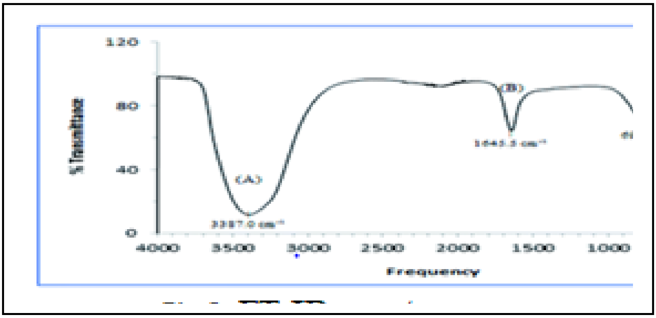
Analytical Techniques

FT-IR spectra of the synthesised samples are measured in the middle infrared region 4000-400 cm-1 at room temperature using a Fourier transform infra-red spectrophotometer (SHIMADZU-IR, affinity-1S FT-IR spectrophotometer). Analysis techniques are used to determine the presence of various chemical functional groups and vibration modes. At a 15 KV accelerating voltage, surface morphology was carefully studied using scanning electron microscopy.

Results and Discussion

FT-IR Spectra

The broad bands in the FTIR spectra displayed in Figure 3 are attributed to the surface hydroxyl group and are located between 3296 and 3387 cm-1. The C=O from esters is at 1743 cm-1, the C=C aromatics is at 1648 cm-1, the C-H group of alkenes is responsible for the bands at 2925 and 2851 cm-1, and the C-O from carboxylic acids is at 1457 to 1045 cm-1. Figure 3 illustrates the shift and intensity decrease of the aforementioned peaks. The surface features of carbon have a significant impact on the metal adsorption capacity.



Surface Morphology

The surface morphology of prepared coconut shell images show non-uniform small-sized size, closely packed flakes forming a sheet with agglomeration.

Figure 4. Morphological images of carbon powder

Experiment studies

The usual procedure was followed; 500ml of ground water is mixed with 1 gram of carbon powder and stirred well, which called for quick agitation for ten minutes at a rate of 120 revolutions per minute. The mixture was then allowed to settle for 60 minutes after 20 minutes of mild agitation at a speed of 20 rotations per minute. After an hour the solutions were filtered through Whatman 42 filter paper. An atomic absorption spectrophotometer was then used to ascertain the concentration of heavy metals, as shown in Table 2. The removal percentages of Cu, Fe, Zn and Cr were 90%, 98%, 99%, and 94% respectively.

Table 2. Heavy metals removal by coconut shells carbon powder.

Parameter	**Coconut shells carbon powder**
Copper	90.52±0.031
Iron	98.24±0.216
Zinc	98.35±0.219
Chromium	94.66±0.108

The greater porous nature of carbon powder could be the cause of absorption. Since the chosen absorbent material removed heavy metals effectively, companies can adopt and use them extensively to cut costs and increase the financial benefits of commercial uses for a sustainable environment.

Statistical Analysis for Adsorption Studies

To investigate the adsorption of metals, a quadratic model in the form of the expression below was created.

Assume x and y are the two functions. By calculating the least-squares fit of the data by minimising the sum of the squares of the data's deviations from the model, the unknown coefficients a, b, and c was found.

Application of the Quadratic Regression Equation

y = ax2 + bx + c

Where coefficients can be computed using the following formula:

S(x^2 y)×S(xx) = a-[(S(xy)×S(xx^2)])/ 〖[(S(xx) × S(x^2 x^2)] - [S(xx^2)]^2 b = ([S(xy)×S(x^2 x^2)]S(x^2 y)×S(xx^2)])/ 〖[S(xx)×S(x^2 x^2)]-[S(xx^2)]^2 c =[((Syi))/n]}-{b ×[((Sxi))/n]}S(xi^2)/n = -a×

Table 3. Regression equations

Parameters	Regression Equations
Iron	$Y = 4.93E^{-06}(x^2) - 0.01172\ (x) + 8.478905$
Zinc	$Y = 1.53E^{-06}(x^2) - 0.00413\ (x) + 2.647512$
Copper	$Y = -3.09E^{-07}(x^2) + 7.92E^{-04}(x) - 0.51016$

Table 4. Software Predicted optimum factors

Parameter	Initial % mg/L	pH	Dosage (g)	Time (min)	Final % mg/L

Iron	0.15	8.0	1	8.5	98
Zinc	0.19	7.0	1	11.4	99
Copper	2.48	7.0	1	10.0	90

The ideal conditions that the software (MATLAB) predicted lead to the maximum adsorption of the three metals are shown in Table 4. The most crucial factor in the removal of ions observed was pH. Due to decreased hydrogen ions (H+), Iron ion removal was encouraged at higher pH level, while Copper and Zinc removal was preferred at loweer pH levels.

The adsorption efficiency increased initially and then decreased with time due to the availability of active sites during the early stages. After a while, the decrease in adsorption stages is also aided by the increase in boundary layer thickness. Long retention periods and a high rate of Zinc adsorption were observed.

The adsorption efficiencies of all metals improve with the adsorbent dose because of the increased active sites.

The experimental results were further validated by modifying r2 by comparing them with the expected outcomes.

Table 5. Validated results

Solution No.	**% removal of iron**		**% removal of zinc**		**% removal of copper**	
	Actual	**Predicted**	**Actual**	**Predicted**	**Actual**	**Predicted**
1	97.5	98.4	99.9	100	91.1	91.9
2	97.8	98.3	98.2	99.0	90.2	90.9
3	98.2	98.5	96.2	99.7	92.2	89.5
r^2	0.96		0.93		0.97	

Conclusion

In this work, low-cost absorbent carbon from coconut shells are made using the green synthesis approach. Using bio-absorbent, the removal efficiency of heavy metals such as copper, iron, zinc, and chromium from ground water was observed. Because they include cellulose, hemicellulose, and lignin, coconut shells are all regarded as lignocellulose adsorbents. The current experimental study demonstrated a considerable ability to remove heavy metals from water and concentrated on the possible usage of natural materials. If affordable adsorbents can efficiently and affordably remove heavy metals, there is much room for their application in industries looking to save costs, improve productivity, and raise profitability. Low-cost adsorbents have unquestionably numerous potential commercial advantages, as the current analysis illustrates. Iron, Zinc, and Copper optimisation study estimated the maximum adsorption with a pH factor that generally coincides with the behaviour of cations adsorbed on surfaces. Only a few metals with significant concentrations in particular samples are employed as a trial study, and the investigation's activation circumstances are strictly limited. Further investigation is needed into ways to improve active conditions as well as other common water contaminants. The present study, however, is in favour of using carbon particles as a naturally occurring absorbent to remove heavy metals from ground water.Carbon powder was direct, reasonably priced, and eco-friendly bio absorbent. The current statistical analysis will help manage and monitor water quality with less money and effort. This statistical analysis can also be used to study other parameters.

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