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Removal of Heavy Metals from Water by Adsorbent Method

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Abstract: This study investigates the removal of heavy metals from water using adsorbents, focusing on the effectiveness of various materials, their mechanisms of action, and factors influencing adsorption efficiency, aiming to develop sustainable and cost-effective water treatment solutions.

Heavy metal contamination poses a significant threat to water resources and human health, necessitating effective removal strategies. This study explores the application of adsorption techniques for the removal of heavy metals from water, focusing on the characteristics and performance of different adsorbents. The research investigates the adsorption capacity, influencing factors like pH, temperature, and contact time, and the mechanisms of heavy metal removal by various adsorbents, including activated carbon, bio-adsorbents, and modified materials. The findings aim to provide insights into the development of sustainable and cost-effective water treatment technologies, emphasizing the importance of adsorbent selection and optimization for efficient heavy metal removal.

Sustainability of good health depends upon the purity of water. However groundwater may be exposed towards to contamination by various anthropogenic activities such as agricultural, domestic and industrial. Groundwater quality problem are typically associated with high level of iron concentration in and Futala lake Nagpur. The normal drinking water contains permissible limit of iron concentration 0.3mg/l but the Groundwater contains 17mg/L and Futala Lake contains 1.16mg/L of iron concentration. In the present study Sugarcane Bagasse (SCB) and Coconut coir (COC) from agricultural waste have been selected as solid phase extractor for removal total iron. Sugarcane Bagasse, Coconut coir exhibits remarkable binding characteristics for removal total iron, so special interest was devoted for optimizing its uptake and studying its selectivity properties under static and dynamic conditions. The parameters such as effect of pH, adsorbent dosage, contact time, initial concentration, etc., were studied. Maximum removal of total iron was observed in the pH range of 4-5. The highest percentage removal of total iron was observed at Coconut coir (96%) compared than Sugarcane Bagasse (93%).

***Key Words*:** Adsorbent, Coconut Coir, Activated Charcoal, Heavy Metal, and Carbonization.

1. INTRODUCTION

Purified water is essential for living a healthy life as such everyone should have access to it only source, thus water contaminations are difficult to avoid due to rigorous and reckless use of surface water. Unsafe drinking water may result in fatal diseases. Statistics shows that the diseases resulted in ninety percent of all deaths of children under five years old in developing countries, due to low immunization of children to infections.

Despite of fulfillment of requirement of drinking water standards, the municipal water in used in developing countries is being improved and cost efficient water filtration techniques are being developed commonly used to improve taste or to eliminate any undesired matters. Various types of filters have been designed to be more suitable for the rural areas of the countries, but the cost as well as the filter effectiveness is still not satisfactory and further improvement is still required.

Drinking water is being the biggest issue nowadays in India. Most of the people in the rural areas are not able enough to use water filters or buy mineral water bottles. To overcome this problem many efforts have been done due to which cleaning water may become an affordable commodity. Some of the typically used water filtration methods in India have been discussed here.

Heavy metals such as arsenic, lead, mercury, cadmium and uranium play no significant role in metabolism in human body and are thus toxic. Their exposure in high concentration can cause acute toxicity resulting acute health conditions which is easy to observe

and regulate while similar is not visible for immediate action. These metals are used in several industries and agricultural activities leading to increased environmental contamination and human exposure.

Heavy metals infuse into the environment through several activities such as industrializations, agricultural, wastewater plant, runoff, mining and much more.

Ultimately the aim of development of any low cost water filtration model should be to operate with minimum energy, minimum maintenance, cost effective, and environment friendly. Implementable with ease and can be developed from local artisans. This will subsequently inspire the people to put hygiene in to habit and of course will help in the social and economic growth of the country.

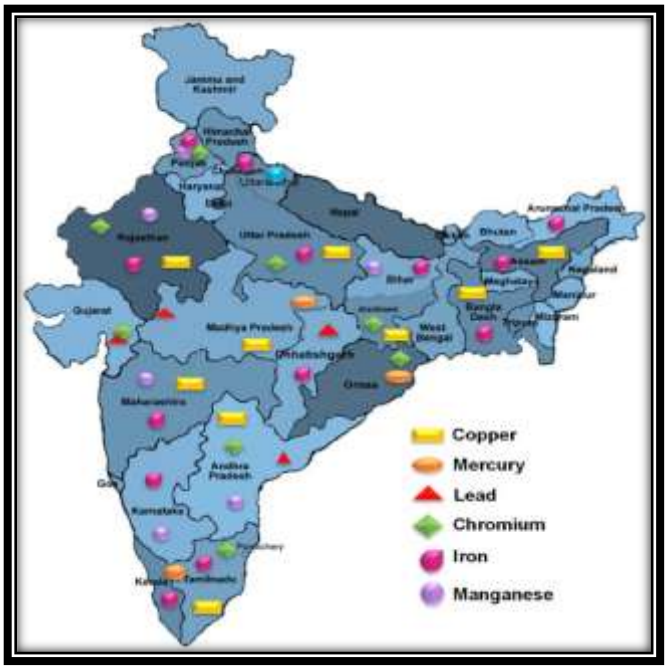

Fig-1: Indian Scenario of Heavy Metals Pollution.

Table-1: List of common heavy metals with their permisible limits & effect on human health.

Heavy Metals	**Toxicity**	**MCL (Mg/L)**
Chromium	Headache, nausea, vomiting, diarrhea, carcinogenic.	0.05
Nickel	Dermatitis, chronic asthma, coughing, human carcinogen.	0.20
Arsenic	Skin manifestation, vascular disease, visceral cancer.	0.050
Lead	Damage fetal brain, kidney disease, damage nervous and circulatory system.	0.006
Cadmium	Kidney damage, human carcinogen, renal disorder.	0.01
Mercury	Rheumatoid arthritis, kidney disease, damage nervous, and circulatory system.	0.00003
Copper	Liver damage, insomnia, Wilson disease.	0.25
Zinc	Depression, neurological signs, increased thirst and lethargy.	0.80

1.1. Objectives

The scope of this project is to study the existing water filtration methods, and use the knowledge to design a Low cost water filtration technique. This water filtration system will focus on cutting down the cost while maintaining filter effectiveness. By providing affordable water filters for the rural and remote areas, will greatly improve people's quality of living, and reduce the risk of any waterborne diseases therefore saving lives.

The basic objectives of the project are as follows.

- Removal of iron from water by using different adsorption media which are locally available at a low cost.
- Designing a simple household setup for water filtration focusing on removal of iron and turbidity.
- Cost estimation of all the adsorption media used as well as the ceramic filter.
- Analysis of filtration effectiveness in removal of iron for different filter media.

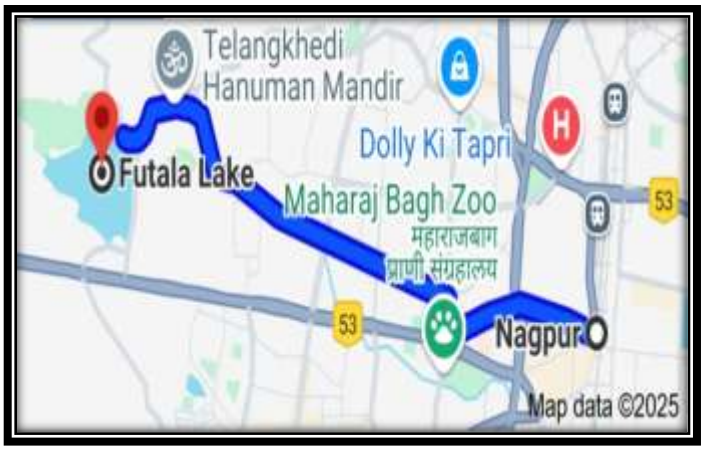

Fig-2: Site Location.

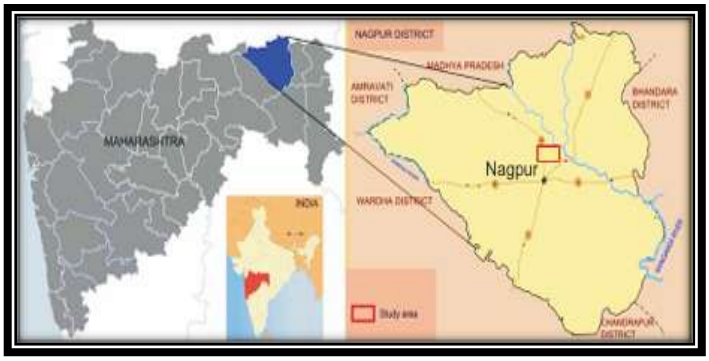

Fig-3: Location map of study area

2. LITERATURE REVIEW

1. "Heavy metals removal from water by efficient adsorbent"

- The work in this paper focusing on removal of heavy metals from water using adsorption with specific implementations of adsorbent approach.
- The remediation methods is used for removal of heavy metals including Carbon based, Natural material, and Bio-adsorbent [1] (copyright reserved Elsevier, 2018).
- In this paper the process of adsorption and desorption in water is used for the overview of adsorption [2] (copyright Heinrich Kayser 1881).

2. "Removal of metals from drinking water by oxidation-coagulation-adsorption at optimized pH"

- The paper highlight the low-cost OCOP method, which effectively removes arsenic, iron, manganese from water.
- To effectively remove metals from drinking water using oxidation, coagulation, and adsorption at an optimized Ph.

3. "Fabrication and characterization of coconut shell activated carbon using variation chemical activation for wastewater treatment application"

- In this paper researchers study on activated carbon which is based on coconut shell has been successfully synthesized and chemical activation which is produce activated carbon.
- There are two activation method can produce activated carbon that is physical activation, and chemical activation [3, 4].
- The purpose of this work is to utilize the coconut shell waste in South Sulawesi province, Indonesia, by fabricating an activated carbon with different activating agent that is sodium hydroxide, alkali earth metal salts, zinc chloride and phosphoric acid.

4. "Assessment of quality of water bidies surrounding bhandewadi landfill site nagpur city"

- The main objective is to evaluate the impact of landfill leachate on groundwater and surface water resources, and to identify potential contamination risks to the surrounding communities.
- In this paper tested sample have higher iron level than WHO recommended guidelines.

5. "Removal of iron from drinking water / ground water by using agricultural waste as natural adsorbents"

- In this paper focusing on maximum removal of total iron was observed in the pH range of 4-5. The highest percentage removal of total iron was observed at Coconut coir (96%) compared than sugarcane bagasse (93%).
- Nowadays efforts have been made to use cheap and available agricultural wastes/Natural products such as sugar cane bagasse, coconut shell, orange peel, rice husk, peanut husk, pecan shells, jackfruit, maize cob, apple waste and sawdust as adsorbents to remove heavy metals from Ground water/waste water [5-10].
- This work was to investigate the feasibility of activated carbon for the maximum removal of total iron from Ground water at optimized parameters such as pH, adsorbent dosage, contact time, initial concentration and temperature.

6. "Hydrogeochemistry of Groundwater in Koradi-Khaparkheda area, Nagpur District, Maharashtra"

- The present study deals with the seasonal variations in hydrogeochemistry of groundwater in Koradi-Khaparkheda area, based on the selected dugwell samples.
- The Koradi-Khaparkheda area is located about 15 km north of the Nagpur city (Fig.1.3). Koradi Khaparkheda is well known for the Thermal Power Station (TPS).
- The concentration of the ions in the studied groundwater samples exceeds the BIS 1991 limits.

3. MATERIALS and PROCESS

3.1 Materials used

a) Aggregate
b) Sand
c) Coconut Coir
d) Coconut Shell

3.1.1 Aggregate

In water filtration systems, coarse aggregate, serves as a supporting layer for finer filter media like sand, and also helps distribute water flow uniformly. It prevents the finer media from being washed away and ensures proper drainage, while also capturing larger particles that may be present in the water.

3.1.2 Sand

The primary purpose of sand in a filter is to trap and remove suspended solids and impurities from water. Sand acts as a filtering medium, allowing clean water to pass through while retaining particles that would otherwise cloud the water. This process is crucial for various applications, including water purification, swimming pool filtration, and industrial processes.

3.1.3 Coconut Coir

Coconut coir, the fibrous outer husk of the coconut, is used in water filters to remove contaminants and improve water quality. It serves as a filter medium, an absorbent, and a substrate for beneficial microbial growth.

3.1.4 Coconut Shell

The coconut shell (CS) used as the raw material to produce activated carbon in this study were obtained from Malaysia. The CS was cleaned with deionized water, dried at 110 °C for 48 hours, ground with a grinder machine and sieved using mechanical sieve shaker to obtain samples of 1.0-2.0 mm particle size.

3.2 Preparation of coconut shell

Coconut coir where first washed thoroughly with normal water to remove dust particles and then washed with distilled water then soaked overnight in 0.1N, NaOH (Sodium hydroxide) solution and again washed well with DDW. Then they were soaked in 0.1N, CH3COOH (Acetic acid) for a period of 2-3 hr. to remove the traces of NaOH. It was thoroughly washed again with DDW till the wash water became colourless and then filtered, well dried powdered and sieved before use.

3.3 Carbonization and activation of coconut shells

The CS was heated up to the carbonization temperature of 400°C at a heating rate of 10°C /min and was held for 1 hour at the carbonization temperature under N2 gas flow. After carbonization the samples were cooled to 200°C under N2 flow to produce char (CH). At 200°C the supply of N2 was stopped and the CO2 gas was introduced to activate the char. Then, the char was heated again to desired temperature (400, 600, 800 °C) at heating rate of 50 °C/min for 1 hour. After activation, the solid samples, i.e. activated carbon (AC) were cooled at ambient temperature. There type of AC produced at the activation temperature of 400, 600 and 800 °C designated as AC-400, AC-600, and AC-800, respectively.

Fig-4: Sand

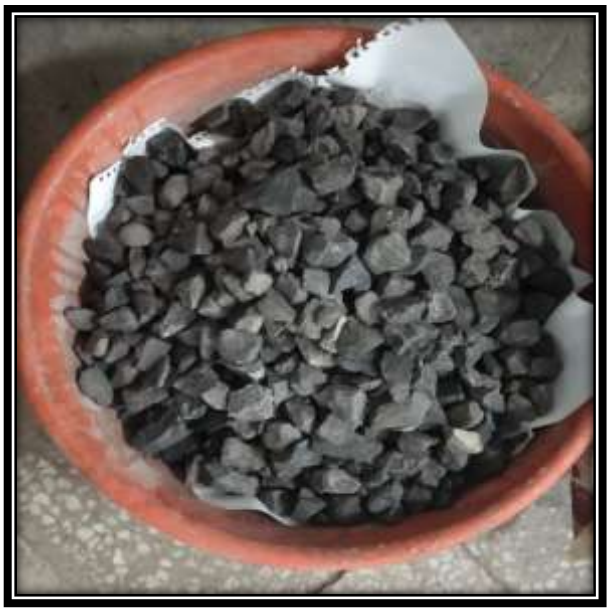

Fig-5: Aggregate

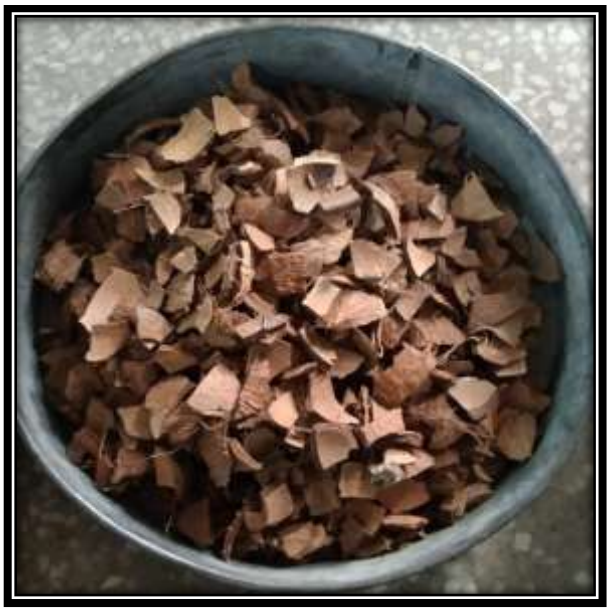

Fig-6: Coconut Shell

Fig-7: Coconut Coir

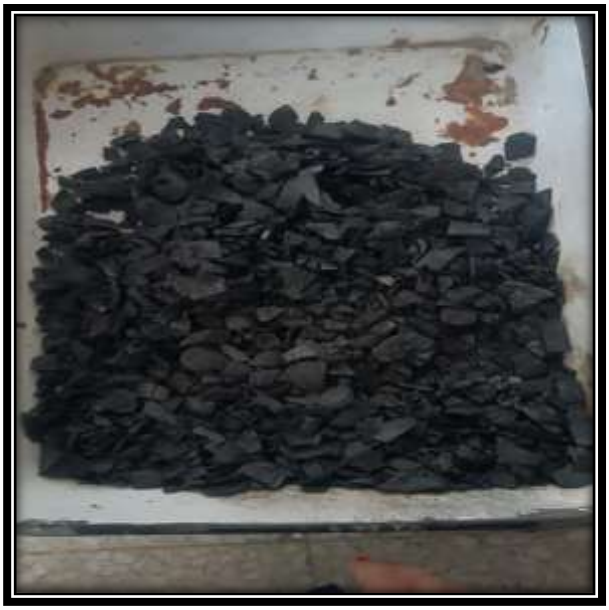

Fig-8: Solid Activated Charcoal

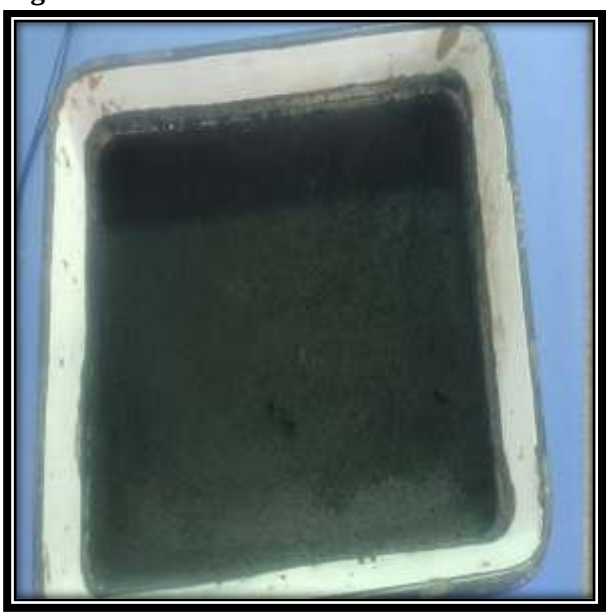

Fig-9: Powder Activated Charcoal

4. WORK DONE

4.1 Adsorption

Adsorption is a water treatment technique where heavy metals are removed by attracting them to the surface of a solid material (adsorbent). The heavy metal ions in the water (adsorbate) are held on the surface of the adsorbent, effectively removing them from the water. This process is often used for cost-effective and environmentally friendly heavy metal remediation.

4.2 Selection of Site and Material :

After studying the literature review we find out the location for water sample. We selected futala lake,Nagpur

as our location for collecting the water sample for testing. We gave the water sample to a private laboratory for testing. After selecting the location we collected waste material from Ganesh Tekadi Mandir, Nagpur.

4.3 Design of filter

Here we have manufacture a simple column filtration tube as shown in fig no.10 with the following dimension.

Length = 100cm

Internal dimension = 28cm X 28cm

Outer dimension = 30cm X 30cm

Layer	Material	Thk
Layer 1	Aggregate	10 cm
Layer 2	Sand	6cm
Layer 3	Activated Charcoal	2cm
Layer 4	Cocnut coir	2cm
Layer 5	Sand	3cm

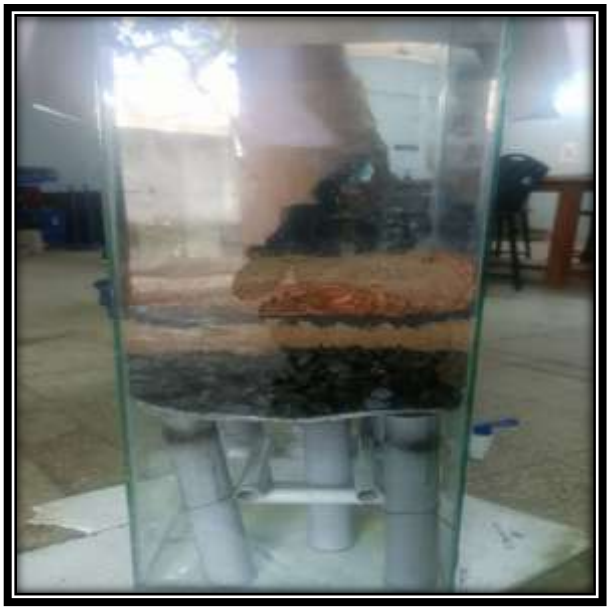

Fig-10: Filter

In the proposed design of the model, the water of known iron concentration was passed through the inlet above. Inside the column, different adsorption media of specified thickness were placed with proper gravel support .Then after filtration, the filtered water was collected through the tap provide in the column and the final iron concentration was measured. The rate of filtration was noted were tested and average iron concentration was consider for analyzing filter effectiveness.

4.4 Working of filter

Layer 1 : Aggregate

In absorbent filter media, filtration primarily occurs through the absorption of liquids into the media, similar to how a sponge works. The aggregate layer itself is not highly absorbent but acts as a structural and hydraulic support for the actual absorbent material layered above it**.** The aggregate layer also aids in removing larger particles by straining and sedimentation before water reaches the finer, more absorbent media

Layer 2 : Sand

As water passes through the sand, suspended particles larger than the pore spaces between sand grains are physically trapped and removed from the water. Sand grains and impurities may carry opposite charges, leading to neutralization and improved removal of certain contaminants. Unfiltered water is distributed over the top of the sand filter. As it percolates downward through the sand layer, impurities are removed by the combined effects of straining, sedimentation, adsorption, and biological activity.

Layer 3 : Activated charcoal

When water passes through the activated charcoal layer, contaminants are attracted to and adhere to the vast, porous surface of the carbon particles. The charcoal is "activated" to create a network of microscopic pores. These pores trap impurities such as organic compounds, chlorine, volatile organic compounds (VOCs), bad tastes, and odours, effectively removing them from the water.

Layer 4 : Coconut Coir

Coconut coir, which consists of fibrous material from the husk of coconuts, acts as a natural filter media due to its porous structure and high lignin and cellulose content. When used as a filter layer, coconut coir physically traps suspended solids, organic matter, and particulate contaminants as water or air passes through it. Its fibrous network provides a large surface area for adsorption, capturing impurities and supporting microbial activity that can further break down organic pollutants

5. RESULTS

As per IS:10500-2012 and IS:3025

The results of Futala Lake, Nagpur are as follows

Metal	Before	After	Acceptable
Iron- Fe, mg/l	1.14	0.5	0.3
Lead- Pb, mg/l	0.04	0.02	0.01
Arsenic- As, mg/l	0.08	0.03	0.01
Mercury- Hg, mg/l	0.008	0.001	0.001

Cadmium- Cd, mg/l	0.006	0.002	0.001

6. CONCLUSION

- Adsorption being the simplest and cheapest technique iron removal, it has several advantages, like longer filtration runs, shorter ripening time, better filter quality .But the only limitation is back wash water requirement is essential for the media to run effectively.
- In case of activated carbon the removal is significant. This may be due to larger particle size of material being used. Smaller the size of particle larger will be the specific surface and better will be the removal.
- Sand being the cheapest adsorbing surface is very effective in removal of dissolved iron from water and the rate of filtration is also very high. The only demerit is subsequent development of bacterial layer due to rigorous use. Again back washing is needed time to time

REFERENCES

- HEAVT METALS REMOVAL FROM WATER BY EFFICIENT ADSORBENT Industrial Chemistry Program, Faculty of Science and Natural Resources, University Sabah Malaysia Kota Kinabalu 88400.

- "REMOVAL OF METALS FROM DRINKING WATER BY OXIDATION-COAGULATON-ADSORPTION AT OPTIMIZED pH"Anup Jyoti Bora, Robin Kumar Dutta Department of Chemical Sciences, Tezpur University, Napaam, Tezpur 784028, Assam.

- FABRICATION AND CHARACTERIZATION OF COCONUT SHELL ACTIVATED CARBON USING VARIATION CHEMICAL ACTIVATION FOR WASTEWATER TREATMENT APPLICATION" E. H. Sujiono, D. Zabrian, Zurnanshay, Mulyati, V. Zharvan, Samnur, N. A. Humairah

- ASSESSMENT OF QUALITY OF WATER BIDIES SURROUNDING BHANDEWADI LANDFILL SITE NAGPUR CITY" Prof. Arpita A. Nandanwar, Akshay U. Ingle, Department of Civil Engineering, Guru Nanak Institute of technology, Nagpur, Maharashtra India.

- REMOVAL OF IRON FROM DRINKING WATER / GROUND WATER BY USING AGRICULTURAL WASTE AS NATURAL ADSORBENTS R. Balaji, S. Sasikala, G. Muthuraman University of Madras, Department of Chemistry, Presidency College, Chennai-600 005, India

- Hydrogeochemistry of Groundwater in Koradi-Khaparkheda area, Nagpur District, Maharashtra R. A. Rathod, R. K. Bopche, P. Kundal Department of Civil Engineering, Kavikulguru Institute of Technology and Science, Ramtek-441 106, India.

- World Health Organisation, Guidelines for drinking water quality (3rd Ed.),WHO , Geneva, 2004.

- An overview of adsorption technique for heavy metal from water/wastewater: a critical review. Muharrem Ince , Olcay Kaplan Ince.