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Removal of Heavy Metal from Textile Industry Waste by Using Moringa Oleifera and Agave Plant as Bio-Absorbents

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Abstract: *This Project report investigates the application of "REMOVAL OF HEAVY METALS FROM TEXTILE INDUSTRY WASTE WATER BY USING MORINGA OLEIFERA AND AGAVE PLANT AS BIO-ABSORBENTS". The discharge of untreated textile industry wastewater containing dyes, suspended solids, and organic pollutants causes severe environmental pollution and health hazards. This project focuses on the treatment of textile wastewater using eco-friendly bio-adsorbents prepared from Moringa oleifera seeds and Agave plant fibers. The bio-adsorbents were processed by drying, grinding, and sieving to enhance adsorption efficiency. Batch adsorption experiments were conducted to evaluate the removal efficiency of color, turbidity, chemical oxygen demand (COD), and biological oxygen demand (BOD) at varying dosages and contact times. The results demonstrated significant reduction in pollutants, indicating that Moringa and Agave are effective natural alternatives to chemical coagulants. The study concludes that plant-based bio-adsorbents provide a cost-effective, sustainable, and environmentally safe solution for textile wastewater treat*ment.

Keywords: Textile wastewater, Bio-adsorbent, Moringa oleifera, Agave plant, Dye removal, Wastewater treatment, Eco-friendly treatment, COD reduction, BOD reduction, Sustainable water management

I. INTRODUCTION

The jean's washing industry is an important part of the textile sector, responsible for giving denim fabrics their distinctive appearance, texture, and style. However, during various washing processes—such as enzymatic washing, bleaching, stone washing, and acid washing—a large volume of wastewater is generated. The textile industry is one of the largest contributors to industrial water pollution worldwide, with denim or jeans manufacturing units being particularly significant sources. During the processes of dyeing, washing, and finishing, a large volume of wastewater is generated. This wastewater is characterized by high colour intensity, alkaline pH, and elevated levels of total dissolved solids (TDS), biological oxygen demand (BOD), and chemical oxygen demand (COD). The presence of synthetic dyes, especially indigo dye, along with chemicals such as sodium hydroxide, detergents, and surfactants, makes the wastewater highly resistant to biodegradation. Discharging such untreated effluents into natural water bodies leads to reduced light penetration, oxygen depletion, and toxicity to aquatic organisms, thereby posing a serious environmental threat. To address these challenges, researchers and industries are exploring eco-friendly and cost-effective treatment methods. One promising approach is the use of natural adsorbents for the removal of colour and pollutants from textile wastewater. Adsorption is an efficient and simple process that does not produce harmful by-products.

Bio-Adsorbents for Wastewater Treatment

- Eco-Friendly Alternative: Bio-adsorbents are natural materials derived from plants, agricultural waste, or biomass that provide an environmentally friendly substitute for synthetic or chemical adsorbents.
- Low-Cost and Readily Available: They are inexpensive and easily obtainable, often made from locally available plants, seeds, leaves, peels, or fibres that would otherwise be discarded as waste.

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- High Adsorption Capacity: Bio-adsorbents contain various functional groups such as hydroxyl (-OH), carboxyl
- (-COOH), and amino (-NH_2) groups, which can bind effectively with dye molecules and heavy metals present in wastewater.
- Renewable and Biodegradable: Unlike activated carbon or chemical coagulants, natural adsorbents are renewable resources that degrade naturally without causing secondary pollution.
- Examples of Common Bio-Adsorbents: Materials like Moringa oleifera, Agave fibres, banana peels, neem leaves, rice husk, and coconut shells are proven to efficiently remove colour and contaminants from textile effluents.

II. LITERATURE SURVEY

Effects of Solution Matrix on Moringa oleifera Seeds in Eliminating Heavy Metals, Fluoride, Zinc and Lead, Turbidity from Synthetic Samples: A review by Nur Adila Ab Aziz1 (29 December 2018)

Plant-based biomass has become an environmental-friendly water purification agent in replacing conventional chemicals. In the previous study, Moringa oleifera (MO) seeds a have been selected based on their moderate to high effectiveness in removing lead, cadmium, nickel, arsenic, turbidity, and fluoride from synthetic groundwater samples. This study was aimed to investigate further the effects of solution matrix on the biomass effectiveness. Batch experiments were conducted by using coagulation technique and the initial pH of the solutions was controlled to be at pH 7. The results demonstrate that the removal rates for most of the pollutants in multi-contaminant solution were higher compared to the single-contaminant solution. The reason could be due to electrostatic or mutual interactions between contaminants present in the solution thus improved the removal rates of those contaminants. In terms of performance, combination of MO and BP either dosed in mixing MO or sequential manner MO are seen can improve the treatment performance by single biomass for most of the target contaminants. The findings are significantly important to understand the effects and removal behaviour of the biomass in different solution matrix.

Removal of heavy metals present in Industry waste water from a community using Agave Plant: A review by F.A. Alcazar-medina (January 10, 2020)

Groundwater samples from a mining community in North of Mexico were studied. Concentration of metals above the maximum allowable concentration from Mexican regulation were found. Spherical agglomeration technique (SAT) was used to remove metals (Zn, Cd). Two precipitating agents were tested: Ca (OH)2. Also, Agave tequilana Weber extract as hydrophobic zing agent was employed to avoid metal redissolution. High metal removal proved SAT effectiveness under pH ranging between 9-11 and extract doses from 0.3 g extract/g pollutant. Better removal percentages were reached when using Ca as precipitating. Reported removal efficiency in that case yielded removal percentages as high as 99% removal for Pb under the three-pH tested. The heavy metal evaluation index before treatment was 2354.91, but decreased to levels as low as 4.7 after SAT application.

Water Purification using Moringa oleifera and Other Locally Available Seeds in Fiji for Heavy Metal Removal: A review by Vikash Nand (May 2012)

In this paper, the use of local seeds to improve the quality of drinking water in Fiji was investigated. Analysis of the heavy metals cadmium, copper, chromium, lead and zinc were performed before and after treatment of water with the local seeds Moringa oleifera, Arachis hypogaea (peanuts), Vigna unguiculata (cowpeas), Vigna mungo (urad) and Zea mays (corn). The results showed that Moringa seeds were capable of absorbing the heavy metals tested compared to other seeds in some water samples. The percentage removal by Moringa seeds were 90 % for copper, 80 % for lead, 60 % for cadmium and 50 % for zinc and lead

III. MATERIALS AND METHOD

3.1 Selection of Bio-Absorbents

- Moringa Oleifera
- Agave Plant

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Fig 3.1.1 Moringa Oleifera

Fig 3.1.2 Agave Plant

Moringa oleifera is widely used in industrial water treatment as a natural coagulant and adsorbent for removing heavy metals, colour, turbidity, and microorganisms from wastewater Removal Moringa oleifera seed biomass and extracts demonstrate strong adsorption characteristics, effectively removing heavy metals such as lead, cadmium, and copper from contaminated water. Removal efficiencies of 95% for copper, 93% for lead, 76% for cadmium, and 70% for chromium have been reported. The natural adsorbent works well in acidic to mildly basic conditions and offers an affordable, accessible alternative to conventional chemical coagulant Economic and Environmental Benefits Using Moringa oleifera for water treatment is cost-effective, requires minimal infrastructure, and is sustainable. Moringa-based methods leverage renewable plant resources to minimize chemical use, reduce environmental impact, and provide viable options for both large-scale factories and rural industries.

The leaves of Agave americana are rich in lignocellulosic fibers, which are strong, biodegradable, and capable of absorbing liquids. These fibers can be extracted and processed into mats, pads, or loose-fill absorbents for applications such as oil spill cleanup, wastewater treatment. The Agave plant (Agave americana), a hardy succulent native to arid regions, is known for its strong natural fibers extracted from its leaves. Due to their excellent adsorption and filtration properties, Agave fibers are now being used as a natural filter material for treating wastewater. They effectively help in removing suspended solids, colour, turbidity, and heavy metals, providing an eco-friendly and cost-effective alternative to conventional filtration materials

3.2 Collected water sample of industry jeans manufacturing waste water

Fig 3.2.1 Collecting of waste water from jeans industry

The waste water collected from the jeans industry usually contains a mixture of chemicals and colouring agents that are used during the washing and dyeing processes. When jeans are produced, different steps such as washing, bleaching, dyeing, and finishing release wastewater that often looks dark in colour and may have a strong Odor. This water can carry leftover dyes, detergents, salts, and small particles of fabric. If such wastewater is released without proper treatment, it can pollute rivers and soil, making the water unsafe for plants, animals, and human use. Because of this, it is important to treat wastewater before disposal. In this project, the collected wastewater sample was used to test how well absorbents can remove impurities from industrial water. Absorbents help trap colour and other unwanted

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substances, making the water cleaner. By studying the treatment process, the project aims to find a simple and effective method to reduce pollution from jeans industry wastewater.

3.3 Design of filtration system

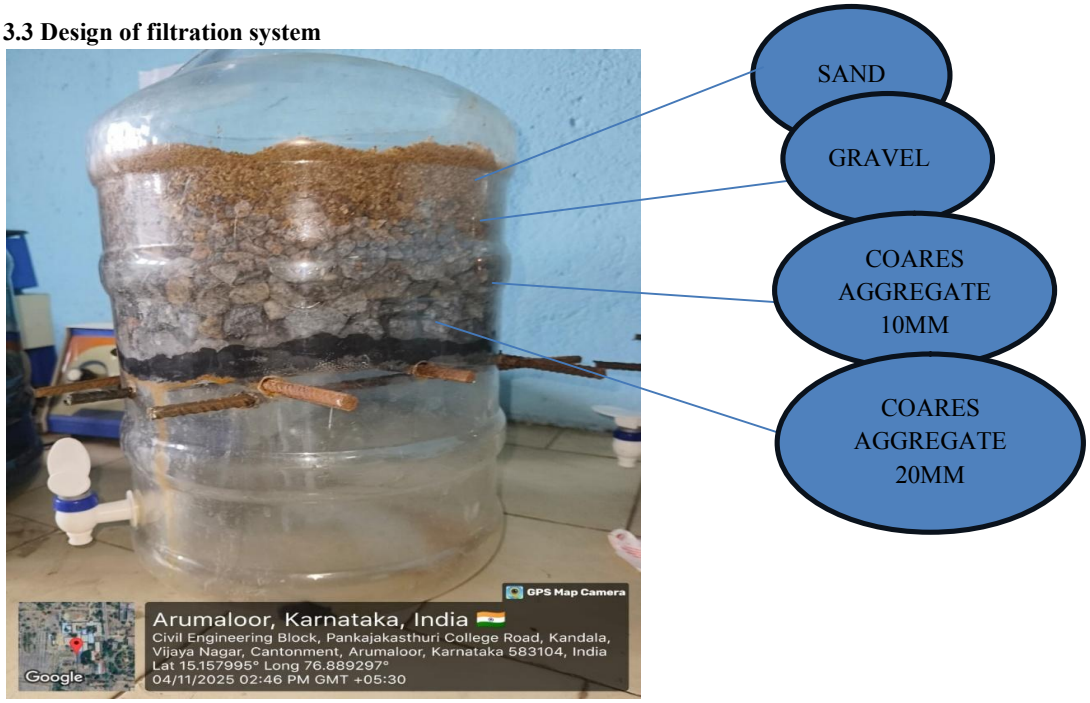

Fig 3.3.1 Process of filtration bed setup

IV. RESULT AND DISCUSSION

Table 1: Results of Preliminary Test

SL NO	PARAMETER	UNIT	RAW WATER SAMPLE
1	Acidity	Mg/l	36
2	Alkalinity	Mg/l	232
3	Chlorides	Mg/l	184.34
4	Hardness	Mg/l	325.2
5	Dissolved Oxygen	Mg/l	7.78
6	Bio-Chemical Oxygen	Mg/l	6.28

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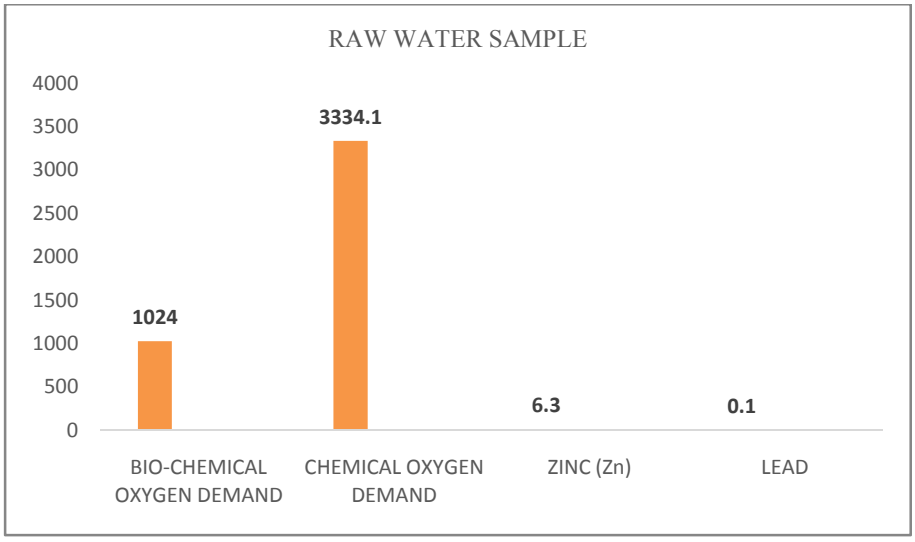
Table 2: Removal of Heavy Metal from Textile Industry Waste Water by Using Moringa Oleifra and Agave Plant as Bio-Absorbents

SL NO	PARAMETERS	UNITS	RAW WATER	TREATED		
				SAND BED+SEED	SAND BED+PEEL	SAND BED+AGAVE
1	Acidity	Mg/l	49.2	505.2	128	60
2	Alkalinity	Mg/l	360	612	445.2	518
3	Total Hardness	Mg/l	409.2	370.4	357.2	376
4	Solids	Mg/l	1	2	3	2
5	Bio-Chemical Oxygen Demand	Mg/l	1024	512.2	625	404
6	Chemical Oxygen Demand	Mg/l	3334.1	1666.5	2083.2	1249
7	Zinc – Zn	Mg/l	6.3	0.89	0.86	1.15
8	Lead – Pb	Mg/l	0.1	0.01	0.01	0.01
9	Colour	<	<5	<5	<5	<5

Before Treating The Raw Waste Water Sample



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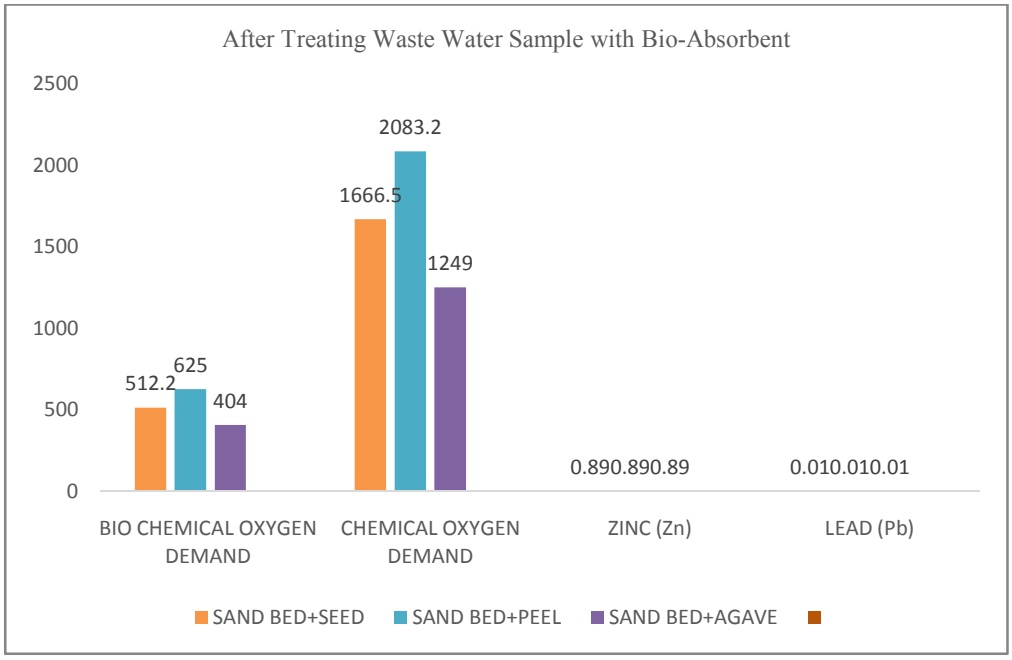
After Treating The Waste Water Sample



The overall result is the sand bed +agave is the best bio-absorbent

V. CONCLUSION

Raw water

The water quality analysis report shows that the jeans manufacturing wastewater is highly polluted. The very high BOD (1024 mg/l) and COD (3334.1 mg/l) values indicate a heavy organic load and poor water quality. The presence of zinc (6.3 mg/l) and lead (0.1 mg/l) confirms metal contamination. Although colour is within acceptable limits, the overall results show that the wastewater is not suitable for discharge or reuse without proper treatment. Therefore, effective wastewater treatment is essential before releasing it into the environment.

After treating waste water

The water quality analysis of different wastewater samples shows that the untreated jeans industry wastewater had very high pollution levels, indicated by extremely high BOD (402 mg/L) and COD (1249.9 mg/l) values. After treatment using natural adsorbents such as Agave water, Drum Stick Peel water, and Drum Stick Seeds water, a significant reduction in BOD, COD, and heavy metal concentration was observed. Zinc levels were reduced to lower (1.15 mg/l) values and lead (0.01) was found to be below detectable limits in treated samples, indicating effective removal of toxic substances. Although colour remained within acceptable limits in all samples, the overall results confirm that the applied treatment methods substantially improved water quality. Therefore, the use of low-cost, eco-friendly adsorbents is effective and suitable for the treatment of industrial wastewater before safe disposal or reuse.

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