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Conversion of grey water to potable water using LDH-Biochar composite

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Abstract. The worldwide freshwater shortage is worsened by the excessive use and contamination of scarce resources. A considerable amount of domestic wastewater is greywater, originating from activities such as bathing and laundry, and can account for as much as 70% of household water discharge. In contrast to black water, greywater contains fewer organic materials and nutrients, making it an ideal candidate for recycling. This research explores a new approach to transform greywater into drinking water using a composite made of Layered Double Hydroxide (LDH) and Biochar. This composite is designed to utilize the combined adsorption abilities of LDH along with the high surface area and filtering properties of Biochar to effectively eliminate pollutants. The study assesses how well this composite purifies greywater to adhere to drinking water regulations, offering a sustainable and creative solution to mitigate water scarcity by allowing safe water reuse.

1. Introduction

Although Earth receives adequate volume of freshwater to meet the need for drinking water, only an incredibly small proportion of the available water can ever be harnessed and utilized. About 97% and only 1% of the available freshwater can be accessed for human use and consumption respectively [1]. Water pollution, contamination by human activity, and over-extraction are the principal reasons for the increasing problem of water scarcity. About 70% of domestic sewage originates from greywater, though it contains a relatively smaller proportion of organic materials and nutrients. Large amounts of wastewater are produced by both domestic and industrial processes, and they can be broadly divided into two categories: blackwater, which comes from toilets, and greywater, which comes from bathing, sinks, and laundry [2].

The effluent discharged from bathrooms usually contains residues of soaps, shampoos, and other personal hygiene products. The laundry wastewater is rich in detergents and surfactants [3]. In the case of sinks, water usually carries toothpaste and soap residues. Kitchen greywater, carrying food particles, oils, and grease, would be more heterogeneous in nature.

The reuse of water is becoming a vital concern since freshwater availability is declining further, especially in developing nations like India where water demand in non-potable uses is high. Greywater is considered the most fitting domestic wastewater streams for on-site reuse because of its lower contamination level [4]. On-site treatment and reuse of lightly contaminated greywater form a feasible approach wherein uses may include landscape irrigation, toilet flushing, vehicle washing, and firefighting [5].

While source-separated greywater carries a much lower microbiological risk compared to blackwater, the potential for chemical and microbial hazards, as well as environmental hazards, still exists if not properly treated. Its quality is very variable depending on household practices, user behaviour, and type of products used [6,7]. Managing greywater remains inadequate mainly due to various pitfalls in planning and poorly implemented technologies. Most developed countries use various treatments from simple filtration to complex processes in order to minimize pollutant loads either before reusing or discharging [8]. Such initiatives notwithstanding, there are still identified crucial knowledge gaps, especially on microbial behaviour and transformation processes in grey water [9].

Biochar is a rich carbon matrix produced by heating organic feedstocks in the absence of oxygen-a process called pyrolysis. The feedstock for biochar usually comes from agricultural residues and/or municipal waste. It has attracted much attention recently due to its probable use in carbon sequestration, soil improvement, and water treatment applications due to its porous structure, large surface area, and abundance of reactive functional groups [10,11,12]. The production is relatively inexpensive, energy-effective, generates minimal emission, and depends on raw materials that are widely available [13].

Layered double hydroxides (LDHs) are also widely used in water treatment. The general forms of LDHs have the formula: $[M^{2+}_{1-x} M^{3+}_{x} (OH)_2]^{\chi+} [A^{n-}_{x}/_{n}]^{\chi-} \cdot yH_2O$, where M^{2+} and M^{3+} are metals with divalent and trivalent ions, χ

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is the molar ratio of trivalent cations, A^{n-} is the anion within the interlayer.

Combining them with biochar creates composites with superior surface area, functionality, stability, and adsorption. Unlike conventional, costly materials like activated carbon, biochar/ LDH composites are sustainable, inexpensive, and highly effective at removing pollutants. The biochar matrix supports LDH dispersion, preventing aggregation [14], and the composite shows enhanced adsorption capacity and reusability [15,16,17].

2. Material and Methods

2.1. Collection and characterization of grey water

Grey water was collected from a pond in Baranagar Mallic Colony, located in North Kolkata. West Bengal, India. The pond water is mostly involved in domestic activities, which includes handwashing of laundry, and communal bathing.

The grey water samples were collected using bottled containers and analyzed in the laboratory for obtainment of the values for several different parameters.

2.2. Analysis of Samples

The sample water of both pre-treatment and post-treatment was checked for the colony count and determination of the microbial load.

2.3. Preparation of Biochar

Biochar was prepared from rice husk (RH) by initially rinsing the RH twice with tap water, followed by rinsing it twice again with distilled water. The washed RH is then kept in a Hot Air Oven at 105°C for 1 hour. The dry RH is pyrolysed at 350°C for 1 hour in a forging furnace. The final rice husk biochar (RHB) is obtained.

2.4. Preparation of Layered double hydroxide (LDH)

Layered double hydroxide (LDH) is prepared by taking 2.56-gram $MgCl_2.6H_2O$ and 3.75-gram $AlCl_3.6H_2O$, and dissolving it in 50 millilitres of distilled H_2O. The entire solution is then stirred for 5-10 minutes. A clear, yellowish solution is finally obtained.

2.5. Preparation of LDH-RHB Composite by Co-precipitation method

The previously obtained RHB is taken for activation by heating in a hot air oven at 110°C for 1 hour. 5 grams of this Activated RHB is taken in a beaker and 50 millilitres of distilled H_2O is added to it. This solution is taken for ultra-sonification. After sonification, the previously prepared 50 millilitres of LDH is added to the Biochar solution to obtain 100 millilitres of solution. The pH is checked using a pH meter.

The pH is raised by adding 1M NaOH drop-wise with a pipette and continuous stirring until the pH is raised up to 8.5 or 9. After the appropriate pH is raised, the final solution is kept undisturbed for 24 hours. The solution is then centrifuged at 2595 rpm for 10 minutes. The supernatant thus obtained is discarded. This step is repeated. The pellets are finally washed by adding ethanol and centrifuged with the same parameters twice.

The final pellets thus obtained are evenly spread over petri dishes for drying. After drying, solid lumps of LDH-RHB composite are obtained, which are then crushed into fine particles for use, or stored for future use at normal temperatures.

2.6. Preparation of Column for Filtration

The column is prepared for filtration by stacking three layers – two layers of glass wool with a layer of the LDH-RHB fine particles between them.

The column is washed multiple times with distilled H_2O until clear water is obtained. The column is thus ready for filtering untreated grey water. The sample water is poured into the column, and kept undisturbed for 30 minutes. After this duration, the filtered water is collected drop-wise at a rate of 1 drop every 15 seconds. The filtered water is collected in a beaker and stored for post-treatment analysis. The bed depth, loading rate, breakthrough time was 12 cm, 2 ml/min., 500 min respectively.

2.7 Statistical Analysis

All experiments were conducted in triplicate

3. Results & Discussions

The untreated grey water sample was noted to have a total coliform count of 10^{10} CFU/mL, with the count of Fecal Coliform colony at 10^9 CFU/mL. Thus, the Total coliform and fecal coliform counts are extremely high, indicating severe fecal contamination and a significant risk to human and environmental health.

Microbial parameters studied:

A total of ten bacterial colonies, some of which are listed in Table 1 (below) were isolated and identified through biochemical testing (Mannitol, Catalase, Citrate, Urease, Indole, Methyl Red, Voges-Proskaeur, Dextrose tests) and Gram staining. The presence of Fungal Yeast and Mold spores (Fig. 1) was also observed in the water sample.

Table 1. List of some of the bacterial colonies in the Untreated Greywater sample

Bacterium	Significance	Image

Identified		
Listeria monocytogenes	Causes listeriosis (food/waterborne). High risk for pregnant women, immunocompromised.	
Neisseria gonorrhoeae	Sexually transmitted pathogen. Unusual in water; likely indicates human sewage.	
Shigella flexneri	Causes shigellosis (dysentery). Highly infectious via fecal-oral route.	
Escherichia coli	Common fecal indicator; some strains pathogenic (UTI, diarrhea).	

Fig. 1. Observable presence of Fungal spores in Untreated water sample

The treated water sample exhibited a substantial decrease in its overall microbial load (see Table 2), with a reduction in the Total Coliform and Fecal Coliform Count (from 10^{10} to 10^{8} CFU/mL and from 10^{9} to 10^{7} CFU/mL, respectively). Following the treatment, there was an increase in the presence of beneficial bacteria (*Rhizobium sp.*), suggesting that microbial balance within the sample was enhanced. The decline in the population of pathogenic bacteria, Yeast, and Mold, along with the concurrent increase in beneficial bacteria (Fig. 2), serves as a reliable indicator of the treatment's efficacy in suppressing harmful microorganisms. These results indicate that the applied treatment led to a substantial improvement in the safety and microbiological condition of the water sample.

Table 2. List of some of the bacterial organisms in Treated water sample

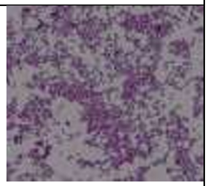
Bacterium Identified	Significance	Image
Enterococcus faecalis	Used as a fecal indicator bacterium to assess treatment efficiency and fecal contamination reduction.	
Bacillus subtilis	Common environmental bacterium; non-pathogenic; used in bioremediation.	
Rhizobium sp.	Enhances soil structure and fertility through organic matter contribution.	

Fig. 2. No observable presence of Fungal spores in Treated sample

Water quality parameters studied:

Table 3. Water quality parameters studied

Parameter	Untreated water sample	Treated water sample	BIS Guidelines (IS 10500)
pH	7.5	7.1	6.5 – 8.5
Turbidity	3.4 NTU	1.1 NTU	1 NTU

TDS (mg/l)	850	250	500
BOD (ppm)	9	3	1
COD (mg /l)	175	10	5
Chlorine (mg/l)	800	10	4
Phosphate (µg/l)	30	15	1
Magnesium (mg/l)	45	30	30
Calcium (mg/l)	80	34	75
Nitrites (mg/l)	0.7	0.5	1
Nitrates (mg/l)	1.5	1	10
Ammoniacal nitrogen (mg/l)	0.7	0.5	1
Lead (mg/l)	0.08	0.02	0.01
Cadmium (mg/l)	0.02	0.01	0.003
Nickel (mg/l)	0.04	0.02	0.02

The above data portrays the enhancement of the treated water quality which will help in its use for everyday human activities.

4. Conclusion

The prepared LDH-Biochar composites showed high level efficacy in the microbial remediation of greywater, it achieved a 2-log reduction in total coliform counts and fecal coliform counts as well total eradication of detectable fungal contaminants. The highly pathogenic bacteria were successfully eliminated and the microbial profile after the treatment was found to be beneficial and having a low risk. It means that the composites operate on a synergistic basis of physical filtration, adsorption, and most probably, electrostatic interactions which is reducing the pathogenic load while preserving the balance of the microbial community. As a pretreatment technology in a multi barrier system, the composite is very effective as potable reuse. Although the residual coliform rates are still above the direct potable requirements, the considerable continuous long term improvement in the microbial spectrum opens a new door towards low-cost sustainable source of conversion of Grey-water into potable water on a daily basis.

5. References

1. HI. Abdel-Shafy, AM. Al-Sulaiman, MS. Mansour, Anaerobic/aerobic treatment of greywater via UASB and MBR for unrestricted reuse. Water Science and Technology. **71**, 630-637 (2015) doi: 10.2166/wst.2014.504
2. M. Benami, O. Gillor and A. Gross, The question of pathogen quantification in disinfected graywater. Sci Total Environ. **506**, 496–504 (2015)
3. R. Birks and S. Hills, Characterisation of indicator organisms and pathogens in domestic greywater for recycling. Environ Monit Assess. **129**, 61–69 (2007)
4. Y. Boyjoo, VK. Pareek and M. Ang, A review of greywater characteristics and treatment processes. Water Sci Techno. **67**, 1403–1424 (2013)
5. AD. Alsulaili, MF. Hamoda, Quantification and characterization of greywater from schools. Water Science and Technology. **72**, 1973-1980 (2015)
6. M. Benami,; A. Gross,; M. Herzberg,; E. Orlofsky,; A. Vonshak,; O. Gillor. Assessment of pathogenic bacteria in treated graywater and irrigated soils. Sci. Total Environ. **458–460**, 298–302 (2013)
7. LM. Casanova, CP. Gerba, M. Karpiscak, Chemical and microbial characterization of household greywater. Journal of environmental science and health, Part A. Toxic/Hazardous Substances and Environmental Engineering, **34**:395–401 (2001)
8. Y. Boyjoo, M. Wang, V.K. Pareek, J. Liu, M. Jaroniec. Synthesis and applications of porous non-silica metal oxide submicrospheres. Chem Soc Rev. 2016 Oct 24;45(21):6013-6047
9. E. Eriksson, K. Auffarth, AM. Eilersen, M. Henze, A. Ledin, Household chemicals and personal care products as sources for xenobiotic organic compounds in grey wastewater. Water SA. **29**:135–146 (2003)
10. H. Lyu, Q. Zhang, B. Shen, Application of biochar and its composites in catalysis. Chemosphere. **240**:124842 (2020)
11. MZ. Rahman, T. Edvinsson, P. Kwong, Biochar for electrochemical applications. Current Opinion in Green and Sustainable Chemistry. **23**:25-30 (2020)
12. T. Wang, C. Li, C. Wang, H. Wang, Biochar/MnAl-LDH composites for Cu (II) removal from aqueous solution. Colloids and Surfaces A: Physicochemical and Engineering Aspects. **538**:443-450 (2018)
13. J. Tang, H. Lv, Y. Gong, Y. Huang, Preparation and characterization of a novel graphene/biochar composite for aqueous phenanthrene and mercury removal. Bioresource Technology. **196**:355-363 (2015)
14. H. He, N. Zhang, N. Chen, Z. Lei, K. Shimizu, Z. Zhang, Efficient phosphate removal from wastewater by MgAl-LDHs modified hydrochar derived from tobacco stalk. Bioresource Technology Reports. **8**:100348 (2019)
15. S. Chen, Y. Huang, X. Han, Z. Wu, C. Lai, J. Wang, Q. Deng, Z. Zeng, S. Deng, Simultaneous and efficient removal of Cr(VI) and methyl orange on LDHs decorated porous carbons. **352**:306-315 (2018)
16. K. Jung, S. Lee, YJ. Lee, Synthesis of novel magnesium ferrite ($MgFe_2O_4$)/biochar magnetic composites and its adsorption behavior for

phosphate in aqueous solutions. **245, Part A**:751-759 (2017)

17. L. Meili, P.V. Lins, C.L.P.S. Zanta, J.I. Soletti, L.M. O. Ribeiro, C.B. Dornelas, T.L. Silva, M.G.A. Vieira, MgAl-LDH/Biochar composites for methylene blue removal by adsorption. **168**:11-20 (2019)