Treatment of Industrial Waste Water Using Biowaste

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Abstract- *Industrial wastewater, especially from textile industries, is loaded with harmful contaminants like methylene blue dye and lead (Pb^{2+}) ions, which can seriously threaten water quality and aquatic life. Traditional treatment methods, such as chemical precipitation and membrane filtration, tend to be costly and often create secondary pollutants. As a more sustainable option, biosorption using affordable, eco-friendly adsorbents has gained traction for its effectiveness. In our study, OPAC showed better adsorption efficiency compared to CGAC, likely due to its larger surface area (867.5 m²/g vs. 812.3 m²/g) and higher porosity. The adsorption process was driven by electrostatic interactions, pore diffusion, and surface complexation. These results underscore OPAC and CGAC as promising, cost-effective adsorbents, providing a practical solution for treating industrial wastewater. Future research should aim at adsorbent regeneration and scaling up for better environmental sustainability.*

Keywords- Adsorption, Biosorption, Activated Carbon, Orange Peel, Coffee Grounds

I. INTRODUCTION

Industrial wastewater is the water that gets contaminated during industrial processes and operations. It usually contains a mix of pollutants, including heavy metals, organic compounds, suspended solids, nutrients, oils, and greases, which can significantly harm water bodies if released untreated. Global statistics show that industrial activities are a major contributor to the total volume of wastewater produced. For instance, industries like textiles, paper, and food processing are among the highest generated of effluents are often marked by high levels of biochemical oxygen demand (BOD), chemical oxygen demand (COD), and various hazardous substances (Kurniawan et al., 2006). When industrial wastewater is released without treatment, it not only pollutes freshwater ecosystems but also poses serious risks to public health, agriculture, and biodiversity.

Importance of Wastewater Treatment:It's essential to have efficient and sustainable wastewater treatment to reduce the environmental dangers linked to industrial wastewater. While traditional treatment methods like physical filtration, chemical coagulation, and flocculation are widely used, they can be expensive, energy-intensive, and may even produce secondary pollutants.

1.2.Research Objectives:

To identify different types of biowaste materials that can be used for treating industrial wastewater.
To assess how effective these materials are at removing specific pollutants, including heavy metals, organic compounds, and nutrients.
To analyze the environmental sustainability of biowaste-based treatment methods compared to conventional technologies.
To suggest practical biowaste treatment solutions that industries can integrate into their wastewater management systems.

II. PREPARATION OF PAPER

Utilizing biowaste for industrial wastewater treatment offers a promising alternative to traditional approaches. However, several challenges remain, such as standardizing biowaste treatment processes, optimizing biowaste materials for specific pollutants, and addressing economic hurdles. More research is needed to find innovative ways to enhance the efficiency of biowaste-based treatment systems and to scale these processes for industrial use.

III. METHODOLOGY:

3.3.1.Preparation of Biosorbents:

Creating effective biosorbents is a vital step in ensuring they can effectively remove pollutants from wastewater. In this study, we focus on preparing activated carbon from (OPAC) and coffee ground-derived activated carbon (CGAC) were created as affordable, eco-friendly adsorbents. The process of making them involved gathering materials, pre-treating, activating, and carbonizing, which all helped boost the surface area and adsorption capacity of the biosorbents. Proper preparation is key to ensuring that these biosorbents have the right porosity, functional groups, and surface chemistry needed for effectively adsorbing contaminants like methylene blue dye and lead (Pb^{2+}) ions. The following sections will walk you through the step-by-step methodology used to prepare OPAC and CGAC.

Figure 3.1Waste orange peel powder

Figure 3.2Waste coffee grounds

3.2 Materials:

3.2.1 Biowaste-Based Adsorbents:

In this study, we used orange peels (OP) and coffee grounds (CG) as our biosorbents. We picked these materials because they are readily available, inexpensive, and have great adsorption properties. Orange peels are packed with pectin, cellulose, and flavonoids, which provide a wealth of functional groups that can effectively adsorb heavy metals and organic pollutants. On the other hand, coffee grounds are rich in lignin, polyphenols, and melanoidins, which enhance their surface area and porosity, making them quite effective for adsorption (Duque-Acevedo et al., 2020). The chemical makeup of these materials is crucial for their ability to interact with and eliminate pollutants from industrial wastewater.

3.2.2 Wastewater Sample:

The industrial wastewater sample we used in this study was sourced from a textile industry wastewater treatment facility. Effluents from the textile industry are known to have high levels of dyes, phenolic compounds, heavy metals (like Pb, Cd, Cr), and total dissolved solids (TDS), making them perfect for testing the efficiency of our biosorbents (Rizzo et al., 2019). We stored the wastewater in acid-washed polyethylene containers at 4°C to keep it from degrading before we analyzed it. We also conducted an initial characterization of the wastewater to assess parameters such as pH, electrical conductivity, total suspended solids (TSS), heavy metalconcentration and chemical oxygen demand (COD) before adsorption the studies.

3.3. Water Quality Improvement

Our analysis of water quality parameters, both before and after the adsorption process, clearly shows that both OPAC and CGAC made a significant difference in improving the quality of textile wastewater. The treated water exhibited lower levels of turbidity, TDS, COD, and BOD, along with impressive removal rates for methylene blue and lead (Pb^{2+}) ions.

These results underscore the promise of OPAC and CGAC as effective, sustainable, and eco-friendly biosorbents for treating industrial wastewater. By efficiently eliminating pollutants, these materials offer a cost-effective alternative to traditional water treatment methods, supporting environmental sustainability and resource recovery.

IV. RESULT

We compared the performance of OPAC and CGAC to see which biosorbent shows better adsorption characteristics and scalability for large-scale wastewater treatment applications.

Table 4.1 Effect of Contact Time on Adsorption

Time (min)	Methylene Blue Removal (%) (OPAC)	Methylene Blue Removal (%) (CGAC)	Lead (Pb^{2+}) Removal (%) (OPAC)	Lead (Pb^{2+}) Removal (%) (CGAC)
10	40.23	38.65	35.51	33.89
20	60.31	57.41	52.84	50.12
30	74.53	71.27	68.19	65.72
60	88.24	84.91	80.42	78.67
120	91.53	89.81	85.23	83.91

Table 4.2 Comparison Between OPAC and CGAC.

Observation	OPAC	CGAC
Initial adsorption rate	Higher	Slightly lower
Final removal efficiency	Higher for both pollutants	Slightly lower
Equilibrium time	60–120 min	60–120 min
Overall adsorption capacity	Greater due to larger surface area	Slightly lower but still effective

Table 4.3 The experimental results for varying adsorbent dosage

Adsorbent Dosage (g/100 mL)	Methylene Blue Removal (%) (OPAC)	Methylene Blue Removal (%) (CGAC)	Lead (Pb^{2+}) Removal (%) (OPAC)	Lead (Pb^{2+}) Removal (%) (CGAC)
0.1	54.28	50.81	46.91	44.17
0.3	72.47	68.93	61.23	58.76
0.5	91.23	89.47	83.56	81.35
1.0	92.54	91.73	85.68	83.98

Table 4.4 Effect of pH on Adsorption

pH	Methylene Blue Removal (%) (OPAC)	Lead (Pb^{2+}) Removal (%) (CGAC)
3	55.28	81.31
5	68.92	85.74
7	90.23	89.61
9	88.12	75.28
11	72.34	50.61

Table 4.5 Experimental Data for Initial Pollutant Concentration.

Initial Concentration (mg/L)	Methylene Blue Removal (%) (OPAC)	Methylene Blue Removal (%) (CGAC)	Lead (Pb^{2+}) Removal (%) (OPAC)	Lead (Pb^{2+}) Removal (%) (CGAC)
10	94.62	92.89	88.31	86.72
50	89.17	86.54	81.54	78.93
100	82.34	78.61	73.45	71.17
200	73.12	69.85	64.82	62.31

Table 4.6 Experimental Data for Adsorption Capacity (qe)

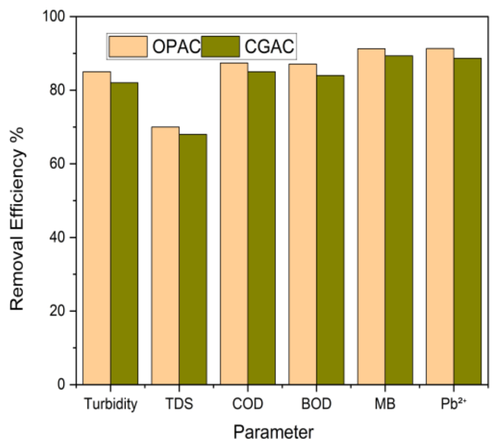
Initial Concentration (mg/L)	Methylene Blue (OPAC)	Methylene Blue (CGAC)	Pb^{2+} (OPAC)	Pb^{2+} (CGAC)
	qe (mg/g)			
10	0.94	0.92	0.88	0.86
50	4.45	4.31	4.07	3.94
100	8.23	7.86	7.34	7.11
200	14.62	13.97	12.96	12.42

Table 4.7 Water Quality Parameters Before and After Adsorption.

Parameter	Before Adsorption (Textile Wastewater)	After Adsorption (Using OPAC)	After Adsorption (Using CGAC)
pH	5.1 (Acidic)	7.2 (Neutral)	7.0 (Slightly Neutral)
Turbidity (NTU)	95.3	14.6	17.3
TDS (mg/L)	1380	410	432
Electrical Conductivity (µS/cm)	1685	720	745
COD (mg/L)	700	88	105
BOD (mg/L)	350	45	56
Methylene Blue Dye (mg/L)	120	10.5	12.8
Lead (Pb^{2+}) (mg/L)	60	5.2	6.8

Table 4.8 Removal efficiency for all parameters

Parameter	% Removal Efficiency (OPAC)	% Removal Efficiency (CGAC)
Turbidity	85	82
TDS	70	68
COD	87.4	85.0
BOD	87.1	84.0
Methylene Blue	91.25	89.33
Lead (Pb^{2+})	91.33	88.67



V. CONCLUSION

This study's results clearly show that activated carbon made from agricultural waste, particularly OPAC and CGAC, is quite effective at removing dyes and heavy metals from textile wastewater. The adsorption process proved to be highly efficient under optimized conditions, achieving over 90% removal of methylene blue and lead ions.

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