Assessment of metal contamination of landfill site and application of polyaniline bio-composites for removal of toxic metals from leachate

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7.1. Conclusion:

The present research was carried out to assess a few heavy metals remediation potential of PAni biocomposites mainly on their removal efficiency (Objective 1) Characterization of landfill leachate, groundwater and soil collected from open landfill sites in the Brahmaputra valley.(Objective 2) Characterization and application of PAni biocomposites (doped and undoped) for removal of toxic heavy metal from landfill leachate.(Objective 3) Assessment of the adsorption kinetics and equilibrium studies for the potential removal of toxic metals using polyaniline (PAni) biocomposite.

Objective 1:

Using a range of statistical techniques, the current work attempted to evaluate and classify intricate soil, ground water, and leachate contamination indices. From this investigation, the following conclusions can be made. Leaching from landfill leachates is the main cause of the contamination of ground water and soil, as suggested by the greater concentrations of heavy metals in the regions closest to the solid waste disposal site.

Even though many locations fell into the "Good" category, the primary component analysis technique used to estimate the values of the heavy metal index showed that the ground water in the Tezpur dumping site is highly contaminated by heavy metals. In order to confirm the accuracy of the recommended indexing method, the calculated heavy metal index values for each location were further connected with the resulting heavy metal pollution index, contamination index values. The discovery of hazardous metals in environmental samples from the study area suggested a potential effect on the neighborhood's inhabitants. Higher enrichment factors for Cd, Pb, Ni, and Mn in soils and sediments indicated moderate to severe Cd contamination of the ecosystem. Due to the bioaccumulation risk of these TMs and HMs and also contamination of drinking water and agricultural soil, regular monitoring is needed and government should make sincere efforts to treat the leachate to protect the environment. It is suggested that all open dumpsites be converted into conventionally built landfills with strong and reliable monitoring in order to prevent the release of hazardous materials from these sites in the future.

Objective 2:

Characterization study were carried out with respect to functional group, Surface Morphology, surface elemental composition for PAni biosorbents and functional group and Crystallographic studies (XRD) were carried out for PAni SC dope, PAni SC UD, PAni SD dope and PAni SD UD. The FTIR analysis revealed important functional groups of different biocomposites present on the biosorbent surfaces that facilitated metal uptake by forming various complexes. The important functional groups responsible for biosorption are C–O , phenol ring, hydrocarbon (C-H), alkanes, ester carbonyl, C–N, alkyl amine, C–O [mainly responsible for metal binding on PAni biocomposites]. XRD analysis of PAni confirmed presence of distinct crystalline structure in polyaniline/iron oxide and polyaniline/carbon nanotube nanocomposites on their bicomposites that was involved in metal sorption. TEM micrographs of PAni showed

that Pani are nanofibers, non-uniform granular aggregation was observed for pristine PAni due to multilevel irregular secondary growth. Nevertheless, smaller particles as confrmed by the compactness of biocomposites. SEM micrograph of the biosorbents prior to adsorption reveals their rough and heterogenous property that enhances their capability for metal uptake. However, upon metal treatment appearance of a shining surface confirms metal deposition due to adsorption. EDX analysis further confirmed the presence of heavy metal ions in the treated biosorbents which were absent in the untreated ones.

Objective 3:

Heavy metal contamination is a significant environmental issue that poses risks to human health and ecosystems One promising method for remediating heavy metal pollution is the use of biosorbents. The natural materials used in this study, such as sugarcane bagasse and sawdust, have shown great potential in removing heavy metals from contaminated water.

In this current study we have evaluated the operational parameter i.e. contact time, dosage, pH, initial ion concentration and regeneration studies for the adsorption of Cd & Pb ions onto the PAni doped/undoped sugarcane bagasse and sawdust. In this study conducted for the heavy metal remediation for Cd and Pb for wastewater treatment it had been found that at 12 hrs of contact time the biosorbent reaches its saturation point may be due to the repulsive interaction between sorbed metal ions on the sorbent surface and ions present in the solution, further sorption of metal ions is difficult. As an outcome, the sorption rate decreased over time, eventually approaching equilibrium. The similar trend is observed for both Cd and Pb `ions. A 0.5g dose is selected as the optimum dosage of biosorbent for the biosorption as there was high rate of removal efficiency is observed for Cd and Pb ions. At pH of 8 the optimum removal is achieved for the Cd & Pb ions. At 30 ppm concentration the PAni dope sugarcane bagasse and PAni undoped sugarcane bagasse shows highest removal rate for Cd ions. There are only some minor changes in the removal percentage of Cd as the increase in initial ion concentration. This may be because it has reached its maximum adsorption capacity, meaning that regardless of the initial concentration, it can only remove a certain percentage of the Cd ions. This could indicate that the biosorbent is nearing its saturation point. Whereas for Pb biosorption at 10 ppm initial concentration shows the highest removal efficiency. This is because there may be fewer external binding sites available on the biosorbent's surface due to saturation, which were easily accessible in the biomass at lower concentrations. As a result, we may conclude that at lower concentrations, the removal percentage is high due to the predominance of more binding sites on the surface of the biosorbents, and at higher concentrations, the removal percentage is lower due to the congestion of adsorption sites by Pb ions. The adsorption kinetics exhibited strong correlation co-efficient for the pseudo-second order kinetic model for both Cd and Pb ions. Regenerations studies show excellent removal efficiency till the 5^{th} cycle for the PAni doped/ undoped sugarcane bagasse and sawdust. It shows good reusability and durability of the biosorbents.

The application of biosorbents offers a cost-effective and environmentally friendly to traditional methods like chemical precipitation. Through the process of biosorption, heavy metals are adsorbed onto the surface of the biosorbent, effectively reducing their concentration in the environment. Studies have demonstrated the effectiveness of various biosorbents in removing heavy metals like lead, cadmium, and arsenic. Overall, the use of

biosorbents for heavy metal remediation shows promise in addressing environmental pollution and protecting human health.

7.2. Limitations & Future scope:

When it comes to eliminating heavy metals using adsorption, there are certain restrictions that need to be considered. One restriction is the potential for saturation of the adsorbent material, which can decrease its efficiency over time. Another problem is the cost associated with utilizing adsorbents, as some materials can be expensive to make or purchase. Additionally, the pH of the solution can alter the efficacy of adsorption, with certain pH levels being more favourable for the process. It is also important to note that the concentration of heavy metals in the solution can alter the adsorption capacity of the material. Despite these limitations, adsorption remains a promising approach for cleanup of heavy metals in different sectors and environmental contexts.

The following are the points that were taken into account for the future continuing this work further:

- Characterization & morphological study of the biosorbent.
- Extraction of heavy metals from the biosorbent and assessing its purity and reusability for industry.
- Further extending it for the treatment of drinking water.
- Comparing with different biosorbent and scale-up for industrialized utilization for waste water treatment.
- Continuing the same topic further for my higher research education.