REMOVAL OF POLLUTANTS FROM WASTEWATER USING NEEM LEAF AS BIOADSORBENT

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Abstract

The challenges of wastewater treatment lie in implementing cost-effective, high performance, ecovative, and straightforward techniques. One of the efficient and economical methods is treating the water by suitable adsorbents. Adsorption is a simple physicochemical process that transfers the pollutant from liquid to solid phase. Though adsorbents like activated carbon, silica, and alumina are commercially available; bio adsorbents gain attention and importance because of their low cost, adsorption capacity, and eco-friendly enabled solutions. Although many bioadsorbents have emerged with significant results in the present review, we extended our vision on the competency of neem (Azadirachta indica) leaves in the removal of heavy metal ions and organic dyes since it is well known for its therapeutic use. The study assesses that the adsorption process's effectiveness and challenges depend on the adsorbate's affinity and the adsorbent. The factors like the dosage of adsorbent, the concentration of adsorbate, the contact time between them, agitation, and pH of the medium also quantify adsorption's viability

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1. Introduction

Indeed, industrialization contributes to the country's growth and economy; the modernization and introduction of newer methods and machinery types led to new-fangled problems on the environment. Numerous pollutants are present in the air we breathe, the water we drink, and the land. Among the pollutants, heavy metals in the water stream pose a significant problem because of their bioaccumulation (Yousafzai *et al.*, 2017) tendency through the food chain. Moreover, they are toxic, mutagenic, neurotoxic, teratogenic, and carcino- genic (Rashmi and Pratima, 2013) in nature. The removal of these pollutants becomes difficult unless otherwise, some specific and efficient techniques are adopted. The improper treatment methods lead to massive destruction of our environment. To combat the effect and treat a diversity of pollutants released from the industries, from the olden days' onwards, traditional methods like adsorption, ion exchange, precipitation, biosorption, oxidation, precipitation, coagulation, and electro-dialysis (Narmadha D, 2012) are in use. Green technologies like bioremediation and phytoremediation are also in use to treat industrial wastewater treatment because of their supremacy in environmental fortification. Among the various treatment methods, low-cost bioadsorption has emerged as an attractive technique because of its lesser inherent limitations. Bioadsorbents are essential compared to four predominantly industrially used adsorbents like activated carbon, zeolites, silica gel, and activated alumina because of their abundance in nature, low-cost, and available (Crini *et al.*, 2019) large in quantities. It was reported that, natural zeolites (Pucarevic, Stojic and Kuzmanovski, 2017) as effective in removal of pesticide atrazine and hence can used to treat water contaminated with pesticides.

2. Bioadsorbents

Some bioadsorbents like mustard husk (Meena *et al.*, 2008), raw wheat bran (Ogata *et al.*, 2014) were effective in the removal of Pb and Cd, apple residue for the Cu, Pd and Cd (Lee *et al.*, 1998), tamarind fruit shell (Popuri *et al.*, 2007), coffee husk (Ahalya, Kanamadi and Ramachandra, 2010), coconut husk and palm pressed fibres (Tan, Ooi and Lee, 1993) and litchi chinensis (Kashif and Mukhtar, 2018) in the removal of chromium(VI), orange fruit peel for Ni (Ajmal *et al.*, 2000) removal, ponkan mandarin peel (Pavan *et al.*, 2006) in the removal of Ni, Co, and Cu, chestnut shell and grape seed activated carbons for Cu (Özc, 2009) removal, spent coffee powder (Hao, Wang and Valiyaveettil, 2017) for the removal of As(V), Cu(II) and P(V), powdered raw avocado seeds for arsenic removal (Mqehe-Nedzivhe *et al.*, 2018), walnut shell powder (Uddin and Nasar, 2020), camelina and sapindus seeds-derived adsorbents (Sharma and Tiwari, 2016) for methylene blue dye and luffa aegyptica peel (Mashkoor and Nasar, 2018) and (Thilagavathi *et al.*, 2015)for malachite green were used. In most of the cases, adsorption behavior fitted with Langmuir model. Among the bioadsorbents, the neem tree is well known for its therapeutic and germicidal activities. This study explores its competence as bio adsorbent in the removal of heavy metals and organic dyes.

2.1 Method of preparation of neem leaf powder

In general, the neem leaves collected from the nearby areas are used as adsorbent. After washing them repeatedly with distilled water, leaves were dried in an oven at a lower temperature to remove moisture, ground, and stored. In a few documented research works, based on the mesh size used for sieving, particles of neem leaf powder were segregated. The prepared adsorbent was stored in airtight containers for further use. More or less, the same procedure was adopted in preparing the adsorbent with slight modification in most of the documented papers.

2.2 The efficiency of neem leaves

2.2.1 *Adsorption of metallic ions*

The stock solutions containing various concentrations of iron, copper, and cadmium (Paul *et al.*, 2017) were treated with powdered neem adsorbent. The prepared neem leaf powder's removal efficiency was compared with adsorbent powders of mango peel and coconut husk. Better adsorption was recorded when the contact time was 8 hours. In the range of 100-200 microns, Neem leaf powder effectively removed the ions, and its efficiency was on par with coconut husk and mango peel. Chemically treated, thermally activated neem leaf powder (Pandhare *et al.*, 2013) showed a better adsorption capacity in removing cadmium and lead ions from the stock solution at the pH range of 6.5. By increasing the adsorbent and keeping the concentration of ions as constant, absorbance decreased. The presence of unsaturated pores on the adsorbent at constant concentration decreased the adsorption. In this case, the adsorption obeyed the Freundlich and Langmuir adsorption isotherms. A comparative study between commercially available activated charcoal and neem leaf powders showed (Tawde and Bhalerao, 2010) maximum chromium removal 100 % efficiency for neem leaf powder when the agitation time was 180min, and at pH 7. 100% removal by neem leaf powder was observed in the selective parameters. In this case, neem leaf powder acted as a better choice than activated carbon in some parameters and a wide range of initial concentrations. It was reported that charcoal was a better option in the acidic medium, while neem is better in the high pH range. Chemically treated and activated carbon of neem leaf powder showed promising results in removing chromium (Pandhare, Trivedi and Pathrabe, 2013) from the stock solution. The activated carbon of neem with particle size 5 micrometer showed an increase in adsorption with an increase in the adsorbent. However, in this case, the treated samples were initially shaken and allowed to stand still for 48 hrs. The results well fitted into Langmuir adsorption isotherm with a better R^2 value. Regularly washed and dried (Gautam and Fatima, 2016), neem leaf powder exhibited effective adsorption in the pH range of 5 and a stirring rate of 100rpm. The maximum adsorption capacity of metallic ions is dependent on agitation or stirring rate or stand still conditions are yet to be explored. Adsorption of chromium ions is maximum in the pH range around 7 (Venkates warlu *et al.*, 2007), (Kovo, Olu and Gwatana, 2014) is reported compared to the acidic medium. It has been reported that the hydrogen ion's competency diminishes as the pH increases, and the adsorption of chromium ion will be effective.

2.2.2 *Adsorption of organic dyes*

Neem leaf powder was used in the absorption of congo red and methyl orange (Ibrahim, Sulaiman and Sani, 2015). As the pH increased from 2-4, adsorption also increased, and after that, a slight decrease in adsorption occurred. The acidic medium was effective in the adsorption of anionic dye molecules and an increase in agitation time. The neem leaf powder, which passed through the mesh size 200-300, was effective in the removal of Acid Red 18 and Acid Orange 7 (Chaudhuri and Hui, 2013) by a low pH range of 2. The negatively charged anionic dye was attracted strongly by positive sites present on the surface. In the case of removing organic dyes, maximum adsorption exhibited only at a lower pH range. Particle size around 150 microns sized neem leaf powder, exhibited the maximum efficiency in removal of reactive red color used in the cotton industries up to 78.18% (Manjunatha and Vagish, 2016) in the contact time of 100 minutes.

3. Conclusion

Treatment of effluents from the industries containing heavy metals and organic dyes involves extensive usage of activated carbon because of its adsorbing capacity, but limits due to its cost. The cost has put the researchers in demand for alternatives, which are economical and ecofriendly materials. The feasible and viable solution to the present issue is using simple, cost-effective, abundant, and eco-friendly bio adsorbents. However, the adsorbents' efficacy depends on the activation of materials, pore size, contact time between the contaminant and adsorbent, and initial pollutant concentrations.

Though various adsorbents give better results in removing pollutants with endless opportunities, experimental details project that the desorption and regeneration of the adsorbents and safe sludge disposal in real-time applications need focus. Further exploration of research may lead to better and suitable alternatives, replacing the commercially predominant activated carbon.

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