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REMOVAL OF MALACHITE GREEN DYE FROM WASTE WATER BY USING NATURAL AND SYNTHETIC ADSORBENTS: A REVIEW

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ABSTRACT

Contaminated water is the primary source of any disease. Water may be contaminated by number of pollutants and dyes are one of them. Malachite green (MG) dye is widely used as biocide in the aquaculture industry to controls fungal attacks, protozoan infections and also used in food and textile industries for various purposes. Surface and ground water is contaminated with dyes due to discharge of untreated waste water from industries. Presence of malachite green in water causes serious health effects such as mutagenesis, teratogenecity, chromosomal, respiratory toxicity, fractures, and carcinogenesis which depend on exposure time, temperature and concentration of dye. Therefore, removal of malachite green from water by using various techniques is an essential concern for living beings as well as environment. This article represents the overall study for removal of malachite green dye from waste water by using natural and synthetic adsorbents. This study also provides a systematic ranking of natural and synthetic adsorbents on the basis of adsorption capacity, cost and toxicity. This study also identifies the knowledge gaps and human safety issues of these sorbents.

Keywords: Malachite Green, Water Purification, Adsorbent, Dye Removal, Dye Health Effect.

I. INTRODUCTION

Industrial wastes are the prime sources of water pollution. Now a day dyes are extensively used by plastics, paper, textile dyeing, rubber, several industries. Malachite green (MG) (triphenylmethane) is a water soluble dye and widely used as biocide in the aquaculture industry to controls fungal attacks, protozoan infections and also used in food, textile and leather industries for dyeing process and in the manufacturing of printing inks and paints [1,2]. Surface and ground water is contaminated with dyes due to untreated waste of dyes from industries.. Presence of malachite green in water causes serious health effects such as mutagenesis, teratogenecity, chromosomal, respiratory toxicity, fractures, and carcinogenesis which depend on exposure time, temperature and concentration of dye [3]. Therefore, removal of malachite green from water by using various techniques is an essential concern for living being and environment. A number of techniques have been applied for removal of dyes from waste water. These include membrane separations, photo-degradation, advanced oxidation and chemical oxidation, flocculation, ozonation and adsorption [4–7]. Among them adsorption process is best methods because of its low cost, easy operation and simple design. The adsorption of dyes from aqueous solution by low-cost natural and synthetic adsorbents can be carried with or without chemical modifications.

Generally, modified adsorbents have been showed higher adsorption capacities compared to unmodified adsorbents because of presence of active groups on the surface sites. In the present paper an attempt has been made to compile the whole work on removal of malachite green dye from aqueous solution by using natural and synthetic adsorbents.

II. METHODOLOGY

This study has been made to compile the comprehensive data on removal of malachite green dye from aqueous solution by using natural and synthetic adsorbents. The study provides a systematic ranking of natural and synthetic adsorbents on the basis of adsorption capacity, cost and toxicity which helps to choose low cost and more efficient adsorbent.

III. DISCUSSION

3.1 Natural and Synthetic Adsorbents Used for Removal of Malachite Green from Aqueous Solution

From the literature review it was found that both natural and synthetic compounds are used as adsorbent for malachite green removal from water. The maximum adsorption capacities of both natural and synthetic compounds are listed in Table 1. The removal of malachite green by using bio-materials such as black tea, fresh water algae, moss rhytidiadelphus squarrosus, raw and modified peanut shell, pleurotus ostreatus (a macro-fungus), wood apple shell, degreased coffee beans, tamarix aphylla leaves, rubber wood (hevea brasiliensis) sawdust, rice husk bio-char produced by liquefaction have been discussed in detail by a number of research groups [10–17]. However, many compound are synthesized by various research groups for their application of removal of malachite green such as zeolitic imidazole framework-67, magnetic litchi pericarps, carboxylate functionalized multi-walled carbon nanotubes, magnetic β-cyclodextrin-graphene oxide nanocomposites, self-assembled ionic-liquid based organosilica, gold nanoparticles loaded on activated carbon, copper nanowires loaded on activated carbon, Graphene oxide caged in cellulose microbeads, granular composite hydrogel, novel superparamagnetic sodium alginate-coated Fe_3O_4 nanoparticles [1–9].The adsorption isotherm obeys the Langmuir model with high correlation coefficients as compared to Freundlich isotherm. Langmuir model suggests that monolayer sorption occurs on the surface of the adsorbent. The adsorption kinetic studies showed that the adsorption process followed the pseudo-second-order kinetic model with a multi-step diffusion process [2,3,6]. Adsorption of malachite green may be attributed by complex mechanism such as ion-exchange, complexation, physical interaction, and surface precipitation.

3.2 Prioritization of adsorbents on the basis of maximum adsorption capacity, cost and toxicity

Natural and synthetic adsorbents are prioritized on the basis of various parameters such as maximum adsorption capacity, cost and toxicity.

Table 1: Different Adsorbents for Removal of Malachite Green from Aqueous Solution

Name of Adsorbent	Q_{max} (mg/g)	Temp.	pH	Reference
Zeolitic imidazole framework-67 (ZIF-67)	2430	20 °C	–	[1]
Magnetic litchi pericarps (MLP)	70.42	25°C	–	[15]
magnetic β-cyclodextrin-graphene oxide nanocomposites (Fe_3O_4/β-CD/GO)	990.10	45 °C	7.0	[4]
Sphagnum peat moss (SPM)	121.95	20 °C	6.5	[12]
A self-assembled ionic liquid based organosilica (SAILBO)	19.23	–	7.0	[9]
Effective Microorganisms based compost(EMBC)	136.6	–	8.0	[11]
Gold nanoparticles loaded on activated carbon (Au-NP-AC).	140–172	–	–	[8]
Copper nanowires loaded on activated carbon (Cu-NWs-AC)	434.8	25 °C	5.5	[6]
Cellulose modified with maleic anhydride (CMA)	370	–	–	[7]
Cellulose modified with phthalic anhydride CPA	111	–	–	[7]
Novel grape waste activated carbon (GWAC)	667	Room Temp.	–	[5]
walnut shell (WS)	90.8	Room Temp.	5.0	[16]
Granular composite hydrogel (AA–IA–APT hydrogel)	2433		4.0–10.0	[2]
Acid-activated sintering process red mud (ASRM)	336.4	25 °C	2–8	[10]
Degreased coffee beans (DCB)	55.3	20 °C	–	[14]
Pithophora sp., fresh water algae thermally activated (PSATA)	117.6	25 °C	–	[13]
Peanut shell (PS)	32.73	25 °C	5.0	[17]

The maximum adsorption capacity of the all reviewed adsorbents follows the order; granular composite hydrogel (AA–IA–APTH)> zeolitic imidazole framework-67 (ZIF-67) > magnetic β-cyclodextrin-graphene oxide nanocomposites (Fe_3O_4/β-CD/GO)> novel grape waste activated carbon (GWAC)> copper nanowires loaded on activated carbon (Cu-NWs-AC) > Cellulose modified with maleic (CMA)> Acid-activated sintering process red mud (ASRM)> gold nanoparticles loaded on activated carbon (Au-NP-AC)> effective microorganisms based compost (EMBC)> sphagnum peat moss (SPM) 127.9 > pithophora sp., freshwater algae thermally activated (PSATA)> walnut shell (WS)> Magnetic litchi pericarps (MLP)> degreased coffee beans (DCB)> peanut shell (PS)> A self-assembled ionic liquid based organosilica (SAILBO) [Figure 1].

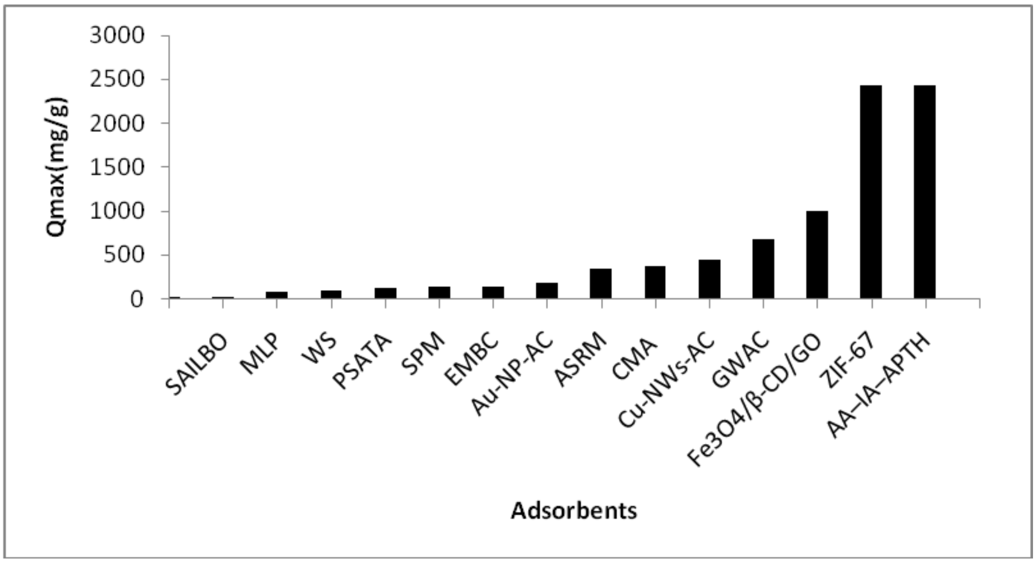

Figure.1: Maximum Adsorption Capacity of Different Adsorbents for Removal of Malachite Green From Aqueous Samples At Ph 2.0–10.

Moreover, it's quite important to evaluate other aspects such as cost and toxicity of the used adsorbent in order to make them environmental friendly and cost effective. Although it is very difficult to find the exact toxicity of all used adsorbents because of knowledge gaps in toxicity evaluations. Natural bio-adsorbents are environmental friendly and cost effective adsorbent but their efficiency is very low. However, synthetic materials are less friendly towards environment because of chemical nature of the compounds and expensive in cost with high maximum efficiency.

IV. CONCLUSION

The aim of this review is to prioritize natural and synthetic adsorbent on the basis of adsorption capacity for removal of malachite green. Synthetic granular composite hydrogel AA–IA–APT hydrogel and zeolitic imidazole framework-67 (ZIF-67) have maximum adsorption capacity for removal of malachite green from aqueous solution. However, the natural adsorbents are friendlier towards environment and also cost effective adsorbents for removal of malachite green.

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