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Research Article

Removal of Methyl Red Dye Effectively Using Sorbents Obtained from Bark and Leaf of *Erythrina Indica*

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Abstract

Dyes entering wastewaters affect both the aquatic creatures and humankind because they are toxic while also carcinogenic. As this is a trouble-free yet effective process, the adsorption system technology is being extensively employed to remove colors all from aqueous solutions for years. We investigated the use of *Erythrina indica* (EI) leaf powder, bark powder, leaf ash and bark ash for the adsorption of methyl red dye (MRD) from aqueous samples for its first time. The %MRD clearance using EI leaf powder, EI leaf ash, EI bark powder and EI bark ash displayed that the optimal condition of MRD clearance happened at pH unit of 4, 100 ppm concentration of MRD, sorbent dose at 1.4 gm/l, 27 ºC temperature, and mechanical shaker agitation speed of 100 rpm. The best equilibration times for greatest percentile MRD removal were 105 minutes with EI leaf powder, EI leaf ash, EI bark powder and EI bark ash. The leaf and bark powder of EI and leaf and bark ash of EI can be considered an alternative feedstock in eliminating MRD in aqueous system because of its strong biosorption capacity and low cost, according to this study.

Keywords: *Erythrina indica;* Biosorption; Biosorbent; Aqueous system; Methyl red clearance.

Introduction

Recent advances in industrial operations have resulted in the production of an enormous amount of wastewater containing artificial colors, polluting waterways and affecting humans as well as other living animals as a consequence. A significant portion of the color schemes applied are dyes of azo reactive nature[1-3]. Those dyes have a vivid colour since one or even more azo radicals are linked to modified aromatic structures[4]. Textile, cosmetic, food processing, leather, paper, and dye industry wastewaters are just only few instances of azo dyes released into the environment[5]. Such dyes or associated degradation products poison living things[6]. Colorants in effluent water are difficult to remove because they are impervious to heat, light, & oxidizing reagents. They are tough to decay in brief[7]. Chemical, biological, and physical methods such as ultra-filtration, coagulation, electro-chemical adsorption, and photo-oxidation have to be coordinated to achieve a significant level of dye removal in sewage systems[8]. Physical adsorption procedures are frequently considered as the best approach for eliminating / filtering organic contaminants due to their high efficacy and ability to separate a wide range of such chemical components[9-11].

Pertaining to reduced price also wide range of availability of waste from agricultural products as the basic resource, its usage tempted huge interest in research sector. Banana peels[12], Sugarcane bagasse[13], Fibres of Palm kernel[14], Wheat and rice barn[15], husk of rice[16], waste from tea[17], coconut shell[18], apple pomace in addition to wheat straw[19], and garlic peels[20], almond shells[21], Eucalyptus globulus seeds[22], and flower spikes[23] are few of the agro residual products employed in colorants elimination.

Methyl Red Dye (MRD) is a prevalent mono azo dye used in laboratory assessments, textiles, and many commercial items; however, it could also cause eye & skin allergies, along with pharyngeal/digestive system irritation if inhaled/eaten[24]. MRD is indeed mutagenic under aerobic settings, since it bioconverts to 2-aminobenzoic acid & N-N' dimethyl-p-phenylene diamine[25,26]. There has recently been such a boom in enthusiasm in developing cost-effective ways for reducing, if not completely eradicating, MRD in effluent water before its discharge into a collecting source of water.

Erythrina indica (EI) is a deciduous tree legume that appears in practically every state in India[27]. The EI bark aids digestion and lowers cholesterol levels. EI bark may also be used to alleviate liver problems, fever, as well as rheumatism[28]. EI flowers & leaves have antidiuretic, antiinflammatory, and antibacterial qualities and are used to alleviate ear inflammation[29]. As in form of paste, it also is utilized as a folk medicine to improve lactation. Like a biosorbent, this herb has never ever been utilized to remove MRD in polluted water.

As a sequel, the core purpose of current study was to see if EI powder and ashes of leaves and barks could well be assessed to create a novel sorbent, as well as to assess its performance in removing MRD from industrial effluents. pH, sorbent dosage, and contact time all were assessed in a methodical manner.

Materials and Methods

EI leaf and bark as sorbents

Locally, EI, belonging to Fabaceae family, was accessible. The leaves and barks of the EI plant were picked, cut as tiny chunks, washed using double distilled water, and left to dry in the sun over 7 days. To prepare powder of leaf/bark powder, dried leaves/bark were ground inside a super high power blender, then sieved to remove the fibres. Then they were fired in a kiln for about two hours to generate the ashes.

Adsorbate – methyl red

The methyl red was supplied by "Merck India Ltd, India," and it was used without further purification. A 100 ppm, methyl red dye (MRD) solution was developed for this study. The prepared MRD solution subsequently wrapped in aluminium foil and stored in the darkness to eliminate unwanted exposure to light.

Adsorption experiments[30-32]

The sorbents (EI's leaf /bark powder and leaf/bark ash) were accurately weighed and added to a well cleansed 500 mL bottles with cap containing 250 mL of MRD -100 ppm quantity, solution. HCl - 0.1 M or NaOH - 0.1 M solutions were used to modify the pH of combinations (sorbent plus MRD solution) based upon respective initial pH value. Mechanical mixers were utilised to violently agitate the mixes (sorbent and MRD solution) before allowing mixture to reach equilibrium for such required period. However, following the equilibration period, an aliquot of both the combination (sorbent plus MRD solution) was taken for spectrophotometric analysis of MRD that remained within mixture. The MRD complies "Beer-Lamberts Law" at low concentrations and even has a peak wavelength 464.9 nm. A UV-Visible spectrophotometer manufactured by "Systronics" was used to test MRD absorption at 464.9 nm. MRD residual content (ppm) can indeed be estimated using MRD absorbance measurements.

The MRD eliminated (percent) and also the adsorbed amount of MRD (mg/gm) were calculated using the formulas below.

$$\text{Percent of MRD removed (\%)} = \frac{\text{MRD IC - MRD EC}}{\text{MRD IC}} \times 100$$

$$\text{Quantity of MRD absorbed (qe)} = \frac{\text{MRD IC - MRD EC}}{\text{AS}} \times \text{V}$$

Where, MRD IC - initial concentration of MRD (mg/l); MRD EC - equilibrium concentration of MRD (mg/l); AS - sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) mass; V - test MRD solution.

Employing the early-mentioned experimental approach, the MRD % clearance from simulate water samples was studied in terms of pH values, equilibration time, mechanical shaker agitation speed, initial MRD quantity, temperature, and concentration of sorbent dose.

Results and Discussion

Equilibration time

At pH units 2, 4, 6, 8, & 10, the equilibration time for maximal percent MRD elimination using sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) was examined. The MRD% clearance improves through period for a

specific sorbent (EI's leaf powder/bark powder/leaf ash/bark ash) at a specified pH, and over a certain time period, the percent clearance of MRD remains static, suggesting thus an equilibrium position has been achieved. The findings are represented as value of clearance of MRD in Tables 1-4. The largest MRD% clearance was accomplished using leaf powder, bark powder, leaf ash and bark ash of EI after a 105-minute equilibration interval (Tables 1-4 and Figures 1-4).

Table 1: Equilibration time for EI leaf powder to clear MRD

Percentage (%) clearance of MRD at different					
Time (min)	**pH =2**	**pH =4**	**pH =6**	**pH =8**	**pH =10**
15	10	25	20	18	12
30	20	33	27	22	19
45	30	42	34	30	26
60	40	50	40	36	31
75	48	55	46	41	36
90	54	60	50	46	40
105	60	66	57	50	44
125	60	66	57	50	44
140	60	66	57	50	44

Table 2: Equilibration time for EI leaf ash to clear MRD

Percentage (%) clearance of MRD at different					
Time (min)	**pH =2**	**pH =4**	**pH =6**	**pH =8**	**pH =10**
15	20	30	21	15	10
30	30	42	30	22	17
45	38	50	36	30	24
60	49	56	42	37	30
75	55	61	50	43	39
90	63	69	56	49	45
105	70	76	60	55	50
125	70	76	60	55	50
140	70	76	60	55	50

Table 3: Equilibration time for EI bark powder to clear MRD

Percentage (%) clearance of MRD at different					
Time (min)	**pH =2**	**pH =4**	**pH =6**	**pH =8**	**pH =10**
15	20	28	23	10	5
30	26	35	31	15	10
45	32	42	36	20	15
60	37	49	41	25	20
75	42	55	47	30	25
90	49	60	53	35	30
105	56	68	60	40	35
125	56	68	60	40	35
140	56	68	60	40	35

Table 4: Equilibration time for EI bark ash to clear MRD

Percentage (%) clearance of MRD at different					
Time (min)	**pH =2**	**pH =4**	**pH =6**	**pH =8**	**pH =10**
15	22	30	27	20	10
30	30	38	33	25	21
45	36	49	41	30	28
60	41	54	49	35	33
75	49	61	54	40	36
90	55	68	59	45	39
105	60	71	65	50	43
125	60	71	65	50	43
140	60	71	65	50	43

Kadam et al.[33] discovered that *Fimbristylis dichotoma* and *Ammannia baccifera* alleviated MRD up to 91% and 89%, respectively after 60 hr of exposure, compared to our inveatigation using leaf powder, bark powder, leaf ash and bark ash of EI. *Salvinia molesta* had been reported to be effective of destroying azo dye up to 97% over 3 days using root biomass, pertaining to Chandanshive et al.[34]

Percentage clearance of MRD by sorbents – optimum pH

The pH value of this reaction does indeed have a substantial impact on MRD molecule adsorptive uptake attributable toits thwack on the sorbents surface character features (EI's leaf powder/bark powder/leaf ash/bark ash) and even the dissociation also ionization of MRD molecule. The

pH influence onpercent clearance of MRD was investigated utilizing an initial quantity of MRD (100 ppm) about 250 ml with 2 g sorbent (EI's leaf powder/bark powder/leaf ash/bark ash). Based on their beginning pH units, the mixtures' pH (sorbent + MRD solution) was changed using 0.1 M HCl / 0.1 M NaOH to generate a series of pH units 2, 4, 6, 8, and 10. At room temp, mechanical shakers have been used to shake the suspensions, and afterwards the percent clearance of MRD was measured. Table 5 shows the MRD percent removal in solutions of varied pH units (2, 4, 6, 8, and 10). From pH units 2 to pH 4, the percent MRD removal capability of examined sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) increased and decreased through pH levels 6 to 10. For all examined sorbents (EI's leaf powder/bark powder/leaf ash/bark ash), the highest percent MRD removal was achieved around pH level 4. In a chemical environment with a pH values (2–4), the intensity of H^+ ions increases. By receiving H^+ ions, sorbents surface of (EI's leaf powder/bark powder/leaf ash/bark ash) gain a positive charge.

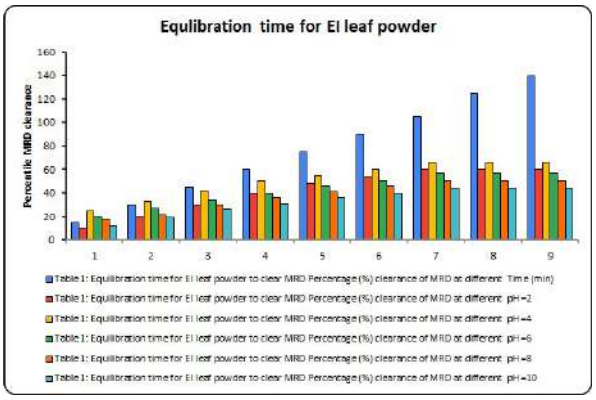

Figure 1: Equilibration time for EI leaf powder to clear MRD

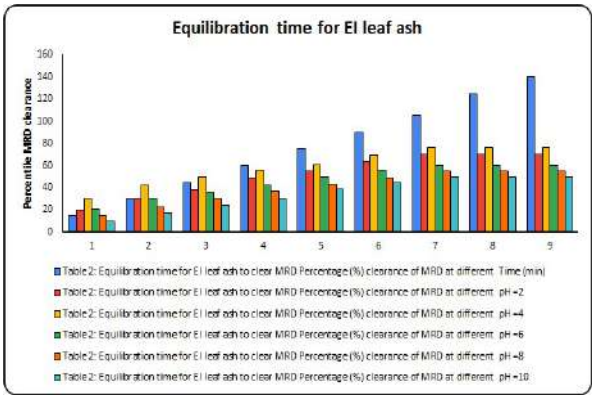

Figure 2: Equilibration time for EI leaf ash to clear MRD

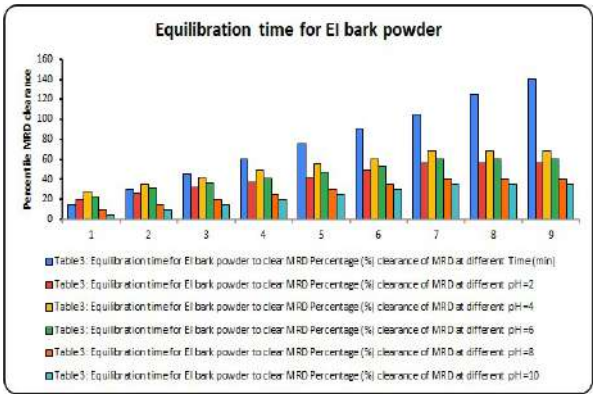

Figure 3: Equilibration time for EI bark powder to clear MRD

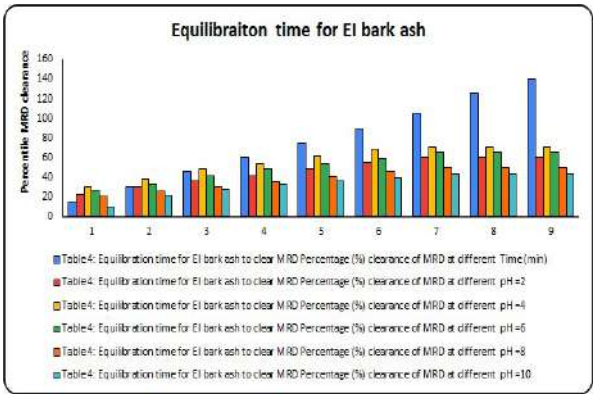

Figure 4: Equilibration time for EI bark ash to clear MRD

As a result, the capacity of adsorption of the sorbents improves, and the percent MRD removal rises. Because MRD loses its H^+ ions, it turns into negatively charged and incapable to participate with explored sorbent (EI's leaf powder/bark powder/leaf ash/bark ash), the adsorption efficiency of explored sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) was lowered at exorbitant pH values (6–10).

Table 5: Optimum pH unit for maximum percentage clearance of MRD by inspected sorbents

pH unit	% MRD clearance with EI's			
	Leaf powder	Bark powder	Leaf ash	Bark ash
2	63	46	51	52
4	73	69	67	62
6	49	56	48	53
8	45	42	42	41
10	31	35	33	30

The data of this research are comparable from those of Ramana et al.[32] and Krishna et al.[35]

Hyacinth plant material (Ramana et al.), *Tinospors cordifolia* plant material (Ramana et al.) Charred Sal sawdust (Krishna et al.), and Xanthated Sal sawdust (Krishna et al.) were shown to have an optimal pH of 4 for optimum MRD clearing.

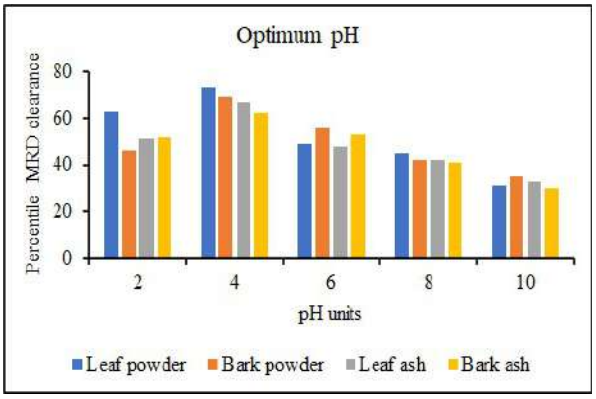

Figure 5: Optimum pH unit for maximum percentage clearance of MRD

Sorbents dose effect on percentage MRD clearance

Using sorbent dosage of 0.2 gm/l, 0.4 gm/l, 0.6 gm/l, 0.8 gm/l, 1.0 gm/l, 1.2 gm/l, 1.4 gm/l& 1.6 gm/l, the impact of examined sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) upon that % MRD removal at optimal MRD concentration The mixture's (sorbent + MRD solution) pH was set to 4 pH with HCl or NaOH of 0.1 M strength solutions. The percent clearing of MRD had been assessed at relating equilibration points of time (105 min for EI's leaf powder/bark powder/leaf ash/bark ash) of explored sorbents employing mechanical shakers at ambient temperature.

Table 6: Optimum dose concentration for maximum percentage clearance of MRD by inspected sorbents

Dose quantity (gm/l)	% MRD clearance with EI's			
	Leaf powder	Bark powder	Leaf ash	Bark ash
0.2	28	29	40	31
0.4	33	37	46	37.5
0.6	41	45	52	49.2
0.8	50	48	56	58
1.0	55	58	62	64
1.2	62	60	68	72
1.4	67	69	77	81
1.6	67	69	77	81

Table 6 shows the percent elimination of MRD in mixtures containing various dose amounts of examined sorbents. At similar equilibration durations and 4 unit pH, the % MRD removal capability of examined sorbents rose from 0.1 to 1.4 gm/l dose quantities. From 1.4 gm/l dose quantities, the MRD % removal capability remained unchanged.

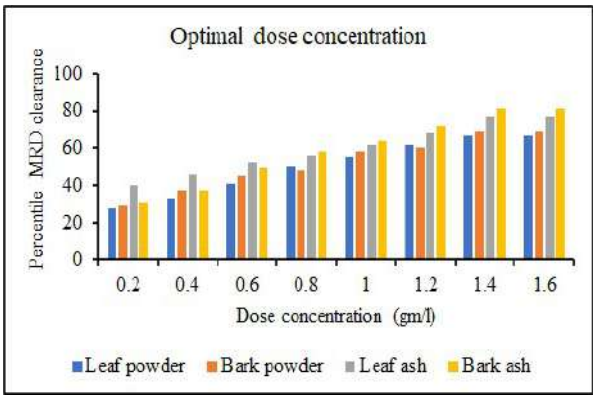

Figure 6: Optimum dose concentration for maximum percentage clearance of MRD

Kaya discovered that a 4 gm dosage quantity of shells of wallnut (79%) and hazelnut (77%) removed MRD effectively[36]. According to Vatsal, the recommended amount of orange peel powder for best MRD removal is 4 to 5 gm[37]. Comparing to Kaya and Vatsal reports, our study proved that 1.4 gm/l dose quantities of leaf powder, bark powder, leaf ash and bark ash of EI is enough for effective removal of MRD.

Temperature effect on percentage MRD clearance

Through a series of studies, the ideal temperature of MRD removal through the investigated sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) had been identified. Table 7 illustrates percentile MRD clearance by investigated sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) against ambient, 40 °C, 50 °C, and 60 °C temperatures. As when the temperature rose, the amounts of colour absorbed by tested sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) were similar. As a consequence, we determined an optimal atmospheric temperature of 27 °C.

Table 7: Optimum temperature for maximum percentage clearance of MRD by inspected sorbents

Sorbent	Percentile MRD clearance at temperature of			
	27°C	40 °C	50 °C	60 °C
Leaf powder	68	56	54	34
Leaf ash	71	63	46	42
Bark powder	78	69	63	61
Bark ash	85	64	59	47

Our results concur those of Eman's earlier studies[38]. Sunil et al. found that raising the

temperature from 25 to 55 degrees Celsius enhanced the amount of MRD eliminated by eggshell waste[39].

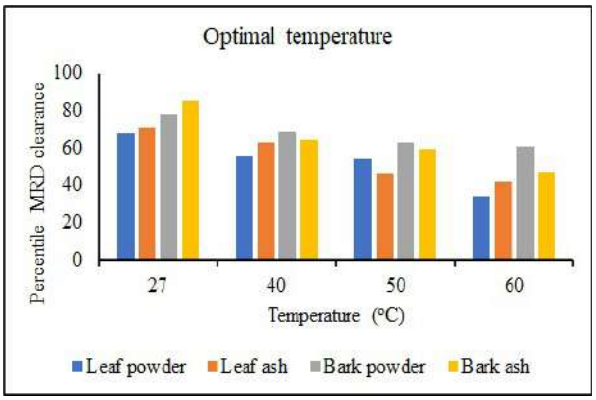

Figure 7: Optimum temperature for maximum percentage clearance of MRD

Optimal MRD initial quantity for maximum percentage of MRD clearance

Using MRD solutions of varying dye amounts, 1.4 gm/l studied sorbents (EI's leaf powder/bark powder/leaf ash/bark ash) were introduced with 100 ppm, 150 ppm, 200 ppm, 250 ppm also 300 ppm. The sorbent with MRD solutions was kept at 4, and was stirred for maximal time of equilibration (105 min). The link among the quantity of MRD removed and the starting concentration of MRD with in solution is shown in Table 8. The higher the baseline MRD quantity, the lower the MRD elimination percent was found to be. In the initial stage of the adsorption activity, the adsorbent's facet has a large number of empty sites. As when the adsorption process continues, these sites' ratio decreases. There are several activated areas upon that facets of sorbents with modest starting MRD levels. However, at great baseline MRD concentrations, there are simply not sufficient unoccupied active sites.

Table 8: Optimal MRD initial quantity for maximum percentage clearance of MRD by inspected sorbents

Sorbent	Percentile MRD clearance at initial quantity of MRD at				
	100 ppm	150 ppm	200 ppm	250 ppm	300 ppm
Leaf powder	75	73	69	58	56
Leaf ash	82	75	62	54	46
Bark powder	69	64	61	58	42
Bark ash	71	63	56	51	39

According to Noha et al., using oil shale, the removal rate of MRD dropped as the beginning MRD content grew from 10 to 100 ppm[40].

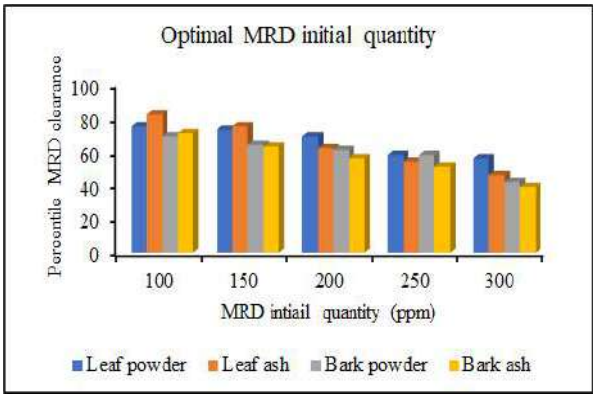

Figure 8: Optimum initial MRD quantity for maximum percentage clearance of MRD

Optimal agitation speed for maximum percentage of MRD clearance

With sorbents dosage as 1.4 gm/l, the effect of agitation rate on % MRD removal at maximum beginning MRD level of 100 ppm at 250 mL was investigated. The sorbent with MRD solution's pH was preserved at 4. The suspensions agitations were carried out with the help of mechanical shakers with varied agitation speeds of 50,100,150,200 as well as 250rpm.The removal % of MRD was assessed with the time of equilibration of the sorbents investigated at 105 min for EI leaf powder, EI leaf ash, EI bark powder and EI bark ash. Table 9 shows the percent removal of MRD from solutions containing the examined sorbents at various agitating rates. As when the agitating velocity rose from 50 through 100 rpm, the percent MRD removal was enhanced. As a consequence, 100 rpm was chosen as the ideal rate of agitation. Following that, while the agitating velocity was increased, the percent MRD elimination declined. When agitation velocity rose, the thinner surface sorbent's endurance reduced, showing that now the MRD had interacted well with sorbent. The % MRD removal declined after that because the sorbent functional areas attained the saturation level by MRD there at optimum agitation rate.

Table 9: Optimal agitation speed for maximum percentage clearance of MRD by inspected sorbents

Sorbent	Percentile MRD clearance at initial quantity of MRD at				
	50 rpm	100 rpm	150 rpm	200 rpm	250 rpm
Leaf powder	59	64	56	52	51
Leaf ash	62	78	64	59	52
Bark powder	69	81	75	72	66
Bark ash	78	86	64	52	51

Tay et al. found that agitation rapidity of 200 rpm was the most effective for removing MRD

utilising adsorbent made from hollow fruit bunches[41]. Ola et al. found that agitation rapidity of 240 rpm was the most effective for removing cationic dyes and anionic dyes utilizing carbon nano tubes as adsorbent[42].

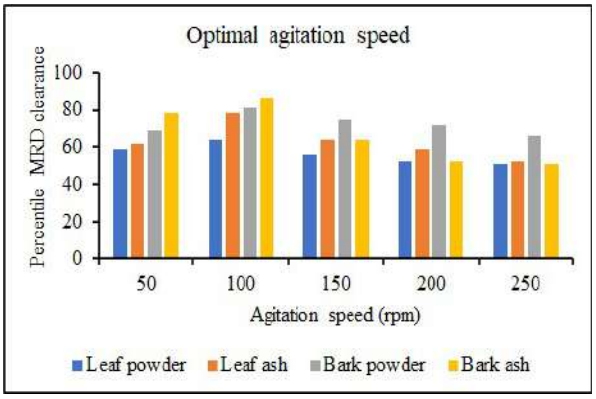

Figure 9: Optimum agitation speed for maximum percentage clearance of MRD

Conclusion

The biosorption capability of leaf powder, bark powder, leaf ash and bark ash of EI plant towards MRD was investigated for the 1st ever. The pH influence, dose of sorbent, mechanical shaker agitating speed, temperature, MRD amount at the beginning along with equilibration rate upon the biosorption efficacy of EI leaf powder, EI leaf ash, EI bark powder and EI bark ash was investigated. According to the findings, EI, which is abundantly available, can be employed as an effective sorbent for said MRD removal from aqueous systems.

Conflict of Interests

The researchers have confirmed that there are no conflicting interests.

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