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Adsorption Studies of Dyes from Aqueous Solution by Low-cost Bio-adsorbents: A Review

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Abstract:*Toxic, carcinogenic, and create hazardous impact on ecosystem. but use of synthetic dyes isconvenient. because preparation of natural dyes is costly, time consuming, and complicated as compare to synthetic dyes.These synthetic dyes used in industries like pulp,paper, paints,plastic, cosmetic,medicine,rubber,food etc.waste water coming out from such industries contain synthetic dyes. for removal of such synthetic dyes from waste water researchers use many techniques in this review article we discuss limitations of this techniques [4] out of that technique's adsorption technique is low-cost, simple,ecofriendly technique. But some adsorbents like CAC and CAA require high investment. To avoid this problem bio-adsorbents used as adsorbents. Plant biomass like rice husk, sawdust, dried, leaves,bark,root,seeds, are used as a bio adsorbent which are show superior adsorption capacity towards dyes. Treated and untreated powder of dried leaves shows significant adsorption capacity for dyes. The main intention of this review article is study of effect of temperature and contact time on various plant derived bio-adsorbent.*

Key Word*:Synthetic dyes, waste water, adsorption capacity, removal efficiency, temperature, contact time.*

I. Introduction

From ancient time we use dyes for coloring the various materials. Until 1856 whole world used natural dyes which are obtained from plant or animal. Forexample,Cochineal dye, cochineal dye has bright red in color and this dye obtained from cochineal insect. About 7000 insects use to prepare one pound this dye. Tyrianpurple, Tyrianpurple dye has purple in color and this dye obtained from sea mollusk. About 12,000 sea mollusks use to prepare 1gm of this dye. Indigo dye is obtained from indigo plant biomass it requires several weeks for preparation. Because of this tedious and costly method used in preparation of natural dyes were used by only rich people. In1856 Sir William Henry Perkin discovered first synthetic dye named as 'Mauveine' and this discovery responsible for modern pulp, plastic, paint,paper,textile,cosmetic,food,medicine industries.Synthetic dyes are cheaper to produce bright,easily apply,fast color because of this properties in every field like paint,paper,pulp,plastic,paint,textile,food,medicine rubber, leather industries use synthetic dyes [1] .This is doubtless synthetic dyes are responsible for today'scolorful world but chemicals used to prepare synthetic dyes are carcinogenic,toxic,and shows hazardous impact on health .Waste water generated in industries like pulp,paint,paper,plastic, rubber, cosmetic,leather, food,medicine contaminated by such chemicals.If this waste water directly discharges in water bodies without any water treatment cause huge amount of water pollution.Because these industries are highly water consumer industries. Thus,color removal from waste water is one of the difficult tasks facing by such industries to control water pollution.To overcome such problems researchers, use various physical,chemical, and biological techniques like froth floation,chemical oxidation, chemical precipitation,coagulation,membrane separation,solvent extraction,membrane filtration,electrochemical and aerobic and anaerobic microbial degradation [2] microfiltration,nanofiltration [4]. These techniques are dominant for removal of contaminant from waste water but have some limitations associated with itlike requirement of high solute concentration [1],high operation cost, toxic by-products,use of variety of chemicals, use of variety of instruments,difficult to install etc. For example, in coagulation technique require chemical treatment [3] and it produce large amount of sludge [1]. In chemical oxidation technique oxidizing agents are very expensive or unstable [4]. Frothfloation is a separation process. It has high capital cost with maintenance and operation cost and it is pH dependent process [4]. In chemical precipitation process done uptake of pollutants from waste water. But it's main disadvantage is chemical consumption and physiochemical monitoring[4].Membrane filtration technique require high investment[4].microfiltration process require high energy [4].For nanofiltration process require high maintenance and operation cost[4].For solvent extraction (liquid-liquid) have high equipment cost[4].While adsorption technique is non-fatal, technologically simple and compliant to many treatment[4].The only disadvantage associated with it is high investment for (CAC) and (CAA) [4].Literature revealed thatdue to cost effectiveness CAC and CAA researchers use bios sorbents.Recent research papers proved that; naturally available bio-adsorbents shows potential adsorption capacity towards dyes. The recent research papers demonstrate that,pH shows significant effect on adsorption capacity of acidic dyes towards bio adsorbents [1]. The main prominence of this reviewed article is studies on temperature and contact time effects on adsorption capacity of bio-adsorbents. Another intention of this review article is to demonstrate the various bio-adsorbents and how temperature and contact time affects adsorption capacity of bio-adsorbents.

Deliberation of adsorbents reported by literature:

Literature survey reveals that, there are various adsorbents available for adsorption of dyes.For examples,

Commercial activated carbon (CAC): The Commercial Activated Carbon shows high adsorption capacity towards dyes[4].There are three main types of CAC available in market for example-granular,irregular,powdered form. The adsorption capacity of CAC depends on various factor such as surface area, pore size,functional group present on surface of adsorbent,solubility etc.[4] For example- adsorption capacity on mesoporous pine cone carbon is more than the microporous commercial F400 carbon [5]. And small molecular mass dye adsorbed on microporous commercial F400 carbon. The many research article reported on CAC but economically it is not better adsorbent.

Commercial activated alumina (CAA): Activated alumina shows about 90% adsorption capacity towards Cibacron (reactive) yellow dye [6].Also activated alumina granules generated chemically as well as thermally [6]. Nano porous alumina also shows high adsorption capacity towards anionic dyes[7] only 30 sec.of contact time it removes 30% dye and after 6 min. it remove 60% dye[7]. Activated Alumina remove Diresul black dye from waste water[8]. Like CAC high investment for CAA. That's why,only few research articles reported on it.Due to requirement of high investment for CAC and CAA literature reported low-cost bio adsorbents.

Some low-cost bio-adsorbent:

Rice husk:

Rice husk used to remove Direct red -31 and Direct orange -26 dye from aqueous solution [10]. Rice husk physically and chemically treated to increase adsorption capacity [10].HCL treated rice husk has more efficiency to remove Direct red -31 and Direct orange-26 dye from aqueous solution than free rice husk[10]. High temperature shows positive affect on adsorption of Direct dyes[10]. Adsorption process of Directred-31 and Direct orange -26 follows pseudo-second order kinetics[10].Rice husk used to remove Acid yellow 36 at pH 3.Rice husk show high adsorption capacity towards acid yellow 36 [17]. Rice husk used as adsorbent to remove Congo red dye from aqueous solution in a column mode. And adsorption of Congo red depends on flow rate, concentration of Congo red in inlet and bed depth[11].Rice husk ash as an effective adsorbent to remove indigo carmine dye [12] from aqueous solution. A rapid adsorption of indigo carmine dye in first 15 min. and after that gradually decreases. Equilibrium reaches in 8h [12]. Adsorption of indigo carmine dye increases with increase in temperature and this is endothermic process shows second order kinetics [12]. Acid green 25 dye also removed by rice husk carbon. Adsorption is pH dependent, endothermic,and follows pseudo second order kinetics[13]. NaoH modified rice husk remove crystal violet dye from aqueous solution [14]. In this case adsorption efficiency of rice husk decreases with increase in temperature [14] Because bond breaking between dye molecule and adsorbent with high temperature.So, this is an exothermic adsorption process[14].Due to more surface area at first 60 min. adsorption rate is very high and at a higher contact time adsorption decreases.

Sawdust:

Orange- G dye removed from an aqueous solution by H2SO4 treated sawdust [15]. About 63.2% Orange-G dye adsorbed at pH 1 and removal of dye increases with increasing contact time with certain limit. Adsorption follow second order kinetics [15]. Congo red dye removed from aqueous solution by untreated sawdust [16] The extent adsorption of conga red dye after 70 min. after that constant and 80% dye removed [16]. Adsorption efficiency of Congo red dye increases with increase in temperature because mobility of dye ions increases [16]. For acid yellow -36 Mahogany sawdust carbon have high adsorption capacity than rice husk [17] and contact time,pH,perform significant role in adsorption process[17].

Dried leaves:

Acid blue,Acid red,and malachite green dye removed by using Nirgudi leaves powder as a adsorbent [18]. For above dyes removal efficiency increases from 67% to 77% when temperature increases from 308.5k to 318.15k[18]. This indicate that this adsorption process is temperature dependent[18]. It flows second order kinetics. *Mangifera indica* leaf powder used as adsorbent for removal of Rhodamine B dye from aqueous solution [19]. In this adsorption process contact time increases from 5 min.to 45min.increases the removal efficiency of Rhodamine B dye from 48% to 77% because availability of large surface area of bio-adsorbent. Adsorption of dye increases with increase in temperature indicate that, this is endothermic adsorption process[19]. Azadirachta indica leaf powder used as adsorbent for removal of Congo red dye [20] from aqueous solution. This adsorbent shows potential removal efficiency for Congo red dye a 1gm of adsorbent remove 35mg of dye if we agitate 5hour[20]. This, is pH independent adsorption process and adsorption decreases with increasing temperature.This indicate adsorption of Congo red dye by Azadirachta indicaleaf powder is an exothermic adsorption process[20] and it follows second order kinetics.*paulownia tomentosasteud*leaf powder used as an adsorbent for removal of Acid orange52 dye from aqueous solution[21]. effect of solution pH indicates that,the adsorption efficiency of adsorbent decreases with increase in pH,adsorption increases with increasing contact time [21] effect of solution temperature indicate that this is exothermic adsorption processmeans adsorption capacity of adsorbent decreases with increase in temperature [21]and adsorption follow second order kinetics. Acid activated jaswand leaf powder used as adsorbentfor removal of Acid blueacid red,and malachite green dye from aqueous solution [22] study of effect of temperature on solution indicate that adsorption capacity of adsorbent increases with increase in temperature so,this is endothermic adsorption process[22]and it follow second order kinetics.Study of pH effect on solution indicate that up to 7.2 pH adsorption increases beyond this pH adsorption decreases because leaf containing organic acid component form aqua complex which decreases dye adsorption[22] low-cost activated carbon obtained from dried leaves of *Aloe barbadensis Mill.*used as adsorbent for removal of basic and acidic dyes like Congo red,Rhodamine B ,and Rose Bengal[23] study of effect of contact time reported that, equilibrium established after 50min.[23]in adsorption of above dyes .And this process is endothermic adsorption process.[23] Olive leaves powder used as adsorbent for removal of crystal violet dye from aqueous solution[24] Study of effect of contact time reported that,adsorptionincreases with increasing contact time till equilibrium and equilibrium attain after 20 min.[24] Effect of temperature not reported for this adsorption process and it follows pseudo second order kinetics[24]. Reactive red dye removed from industrial waste water by using acetic acid treated soyabean dried leaves as a adsorbent[25] In this adsorption process adsorption of Reactive red dye increases with increase in temperature,hence this is endothermic adsorption process[25] and study of effect of contact timeshows thatfirst 30min.adsorption is very fastafter that slightlyincreases up to 90min.and equilibrium reached after 90min.[25].

Bark of Plants:

Eucalyptus sheathiana bark used to remove methylene blue dye from aqueous solution[9]. Kinetic study shows that,adsorption of methylene blue dye on E.S bark follows pseudo second order kinetics and adsorption controlled by chemisorption process. This is multistep process[9] The E.S bark shows high adsorption capacity towards basic dye methylene blue and acidic dye Congo red [9]due to presence of divalent and trivalent salt in methylene blue increase removal tendency of E.S bark biomass [9] This E.S bark biomass is inexpensive bio-adsorbent available which alternative for expensive adsorbent.

Table 1:Effect of temperature of solution and contact time on adsorption capacity of different Bio-adsorbents.

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Bio-adsorbents	**Dyes**	**Temperature in K**	**Adsorption capacity in mg/g**	**Thermal nature of adsorption process**	**Reference**
Rice husk	**Indigo carmine dye**	**293k to 323k**	**26mg/g to 66mg/g**	**Endothermic process**	**[12]**
Rice husk (NaoH modified)	**Crystal violet**	**293k to 313k**	**40mg/g to 33 mg/g**	**Exothermic process**	**[14]**
Untreated sawdust	**Congo red**	**298k to 308k**	**38mg/g to 44mg/g**	**Endothermic process**	**[16]**
Nirgudi leaf powder	**Acid blue,Acid red, Malachite green**	**308.15k to 318.15k,**	**67mg/g to 77mg/g,**	**Endothermic process**	**[18]**
***Mangifera* indica leaf powder**	**Rhodamine B**	**293 to 303k**	**2mg/g to 3mg/g**	**Endothermic process**	**[19]**
***Azadirachta indica* leaf powder**	**Congo red**	**303k to 323k**	**0.16mmol/g to 0.12mmol/g (exceptional)**	**Exothermic process**	**[20]**
***Paulownia tomentosa steud.* Leaf powder**	**Acid orange 52**	**298k to 318k**	**21.9 mg/g to 19.3 mg/g**	**Exothermic process**	**[21]**
Acid activated jaswand leaf powder	**Acid blue, Acid red, Malachite green**	**308k to 318k**	**68.2mg/g to 73mg/g, 68mg/g to 71mg/g, 67.8mg/g to 69mg/g.**	**Endothermic process**	**[22]**
Soyabean leaves (acetic acid activated)	**Reactive red -195**	**298k to 323k**	**82mg/g to 97mg/g**	**Emdothermic process**	**[25]**

Table 2: Effect of contact time on adsorption capacity of different Bio-adsorbents:

Bio-adsorbents	**Dyes**	**Contact time**	**Adsorption capacity**	**Reference**
Rice husk ash	Indigo carmine dye	0 to 540 min.	10% to 98%	[12]
2] Rice husk (NaoH modified)	Crystal violet	0 to 200 min.	2.5% to 4% at 293 k	[14]
3] sawdust (H2s04 activated)	Orange -G dye	0 to 40 min.	0% to 30%	[15]
4] sawdust (untreated)	Congo red	0 to 150 min.	0 % to 80 %	[16]
5] Mangifera indica leaf powder	Rhodamine B	5 to 80 min	48 % to 77 % at 50mg/l Conc. of dye	[19]
6]*Azadirachta indica* leaf powder	Congo red dye	60 to 300 min	49.9 % to 95 % at 1.0 (g/I) Conc. of dye	[20]
7]*paulownia tomentosa steud* leaf powder	Acid orange 52	0 to 200 min	0 % to 2.4 %	[21]
8] *Aloe barbadensismill*.leaf powder	1. congo red 2.malachite green 3. Rhodamine B 4. Rose bengal	0 to 60min.	1. 0% to 80% 2. 2. 0% to 99% 3. 0% to 85% 4. 4. 0% to 72%	[23]
9] Olive leaves	Crystal violet	0 to 60min.	0% to 99%	[24]
10] Soyabean leaves (acetic acid modified)	Reactive red 195	0 to 135 min.	0 to 95% at 323k	[25]

II. Conclusion

In this review article we discuss cost effectivenessof some adsorbents and how bio adsorbents are alternative solution and how effect of contact time and temperature on adsorption capacity of bio adsorbents.This review article focused on effect of adsorption process and gives information about on some adsorption process, whether adsorption process is endothermic or exothermic. Literature review proved that, dried leaves powder of plant Olay significant role as aadsorbent in adsorption of dyes.This, indicate that,now a demand of various bio adsorbents obtained from plant biomass and find out effect of temperature of solution and contact time on adsorption process.

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