INDUSTRY WASTEWATER POLLUTION CONTROL BY ADSORPTION-A LOW COST PROMISING PHYSICO-CHEMICAL TREATMENT

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ABSTRACT

As any kind of industry is consuming hazardous chemicals in large amount, industrial wastewater having high concentration of various chemical parameters causes water pollution. Adsorption is an efficient method for removal of water pollution parameter using natural adsorbent as well as activated carbon materials. Waste water sample was treated with 10 gm/l dose of GLP, at variable contact time (30 min, 60 min, 90 min, and 120 min) at pH 7. Maximum reduction of different parameter of textile waste water was achieved at 30 min contact time at pH 7. Removal efficiency of waste water quality parameters at 30 min was obtained, i.e. Nitrate reduces up to 38.70%, Hardness 41.70%, Nitrite 50.00%, TSS 50.85%, TDS 54.28%, COD 64.51%, BOD 80.00%, Hexavalent Chromium 85.71%, Iron 90.24%, and Turbidity 94.15%. Textile waste water sample was treated with variable dose (5 gm/l, 10 gm/l, 15 gm/l, 20 gm/l) of GLP, at 30 min contact time at pH 7. Maximum reduction of different parameter of textile waste water was achieved at 5 gm/l dose of GLP and 30 min contact time at pH 7. % Removal efficiency of waste water quality parameter at 5 gm/l GLP dose are Nitrate reduces up to 27.74%, Hardness 44.64%, TSS 50.85%, Nitrite 51.56%, TDS 65.71%, COD 76.95%, BOD 86.66%, Hexavalent Chromium 87.14%, Iron 92.70%, Turbidity 92.73%. Experimental data obtained by analysis were tested with adsorption models like Langmuir, Freundlich, Temkin and BET isotherm. The best fit for Turbidity is obtained for Temkin isotherm. The best fit for COD, BOD, TDS, and Hardness were obtained for Langmuir and BET isotherm. The best fit for Iron was obtained for Langmuir isotherm. The best fit for Nitrate was obtained for BET isotherm. TSS, Cr⁺⁶, Nitrite dose not followed any adsorption isotherm. The FTIR report of GLP shows the presence of different functional groups (-OH, alkyl, phenol, -C=O Carbonyl group, Aldehyde, Ester, -C=C-Alkene, -CH₃ bend, C-O, COOH, -O-, COOR, -CN amines) in it. Under adequate agitation these particles then grow in size to form flocks, which can be settled by gravity or can be removed by filtration. If any matter present in the suspended from than they can adsorb on the surface of adsorbent.

KEYWORDS: Guava leaves powder (GLP), Adsorption, Adsorption isotherm, FTIR

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INTRODUCTION

Waste water from manufacturing or chemical processes in industries contributes to water pollution. Industrial waste water usually contains specific and readily identifiable chemical compounds. Water pollution is concentrated within a few subsectors, mainly in the form of toxic wastes and organic pollutants. Large number of chemical, diamond, textile, iron and steel, cement, pharmaceuticals and many other industries are running now-a-days as a result of technical progress. As a result of rapidly expanding industrialization, urbanization and population blast, our

streams, lakes, ponds and other water bodies are being polluted. Water is regarded as polluted when it is changed in its quality or composition directly or indirectly as a result of human activities. [1]

One of the most devastating effects of industrial waste is water pollution. For most industrial processes, heavy amount of water is used which comes in contact with harmful chemicals. These chemicals are usually metals or radioactive material. This heavily effects the environment because most of waste ends up in oceans, lakes, or rivers. As a result, water becomes polluted posing as health hazard to everyone. Farmers rely on this water but if the water is polluted, then crops that are produced can become polluted. These affect the health of society because if industrial companies can't clean up their waste, this begins to affect the life of humans but also animals. Sea creature's health is affected because their lives become endangered by this polluted water. Water pollution can have devastating effects on the human body with the main ones being infections from bacteria, parasites, and chemicals. Diseases that humans can be exposed from drinking unsafe water range from cholera, typhoid, or Giardia.

Today the water pollution becomes a major problem in the whole world. This method is helpful in treatment of ground water pollution [10] due to industrial effluents and also in direct treatment of industrial effluents. This study will give the alternative approach to the industrial waste water treatment by *Guava* leaves powder as low cost adsorbent is eco-friendly and natural treatment will save the chemical cost used for treatment. This treatment is non-hazardous to the human health, environment and whole ecosystem. As *Guava* leaves powder is biodegradable in nature, after treatment it will not create any harmful effects to the environment.

MATERIALS AND METHODS

COLLECTION OF SAMPLE

1. Industrial effluents: were collected from Ankleashwar, GIDC.
2. *GUAVA* leaves: Fresh *Guava* leaves were harvested from *Guava* tree available at Ved gam, Surat.

PREPARATION OF ADSORBENT

The collected material was thoroughly washed with distilled water three to four times to remove dust and other impurities. Then sun dried the washed leaves. Dried leaves were then grinded and sieved. 250 μ m particle size of GLP obtained after sieving. Dried GLP was kept in plastic containers and stored in dry place. [2]

APPLICATION OF DOSAGE

Here, in first phase waste water is treated with 10 gm/l GLP at different contact time 30, 60, 90, 120 min and stirring at 120 rpm and at pH 7.

In second phase waste water was treated at 30 min contact time with 5, 10, 15, 20 gm/l GLP dose and stirring at 120 rpm and at pH 7.

Figure 1: Jar Test apparatus for setting dosage of GLP with effluent sample

METHOD OF ANALYSIS

Analysis of samples before and after treatment with GLP was carried out by following method given in the table 1. Results of the analysis were compared with the standards mention in following table with the reference of WHO guideline. Methods were followed with the reference of APHA. [3]

Table 1: Standard Methods and Permissible Limits

Method	Parameter	Drinking water standard	Waste water Surface Inland standard
pH meter	pH	6.5-8.5	5.5-9.0
Turbidity meter	Turbidity	1 NTU	10 NTU
EDTA titration	Total Hardness	300 mg/l	-
EDTA titration	Ca Hardness	75 mg/l	-
EDTA titration	Mg Hardness	30 mg/l	-
Open refluxing	COD	-	250 mg/l
Titration	BOD	-	30 mg/l
Drying and Gravimetric	TDS	500 mg/l	2100 mg/l
Drying and Gravimetric	TSS	-	100 mg/l
Titration	Iron	0.3 mg/l	3.0 mg/l
Spectrophotometric	Nitrite	-	-
Spectrophotometric	Nitrate	45 mg/l	10 mg/l
Spectrophotometric	Chromium Hexavalent	0.05 mg/l	0.1 mg/l

Batch Isotherm Studies

Isotherm experiments were conducted to investigate the relationship between the solid phase concentration of an adsorbate and the solution phase concentration of the adsorbate at an equilibrium condition. The removal percentage (R %) of SDS was calculated for each run by following equation: $R (\%) = [(C_i - C_e)/C_i] * 100$, Where, C_i and C_e are the initial and final concentration of parameter (mg/L) in the solution. The adsorption capacity of the adsorbent for each concentration of parameter at equilibrium was calculated using following equation: $q_e (mg/g) = [(C_i - C_e)/M] * V$, Where, C_i and C_e were the initial and final concentration of parameter (mg/L) in the test solution respectively. V is the volume of solution (in Litter) and M is the mass of adsorbent (gm). [3,4]

RESULT AND DISCUSSIONS

Result for Effect Of Different Contact Time on Adsorption of Industrial Waste Water

Analysis of effluent before treated with Guava leaves adsorbent showed that values of all the water quality parameters were observed above the discharge limit.

Result of waste water quality parameter after treatment with 10 gm/l GLP at different contact time 30, 60, 90, 120 min and stirring at 120 rpm and at pH 7 are given in table 2. Removal efficiency of different parameter of waste water was achieved at 30 min contact time from 38 to 94 %, i.e. 30 min contact time was considered because maximum COD removal (64.51%), BOD (80.0 %), Hexavalent Chromium (85.71%), Hardness (41.70%), Nitrite (50.00%), TSS (50.85%), TDS (54.28%). Iron removal was 90.24% at 30 min contact time. Turbidity was also removed up to 94.15%.

Removal efficiency of different parameter of waste water treated at 30 min contact time with 5 gm/l GLP dose from 27 to 92 %.i.e. 5 gm/l dosage of GLP was considered as optimum dosage for textile waste water because maximum BOD removal (86.66%), COD (76.95%), Hexavalent Chromium (87.14%), Iron (92.70%), Turbidity (92.73%), Hardness (44.64%), TSS (50.85%), Nitrite (51.56%), TDS (65.71%), Nitrate reduces up to (27.74%).

Table 2: Parameter Studied before and after Treatment of Waste Water WITH 10gm/L GLP AT different Contact Time and at pH 7

Sr no	Parameter	Discharge Limits of effluent into Inland surface water (mg/l)	Initial (mg/l)	After treatment				Maximum % Removal (30 min)
				Time variable				
				30 min	60 min	90 min	120 min	
1	pH	5.5 to 9.0	7	7	7	7	7	-
2	Turbidity NTU	—	217.4	12.7	13.8	14.0	14.0	94.15%
3	COD mg/l	250	3472	1232	1680	1696	1728	64.51%
4	BOD mg/l	30	500	100	300	600	900	80.0%
5	TDS mg/l	2100	3500	1600	1600	1800	1700	54.28%
6	TSS mg/l	100	1628	800	800	900	864	50.85%
7	Hardness mg/l	600	560	330	340	350	340	41.07%
8	Iron mg/l	3	2289.8	223.4	223.4	223.4	223.4	90.24%
9	Hexavalent Chromium mg/l	0.1	0.70	0.10	0.11	0.10	0.10	85.71%
10	Nitrate mg/l	10	31.0	19	20.1	21.0	20.8	38.70%
11	Nitrite mg/l	—	0.64	0.32	0.37	0.33	0.32	50.0%

RESULT OF EFFECT OF GLP DOSE VARIATION ON ADSORPTION OF WASTE WATER CONSTITUENT

The result of waste water quality parameter at different dosage of GLP at pH 7 and 30 min contact time is given in table 3.

Table 3: Parameter Studied before and after Treatment of Waste Water with different GLP dosage 5 gm/l, 10 gm/l, 15 gm/l AND 20gm/l AND 30 min Contact time and AT pH 7

Sr no	Parameter	Dischargeable Limits of Inland surface water (mg/l)	Initial (mg/l)	After treatment				Maximum % Removal (5 gm/l)
				Dose variable (gm/l)				
				5 gm/l	10 gm/l	15 gm/l	20 gm/l	
1	pH	5.5 to 9.0	7	7	7	7	7	-
2	Turbidity NTU	—	217.4	15.8	12.7	11.8	10.0	92.73%
3	COD mg/l	250	3472	800	1232	1760	1456	76.95%
4	BOD mg/l	30	500	66.67	100	153.8	187.5	86.66%
5	TDS mg/l	2100	3500	1200	1600	2400	2800	65.71%
6	TSS mg/l	100	1628	800	800	800	1200	50.85%
7	Hardness mg/l	600	560	310	330	340	350	44.64%
8	Iron mg/l	3	2289.8	167.55	223.4	446.8	614.35	92.70%
9	Hexavalent Chromium mg/l	0.1	0.70	0.09	0.10	0.09	0.09	87.14%
10	Nitrate mg/l	10	31.0	22.4	19	14.9	6.1	27.74%
11	Nitrite mg/l	—	0.64	0.31	0.32	0.34	0.32	51.56%

% REMOVAL EFFICIENCY OF WASTE WATER QUALITY PARAMETER AT DIFFERENT DOSAGE OF GLP AT pH 7 for 30 MIN CONTACT TIME

Graphical representation for % removal efficiency of waste water quality parameter at different Dose of GLP is shown in figure 1. % Removal efficiency of waste water quality parameter at 5 gm/l GLP dose are Nitrate reduces up to 27.74%, Hardness 44.64%, TSS 50.85%, Nitrite 51.56%, TDS 65.71%, COD 76.95%, BOD 86.66%, Hexavalent Chromium 87.14%, Iron 92.70%, Turbidity 92.73%.

Figure 1: % Removal efficiency of waste water quality parameter at pH 7 and 30 min contact time and dosage 5 gm/l of GLP.

Adsorption Isotherm:

Various equilibrium parameters for Langmuir, BET and Freundlich, Temkin isotherms were calculated [3,4,5,6,8,11,12] and are shown in table 4.

Table 4: Various Equilibrium Parameters For Different Isotherm:

Parameter	Langmuir Isotherm			Freundlich Isotherm			Temkin Isotherm			BET Isotherm		
	R ²	Q ₀ (mg/g)	B (L/mg)	R ²	K _f (mg/g)	n (L/mg)	R ²	a (mg/g)	b (L/mg)	R ²	q _{max} (mg/g)	B (L/mg)
Turbidity	0.9428	- 9.7560	- 0.0512	0.0609	1.448	1.0332	0.09186	- 149.35	67.737	0.9402	- 10.4166	-10
COD	0.8877	62.8930	- 0.001368	0.9068	1006E-10	- 0.4615	0.9228	4356.7	- 576.15	0.9169	40.1606	- 3.3333
BOD	0.9536	11.0619	- 0.0150	0.9927	7046E-05	- 0.6230	0.9237	358.26	- 66.46	0.9288	7.9617	- 6.0432
TDS	0.8622	22.3214	- 0.000764	0.9876	3707E-12	- 0.3456	0.9076	3770.6	- 474.48	0.7563	7.5930	- 1.4909
TSS	0.97	8.620	-	0.71	215	-	0.419	141	-	0.99	3.866	-

	19	6	0.00	84	8E-	0.27	8	6.8	196.	37	9	1.139
			139		13	98			81			6
			4									
Hardness	0.948	1.5037	0.003294	0.9985	7328E-35	-0.0751	0.9622	1971.1	-335.3	0.9353	1.2049	-0.8325
Iron	0.9733	66.6667	0.006417	0.9452	1207E-06	-0.8805	0.8221	1532.5	-229.57	0.696	68.4931	-73
Hexavalent Chromium	0.026	0.0332	-6.4329	0.9566	5.843	5.0632	0.0028	-0.0354	-0.0414	0.0215	-0.0415	-3.3178
Nitrate	0.7166	1.7247	0.2023	0.1385	1.094	7.6863	0.1622	0.79	0.1967	0.9927	0.3892	-8.0387
Nitrite	0.3952	0.00290	-3.5085	0.443	7089E-07	-0.0926	0.4945	-0.4346	-0.4135	0.4652	0.00233	-1.2164

Experimental data obtained by above analysis were tested with adsorption models....The values of coefficient of correlation(R^2) in good agreement with Langmuir, Freundlich, BET, Temkin isotherms. Values of coefficient of correlation (R^2) are not nearer to 1.0. Therefore, it is confirmed that the adsorption process occurred over here is quite good process.[2,4]Some of the best fits are represented here for adsorption isotherms in figure 6.Langmuir isotherms suggests homogenous surface by monolayer adsorption. BET isotherms indicate monolayer sorption and subsequent layers.[13] Temkin and Freundlich isotherms shows heterogeneous surface by multilayer adsorption. The Temkin isotherm fits the present data because it takes into account the occupation of the more energetic adsorption sites at first.[3]

Experimental data obtained by above analysis were tested with adsorption models....The best fit for Turbidity is obtained for Temkin isotherm. The GLP also followed Temkin isotherm as the value of b is 67.737 in Turbidity. The Temkin isotherm fits the present data because it takes into account the occupation of the more energetic adsorption sites at first. The best fit for COD, BOD, TDS, TSS and Hardness is obtained for Langmuir and BET isotherm. The best fit for Iron is obtained for Langmuir isotherm. Chromium Hexavalent dose not the followed any adsorption isotherm. Chromium hexavalent followed the Freundlich isotherm in reverse manner i.e. with increasing dosage q_e decreasing. The best fit for Nitrate is obtained for BET isotherm. Nitrite followed the adsorption pattern of Langmuir and BET isotherm.

Some of the Best fit Adsorption Isotherms obtained in the various models are shown here in figure 2.

Figure 2: Best fit Adsorption Isotherm obtained in the various models.

The FTIR report of GLP shows the different functional group are present in it is shown in figure 3. The FTIR report of GLP shows the presence of different functional groups (-OH, alkanol, phenol, -C=O Carbonyl group, Aldehyde, ester, -C=C- alkene, -CH₃ bend, C-O, COOH, -O-, COOR, -CN amines) in it. The experimental values are compared with standard value[5,9] is shown in table 5.

The samples were treated with GLP adsorbent-natural electrolyte by directly applying the different dosage of adsorbent. It increases the nutrition values of the treated water. Under adequate agitation these particles then grow in size to form flocks, which can be settled by gravity or be removed by filtration any matter present in the suspended form than they can adsorb on the surface of adsorbent.

Table 5: Identification of Peaks of FTIR

Wave number ν cm^{-1}		Types of Vibration
Standard	Experimental	
3500-3200	3363.00	-OH, alkol, phenol, H-Bond free
	3292.60	(isolated)
3150-3050	3181.69 3064.99	Aromatic stretch
2850-2990	2974.33	-CH, alkane
2900-2700	2749.62 2656.07	Aldehyde stretch
1740-1710	1734.06	-C=O Carbonyl group, Aldehyde, ester
1680-1600	1653.05	-C=C- alkene

1600-1480	1556.61	Aromatic	
	1512.24		
1450-1390	1452.45	-CH ₃ bend	
	1370.47		
1000-1350	1319.35	C-O, OH, COOH, -O-, COOR -CN amines	
	1245.09		
	1141.90		
	1102.35		
	1060.88		
	1027.13		
900-650	1002.05	Out of plane bend	
	828.45		
	668.36

Figure: 3: FTIR result of GLP

CONCLUSIONS

Any Wastewater can be treated with GLP (5 gm/l) dosage , 30 min contact time and at 7 pH. After treating with this cost effective, eco- friendly technique , the water quality parameters are found within the range of drinking water quality. This technique will save cost of chemicals and operation-maintenance of treatment plant and will not produce hazardous sludge. We can directly apply. No primary treatment is required before applying adsorbent to the sample. It is a cheap and easy method for treatment of effluent. This method is efficient because GLP used is biodegradable and can be used as a part in fertilizing materials for agriculture purpose.

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