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Domestic Wastewater Treatment Using Jamun Leaves As Adsorbents

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Abstract *–From the inception of the coronavirus pandemic for the more than a year, it has now become exigent that the water supplies and wastewater be treated at its fullest efficiency as their nexus is quite ubiquitous in this domestic society. To design a robust wastewater treatment incurs a hefty cost, so the need of the hour is to resort towards treatment techniques which incurs minimal cost and adsorption techniques are one of them. Adsorption is a process where contaminants or compound in one phase gets attached or condensed to other phase, finally removing them. Adsorption by using activated carbon is a prominent method to remove the contaminants from water and wastewater remarkably, but still many researches shows the same as expensive and therefore, low cost adsorbents extracted naturally is a best and cheapest alternative to remove the same. Numerous researches showed the potency of such low cost adsorbents in removing heavy metals, dyes etc. from the wastewater, but there is no literature available pertinent to the removal of parameters viz. COD, BOD etc. from the wastewater. The present research aims to study the alteration of functional parameters viz. Adsorbent Dosages and pH in the removal of COD supplemented with batch adsorption studies on the low cost adsorbents viz. Jamun Leaves.*

Keywords - Adsorption, Jamun Leaves, COD, pH, Adsorbent Dosages, Wastewater.

I. INTRODUCTION

Now as the world is grappling through the ferocious sub sequential wave of Coronavirus pandemic for more than a year, it is exigent that all types of wastewater and water is treated with efficiency at its fullest, as the nexus between the two is ubiquitous in our domestic society. The treatment of the wastewater incurs marginal costs to be borne by the Taxpayers Money and cess tax if it is managed publicly and hefty costs if managed privately in urban areas, the rural areas still are devoid of a holistic wastewater treatment facility. One question might be pondering over one's head is that can wastewater treatment be carried out by incurring minimal cost for the same? The answer to thisquestionlies in the nature itself, that is, by making use of natural materials to adsorb the contaminants present in the wastewater which in turn will reduce the likelihood of the impairment of the quality of ground water which is mainly used for irrigation (**Bokil et al, 2005**). Adsorption is basically the process in which contaminants present in one medium or phase tend to condense and concentrate on the surface of other face, wherein the material being concentrated is adsorbate and the adsorbing solid is called as adsorbent (**Sawyer et al, 2003**). In the extant research work the natural materials viz. Jamun leaves powder is used as an adsorbent and wastewater as an adsorbate. Numerous works proves the simplicity and the audacity of the adsorption process (**RanaJyoti et al, 2019; N. Mathur et al, 2013; Sudarjanto G et al, 2006; Reza KM et al, 2015; Zhezova S et al, 2014**). Adsorption is mainly used in the conventional wastewater treatment to remove the color, organic pollutants and other contaminants present in the wastewater with Activated carbon as one of the prominent adsorbent. Despite of its remarkable

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properties, still many found it as expensive and the exigent need of the hour is to resort towards the adsorbents that incurs minimal costs. In this regard many researchers have made their fruitful contributions by utilizing numerous substances viz. agricultural wastes, coir pith, banana pith, sugarcane dust, sawdust etc. (**PandhareGhanshyam et al, 2013**). These low cost adsorbents are best suited to treat the contaminants in the water and wastewater efficiently in the laboratory scale. (**Ho and McKay, 1999; Bailey et al, 1999; Sharma Arunima and Bhattacharya Krishna, 2004**). The study of such low cost adsorbents has been extensively carried out by numerous researchers' viz. Study of Dye removal from textile wastewater using hardwood, saw dust and charcoal (**Asfour et al, 1985; Hameed and El-Khaiyary, 2008; Ferrero,2007**), Study of removal of hexavalent chromium and dyes from textile industry wastewater using saw dust (**Siboni et al, 2011; Das et al 2015; Karunanithi et al. 2000**), study of removal of toxic metal chromium using low cost rice husk (**Mullick et al, 2017**), study of dye removal by using timber wastes as adsorbent (**Garg et al, 2004; Ho and Mckay, 1998**).Syzygiumcumini, which is prominently known as jambul, or jamun, is tree which normally grows in a tropical environment and bears flowers by virtue of which it is included in plant family of Myrtaceae. It is indigenously grown in Indian sub-continent in colossal amount (**Royal Botanic Gardens, Kew. Retrieved 16 June 2017**). The growing pace of this tree is little bit sluggish but can reach the peak height of 30 m and has a long life span upto 100 years.The aroma and the odor of the jamun leaves resembles to that of the Turpentine. These leaves are utilized as a commodity in the market and also for feeding livestock.There is no literature available wherein the utilization of the low cost adsorbents mentioned hitherto above for the removal of various parameter present in the wastewater viz. COD, BOD, and TDS etc. The present research investigation's aims to study the percentage removal of COD by altering two functional parameters viz. Adsorbent dosages (1, 2, 3, 4 and 5 g/L) and pH (6, 7.2 and 8) supplemented with batch scale adsorption studies for the natural low cost adsorbents (presently Jamun Leaves).

II- MATERIALS AND METHODS

2.1 Preparation of Adsorbents:

The adsorbents were prepared in the present study by collecting Jamun Leaves which are ubiquitously found in mammoth quantities in nature. Jamun Leaves were obtained from the Syzygiumcuminitree in our institute campus i.e. SSBT COET Bambhori, Jalgaon. Now it is obvious that after extracting the materials required for the preparation of adsorbents, the screening for the same too becomes paramount as it is laden by dirt and soil. This dirt and soil were removed by washing the jamunleaves with demineralized water and the Jamun leaves were kept desiccated in the natural sunlight for a week after which it was grinded to a powdered form.The concentrated sulfuric acid (from Environmental Engineering Lab of our institute) was added to the powderedJamun Leaves in ratio 1:2 (Jamun leaves powder: Sulfuric acid). After that this mixture was heated in a muffle furnace at a temperature range of 155-160 ^{o}C and then again rinsed with water to eradicate the traces of acid in it and again the resultant mix is dried in the oven at a temperature range of 100-110^{o}C. Now the resultant sample obtained has altered its color to dark black to which 5% sodium chloride was added and was magnetically stirred for a day. The resultant product was sieved with the help of whatmann filter paper and it was rinsed again with water and dried at temperature range of 100-110^{o}C until a particle size of 80 µm is obtained. The process mentioned hitherto is shown in the figure 1 as below:

Figure 1: Process flow diagram of the preparation of adsorbents viz. Jamun leaves.

2.2 Characteristics of Adsorbents:

The adsorbents used in the present study is Jamun Leaves, and to evaluate its adsorption capacities, characterization for the same viz. Physical and Chemical becomes paramount. The physical characteristics of the adsorbents to be determined are Bulk density, pore size and proximate analysis and chemical or elemental characteristics of the adsorbent are determined by X Ray Fluroscence (XRF Technique). Proximate Analysis was done by employing standard procedure and the instruments like densitometer and Sieve Analysis

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Machine was employed to determine the bulk density and particle size of the adsorbent. The characteristics of the adsorbents as iterated above are represented in the table 1 as shown below and all these parameters were determined in the research laboratory of KavyitriBahinabai Chaudhry North Maharashtra University, Jalgaon:

Table 1: Physico-Chemical Characterization of Jamun Leaves as an adsorbent.

Sr. No	**Characteristics**	**Adsorbent Type**
		Jamun Leaves
Typical Chracteristics		
1	Specific Surface Area (m^2/g)	250.15
2	Total Pore Volume (cm^3/g)	0.48
3	Average Pore Diameter (D)	52.45
4	Bulk Density (g/cm^3)	0.60
Proximate Analysis (in weight percentage)		
1	Moisture content	12.36
2	Volatile Matter	30.23
3	Fixed Carbon	60
4	Ash Content	3.15
Ultimate or Elemental Analysis by XRF Technique (in percentage)		
1	Carbon (C)	65
2	Magnesium (Mg)	0.8
3	Calcium (Ca)	0.5
4	Phosphorous (P)	2.28
5	Oxygen (O)	33.85
6	Iron (Fe)	0.12
7	Silicon	0.2

2.3 Study Area and Characteristics of Wastewater:

The study area opted for this current research work is Jalgaon city. It is located in the north western region of Maharashtra, and is surrounded by Satpuda mountain range in the north andAjanta Mountains in the south.Jalgaon city is abundantly rich in volcanic soil wherein the cotton grows effectively. The city receives 700 mm rainfall in the monsoons. The principal river of the city is Waghur River which is actually the tributary of Tapi River, wherein all the drains of the city discharge in the same and finally it gets confluence to Arabian Sea. The wastewater collection for our study was collected from the LendiNala which is located near Pimprala, in Jalgaon City which is as shown in Figure 2. If the Figure below is meticulously looked upon, it is explicit that the LendiNala absorbs wastewater mainly from the residential, commercial complexes and the religious places especially the mosques in its cheek and jowl, which in turn can be integrated to be called as domestic wastewater:

Fig 2- *Wastewater Sampling Point LendiNala, Pimprala, Jalgaon.*

The characteristics of raw wastewater collected from the above sampling site was evaluated in the laboratory which were, pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Solids, Total Dissolved Solids, Suspended Solids, Alkalinity, and Total Nitrogen. The characteristics of the wastewater is as tabulated below in Table 2, all these tests were carried out in the laboratory by Indian Standard Code and standards viz. **IS 3025**:

Table 2: Characteristics of Raw Wastewater near LendiNala, Jalgaon

Parameters	Characteristics of Raw Wastewater at sampling Site
pH	7.4
Total Solids	1200 mg/l
Total Dissolved Solids	1102 mg/l
Total Suspended Solids	80 mg/l
Alkalinity	335 mg/l
BOD	457 mg/l
COD	855 mg/l
Total Nitrogen	5.8 mg/l
Sulfate	118 mg/l
Nitrate	1 mg/l

2.4 Batch Adsorption Studies Experimental Procedure:

The tests were done for the removal/adsorption of the parameter of wastewater (presently COD) with Jamun Leaves as adsorbent. The batch adsorption Studies were done primarily on various functional parameters (Presently 2 viz. Adsorption dosage and pH) such as namely, adsorbent dose (1, 2, 3, 4, 5 g/L) and pH (6, 7.2,

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8). The experimental adsorption studies were carried in complete mix Batch reactor (CMBR). At 300 rpm the isothermal shaker was shaked to achieve balance for a contact period of 240 mins. The COD concentrations in the adsorbent was determined before and after adsorption was determined from **IS 3025** using the following equation:

(A – B) x N x 1000 = COD in mg/l(1)

Where, A = ml of titrant used for sample, B = ml of titrant used for blank, N = Normality of titrant.

The adsorption capacity at equilibrium was evaluated using the following equation:

$q= (C_0 – C_s)*V/X$ (2)

Where q is mg of COD removed per gram of Adsorbent, C0 is the initial Concentration of Adsorbent, Cs is the final concentration of adsorbent, V is the Volume of Solution in ml, X is the adsorbent dosage. The samples of adsorbent were pipetted out at regular intervals.

The batch adsorption studies became more explicit when the adsorption isotherms were plotted, the equation of the Adsorption isotherms are as given below (Sawyer et al, 2003):

Langmuir Isotherm: It is based on surface Complexion Theory and the equations for the same is as given below:

q = qm (Kads C)/(1+ KadsC) (3)

The above equation once rearranged gets deduced in the following form:

(1/q) = (1/(qmKads)) (1/C) + (1/qm) (4)

Where, q = Sorbed Concentration, qm = Maximum Capacity of adsorbent for adsorbate, C = Aqueous Concentration of Adsorbate, Kads = measure of affinity of adsorbate for adsorbent.

III- RESULTS& DISCUSSION

3.1 Influence of Functional parameters

The design of any treatment process pertinent to the sorbent systems mainly depends on the functional parameters which can be altered to see an explicit and significant effect on the percentage removal of the impurities present in the wastewater. These functional parameters are pH, adsorbent dosage, temperature, agitation speed, initial concentration of Wastewater, particle size etc. but in the present research work we have studied the effect of 2 functional parameters viz. Adsorbent Dosages and pH for the adsorbent Jamun Leaves on the percentage removal of impurities (that is Chemical Oxygen demand (COD) in this research) are exhibited as below graphically.

3.1.1 Alteration of Adsorbent Dosage with contact time

The alteration of dosage of adsorbents plays a paramount role in determining the efficiency of the adsorbent to remove characteristic parameters of Wastewater that is Chemical Oxygen Demand (COD) in this research by keeping the initial COD of the wastewater as sustained. The effect of alteration of adsorbent dosages of theadsorbents viz. Jamun Leaves on the percentage removal of COD was studied meticulously for different contact period with an interval of 30 minutes, sustained initial COD of wastewater at 824 mg/l, pH tuned at 7.6 and agitation speed of 300 rpm as shown in the Figure 3 below:

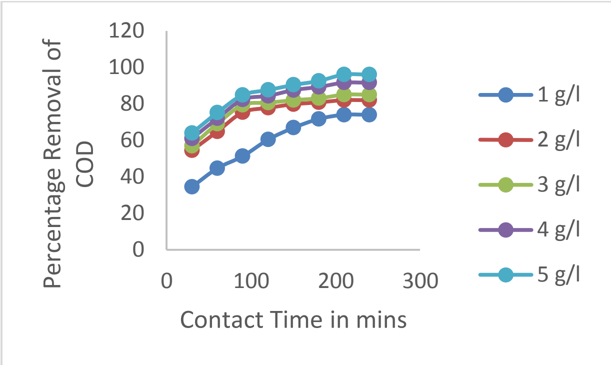

Fig 3-Adsorbent dose alteration on percentage removal of COD for sorbent Jamun Leaves.

From Figure 3 it is explicit that by altering the adsorbent (Jamun Leaves) dose from 1 g/l to 5 g/l, proportionately spurs the efficiency of the sorbent system at different contact periods, it is because the increase in the dosage, correspondingly augments the availablesurface area which causes increased saturation of adsorption sites. The equilibrium level of removal of COD is generally achieved after 3 hrs 30 mins for each altering adsorbent doses and between adsorbent doses 4 g/l and 5 g/l the efficiency of the removal of COD is maximum and is averagely around 95%. So, 4.5 g/l was exactly selected as an optimum dose for Sorbent Jamun Leaves in the removal of COD.

3.1.2 Alteration of pH value with contact time

The wastewater especially the domestic wastewater traverses through network of sewers and prior to its disposal the COD and BOD values are plunged down to acceptable limits via robust treatment mechanisms. So, from the source of generation of wastewater to the disposal the pH of the wastewater alters dramatically. The effect of alteration of pH of the adsorbent vizJamun leaveson the percentage removal of COD was studied meticulously for different contact period with an interval of 30 minutes, sustained initial COD of wastewater at 824 mg/l, at pH 6, 7.2, 8, adsorbent dose of 4.5 g/l and agitation speed of 300 rpm as shown in the Figure 4 below and the pH was adjusted with 0.2 N NaOH and 0.2 N HCl:

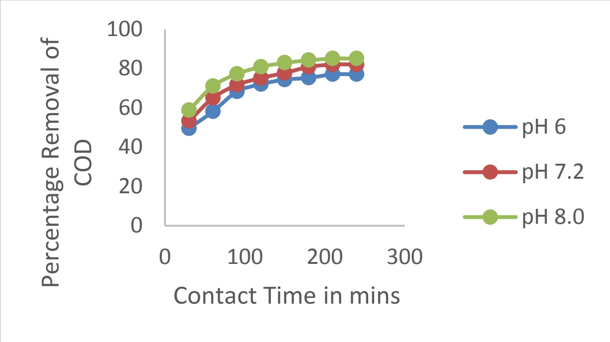

Fig 4- Alteration of pH on percentage removal of COD for sorbent Jamun Leaves.

From Figure 4 it is explicit that by altering the pH from 6 to 8 proportionately spurs the efficiency of the sorbent system at different contact periods, it is because the increase in the pH value, correspondingly augments the potency of the cations to get adsorbed to the surface due to the development of negative charges on its surface. The equilibrium level of removal of COD is generally achieved after 3 hrs 30 mins for each altering pH. The Percentage removal of COD occurs maximum between pH 7.2 to 8 and the optimum pH comes to be around 7.6.

3.2 Isotherm Results:

The Isotherm analysis was done based on equilibrium COD removal data for sorbent Jamun Leaves.In the present study the Langmuir and Freundlich Isotherm models were utilized for determining the adsorption capacity of the adsorbents to remove the COD present in the wastewater. The isotherm study (viz. Langmuir and Freundlich) were done at different pH level viz. 6, 7.2 and 8. The value of coefficient of linear regression (R^2) is taken as deciding parameter for checking as to which isotherm is more appropriate or best fit for particular sorbent, in other words, more the value of R^2 for a particular isotherm of a sorbent more appropriate is the isotherm for the sorbent at that corresponding pH. The following tables 3 and 4 exhibits the value of R^2 and constants of the Freundlich and Langmuir Isotherms which is calculated from the equilibrium COD data.

Table 3: Isotherm Results for Sorbent (Neem Leaves)

Sr. No	pH value	Coefficient of Correlation Values (R2)		Constants for Freundlich Isotherm		Constants for Langmuir Isotherm	
		Freundlich	Langmuir	K	n	qm (g)	Kads (L/g)
1	6	0.733	0.609	0.502	0.854	NA	NA
2	7.2	0.93	0.822	0.134	0.598	NA	NA
3	8	0.659	0.797	NA	NA	28.57	179.73

From table 3 it is evident that Freundlich Isotherm is the best fit or appropriate at pH 6 and pH 7.2 and Langmuir Isotherm is appropriate or best fit at pH 8.0 based on the maximum value of R^2 for both the sorbents. The Maximum adsorption capacity of the sorbent occurs at pH 7.2 because value of $R^2$for Freundlich isotherm is 0.93 which is near to 1. So, overall, for the sorbent Jamun Leaves, the Freundlich Isotherm is most appropriate than the Langmuir Isotherm. The value of the constant n whose maximum value is 0.854 is less than 1 which makes the value of 1/n as per the equation of Freundlich Isotherm more than 1 by virtue of which the Freundlich isotherm strives towards linearity.

IV- CONCLUSION

The following inferences can be made based on the research work conducted on the sorbent Jamun Leaves to check their efficiency in the removal of COD from the adsorbate that is Wastewater:

1. With the alteration of dosage of adsorbent and pH value, it is evident that sorbent Jamun Leaves more effectively removes the COD present in wastewater when the dosages of sorbents are altered than the alteration of pH of the sorbent medium.
2. The Freundlich Adsorption Isotherm model suits more appropriate or is the best fit in case of Sorbent Jamun leaves where value of coefficient of linear regression (R^2) is more than that of the Langmuir Isotherm Model except at pH value of 8.0. The highest adsorption capacity is met at pH 7.2.

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