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Studies on Teak Leaves *(Tectona Grandis) as* Low - Cost Adsorbent for the Treatment of Detergent Industrial Waste Water

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Abstract: ***The present study aims to reduce the contaminants, mainly phosphate present in detergent industrial wastewater by using indigenously available natural resources such as teak leaves (Tectona Grandis) as a low-cost adsorbent. The physical and chemical characteristics of teak leaves adsorbent were analyzed such as particle size, surface area, etc. Further, characteristics of detergent wastewater were also studied to find out the contaminants level. Herewith, the adsorption study was conducted on fundamental parameters such as pH, dosage and contact time etc. From the above study and obtained results, it has been found that the percentage adsorption of phosphate from detergent wastewater such as 91.41% was achieved for 6gm of activated teak leaves adsorbent within 1 hour at pH 2 and COD was removed about 92.2 % using teak leaves as adsorbent which was another important issue which was addressed. Overall, the conducted study confirms the benefits for the sake of whole environment.***

Keywords: Activated Carbon, Low-Cost Adsorbent, Phosphorous, Teak Leaves Activated Carbon, Teak Leaves

1. Introduction

Industrialization is the backbone for the development of any country, but pollution caused by industries has become a serious concern throughout the world [1]. The increasing demand increases the production which in turn produces a huge quantum of effluents which are highly toxic and deleterious. The pollutants were ubiquitous at present situation and their treatment has to be given prime importance. Of all industrial sectors, the domestic products such as soaps, detergents, and food sector are the one which consumes the highest quantity of water and it is also one of the biggest producers of effluent per unit of production. Soaps and detergents were inevitable in households. The disposal of streams containing hazardous heavy metals into the environment has made the governments impose stringent standards for waste management [2].

Soap is a cleansing agent created by the chemical reaction of a fatty acid with an alkali metal hydroxide. Water-soluble sodium or potassium salts of fatty acids made from fats and oils, or their fatty acids, by treating them chemically with a strong alkali. It has the general chemical formula RCOOX. Three main components of soap by both cost and volume are oils, caustic and perfumes. Anionic surfactants are the major class of surfactants used in detergent formulations and represent about 59 % of surfactants used [3].

The waste effluent from soap industry was very rich in various parameters such as pH, TDS, COD, BOD, DO, Colour etc as their ranges were in effluent level. [1], [29], [34]. Surfactant wastewater was treated by biological processes such as activated sludge process which was problematic due to the low kinetics of degradation and to foam production and it was treated by various processes such as flocculation, coagulation, nano–filtration, ion exchange, and ozonation [40]. Sometimes adsorption (adsorbent bed) was used as post-treatment process which effectively removes non-biodegradable non-ionic and anionic surfactants [28]. Phosphorus is produced in large quantities from various industrial productions, agricultural and mining activities [18], [21], [22]. P is an essential nutrient for the growth of biological organisms [3].But Phosphorus present in high quantity will lead to the eutrophication of the receiving water bodies[4] and water quality deteriorates[5].So, the removal of phosphorus is a major concern in recent decades[12], [13]. And it is the crucial solution for the enrichment of aquatic growth[30].Various treatment technologies such as physical, chemical and biological are used in the past[26], [24]. Those treatments such as electrodialysis, membrane, conventional ASP, reverse osmosis and chemical precipitation [31], [33], [34]. But their economic viability and sludge associated with process such chemical precipitation Phosphorus, generally in the form of phosphates, has historically been one of the main ingredients in detergents (which are soaps made from synthetic materials) In the detergents, phosphates served as a "builder" to improve the detergent's cleaning efficiency. Builders, such as STPP(Sodium Tri Poly Phosphate), are important to the cleaning process, as they help to remove dirt from the clothes and to minimize soap scum (often seen as a ring on the tub, washing machine, or shirt collars) [36].The need for builders in detergents and soaps is especially important in areas with "hard" water that contain calcium and magnesium ions, since the builders prevent these ions from interfering with the cleaning process[38]. Their strong cleaning performance, however, has increasingly been overshadowed by their harmful effects on rivers, lakes, streams, and other fresh waters. Levels of phosphates in these fresh water bodies can be much higher than normal as the result of contamination from municipal and domestic wastewater that contains phosphate [37].

Adsorption has been used as a physicochemical process over the last decades. In adsorption, molecules diffuse through the bulk of fluid to the surface of the solid adsorbent and form a distinct adsorbent phase. Physisorption and Chemisorption are two type of adsorption in which the adsorbate adheres to the surface only through Van der Waals and through the formation of a chemical bond respectively [18]. However, commercially available activated carbon which is widely used as the adsorbent is expensive [28][29]. Higher production cost and regeneration difficulties make them unviable and made way to research on the use of non-conventional low-cost adsorbents such as neem leaves, sawdust, and teak leaves. Researchers have studied the production of activated carbon from plum kernels, cassava peel, bagasse, jute fiber, rice husks, olive stones, rice bran, date pits, fruit stones, and nutshells are very effective [21][22].

Low-cost adsorbents were engaged for the treatment of the waste streams. The abundant availability and their regeneration trends make them most astute adsorbent. With a view to developing teak leaf as an adsorbent, various factors back it up such as the insoluble wall where adsorption takes place was made of cellulose, lignin, condensed tannins and structural proteins which support adsorption [34]. In previous, teak leaf was used for the treatment of various pollutant such as heavy metal (Pb, Cu, Cr, Cd. Zn) [20] and dyes (MB and MG) [6], [14], [17], [19]. The adsorptive characteristics of teak leaves are expected to be highly effective [20].

2. Materials and Methods

2.1 Preparation of Adsorbent

Teak leaves were collected from PEC campus and they were thoroughly washed using distilled water to remove dust particles and they were sun dried to attain deep brown color which was brittle and crisp. A Huge quantity of leaves was collected as it yields a very low quantity of end product [24][8].

Teak leaves were crushed using domestic mixer into a fine powder, and they were sieved using a 355µ sieve and particles pass through was again sieved ina150µ sieve. Finally, it was sieved using a 75µ sieve [33]. The particles which pass through 75µ sieve collected and its quantity was about 1 - 5 % of the initial quantity of collected teak leaves.

Figure 1: Powdered Teak

Figure 2: Activated Teak Leaves

Leaves

Sieved Teak leaf powder was repeated washed to remove dust and impregnated with 0.1N of nitric acid to remove impurities and it was washed with distilled water. It was kept in the hot air oven at 101°C for 1 hour, and it was taken out from the oven and kept in the muffle furnace till it reaches 410°C. Then it was taken back from the oven. The contemplation of the dark black colour powder from brown colour indicates that it was carbonized. It was washed and filtered to remove the acid [13], [25].

Table 1: Characteristics of adsorbent

Sl. No.	Parameters	TLAC
1	pH	6.7
2	EC	140.8µs
3	TDS	92.6 mg/l
4	Moisture Content , %	0.93
5	Ash Content, %	2.16
6	Matter soluble in water, %	1.81
7	Matter soluble in acid, %	4.60
8	Surface Area(BET)	117.63m2/g
9	Temperature	29°C
10	pH	6.7

Table 2: Characteristics of Raw Effluent

Sl. No.	Parameter	Result
1	pH	5.56
2	TDS	1680 mg/l
3	EC	1.67ms@ 20˚C
4	Temperature	32˚C
5	COD	3126 mg/l
6	Phosphorus	57.6 mg/l.

2.2. Experimental Procedure

The wastewater sample from soap and detergent industry will be collected and it was subjected to the various laboratory tests, characterized, tabulated and was checked with permissible standards to evaluate the level of pollutant [35] [36].

Figure 3: Batch Setup

The Soap and detergent waste water sample of 100 ml was measured and will be taken in a 500 ml Erlenmeyer's flask and the stir bar was inserted into it and the setup was placed on the magnetic stirrer [23]. Then, the teak adsorbent of required dosage was added to it and the magnetic stirrer was switched on for a thorough mixing of the sample with the adsorbent. The treatment of the wastewater using the adsorbent will be carried out and the effectiveness will be studied by varying the dosage of the adsorbent and the detention periods.

In this study, SIX levels of dosages, namely 0.5g, 1.0g, 2g, 3.0g, 4.0g, 5.0 g and 6.0g and FOUR durations of detention levels, namely, 1, 2, 3 hours will be analyzed. [7], [15]. The results from the above combinations were analyzed to understand the effectiveness of the treatment process and to sort out the optimum / desirable dosage and detention time [43]. Then, the treated samples will be filtered using the Whatman filter paper, thus removing the adsorbent particles from the treated sample. Then the treated sample will be analyzed for the parameters such as pH, EC, TDS, and COD [9], [10], [42].

3. Results and Discussion

Table 3: Effect of Contact Time

S. No	Contact Time (min)	Phosphate Present in Effluent post treatment (mg/l)	Removal Efficiency (%)
1	30	31.8	40.12
2	45	21.6	62.5
3	60	4.64	91.4
4	90	11.74	79.8
5	120	16.12	72.01
6	150	17.16	70.2
7	180	18.32	68.1

Table 4: Effect of Dosage

S. No	Dosage (g)	Initial Phosphate Conc. (mg/l)	Phosphate Present in Effluent After Treatment (mg/l)	Removal Efficiency %
1	0	57.6	57.6	0
2	0.5	57.6	34.8	39.5
3	1	57.6	23.43	59.3
4	2	57.6	19.62	64.2
5	3	57.6	15.54	71.28
6	4	57.6	11.96	79.2
7	5	57.6	7.83	86.4
8	6	57.6	4.64	91.4

Table 5: Effect of pH

S. No	pH	Phosphate Present in Effluent post treatment (mg/l)	Removal Efficiency (%)
1	Initial Level (5.5) (Without Treatment)	57.6	0
2	5.5	34.8	39.5
3	2	4.64	91.4
4	4	21.45	62.7
5	7	35.6	38.1
6	10	37.2	35.4
7	12	39.45	31.5

Table 6: Effect on COD

S. No	Dosage (g)	COD Present in the Influent	COD Present in Effluent post treatment (mg/l)	Removal Efficiency (%)
1	0.5	3126	2146	31.3
2	1	3126	1271	59.3
3	2	3126	791	74.7
4	3	3126	640	79.5
5	4	3126	536	82.8
6	5	3126	391	87.4
7	6	3126	243	92.2

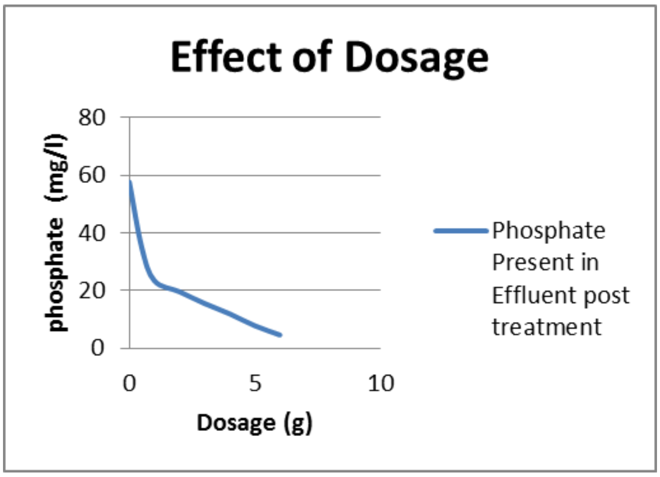

Figure 3: Dosage vs. Phosphate

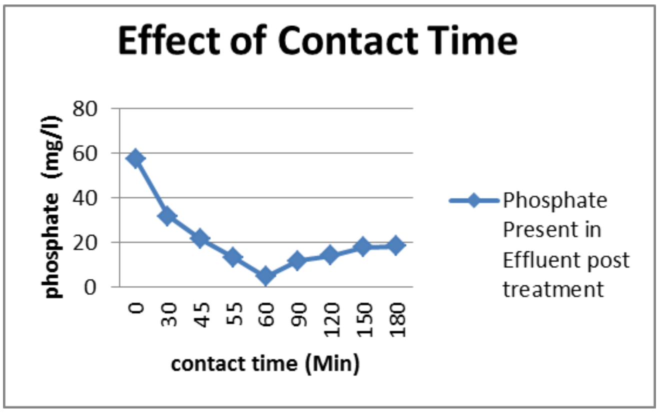

Figure 4: Contact Time vs Phosphate

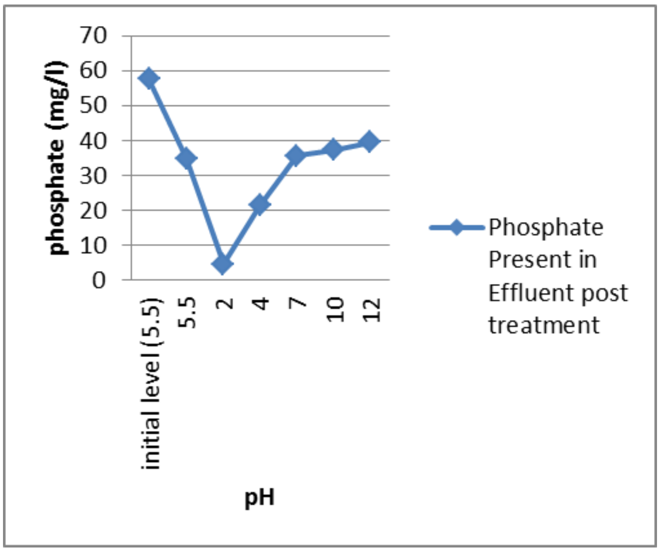

Figure 5: pH vs Phosphate

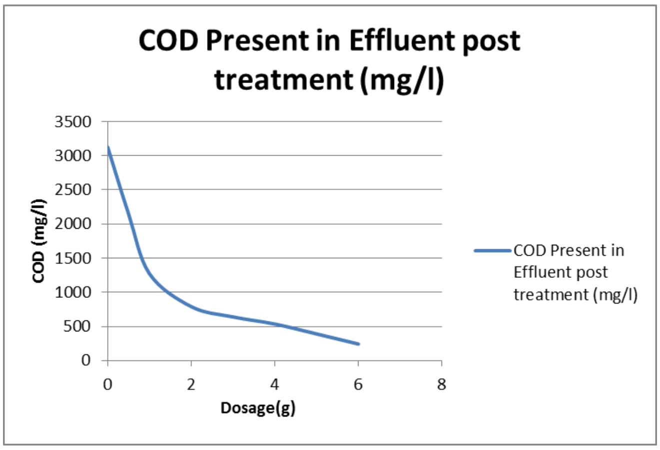

Figure 6: Dosage vs COD

3.1 Effect of Dosage - The graph (Fig 3) shows that the dosage increases with increase in removal of Phosphorus which was due to increase in binding sites of adsorbent. The decreasing trend slows down as the dosage increases because the system became bulky and this reduces flux of mixing.

3.2 Effect of Contact Time – Fig 4 reveals that the removal was very faster for period of ½ hour to 1 hour. After that period of time the decreasing trend reduces and the system reaches the breakthrough time at some point. After that period desorption occurs.

3.3 Effect of pH – The pH is important governing factor as it decreases the positive charge increase which in turn increases the adsorption of cations which pollutant possess. The surface charge decreases as pH increases so, the decreasing trend was followed till pH reaches 7 and after that adsorption decrease due to increase in negative charge.

3.4 Effect of COD – The COD present in the effluent decreases as the dosage of adsorbent increase which increases the binding sites and affinity. But, after certain period or optimum contact time the binding sited got reduced and the system became stable. Maximum of 92.2% removal efficiency was achieved using 6 g of adsorbent.

Soap and detergent wastewater tend to clog quickly and break through time will be believed to be quick in this process. To avoid that, coagulant will be used to remove the clog from the surface of the adsorbent. It will help to increase the removal rate and regeneration of adsorbent.

4. Conclusion

Teak leaves activated carbon (TLAC) found to be efficient through a deliberate literature survey. And they are equipped to treat the Detergent industry. The experimental procedure disclosed that the optimum level of treatment was found to be 6 g of adsorption for the treatment of 1 hour at pH 2.This treatment process help to achieve maximum efficiency with minimum energy requirement and expenses. This was the first time the phosphorus was emphasized and removed using teak leaves as adsorbent and about 91.4% was achieved about 4 mg/l of phosphate which was under the permissible limit of IS standards (5 mg/l). COD which is another important parameter was also treated and about 92.2% removal efficiency was achieved using 6g of adsorbent. Most importantly, Habitants and the surrounding environment will be benefited from the decrease or elimination of the potential toxicity due to the Phosphorus and other major pollutants.

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