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COMPARATIVE STUDIES ON THE EFFICIENCY OF *CITRULLUS LANATUS (*WATERMELON) AND *MOMORDICA CHARANTIA* (BITTER-GOURD) SEED POWDER IN THE BIOREMEDIATION OF THE DYE EFFLUENT

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ABSTRACT

Textile dying industries generate an enormous amount of effluent which needs a proper treatment. As previous methods were inefficient in treating them, new alternatives were needed to examine their possibilities of usage in a large scale. Adsorption to low-cost materials like seed powder is one among those alternatives which could be scaled up to treat the industrial scale level without creating an impact towards environment. This could be an added advantage for biodegradability and for easy availability. In this comparative study, we have used different concentrations of *Citrullus lanatus and Momordica charantia* seed powder to acquire their efficiency in some of the reducing properties like pH, TDS, TSS, chloride, alkalinity, turbidity, colour, total hardness, calcium hardness, magnesium hardness, free residual chlorine and COD. While comparing with the raw effluent it was founded that when the *C. lanatus* seed powder has some effectiveness in bringing down the reduction percentage of those parameters. When the seed powder combined with the Biofilter column, there occurs a change in the percentage levels of parameters such as colour, turbidity, total hardness and COD to 86.3, 74.9, 83.3, 45.2, 25.5% respectively. Finally, it was concluded that the seed powder along with the biofilter column can be used as an alternative method for treating the dye containing effluents.

***Keywords* :** Biodegradability, Biofilter column, Seed powder, Adsorption, *Citrullus lanatus*, *Momordica charantia*

INTRODUCTION

Dying industries have been consuming a huge amount water which returns to the environment in the form of harmful chemical compounds including cancer causing agents (Chen *et al*., 2003). Largely owing to the nature of low biodegradability, it possess a grave threat to the well-being of human beings and to the environment (Kumar *et al*., 2014). They were also loaded with more permissible levels of pH, BOD, COD, TDS, TSS, colour, odour (Kabraet *et al*., 2012). When the untreated effluents of dye mixes with the water reservoirs, it could be a threat for domestic use and there might be a loss of aquatic plants and animals in large number particularly fishes (Hu *et al*., 2009 and Markou *et al*., 2016). Therefore, the discharged effluents should be treated effectively for the removal of the contaminants before discharging it into the water bodies.

Different methods had been proposed by different researchers for treating the dye effluents. It includes physical, chemical and biological methods. Mostly, the dye effluents were treated by physical or by chemical methods such as oxidation or ozonation (Malik and Saha, 2003), bio-degradation (Daneshvar *et al*., 2007), adsorption towards activated carbon (Tan *et al*., 2015), coagulation and flocculation (Zonoozi *et al*. 2009), reverse osmosis (Kumar and Saravanan, 2011) and ion-exchange (Khan *et al*., 2015). The synthetic dyes which were present in the effluents aren't removed effectively by the current methods (Mondal, 2008). Most of the usually followed methods has demonstrated some disadvantages on the effectiveness of dye removal from the effluent and at times it exceeds the acceptable limits prescribed by the environmental agencies. Moreover, they incur high capital and operational cost to produce an elevated sludge level. By employing different kinds of methods for the treatment, is essential to get rid of these hazardous chemical contaminants that were present in the dye effluent.

In India, agriculture has played a major role in livelihood and the net amount of agricultural by-products were enormously present. It could be renewed in an economically feasible manner. Moreover, they present an alternative method of disposing them in a safer manner. Environmentally friendly, cost-effective and easily available adsorbents had been used as a principle substitute for the existing expensive means of dye removal from wastewater (Hameed *et al*., 2013). The main advantage for the usage of waste material like adsorbents in dye removal would be their low cost, versatility and straightforward operating conditions (Rafatulla *et al*., 2010). On account of this, the adsorption techniques were established as a possible substitute for the dye removal from effluent. It is very effective in treating the effluent and removal of dyes from the wastewater. The reason that lies behind this would be its simple design, operational convenience and capability to withstand towards toxic substances (Senthamarai *et al*., 2012).

Activated carbons were widely used as an adsorbent for treating the effluents but its usage was hampered as a result of high cost. This leads to a search of new alternative adsorbents. The plant seeds were widely used for the wastewater treatment. To mention a few among them were seeds of *Carica papaya* (Hameed, 2009), *Moringa oliefera* (Vieira *et al*., 2010, Patel and Vashi, 2015), *Ziziphus maruritiana* (Reddy *et al*., 2012), *Strychnos potatorum* (Senthamarai *et al*., 2012), *Artocarpus heterophyllus* (Anoop Raj *et al*., 2014), *Annona squmosa* (Santhi *et al*., 2016), *Mucuna pruriens* (Igwegbe *et al*., 2016), *Phyllanthus emblica, Syzygium cumini, Tamarindus indica, Acacia sinuate* (Hameed *et al*., 2017) and *Phoenix dactylifera* (Marouani *et al*., 2018) were used for the various dye removal from the effluents. Watermelon (*Citrullus lanatus* (Thunb.) Matsum & Nakai) - Schaffer and Paris (2003) Watermelons, native of tropical Africa, are prostrate, basally branched, softly hairy vines possessing deeply and roundly indented, blue-grey green leaves with branched tendrils. Spherical to oval shaped fruits are mostly present in green colour with some being yellow. The fruit's outer skin can be formed with a single green shade like black-green, dark or light green. It could have two shades of green as striping.

Most cultivars have red flesh, with size ranges from 8-11 kg with some small brown seeds. The seeds of Watermelon could be black, brown, tan, white, red or green. It could be in a combination of these patterns too. Seed size and number per fruit also vary considerably. The seeds were smoothy, flat with 0.5-1.8 cm long and 0.3-1.1 cm broad point. In addition to that, 1000 seeds weigh nearly 60-150g. They didn't need a latency period, remains viable for up to 10 years and germinates epigealy. (http://climbers.lsa.umich.edu). The cadmium removal from the experimental wastewater by using melon husk was carried out by Giwa*et al* (2013). Adsorption studies determined the influence of duration of time, cadmium concentration, dosage and the size of the particle on the effectiveness of removal which was found to decrease with increase in cadmium ion concentration, but increased with decrease in size of the particle and increasing adsorbent dosage.Samra *et al*. (2014). By using the seeds of C. lanatus the lead (II) ion can be eliminated from the aqueous solution by employing adsorption technique. It was founded that about 97% of Pb^{2+} was adsorbed with pH 6 in 120 minutes. Malunjkar and Ambedkar (2015) used the C. lanatus seeds and then come to a conclusion that the phenolic compounds were found in the wastewater can be adsorbed to these watermelon seeds with a help of an activating agent.

By examining the effect of pH, temperature, dose, time duration and phenol concentration it was founded that the ability to uptake the highest quantity of phenol onto the activated carbon of *C. lanatus* was around 38.20 mg/g of Bitter gourd (*Momordica charantia*) - (Englberger, 2009). *M. charantia* a tropical and subtropical species which belongs to the Cucurbitaceae family. It has been widely grown for the edible fruit which is one among the most bitter fruits. Generally they were 2-3 m tall, annual to perennial monoecious climbing.

They were well branched, slender and green stems were usually 5- angled or ridged slightly. And also, they carry unbranched tendrils in their leaf axils. The leaves were carried singly along the stems with 3 - 5cm long. The stalks with each leaf were about 4-10 cm long and they were deeply lobed with 5 - 9 lobes. The leaves would have an unpleasant smell when they were crushed. They were comprised with both the male and female flowers which occurs singly in the upper axils of the leaf with a small leaf - like bract pointing towards the base.

There were 5 oval shaped petals about 10-20 cm long along with five central stamens. The pendulous cylindrical fruits were egg-shaped with 2-10 cm long and (up to 20cm in cultivated varieties). They were covered with longitudinal ridges and warts. While attaining the maturity stage, they turn from orange to yellow colour and the tips were splited into three. They used to turn back to reveal the yellow pulp and bright red arils which enclose the seeds adhere towards the inside of the fruit. Every flattened woody seeds were about 5-9 mm long and it had some finely pitted surfaces. Satar and Husain (2009) had used the salt fractionated peroxidase of *M.charantia* for the decolonization of water insoluble dyes, Disperse Red 17 and Disperse Brown 1 with the help of some redox mediators. By within 1 hour of incubation with pH 3.0 and 40°C, *Charantia* peroxidase (0.36 U/mL) had the capability to decolorize 90% and 65% of Disperse Red 17 and Disperse Brown 1, respectively.

It was declared that that the application of enzyme and the redox mediator system might be applicable for the removal of other synthetic dyes. Munichandran *et al*. (2016) examined the applications of *M. charantia* seed powder for both adsorption and removal of nickel and lead from the aqueous solution. Finally, it was concluded that it might be used as an excellent alternative, natural, low-cost adsorbent. Aziz and Shamoona (2018) had examined the adsorption of malachite green with chickoo peels, yellow cucumber peels, bitter gourd seeds and their activated carbon. Through this they concluded that the activated carbon that obtained from these biomaterials were found to be more efficient than their native forms. In this study we proposed the comparative analysis on the effectiveness of *C. lanatus and M. charantia* seed powder for the treatment of dye removal from the effluent collected from a textile dying unit and by analyzing the parameters with an in-built combination of Biofilter column.

MATERIALS AND METHODS

Sample collection: The effluent samples were collected from the Common Effluent Treatment Plant (CETP) at Angeripalayam, Tirupur district, Tamil Nadu. The effluents from 58 dying units were being treated at this CETP.

Preparation of *C. lanatus* and *M. charantia* seed powder: The seeds of *C. lanatus and M. charantia* were collected from the fresh, ripened fruit and were sun dried under shade. The dried seeds were kept in a separate closed airtight container. Then the seeds were ground into powder individually by using a domestic blender. The powder was then sieved through 600nm stainless steel sieve. The seed powder was prepared and stored in airtight containers separately for further use. No other additives were being added prior to adsorption experiments.

Determination of the coagulant activity (Standard Jar Test Method)

In separate experiments, the *C. lanatus and M. charantia* seed powder were used in the following doses as

(1g/L, 2g/L, 3g/L, 4g/L, 5g/L) for the treatment of 1 litre of dye effluent samples. The required quantity of *C. lanatus and M. charantia* seed powder were added to the dye effluents individually and left for mixing, flocculation and settling with the help of a Jar Test apparatus. This step was achieved by mixing it at a high speed (120 rpm) for 1 minute initially. Then it was followed by 15 minutes with slow speed (30 rpm) by stirring for flocculation. And then, the mixture was allowed to settle down for 60 minutes.

Biofilter Column Treatment

The filter column was prepared with the help of sand, activated carbon and dry egg shells. Initially all the ingredients of the filter column were washed with 1N hydrochloric acid in order to remove the dust particles which were attached to it. Then, the sand was washed with distilled water. After that, 50mL of sand was packed into the filter column. Along with that, activated charcoal was prepared with the help of dried Amla seeds. The seeds were crushed in a blender and were burnt at 2500ºC for few minutes by using a Muffle furnace.

The charcoal which was obtained from the seed powder was again washed with 1N hydrochloric acid until the pH becomes neutral. Further it was washed with distilled water and dried in an oven. After that, it was packed into the column for about 50ml. And then, with 75ml of eggshells which were pre-treated with the same 1N hydrochloric acid followed by heating in an oven for about 24 hours. After the primary treatment with *C. lanatus and M. charantia* seed powder, the effluent was then passed via the column at a rate of 2ml/min approximately (resident time for effluent is approximately 1 min).

RESULTS AND DISCUSSION

Dyeing industries which were present in and around the Tirupur district in Tamil Nadu had continuously discharging large quantities of effluents. These discharged effluents shows the water quality parameters above the levels of permissible limits prescribed by the Central Pollution Control Board (CPCBC) standards.

All these effluents should be treated efficiently because these were the major threats for water pollution. There might be different contaminants like detergents, dyes and salts which were present in the wastewater would go through some chemical and biological modifications. By consuming the dissolved oxygen in the water the aquatic life forms were destroyed. It also appears to be a major threat for human health due to their toxicity levels (Patel and Vashi., 2015).

Several kinds of techniques and methods were available for the removal these dyes in the effluents. In physical method, it includes sedimentation and filtration. (Cheremisinoff, 2002). In chemical methods, it includes advanced oxidation, hydrogen peroxide technique, Fenton's reagent, ozonisation, electro-coagulation, solvent extraction technique and surfactants (Sharma and Kaur, 2018). Among a wide range of processes, the adsorption technique plays a vital role in removing the dyes. Since, the synthetic dyes which were present in the effluents were unable to economically decolorize with the help of conventional methods because it was employed as a very simple and an inexpensive method for the removal of dyes from wastewater (Hameed *et al*., 2017).

The increasing requirement for an efficient and low-cost treatment methods with the importance of adsorption technique it had given rise towards low-cost alternative adsorbents. These biomaterials were particularly made from the sources like roots, leaves and peels of plants. Batch adsorption, a single step process was considered to be the simplest method available when compared with other methods (Patel and Vashi., 2015).

Textile effluents were collected from the CETP at Angeripalayam, Tirupur district. Because of their simplicity, low-cost and easy availability we had selected the seeds of *C. lanatus and M. charantia* for comparing their effectiveness on the effluent treatment. Adsorption technique with the help of biological materials and other such methods were used for water purification. It's because they were quick, economical and widely used.

The performances were depended on the type of which carbon source was used, characteristics of wastewater and the types of dyes present in it (Yagub *et al*., 2014). In this present study, different kinds of parameters like pH, TDS, TSS, chloride, alkalinity, colour, total hardness, calcium and magnesium hardness, free residual chlorine and COD levels were characterised with the raw dye effluent. The results of post-treatment with hypochlorite under different concentrations (1 - 5g) of *C. lanatus and M. charantia* were shown in Table 2 and Table 3 respectively. After careful analysis, the following criteria were selected for further treatment of dye effluent by using Biofilter column.

Table 1 : Treatment conditions:

Plant species	Sludge Weight	Selected pH	Selected dosing	Time duration
C. lanatus	5.086g	7	5g	17 hours
M. charantia	4.186g	7	4g	15 hours

In the past, several authors have used the combination methods to effectively treat the dyes/effluents discharged from the textile industries. Sundaram and Hameed (2012) successfully used Amla (*Phyllanthus emblica*) seed carbon as a low-cost carbon for the chromotrope dye removal from the aqueous solution. Combined techniques of filtration and coagulation were used in subsequent process. Graham *et al*. (1992)

Chakraborty *et al.* (2005) employed adsorption and nanofiltration as the successive steps for treating the dye effluents. As a result of that, it was founded that dye and COD concentration were removed for more than 90%. Hence we used successive methods by treating with various concentrations of C. lanatus and M. charantia seed powder. It was followed by filtration via Biofilter column with activated carbon from the seeds of *Phyllanthus emblica*, sand and egg shells.

The percentage deduction of various constituents with the comparison between the raw dye effluent, dye effluent and post-treatment with the Biofilter column were calculated by using the formula and represented as graphical figure (Fig.1). Percentage removal = (Ci - Ce)/Ci*100 Where, Ci = Initial concentration of the effluent and Ce= end concentration of the effluent as shown in Fig.

The performance of the *C. lanatus* seeds + Biofilter column was better than the combination of *M. charantia* seeds + Biofilter column, because it had reduced the concentration of many parameters. In *C. lanatus* seeds + Biofilter column the % reduction of colour and total soluble solids were very high, whereas reduction in total alkalinity and COD concentration was moderate to low respectively. But, in the case of *M. charantia* seeds + Biofilter column, it was slightly superior with reducing pH and the magnesium hardness in comparison to *C.lanatus*seeds + Biofilter column. Adsorption process involves a solid and liquid phase where the dissolved contaminants present in the liquid phase were adsorbed to the solid phase. This would act as a physiochemical method which permits dyes to inertly concentrate and bind contaminants (Bharathi and Ramesh, 2013). Hence, it was hypothesized that the seed powder of *C. lanatus* might be more effective in bind, concentrate and treat the dye effluent with an effective manner.

Giwa *et al.* (2013) had shown that the husk of *C. lanatus* seeds, a cheaper source, which has a substantial potential with valuable adsorbent for cadmium ion removal from the aqueous solutions. Thus, it could be used for treating the effluents from industries, thereby reducing the water pollution level. In a study conducted by Muhammad *et al.* (2015), the effectiveness of pH, dosage, stirring speed and time duration were assessed on the use of *C. lanatus* for wastewater treatment.

An optimum level of pH - 7.0, dosage - 0.1g/L, speed - 100rpm and stirring time - 8 minutes were found. Nearly 100% removal in colour and turbidity were observed when the watermelon seeds were used in tandem along with alum. Manyuchi and Chikomo (2016) successfully treated the portable water by using the seeds of *C. lanatus* which decrease the COD, BOD, EC and TDS to meet the acceptable levels of portable water. And, it had shown that this technology would be economically applicable in the developing countries. In concurrence, with the work of researchers cited above, it was concluded that the combination of *C. lanatus* seeds + Biofilter column could be utilized to reduce some parameters in dye effluent, that might harm the environment, the flora and fauna which depends on it, to a considerable level than the original raw effluent.

However, the major disadvantage of previous works on dye adsorption by biomaterials was that they were still in their infancy stage without pilot studies or commercialization as only limited attempts for detailed economic and market analyses were being explored. The major prospect was to move this technique to an industrial scale. Since it was easy to exhibit that in laboratory with a significant fiscal and technical effort.

Table 2: Change in levels of parameters after treatment of dye effluent using different concentrations of seed powder of *C. lanatus* and the improvement rates in Bio-filtration:

S. No.	Parameters	Raw Effluent	Hypo 2.3 mL	Concentration of Water melon seed					Eggshell, sand, & carbon
				1 g/L	2g/L	3 g/L	4 g/L	5 g/L	
1	Color (pt co)	5950	1280	6740	6540	6170	5590	5940	810
2	pH	9.56	9.86	7.46	7.29	7.52	7.61	7.53	7.24
3	Turbidity	74.6	56.4	96.3	102.4	99.8	86.3	92.4	18.7
4	Total dissolved solids (mg/L)	7190	7220	7242	7278	7194	7236	7254	7293
5	Total suspended solids (mg/L)	204	98	259	228	194	189	201	34
6	total hardness (mg/L)	450	480	460	470	460	450	450	470
7	Calcium hardness (mg/L)	270	290	260	260	270	240	250	280
8	Magnesium hardness (mg/L)	180	190	200	210	190	210	200	190
9	Free Residual chloride (mg/L)	Nil	42.0	Nil	Nil	Nil	Nil	Nil	Nil
10	Chloride (mg/L)	3272	3578	3318	3374	3293	3318	3354	3303
11	Total alkalinity (mg/L)	1570	1170	860	900	880	850	850	860
12	COD (mg/L)	1172	1322	2388	2412	2396	2018	2218	872
13.	Colour (visual)	Dark purple	Dark yellow	Dark green	Dark green	green	Brownish green	Dark yellow	Lightly yellow

Table 3: Change in levels of parameters after treatment of dye effluent using different concentrations of seed powder of *M. charantia* and the improvement rates in Bio-filtration*:*

S. No	Parameters	Raw Effluent	Hypo 2.3 mL	Concentration of *M. charantia* seed powder					Eggshell, sand, & carbon
				1 g/L	2g/L	3 g/L	4 g/L	5 g/L	
1	Color (pt co)	5580	1200	6840	6590	6610	5430	5310	1190
2	pH	9.49	9.89	7.28	7.39	7.14	7.36	7.20	7.01
3	Turbidity	72.4	54.6	174.6	182.3	179.6	154.8	148.3	32.4
4	Total dissolved solids (mg/L)	7240	7310	7276	7243	7312	7298	7288	7484
5	Total suspended solids (mg/L)	186	112	256	268	243	220	208	66
6	Total hardness (mg/L)	430	480	440	420	430	430	440	460
7	Calcium hardness (mg/L)	240	290	240	250	250	250	260	280
8	Magnesium hardness (mg/L)	190	190	200	170	180	180	180	180
9	Free Residual chloride (mg/L)	Nil	43	Nil	Nil	Nil	Nil	Nil	Nil
10	Chloride (mg/L)	3348	3464	3412	3284	3378	3294	3318	3363
11	Total alkalinity (mg/L)	1480	1150	1080	1000	980	920	940	920
12	COD (mg/L)	1242	1296	2454	2592	2318	2304	2270	1008
13.	Colour (visual)	Dark purple	Dark yellow	Dark green	Dark green	green	Brownish green	Dark yellow	Lightly yellow

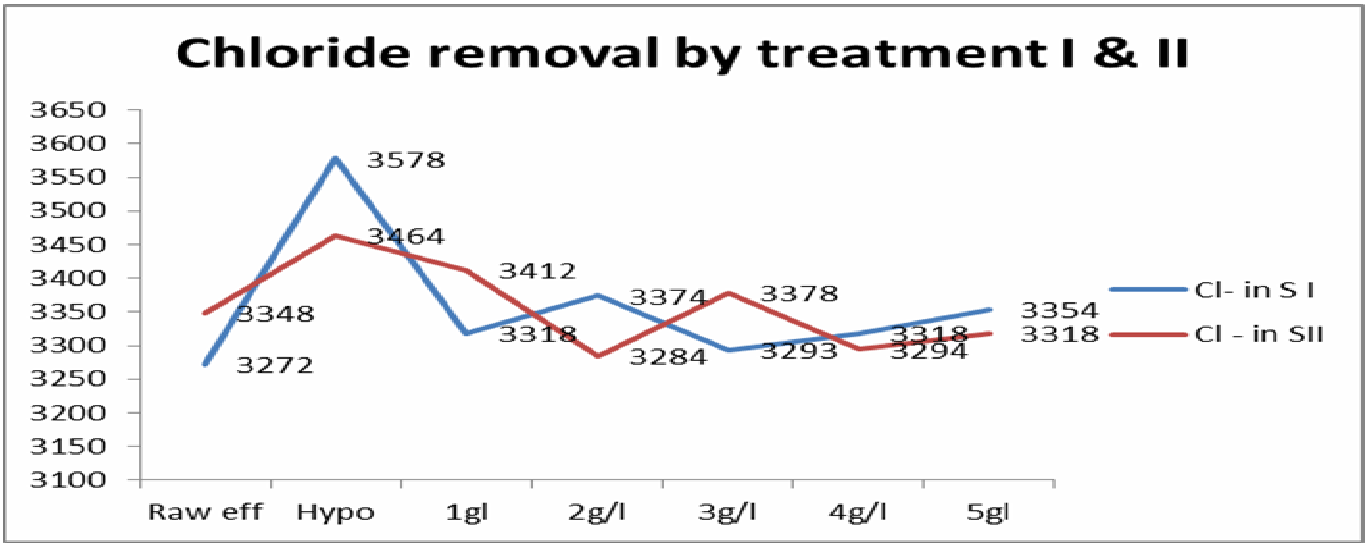

Fig. 1 : Depicts about the variation in the treatment efficiencies of chosen seed powder of watermelon & bitter guard. SI is watermelon seeds and SII is bitter guard seeds. The SII was found to be better than SII in terms of Cl- removal rate.

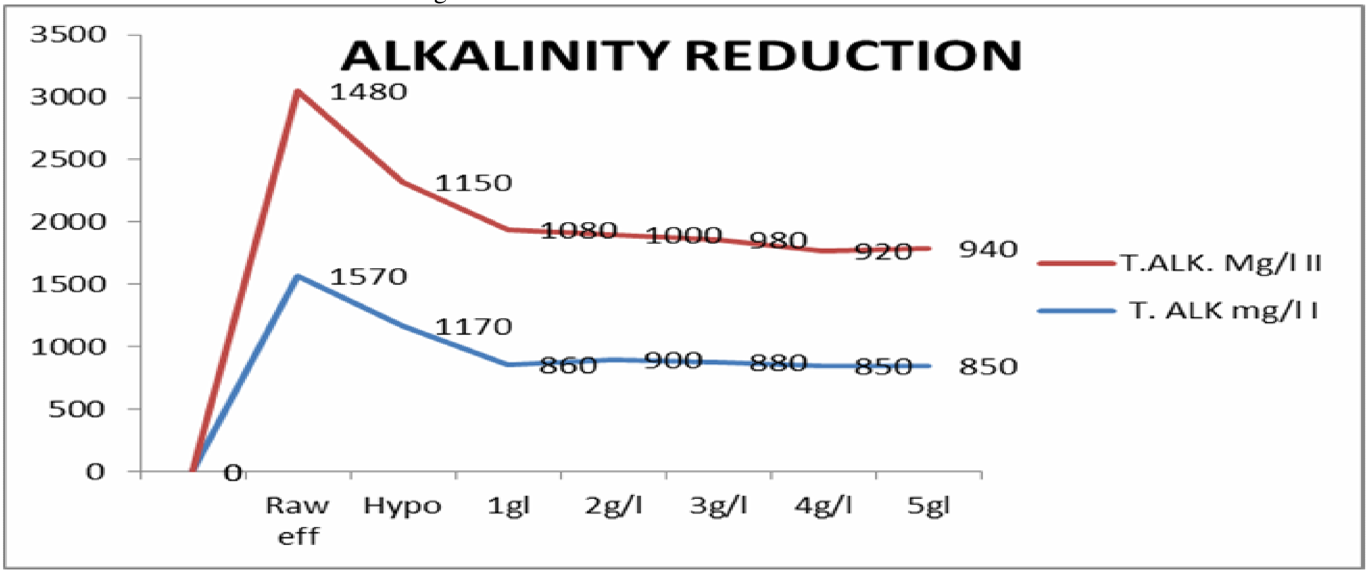

Fig. 2 : Depicts about the variation in the treatment efficiencies of chosen seed powder of watermelon & bitter guard. SI is watermelon seeds and SII is bitter guard seeds. The SII was found to be better than SII in terms of total alkalinity removal rate.

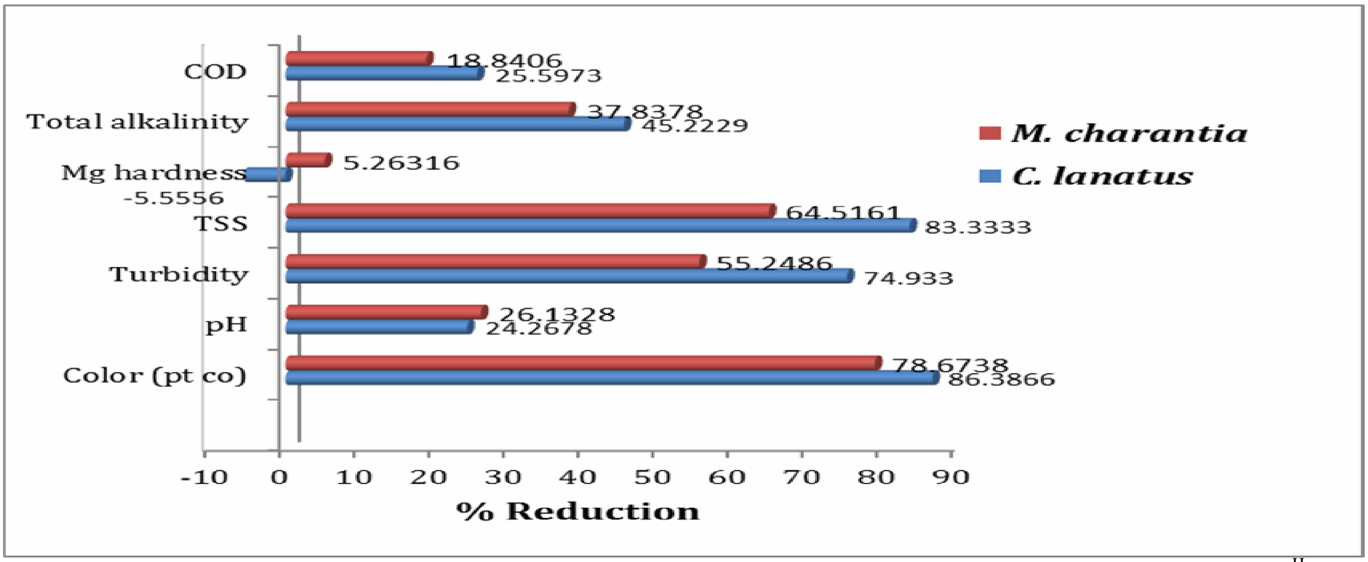

Fig. 3: Graph showing the % reduction of various parameters after filtration through Biofilter column (*C. lanatus* = p^H7, dosing = 4 g, time =15 hrs; *M. charantia* = p^H7, dosing = 5 g, time =17 hrs)

All the above parameters present in the effluent was again estimated after the treatment using bio-filtration arrangement. The percentage reduction rates were found to significant and effective.

STATISTICAL ANALYSIS

t-Test Result for Datasets:

Set 1 Range = Data for analysis!$F$5:$F$10 C1 pagarkai seed

Set 2 Range = Data for analysis!$F$15:$F$20 C2 watermelon seed

Descriptive Statistics

Variable	Mean	Std Dev.	Std Err	Lower 95% CL	Upper 95% CL	N
C1	7283.400	26.169	11.703	7250.907	7315.893	5
C2	7240.800	30.712	13.735	7202.667	7278.933	5

1-tailed t-Test (C1 > C2)

Ho. Diff	Mean Diff.	SE Diff.	't' value	DF	'p' value
0.000	42.600	18.044	2.361	8	0.023
			Significant		'p' < 0.05

Inference

't' value 2.361 is significant ('p' < 0.01)

Hence the mean Dissolved solids values differ significantly

Mean Dissolved solids in Pagarkai seed [7283.4] is greater than Mean Dissolved solids [7240.8] in Watermelon seed

Descriptive Statistics

Variable	Mean	Std Dev.	Std Err	Lower 95% CL	Upper 95% CL	N
E1	432.000	8.367	3.742	421.611	442.389	5
E2	458.000	8.367	3.742	447.611	468.389	5

1-tailed t-Test (E1 < E2)

Ho. Diff	Mean Diff.	SE Diff.	't' value	DF	'p' value
0.000	-26.000	5.292	4.914	8	0.001
			Significant		'p' < 0.01

Variable	Mean	Std Dev.
Mean suspended solids Pagarkai seed	432.000	8.367
Mean suspended solids Watermelon seed	458.000	8.367

Inference

't' value 4.914 is significant ('p' < 0.05)

Hence the Mean suspended solids values differ significantly

Mean Mean suspended solids in Pagarkai seed [432.0] is less than Mean suspended solids in Watermelon seed [458.0] of Watermelon seed

t-Test Result for Datasets:

Descriptive Statistics

Variable	Mean	Std Dev.	Std Err	Lower 95% CL	Upper 95% CL	N
F1	250.000	7.071	3.162	241.220	258.780	5
F2	256.000	11.402	5.099	241.843	270.157	5

1-tailed t-Test (F1 < F2)

Ho. Diff	Mean Diff.	SE Diff.	't' value	DF	'p' value
0.000	-6.000	6.000	1.000	8	0.173
			NOT Significant		'p' > 0.05

Variable	Mean	Std Dev.
Mean calcium Pagarkai seed	250.000	7.071
Mean calcium solids Watermelon seed	256.000	11.402

Inference

't' value 1.0 is NOT significant ('p' > 0.05)

Hence the Mean calcium values DO NOT differ significantly

Mean Mean calcium in Pagarkai seed [250.0] and Mean calcium in Watermelon seed [256.0] of Watermelon seed are ALMOST SIMILAR

G1	182.000	10.954	4.899	168.398	195.602	5
G2	202.000	8.367	3.742	191.611	212.389	5

1-tailed t-Test (G1 < G2)

Ho. Diff	Mean Diff.	SE Diff.	't' value	DF	'p' value
0.000	-20.000	6.164	3.244	8	0.006
			Significant		'p' < 0.01

Variable	Mean	Std Dev.
Mean magnesium Pagarkai seed	182.000	10.954
Mean magnesium Watermelon seed	202.000	8.367

Inference

't' value 3.244 is significant ('p' < 0.01)

Hence the meanmegnesium values differ significantly

Mean magnesium of Pagarkai seed [182.0] is less than Mean magnesium [202.0] of Watermelon seed

Descriptive Statistics

Variable	Mean	Std Dev.	Std Err	Lower 95% CL	Upper 95% CL	N
H1	3337.200	55.509	24.824	3268.277	3406.123	5
H2	3331.400	32.246	14.421	3291.361	3371.439	5

1-tailed t-Test (H1 < H2)

Ho. Diff	Mean Diff.	SE Diff.	't' value	DF	'p' value
0.000	5.800	28.709	0.202	8	0.578
			NOT Significant		'p' > 0.05

Variable	Mean	Std Dev.
Mean chloride Pagarkai seed	3337.200	55.509
Mean chloride Watermelon seed	3331.400	32.246

Inference

't' value 0.202 is NOT significant ('p' > 0 .05)

Hence the mean chloride values DO NOT differ significantly

Mean Mean chloride in Pagarkai seed [3337.2] and Mean chloride in Watermelon seed [3331.4] of Watermelon seed are ALMOST SIMILAR

Descriptive Statistics

Variable	Mean	Std Dev.	Std Err	Lower 95% CL	Upper 95% CL	N
J1	818.400	409.259	183.026	310.238	1326.562	5
J2	868.000	21.679	9.695	841.081	894.919	5

1-tailed t-Test (J1 < J2)

Ho. Diff	Mean Diff.	SE Diff.	't' value	DF	'p' value
0.000	-49.600	183.283	0.271	4.022	0.400
			NOT Significant		'p' > 0.05

Variable	Mean	Std Dev.
Mean alkalinity Pagarkai seed	818.400	409.259
Mean alkalinity Watermelon seed	868.000	21.679

Inference

't' value 0.271 is NOT significant ('p' > 0 .05)

Hence the mean alkalinity values DO NOT differ significantly

Mean Mean alkalinity in Pagarkai seed [818.4] and Mean alkalinity in Watermelon seed [868.0] of Watermelon seed are ALMOST SIMILAR

K1	2387.600	134.025	59.938	2221.186	2554.014	5
K2	2286.400	169.431	75.772	2076.024	2496.776	5

1-tailed t-Test (K1 > K2)

Ho. Diff	Mean Diff.	SE Diff.	't' value	DF	'p' value
0.000	101.200	96.612	1.047	8	0.163
			NOT Significant		'p' > 0.05

Variable	Mean	Std Dev.
Mean COD Pagarkai seed	2387.600	134.025
Mean COD Watermelon seed	2286.400	169.431

Inference

't' value 1.047 is NOT significant ('p' > 0 .05)

Hence the mean COD values DO NOT differ significantly

Mean Mean COD in Pagarkai seed [2387.6] and Mean COD in Watermelon seed [2286.4] of Watermelon seed are ALMOST SIMILAR

CONCLUSION

The dye effluent was treated to remove the elevated parameters ofpH, TDS, TSS, chloride, alkalinity, turbidity, colour, total hardness, calcium hardness, magnesium hardness, free residual chlorine and COD using *Citrullus lanatus and Momordica charantia* seed powder. There was a significant higher efficiency for *Momordica charantia* seed than *Citrullus lanatus seeds.* However, the permissible level was not reached only using the seed treatments. Hence the bio-filtration treatment was adapted along with the seed powder treatment. There occurs a change in the percentage levels of parameters such as colour, turbidity, total hardness and COD to 86.3, 74.9, 83.3, 45.2, 25.5% respectively. Finally, it was concluded that the seed powder along with the biofilter column can be used as an alternative method for treating the dye containing effluents.

REFERENCES

Anoop Raj, J.R.; Anil, K.; Das, B.S. and Suresh, A.S. (2014). Effect of Process Parameters on Adsorption of Methylene Blue from Synthetic Effluent Using Jack Fruit Seed Powder. *International Journal of Innovations in Engineering and Technology.* 4(4): 340-345.

Aziz, S.S. and Shamoona, H. (2018). Adsorption of Malachite Green with Chickoo peels, Yellow cucumber peels, Bitter gourd seeds and their activated carbon. *International Journal of Engineering Development and Research*, 6(3):7-10.

Bharathi, K.S. and Ramesh, S.T. (2013). Removal of dyes using agricultural waste as low-cost adsorbents: a review. *Applied Water Science*, 3: 773-790.

Chakraborty, S.; De, S.; Basu, J.K. and Gupta, S.D. (2005). Treatment of a textile effluent: application of a combination method involving adsorption and nanofiltration. *Desalination*, 174: 73-85.

Chen, K.C.; Wu, J.Y.; Huang, C.C.; Liang, Y.M. and Hwang, S.C.J. (2003). Decolorization of azo dye using PVA-immobilized microorganisms. *Journal of Biotechnology*, 101: 241-252.

Cheremisinoff, N.P. (2002). Handbook of Water and Wastewater Treatment Technologies. Butterworth-Heinemann, Boston.

Daneshvar, N.; Khataee, A.R.; Rasoulifard, M.H. and Pourhassan, M. (2007). Biodegradation of dye solution containing Malachite Green: optimization of effective parameters using Taguchi method. *Journal of Hazardous Materials*, 143: 214-219.

El-Marouani, M.; Azoulay, K.; Bencheikh, I.; El-Fakir, L.; Rghioui, L.; El-Hajji, A.; Sebbahi, S.; El- Hajjaji, S. and Kifani-Sahban, F. (2018). Application of raw and roasted date seeds for dyes removal from aqueous solution. *Journal of Materials and Environmental Sciences*, 9(8): 2387-2396.

Englberger, K. (2009). Invasive weeds of Pohnpei: A guide for identification and public awareness. Kolonia, Federated States of Micronesia: Conservation Society of Pohnpei, 29 pp.

Giwa, A.; Bello, I.A.; Oladipo, M.A.; Adeoye, D.O. (2013). Removal of Cadmium from Waste-water by Adsorption Using the Husk of Melon (*Citrullus lanatus*) Seed. *International Journal of Basic and Applied Science*, 2(1):110-123.

Graham, N.J.D.; Brandao, C.C.S. and Luckham, P.F. (1992). Evaluating the removal of color from water using direct-filtration and dual coagulants. *Journal of American Water Works Association*. 84: 105–113.

Hameed, B.H. (2009). Evaluation of papaya seed as a novel non-conventional low-cost adsorbent for removal of methylene blue. *Journal of Hazardous Materials*, 162: 939-994.

Hameed, K.S.; Muthirulan, P.; Sundaram, M.M. (2017). Adsorption of chromotrope dye onto activated carbons obtained from the seeds of various plants: Equilibrium and kinetics studies. *Arabian Journal of Chemistry*, 10: 2225-2233.

Holkar, C.R.; Jadhav, A.J.; Pinjari, D.V.; Mahamuni, N.M.; Pandit, A.B. (2016). A critical review on textile wastewater treatments: Possible approaches. *Journal of Environmental Management*, 182: 351-366.

http://climbers.lsa.umich.edu/?p=248

Hu, M.R.; Chao, Y.P.; Zhang, G.Q.; Xue, Z.H. and Qian, S. (2009). Laccase mediator system in the decolorization of different types of recalcitrant dyes. *Journal of Industrial Microbiology and Biotechnology*, 36: 45-51.

Igwegbe, C.A.; Onyechi, P.C.; Onukwuli, O.D.; Nwokedi, I.C. (2016). Adsorptive Treatment of Textile Wastewater Using Activated Carbon Produced from *Mucuna pruriens* Seed Shells. *World Journal of Engineering and Technology*, 4: 21-37.

Kabra, A.N.; Khandare, R.V.; Waghmode, T.R.; Govindwar, S.P. (2012). Phytoremediation of textile effluent and mixture of structurally different dyes by *Glandularia pulchella* (Sweet) Tronc., *Chemosphere*, 87(3): 265-272.

Khan, M.I.; Akhtar, S.; Zafar, S.; Shaheen, A.; Khan, M.A.; Luque, R. and Rehman, A. (2015). Removal of Congo red from Aqueous Solution by Anion Exchange Membrane (EBTAC): Adsorption Kinetics and Themodynamics. *Materials*, 8: 4147-4161.

Kumar, M.R. and Saravanan, K. (2015). Application of reverse osmosis membrane system for treatment of effluent in textile knitted fabric dyeing. *African Journal of Biotechnology*, 10(70): 15756-15762.

Kumar, P.S.; Sivaranjanee, R.; Vinothini, U.; Raghavi, M.; Rajasekar, K. and Ramakrishnan, K. (**2014**). *Desalination and Water Treatment*, 52: 2620-2633.

Kyzas, G.Z.; Fu, J.; Matis, K.A. (2013). The Change from Past to Future for Adsorbent Materials in Treatment of Dyeing Wastewaters. *Materials*, 6: 5131-5158.

Malik, P.K. and Saha, S.K. (2003). Oxidation of direct dyes with hydrogen peroxide using ferrous ion as catalyst. *Separation and Purification Technology*, 31: 241-250.

Malunjkar, S.A. and Ambekar, K.R. (2015). Treatment of Phenolic Water Using Watermelon Seeds. *International Journal of Engineering and Technical Research,* 3(5): 263-266.

Manyuchi, M.M. and Chikomo, T. (2016). Treatment of water using watermelon (Citrullus lanatus) seeds as organic coagulant and microbial filter. *International Conference on Pure and Applied Chemistry,* Emerging Trends in Chemical Sciences. Flic en Flac, Mauritius, 18-22 July 2016.

Mondal, S. (2008). Methods of Dye Removal from Dye House Effluent - An Overview. *Environmental Engineering Science*, 25(3):383-396.

Muhammad, I.M.; Abdulsalam, S.; Abdulkarim, A. and Bello, A.A. (2015). Water Melon Seed as a Potential Coagulant for Water Treatment. *Global Journal of Researches in Engineering: C Chemical Engineering*, 15(1): 17-23.

Munichandran, M.; Gangadhar, B. and Naidu, G.R.K. (2016). Bioremoval of Nickel and lead using bitter gourd (*Momordica charantia*) seeds. **2016**. *International Journal of Advanced Research in Science, Engineering and Technology*, 3(8): 2475-2484.

Patel, H.; Vashi, R.T. (2015). Chapter 4 - Batch Adsorption Treatment of Textile Wastewater, Ed: Patel, H and Vashi, R.T. Characterization and Treatment of Textile Wastewater, *Elsevier*, 111-125.

Rafatullah, M.; Sulaiman, O.; Hashim, R. and Ahmad, A. (2010). Adsorption of methylene blue on low-cost adsorbents: A review. *Journal of Hazardous Materials*, 177: 70-80.

Reddy, M.C.S.; Sivaramakrishna, L. and Reddy, A.V. (2012). The use of an agricultural waste material, Jujuba seeds for the removal of anionic dye (Congo red) from aqueous medium. *Journal of Hazardous Materials*, 203– 204:118-127.

Sachdeva, S. and Kumar, A. (2009). Preparation of nonporous composite carbon membrane for separation of Rhodamine B dye. *Journal of Membrane Science*, 329: 2-10.

Samra, S.E.; Jeragh, B.; EL-Nokrashy, A.M. and El-Asmy, A.A. (2014). Adsorption and thermodynamics of lead (II) using seeds of watermelon (SWM) as a low cost sorbent. International *Journal of Engineering and Applied Sciences*, 1(1): 19-24.

Santhi, T.; Manonmani, S.; Vasantha, V.S. and Chang, Y.T. (2016). A new alternative adsorbent for the removal of cationic dyes from aqueous solution. *Arabian Journal of Chemistry*, 9: 466-S474.

Schaffer, A.A.; Paris, H.S.; Melons, S. and Gourds (**2003**). *Encyclopaedia of Food Sciences and Nutrition*. 2^{nd} Ed, 3817-3826.

Senthamarai, C.; Senthil Kumar, P.; Priyadharshini, M.; Vijayalakshmi, P.; Kumar, V.; Baskaralingam, P.; Thiruvengadaravi, K.V. and Sivanesana, S. (2012). Adsorption Behavior of Methylene Blue Dye onto Surface Modified *Strychnos potatorum* Seeds. *Environmental Progress and Sustainable Energy*, 32(3): 624-632.

Sharma, S. and Kaur, A. (2018). Various Methods for Removal of Dyes from Industrial Effluents - A Review. *Indian Journal of Science and Technology*, 11(12):1-21.

Sohrabi, M.R. and Ghavami, M. (2008). Photocatalytic degradation of Direct Red 23 dye using UV/TiO2: effect of operational parameters. *Journal of Hazardous Materials*, 153: 1235-1239.

Sundaram, M.M. and Hameed, K.S. (2012). Removal of chromotrope dye from aqueous solution using amla seed carbon: A new non-conventional low cost adsorbent. *Indian Journal of Environmental Protection*. 32: 241-248.

Tan, I.A.W.; Ahmad, A.L. and Hameed, B.H. (2008). Adsorption of basic dye on high-surface area activated carbon prepared from coconut husk: equilibrium, kinetic and thermodynamic studies. *Journal of Hazardous Materials*, 154: 337-346.

Vieira, A.M.S.; Vieira, M.F.; Silva, G.F.; Araujo, A.A.; Fagundes-Klen, M.R.; Veit, M.T.; Bergamasco, R. (2010). Use of Moringa oleifera seed as a natural adsorbent for wastewater treatment. *Water, Air and Soil Pollution*, 206(1-4): 273-281.

Yagub, M.T.; Sen, T.K.; Afroze, S. and Ang, H.M. (2014). Dye and its Removal from aqueous solution by Adsorption: A review. *Advances in Colloid and Interface Science*. doi: 10.1016/j.cis.2014.04.00

Zonoozi, M.H.; Moghaddam, M.R.A. and Arami, M. (2009). Coagulation/flocculation of dye containing solutions using polyaluminium chloride and alum. *Water Science and Technology*, 59: 1343-1351.