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ORIGINAL ARTICLE

Treatment of Disperse Blue 14 Wastewater and Sugar Wastewater By Low Cost Adsorbents

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ABSTRACT
Orange peel and Peanut hull are used in this research to treat the combined binary mixture of Disperse Blue 14and sugar wastewater. The combined wastewater is treated with adsorption followed by micro-filtration. The dosages, sizes and concentrations used in this research are based on trail and error method. Whatman-41 is used in the micro-filtration treatment process. This research is mainly based on color removal. The color removal is estimated and compared from the measured transmittance and absorbance values. The same treatment tests are performed on the activated carbon and taken as datum and compared with the low-cost adsorbents. NPOC values were also estimated using Shimadzu TOC-L analyzer which followed catalytic oxidation method. Finally, the data is analyzed with Langmuir and Freundlich isotherm equations.
Keywords: Disperse Blue 14, Color removal, Orange peel, Peanut hull, Transmittance, Sugar wastewater, Dye wastewater.

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INTRODUCTION

Disperse dyes are a kind of organic substances which are free from ionizing group. These are mainly insoluble in water and mainly used for synthetic textile materials like polyester in the process of dyeing [1]. Whereas dyes like reactive dyes are used for natural fibers. They have capability to interact with polyester chains in order to form disperse particles. According to industrial classification dyes are classified into three types. They are protein textile dyes, cellulose textile dyes, synthetic textile dyes. Cellulose textile dyes are further classified into direct dyes, vat dyes, basic dyes, fiber reactive dyes. Protein textile dyes are further classified into acid dyes, mordant dyes. Synthetic textile dyes are further classified into disperse dyes and solvent dyes.

The dye used in this research has C.I. name Disperse blue 14 with C.I. number 61500. Its molecular structure is anthraquinones. Its molecular formula is $C_{16}H_{14}N_2O_2$ with molecular weight 266.29 g/mol with bright blue. It is basically a blue powder. Soluble in acetone, glacial acetic acid, the difficulties, pyridine, and toluene [1, 4]. It has ability for reacting with strong sulfuric acid to red light brown. Used for polyester, vinegar, and polyamide fiber dyeing, also can be used to transfer printing. And is fit for manufacturing fireworks, hair color components. Can also be used in such of surface coloring and plastic.

Every day over billions of wastewaters are generated in United States from one or the other sources. If all the wastewater float untreated right back into our water system and ocean it causes a serious problem. Dyeing industries is among the one of the major polluting sources. But, research on treating these wastewater is developing in this emerging world of urbanization due to its impacts on humans [2]. Dye can affect us and things around us. For example: It can affect us either through our drinking water or the fish we eat. Dye wastewater can be also considered as toxic run off.

Sugar processing wastewater has a high content of organic material and subsequently a high biochemical oxygen demand $(BOD)_2$, particularly because of the presence of sugars and organic material arriving with the beet or cane [3]. Wastewater resulting from the washing of incoming raw materials may also contain crop pests, pesticide residues, and pathogens. The disposal of untreated waste water from the sugar industry is the major environmental problem. Back pumping of polluted water in to natural water resources may cause serious ecological disaster. It also have an impact on natural flow of lakes [3].

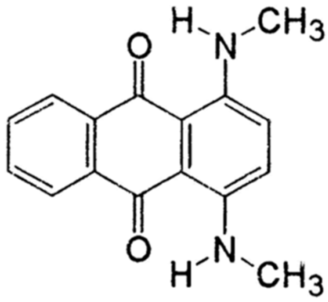

Fig 1: Chemical Structure of Disperse Blue 14

MATERIAL AND METHODS

Equipment used

Weighing balance (OHAUS PA1502)

This machine consists of a metal base with ABS top housing with stainless steel pan. It also has up-front level indicator with integral weigh below the hook. It is equipped with security bracket and calibration lock along with full housing in-use cover. The maximum capacity of the machine is 1,510g with reliability of 0.01g. The pan size is 7.1 inch (180mm) with no applicable internal calibration. Auxiliary display model is available as an accessory. The communication used is RS232 with LCD display. The linearity is ±0.02g with minimum weight USP 20g and stabilization time of 2sec. It can be used in the environment conditions between 10˚C - 30˚C and 80%RH.

Spectrophotometer (Carolina #65-3303)

This spectrophotometer is easy to operate. It consists of a nob to set the wavelength in the units of nanometer. Button 1 helps to blank the standard. It displays both absorbance and % transmittance to using the mode bottom to toggle between them. The absorbance accuracy check is ±2% at 1A. Accepts 10mm test tube or 10mm square cuvette. The wavelength range is 335 – 1000mm with spectral band pass 20nm. The wavelength accuracy is ±2 nm and wavelength repeatability is ± 1 nm. The stray radiant energy of < 0.5% T at 340 and 400nm with 0-125 T & 0-2.0 Abs. The photometric accuracy of ± 2.0% T. the power requirements are 115/230 V ± 10%, 60/50 Hz.

Innova 2300 - Platform Shaker, 115 V 60 CV AC

It consists of triple–eccentric counter balanced drive in cast iron housing which provides vibration. It shakes between 25-500rpm with 2.5cm orbit and 25-300rpm with 5.1cm orbit. Speed can be controlled and displayed in increments of 1rpm. It has a timer 0.1-0.99h along with the audible and visual alarms. The platform size is 76 cm x 46 cm and requires power of 120 V, 50/60 Hz.

TOC analyzer (Shimadzu TOC-L)

The TOC-L analyzer adopts the 680˚C combustion catalytic oxidation method. It has a wide range of 4μg/L to 30,000 mg/L. The capacity to detect up to 4μg/L is due to usage of non-dispersive infrared sensor (NDIR). It can be used to detect the hard-to-decompose insoluble and macro molecular organic compounds. It is capable of measuring TC, IC, TOC, NPOC, POC, and TN. It is featured with automatic sample acidification and sparging. It associated with accessories high-salt sample combustion tube kit, B-type halogen scrubber, carrier gas purification kit, Gas sample injection kit, POC measurement kit, Nitrogen carrier gas kit, Suspended sample kit.

Fisher Oven 200 SERIES (Model 230F)

It is a conventional benchtop laboratory oven with adjustable height interior shelf for additional flexibility. It works with 115VAC, 50/60Hz. It has a regulator to control the temperature with a LED light indicator.

Adsorbents

The peanut hull and orange peel is prepared from the purchased shelled peanuts and oranges from the Walmart. The shell and peel is removed from peanuts and oranges respectively. The peanut hull is washed with water thoroughly with tap water. Then it are oven dried at 70˚C for 24hrs. Then the dried peanut hull is ground with Preethi blender and sieved into five different sizes. The retained matter on five sizes sieves are used in this research to treat the combined wastewater of Disperse Blue 14 and Sugar Wastewater [5, 6]. This change in surface area helps to determine the variation in adsorption capacity.In the similar way orange peel is oven dried at 70˚C for 24hrs. The dried orange peels are grounded with Preethi blender and sieved. The matter which is passed through 425 μm. Single size is maintained with different dosages in the case of orange peel [7, 8, 9].

Method

The treatment method starts with the preparation of mother samples of the selected dyes. First weigh the dye using Weighing balance (OHAUS PA1502) with ±0.01g precision [10]. Prepare mother samples of the three dyes with 1000ppm and of volume 1000ml in a glass jar by adding the measured dye to a 1000ml. Stir it thoroughly with a glass stirrer. Cover it immediately with the silver foils to prevent it from oxidizing. Then prepare four different concentrations of Disperse Blue 14 by taking the samples from the mother sample in glass jar. 250ppm, 500ppm, 750ppm, 1000 ppm are considered as low, lower medium, upper medium, high concentrations for Disperse Blue 14 respectively. This consideration is based on trial and error process to distinguish transmissivity of the dye [11]. Fill each concentration of dye in 78 vails of 100ml maximum capacity up to 50ml in it. Then prepare the sugar wastewater mother samples in the laboratory of 1000ppm. Then prepare 6 different concentrations of sugar wastewater from the mother samples of 100ppm, 200ppm, 300ppm, 400ppm, 500ppm, 600ppm. Add 50ml of 6 different concentrations of sugar wastewater solutions to the vails half filled with dye samples. Then calculate the absorbance and transmittance values for the samples before treatment using the Spectrophotometer (Carolina #65-3303).

Then prepare the low-cost absorbents from the orange peel and peanut hull. First dry the Orange peels and Peanut hull in the oven for 24hrs at 100˚C. A fine powder is prepared using blender after removing the moisture content from the orange peel and peanut hull. Then orange peel is used to sample at 4 different weighs of 0.5g, 1g, 1.5g, and 2g. Then the peanut hull is grounded into 5 different sizes using the sieves in the laboratory. Add them to samples in the vails according to the sizes and weighs taken. Use the mechanical shaker to mix the absorbents thoroughly at 100rpm for 1 minute and 30rpm for 45mins. Allow them to undergo adsorption process for 24hrs and filter them with micro filters. Then again calculate the absorbance and transmittance values for the samples after treatment using the Spectrophotometer (Carolina #65-3303). Results are evaluated using these values [12, 13].

Run protocol

The parameters which are varied in this research consists of varied binary mix concentrations of Disperse Blue 14 wastewater and sugar wastewater, type of adsorbents, size of adsorbent and dosage of adsorbents.

Table 1. Run protocol for low concentration dye treated with orange peel

Run order	**Dye concentration (ppm)**	**Adsorbent concentration (g)**	**Sugar Waste water concentration (ppm)**
1	250	0.5	100
2	250	1	100
3	250	1.5	100
4	250	2	100
5	250	0.5	200
6	250	1	200
7	250	1.5	200
8	250	2	200
9	250	0.5	300
10	250	1	300
11	250	1.5	300
12	250	2	300
13	250	0.5	400
14	250	1	400
15	250	1.5	400
16	250	2	400
17	250	0.5	500
18	250	1	500
19	250	1.5	500
20	250	2	500
21	250	0.5	600
22	250	1	600
23	250	1.5	600
24	250	2	600

Table 2. Run protocol for low concentration dye treated with peanut hull

Run order	Dye concentration (ppm)	Adsorbent size	Sugar waste water concentration (ppm)
1	250	3327 µm - 2380µm	100
2	250	2380 µm - 2362 µm	100
3	250	2362 µm - 600 µm	100
4	250	600 µm - 425 µm	100
5	250	< 425 µm	100
6	250	3327 µm - 2380µm	200
7	250	2380 µm - 2362 µm	200
8	250	2362 µm - 600 µm	200
9	250	600 µm - 425 µm	200
10	250	< 425 µm	200
11	250	3327 µm - 2380µm	300
12	250	2380 µm - 2362 µm	300
13	250	2362 µm - 600 µm	300
14	250	600 µm - 425 µm	300
15	250	< 425 µm	300
16	250	3327 µm - 2380µm	400
17	250	2380 µm - 2362 µm	400
18	250	2362 µm - 600 µm	400
19	250	600 µm - 425 µm	400
20	250	< 425 µm	400
21	250	3327 µm - 2380µm	500
22	250	2380 µm - 2362 µm	500
23	250	2362 µm - 600 µm	500
24	250	600 µm - 425 µm	500
25	250	< 425 µm	500
26	250	3327 µm - 2380µm	600
27	250	2380 µm - 2362 µm	600
28	250	2362 µm - 600 µm	600
29	250	600 µm - 425 µm	600
30	250	< 425 µm	600

RESULTS AND DISCUSSION

The transmittance after treatment with two different adsorbents is used to describe the relationship between the transmittance and varying dye *(Disperse Blue 14)* concentration with different low-cost adsorbents *(Orange Peel, Peanut Hull)*and the reference adsorbent activated carbon for the various wastewater samples. We can observe that the transmittance decreases from 98.86% to 95.63% with the increase in dye concentration from low to high when treated with activated carbon. Similarly, we can observe that the transmittance decreases from 97.83% to 90.01% & 78.67% to 72.24% with the increase in dye concentration from low to high when treated with Orange Peel and Peanut Hull respectively. These are the results achieved at optimum size of peanut hull and optimum dosage of orange peel.

The non-purgeable organic carbon *(NPOC)* after treatment with different adsorbents which is used to describe the relationship between the NPOC and varying sugar wastewater concentration with different low-cost adsorbents *(Orange Peel, Peanut Hull)* and the reference adsorbent activated carbonfor high Disperse Blue 14 concentration. We can observe that combined binary wastewater treated with peanut hull has the high NPOC value of 60.84 mg/l, orange peel and activated carbon has NPOC value of 57.9 mg/l and 46.78 mg/l respectively. We can also observe that the NPOC values increases with increase in sugar wastewater concentration from 100ppm to 600ppm.

Langmuir isotherm model has the best fit for Disperse Blue 14 at the optimum dosage of low-cost adsorbents with linear equation: $y = 492.94x - 0.0102$ with coefficient: 0.00203 and Coefficient of determination $R^2 = 0.9981$ for orange peel and linear equation: $y = 8.3635x + 0.0002$ with coefficient: 0.11957 and Coefficient of determination $R^2 = 0.8779$ for peanut hull.

The results we achieved for the Disperse Blue 14 are (7.6, 8.1, 6.8) when treated with activated carbon, orange peel, peanut hull respectively at their optimum dosages. The pH factor is very important in the adsorption process especially for dye adsorption. The pH of a medium will control the magnitude of electrostatic charges which are imparted by the dye molecules. Consequently, the rate of adsorption will vary with the pH of an aqueous medium.

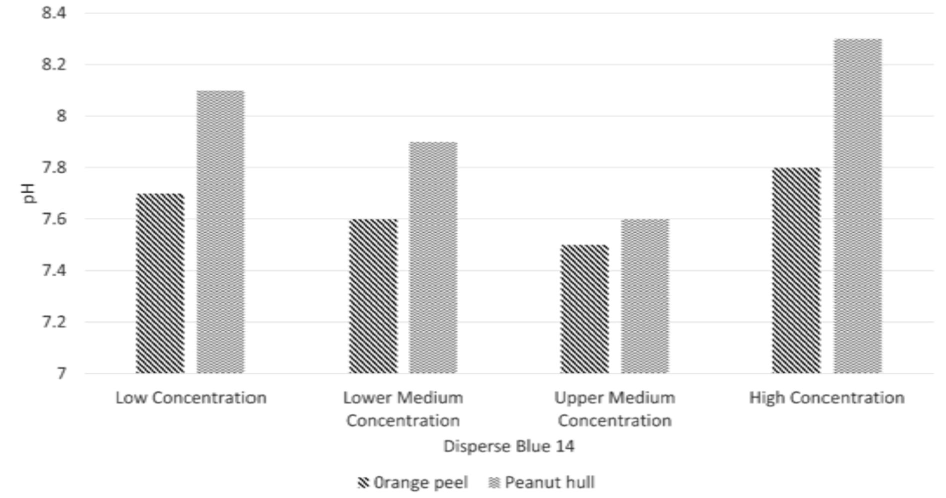

Figure 1. Effect of pH on combined sugar and dye wastewater with varying dyes

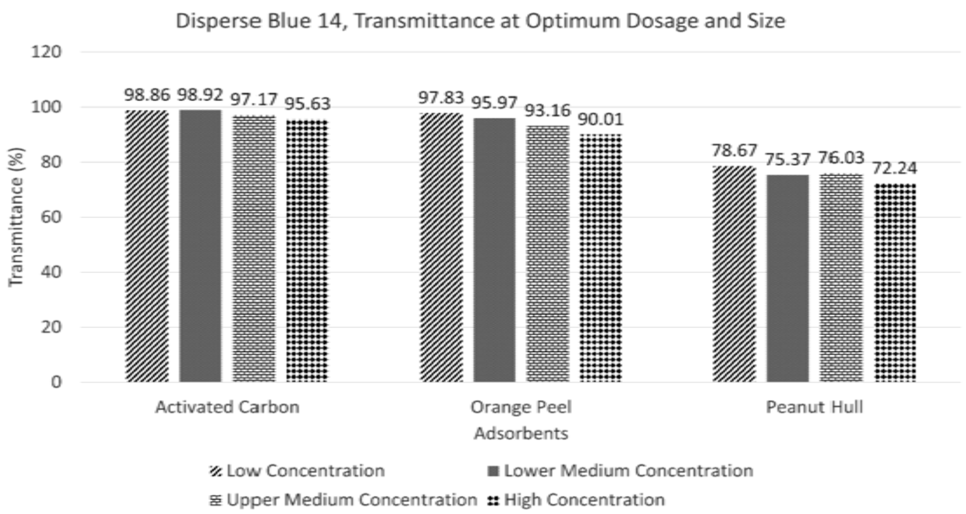

Figure 2. Transmittance of Disperse Blue 14 at optimum adsorbent size and dosage.

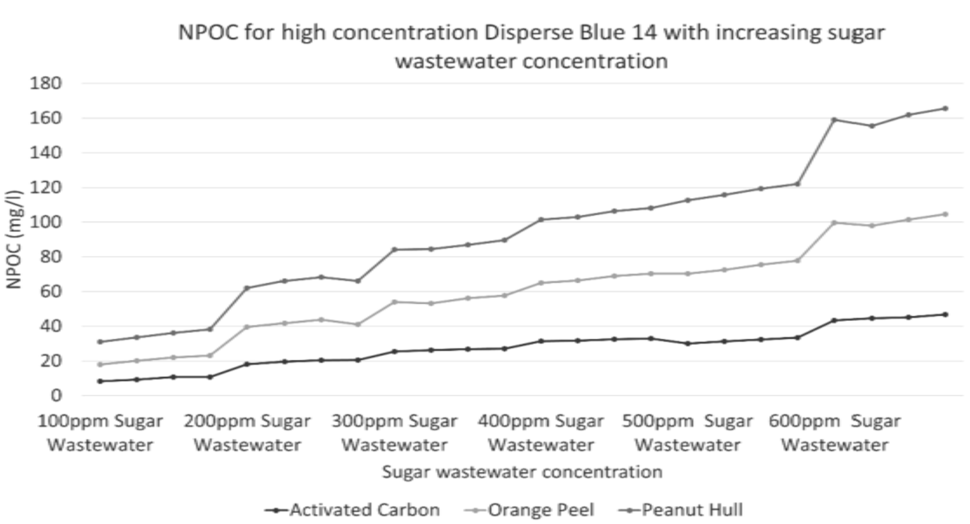

Figure 3. Comparison of NPOC at high concentration Disperse Blue 14

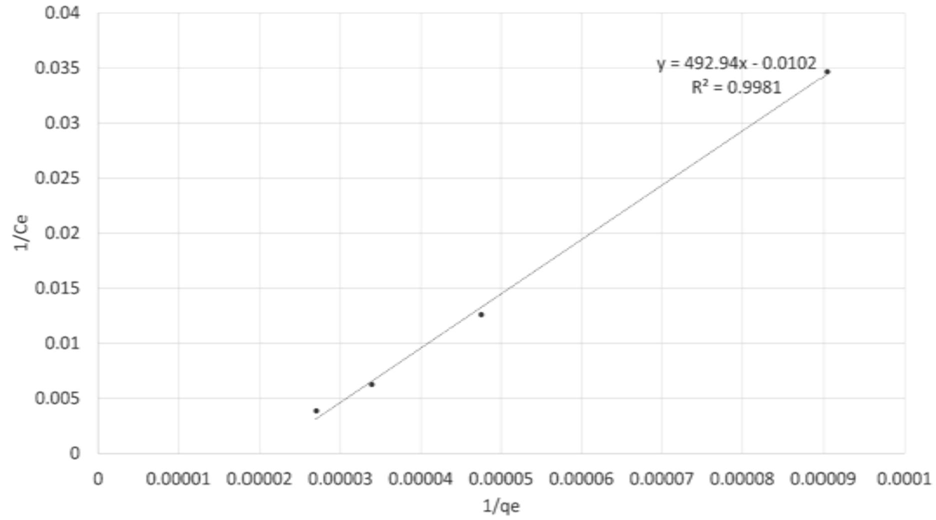

Figure 4. Langmuir isotherm model of Disperse Blue 14 adsorption on Orange peel

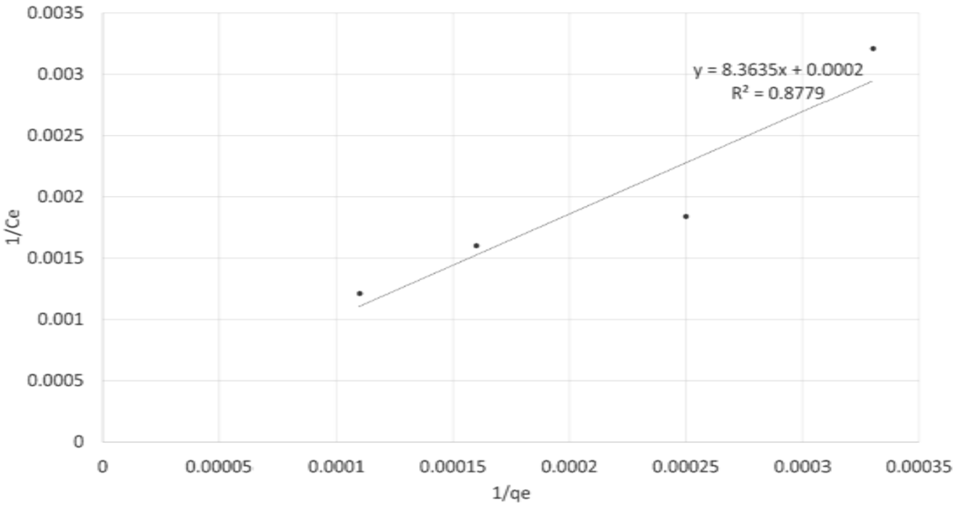

Figure 5. Langmuir isotherm model of Disperse Blue 14 adsorption on Peanut Hull

CONCLUSION

Transmittance and absorbance are the two major parameters which are effectively used to distinguish the level of color removal. The maximum transmittance and minimum absorbance represents the high efficiency of color removal. pH is another factor that is considered but as this treatment method is territory treatment method in which pH doesn't affect much. But, the measured pH values for the samples at optimum dosages and optimum size. As the experiments are conducted in laboratories, constant temperature is maintained. The NPOC depends on the organic carbon present in the wastewater. Lower the NPOC represents higher the treatment efficiency. This study shows significant relationship between the dye wastewater samples mixed with sugar wastewater and adsorbent-microfiltration method. As the conventional method to treat the dye waste water requires high capital and operating costs, this treatment method using low cost adsorbents is one of the economical way of treatment. The combined approach allows better achievement of decolonization efficiency along with reduced treatment costs.

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