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Treatment of Dye Wastewater using Dehydrated Peanut Hull

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TREATMENT OF DYE WASTEWATER USING DEHYDRATED PEANUT HULL

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DEDICATION

This book is dedicated to my parents.

We hereby approve this thesis for

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ABSTRACT

The release of dye waste water into environment causes harm to aquatic life when they reach drains or other water sources. They pollute the soil and causes change in cycles of plant and animal life through bio-accumulation and nutrient cycle. Dyes which form residue or precipitate causes mutations or changes in the DNA of living organisms in and around the area of release of the dye into atmosphere.

In this thesis, several runs were attempted to treat the synthetically prepared dye waste water using dehydrated peanut hull. The initial dye waste water samples were all collected and checked for absorbance, transmittance, pH and Organic Carbon content. Then the prepared samples were treated with the dehydrated peanut hull. The peanut hull was used as a media on which the dye particles were adsorbed. The adsorbed dye particles were along with the peanut hull by micro fi techniques. The wastes were disposed and the surpernatant was collected and checked for the readings of absorbance, transmittance, pH and organic carbon content. The values were later compared, tabulated and graphs were drawn to study the efficiency of the treatment.

In this research, description of the dyes and their properties, adsorbent and its sizes and dosages, equipment used to conduct the experiments and techniques by which the treatment process of dye waste water was carried out was provided.

The results indicated that the dyes with lower molecular weight gave better results of color removal than the dyes with higher molecular weight and the smaller particle size of the adsorbent gave better results of color removal than the larger particle size because of larger surface area.

Keywords: Dye-waste water, Dehydrated Peanut hull, absorbance, transmittance, pH, Organic Carbon content, Adsorption, Micro-filtration.

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CHAPTER I

INTRODUCTION

1.1 Introduction

Dyes have become the basic necessity in our daily life not in just one aspect but it is one most essential term we use in our day to day life. The world is all colorful with these dyes. Where ever you see and whatever you like will have colors in it for sure. Attractiveness is with color and these colors are the ones which have dyes in it. Usage of natural dyes was more previously and as years passed by, demand for more colors increased on a large scale, which was not an easy task with the natural dyes. With the increase in demand of dyes in several industries the world stepped from natural dyes to synthetic dyes.

Synthetic dye manufacture was a successful idea which turned over huge profits. Without considering the harm caused to the environment with these dyes, there were many creations and updates to the traditional colors and now they have reactive and bright colors. The change in the quality and quantity was observed but how it affected the environment was always an unwanted and unanswered question.

Then came the environmentalists complaining about the synthetic dyes, their manufacture, release of their byproducts and wastes into the environment.

There is now enough loss to the environment which can maybe controlled if we take a step towards these issues was what thought by these environmentalists and now here we are, to take care of these synthetic dyes. These industries released dye waste water into the environment. This dye waste water was an intermediate waste for a few industries and a final waste for a few industries. Since there were no such complaints regarding the dye waste water earlier, waste water treatment plants had no much idea on how to treat these waters.

With the increase in number of industries, industrial waste water treatment plants employed a few methods to treat this dye waste water and then released into the environment. But they later realized that they could remove the color but could not reduce the impact of chemicals used to treat these waters. Activated carbon was one such adsorbent which gave the best results with almost all the dyes available in market. But this activated carbon is high in cost and disposing the dye contained activated carbon (powered or granular) was always a problem and its regeneration is more costly.

To have a control over this situation, since the amount of wastes generated after the treatment process is high, the disposal or recycling would cost more or less the same amount of money for any chemical. So in order to lessen the total cost from purchase of raw materials for treatment to their disposal, they decided to research on the low cost raw materials. Which means, they typically need low in cost and high in efficiency type of adsorbents.

Adsorption is one such technique which requires easily available equipment and an adsorbent to treat the dye waste water. The adsorption technique is comparatively cost effective than the coagulation or electro-flotation or any electrolysis methods since coagulation techniques require more chemicals, which is again costly and other electrolysis related techniques require costly equipment and chemicals.

1.2 Objective

The objective of this thesis is to study the properties of dye and its treatment analysis with respect to the particle size and amount or dosage of peanut shell added to the sample. The efficiency of the treatment was calculated using the transmittance and absorbance values of the dye solution samples along with the calculation of pH and Organic Carbon content of the samples before and after the treatment.

The only adsorbent used is the peanut hull, which is graded into three varied sizes and is added in quantities of 1 to 12 grams with an increment of 1 gram. The experiment was carried out with three diff t dyes, Victoria Blue B, Congo Red and Direct Blue 15.

To be short and clear, it is to study the strength of dye, treat-ability of the dye, to study the efficiency of peanut hull to reduce the impact of dye, to obtain the optimal dosage of the peanut hull to treat the dye waste water which is summarized in depth below.

The objectives are to

1. Study the impact and strength of the dyes considered.
2. Study the efficiency of this treatment method (adsorption with micro fi by observing the transmittance and absorbance values, Organic Carbon content and initial pH.

3. Determine the maximum efficiency of the treatment based on the amount of adsorbent added to the dye solutions.
4. Study the efficiency of treatment based on the size of the adsorbent.
5. Study the strength of the dye relating to its molecular weight.

CHAPTER II

LITERATURE REVIEW

2.1 Background

Attractiveness is with color and these colors are the ones which have dyes in it. Dye manufacture industries have dye waste water as their waste product and these dye manufacture industries supply dyes as intermediate products to other industries which use dyes like food industry, textile and paint industries, automobile and construction industries and nevertheless, cosmetic industries. All these industries have their waste generated with dyes. This highly colored waste water, typically termed as dye waste water is released into environment.

The release of dye waste water into environment causes harm to aquatic life when they reach drains or other water sources. They pollute the soil and causes change in cycles of plant and animal life through bio-accumulation and nutrient cycle. Dyes which form residue or precipitate causes mutations or changes in the DNA of living organisms in and around the area of release of the dye into atmosphere [1].

To have a control over this situation on animal, plant and human life, treatment of the waste water generated in these industries was proposed. The treatment methods and techniques were all developed like adsorption, coagulation, micro filtration, etc. Chemicals were used to treat the water but since dyes are not good for the environment, chemicals once used were not allowed to be reused. Disposal of chemicals used or their regeneration was very costly.

2.2 Dyes

Dyes are colored organic compounds. It is because of these dyes that we are able to impart colors to almost all the things we use in our daily life. What don't all the compounds have colors was always a question. Let's talk about why dyes have colors. Dyes are basically chemical compounds. They have a molecular formula and the arrangement of the atoms and the excited electrons are the one which help these dyes attain few colors.

Dyes have color because:

a. they absorb light [2].

The color they have depends on the wave length they absorb in the visible spectrum e, in 400 to 700 Nano meters.

b. they have a minimum of one set of chromophores [2].

Chromophore is an atom or group of atoms in the dye which is responsible for the color i.e., a color bearing group.

c. they have alternating single and double bonds in their chemical structure [2].

d. they have at least one pair of delocalized electrons.

The delocalized electrons are called resonance electrons, which exhibit resonating property and hence keeps the molecule stable [3].

Many industries use dyes, both natural and artificial. Dye waste water is not limited to the textile industries. The food industries previously used natural dyes but started using synthetic dyes now. Along with food industries, textile industries, automobile industries, paint manufacturing industries, ink industries, slime and clay manufacture industries, construction-based industries which use fi and pigments like flooring industries, paint industries, roofing industries and a wide range of other industries use synthetic dyes.

Synthetic dyes are manmade dyes and are usually made of petroleum. Organic dyes are the ones which are made of other chemical substances. All the used in the labs and for experimental and testing purposes are organic dyes. Since these organic dyes are also synthesized, they come under the category of synthetic dyes. Natural dyes are the dyes usually derived from plant parts like roots, fruits, fungus and leaves. Since they naturally occur, they cause less harm to the environment compared to the synthetic dyes.

2.3 Classification of Dyes

By the nature of their chromophore, dyes are divided into Acridine dyes, Anthraquinone dyes (derivates of anthraquinone), Arylmethane dyes, Diarylmethane dyes (based on diphenyl methane), Triarylmethane dyes (derivates of triphenylmethane), Azo dyes (based on -N=N- azo structure), Diazonium dyes (based on diazonium salts), Nitro dyes (based on a -NO2 nitro functional group), Nitroso dyes (based on a -N=O nitroso functional group), Phthalocyanine dyes (derivatives of phthalocyanine), Quinone-imine dyes (derivatives of quinone), Azin dyes, Eurhodin dyes, Safranin dyes (derivates of safranin), Indamins, Indophenol dyes, Oxazin dyes, Oxazone dyes, Thiazine dyes derivatives of thiazine), Thiazole dyes (derivatives of Thiazole), Safranin dyes, Xanthene dyes, Fluorene dyes (based on fluorene), Pyronin dyes (derivatives of Pyronin), Fluorone dyes (derivatives of fluorone), Rhodamine dyes (derivatives of Rhodamine) [4].

2.4 Dye Wastewater

Waste water is the water which is usually released from residences or commercial buildings or industries. The waste water released from domestic uses and commercial buildings are termed as domestic waste water and the water released from industries are termed as industrial waste water. Most of the times, the industrial waste water is polluted since they deal with lots of chemicals. Here in this paper, the dye waste water and its purification technique using a low-cost absorbent, the peanut hull is discussed.

Dye waste water is highly colored waste water, released from any industries which manufactures or uses dyes in any form [5]. The dye waste water is usually complicated to treat since it depends on the type of dyes used and its characteristics and it is not just one dye that comes out of a waste water stream. It has a mixture of dyes and diff t dye concentrations and is combined with other chemicals or organic and inorganic matter released from that industry [6].

Dyes are usually classified into three types based on their solubility. They are Water Soluble Dyes, Water Insoluble Dyes and In-situ Color Formation Dyes. Water soluble dyes are easier to remove and cause less harm to the environment compared to the other two dyes since they are diluted easily in water but are harmful to the aquatic organisms since the intake of these dyes soluble in water is more compared to the dyes insoluble in water. The water soluble dyes are mainly of six types.

The reactive dyes are most commonly used these days for brighter colors in textile industries and their degree of fastness is comparatively high.

2.5 Adsorbent

The Adsorbent used for the study is the peanut hull. This adsorbent was chosen because of its low cost. It has an average to good efficiency as per literature. It is easily available all over United States and is easily transportable. The storage cost and transportation cost is low. There is no much maintenance needed in handling. The one main reason to consider peanut hull is that it is an agricultural waste and is a waste from peanut based product’s commercial industries.

2.6 Adsorption and Adsorption Isotherms

Adsorption is a process that occurs at the interface of two or more states. Gas over liquid and gas over solid are gaseous adsorption and liquid over solid is called condensate adsorption. Adsorption is the most effective technologies and is widely used around the world [7]. This is because the equipment used for the experiment is easily available and accessible.

The procedure is short and simple which makes it more time efficient and resource efficient. The adsorption-based process is considered to be most efficient to remove various pollutants in water and waste water [8]. Adsorption is a process that occurs at the interface of two or more states. Gas over liquid and gas over solid are gaseous adsorption and liquid over solid is called condensate adsorption.

The process of Adsorption is usually studied through graphs known as adsorption isotherms. It is the graph between the amounts of adsorbate adsorbed on the surface of adsorbent and pressure at constant temperature. There are three main theories to plot the adsorption isotherms and they are Linear, Freundlich and Langmuir theories [9]

CHAPTER III

MATERIALS AND METHODS

In this chapter, materials used and their basic preparation before getting into the procedure as discussed.

3.1 Synthetic Dye Wastewater

Dye solution is prepared by measuring one gram of powdered dye on the sensitive balance, mixed with 1000 ml or 1 liter of regular tap water. The dyes Victoria Blue B, Congo Red and Direct Blue 15 were dissolved in the same way to get 1000 ppm of dye solution each. Of these three, Victoria Blue B is low colored dye, Congo Red is medium colored dye and Direct Blue 15 is high colored dye. This means, the transmittance values of Victoria Blue B were higher than the Congo Red, which was higher than the Direct Blue 15.

Higher the transmittance values, easy is the treatment method. The molecular weight of the dye plays a key role in this context. Higher the molecular value, denser the structure will be and hence, harder will be the treatment.

3.2 Dyes

The materials used for this experiment are dyes and adsorbents. Three dyes were used in this research. They are Victoria Blue B, Congo red and Direct Blue 15. We will discuss about these dyes in detail in the sections below.

3.3 Victoria Blue B, pure

The dye Victoria Blue B used for this experiment is manufactured by ACROS Organic. The molecular weight of this dye is 506.09 grams per mole. This dye is deep brown in color, odorless and gives a dark violet shade once dissolved in water, as shown in Figure 3.2. This dye is soluble in hot water than in cold water. It is not much reactive in room temperature and pressure. It is a cationic dye with chemical structure as shown in Figure 3.1 [10]

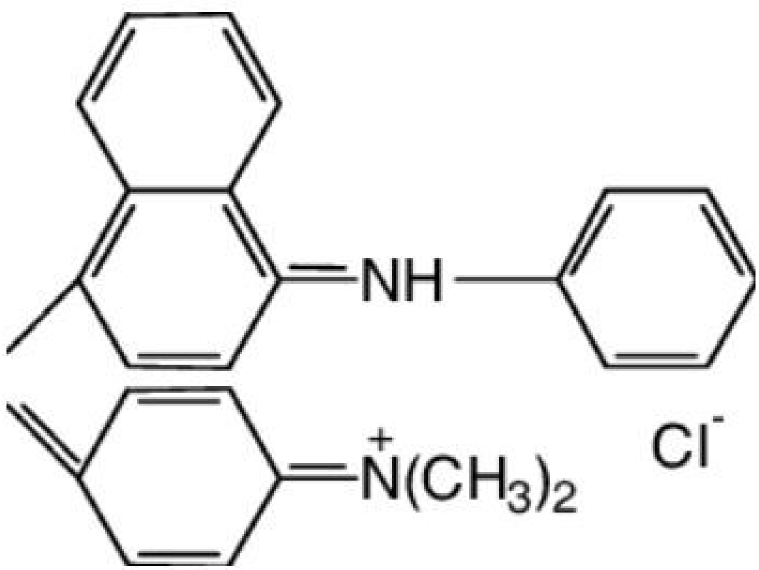

Figure 3.1: Chemical Structure of Victoria Blue B dye molecule.

It is labeled with a warning sign and is certified as hazardous according to 2012 Occupational Health and Safety Administration (OSHA) Hazard Communication Standard (29 CFR 1910. 1200) [11]. The disposable techniques of this dye and dye contaminated products mentioned not to dispose in drains since it is toxic to aquatic animals.

It was mentioned that it can be recycled and disposed under consultation of Waste Management Authority. It is also mentioned that it can be buried in a landfill [12]. The later revised versions of the safety data sheets said that it can be incinerated but must be followed by a scrubbing action or the tower in which this has been incinerated should be connected to an after burner for safety [13]. 9 dye concentrations of Victoria Blue B dye were considered. They are 40 ppm, 80 ppm, 120 ppm, 160 ppm, 200 ppm, 240 ppm, 280 ppm, 320 ppm and 360 ppm.

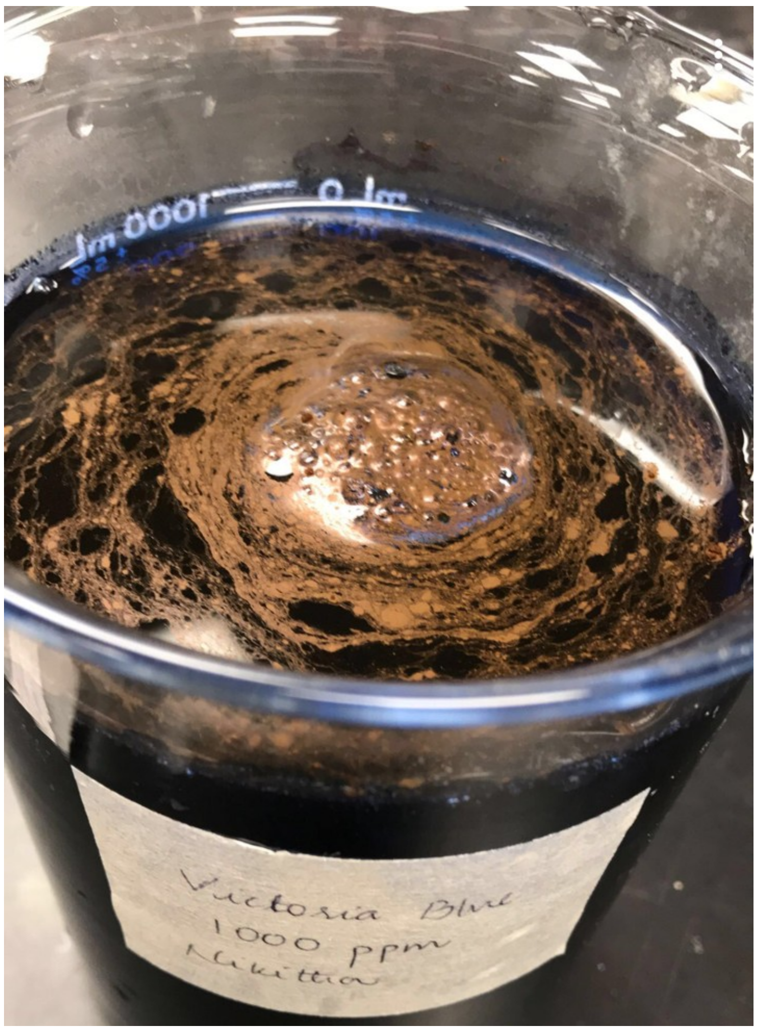

Figure 3.2: 1000 ppm mother sample of Victoria Blue B, dissolved in water

3.2.1 Congo Red

The second dye considered is the Congo Red, which is manufactured by MP Biomedicals. The molecular weight of Congo Red dye is 696.7 grams per mole. Coming to the physical properties of this dye, it is in a powdered form and is maroon in color. When dissolved in water, it forms a red colloidal solution. It is soluble in water and organic solvents both.

This dye is labeled hazardous by Globally Harmonized System (GHS) and is listed in the toxic substances act. This dye was banned long back because of its carcinogenic properties. It was stated that the contact with this dye may cause cancer. It is suspected of damaging the fertility or causes problems to the unborn child [14]. This dye is soluble in water but is stated that it is hazardous when in water. Even a small quantity into the ground will seep into the water table and is a danger for drinking water. Low concentrations of dye in water has high impacts on the aquatic life.

It is stated that even low dye concentrations of this dye are not to be disposed with the domestic sewage [14]. The dye mixed resources are not allowed to reach the sewage systems. There are 9 dye concentrations of Congo Red and they are 20 ppm, 40 ppm, 60 ppm, 80 ppm, 100 ppm, 120 ppm, 140 ppm, 160 ppm and 180 ppm.

3.2.2 Direct Blue 15

The third dye used for my experiment is the Direct Blue 15, which is also manufactured by MP Biomedicals. The molecular weight of this dye is 992.8 grams per mole. This dye is in a powdered form and is dark blue in color. There were many studies on this dye, the Direct Blue 15. It was banned in a few countries.

This dye is labeled hazardous by 2012 OSHA Hazard Communication Standard (29 CFR 1910. 1200). This dye was stated as carcinogenic, meaning it causes cancer. The usage of this dye was suspected to have effect on the genetic mutations, it even has a power of damaging the unborn child [15]. They did a lot of researches on the effects of these dyes on living creatures. Rats were one of the experimental animals used for the study and they found that the interaction with this dye lead to loss of life in rats, on which this dye was tested [16]. The dye was labeled toxic and carcinogenic as shown in Figure 3.3

Since this dye was thicker compared to the other two dyes and transmittance values were very low, I've considered only 7 dye concentrations for this dye. They are 20 ppm, 40 ppm, 60 ppm, 80 ppm, 100 ppm, 120 ppm, 140 ppm.

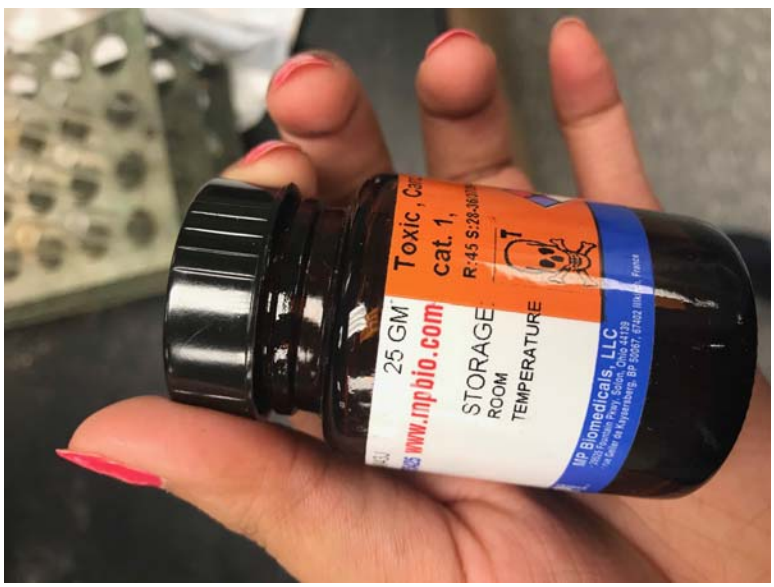

Figure 3.3: Label on Direct Blue 15 bottle stating it as toxic and carcinogenic

3.3 Adsorbent

The Adsorbent used for the study is the peanut hull. This adsorbent was chosen because of its low cost. It has an average to good efficiency as per literature. It is easily available all over United States and is easily transportable. The storage cost and transportation cost is low. There is no much maintenance needed in handling.

The one main reason to consider peanut hull is that it is an agricultural waste and is a waste from peanut based product's commercial industries.

Five numbers of 2 lb. bags of peanuts were bought from grocery store and shell was separated from the nuts. The peanut shell separated was processed a little as discussed below and used for the treatment.

Preparation of dehydrated hull:

1. The peanut hull was taken and was spread evenly in one layer on the tray.
2. The tray was placed in the oven for 24 hours to make it dehydrated.
3. The placing in oven ensures the reduction of the moisture content in the hull.
4. The hull after drying was crushed lightly in a blender.
5. The pieces of the hull were sieved into three different sizes. Three different sizes of the peanut hull are:
    a. Particles retained on 640 microns sieve.
    b. Particles passing from 640 microns sieve and retained on 420 microns sieve.
    c. Particles passing through 420 microns sieve and retained on pan.

3.4 Experiment Procedure

In this section, procedure for the experiment is discussed as follows.

1. The mother dye solution is prepared as discussed in the section 3.1.
2. The concentration of this mother solution is 1000 ppm.
3. Dye concentrations considered are 40 ppm to 360 ppm for Victoria Blue B with an increment of 40 ppm, and 20 ppm to 180 ppm for Congo Red with an increment of 20 ppm, and 20 ppm to 140 ppm for Direct Blue 15 with an increment of 20 ppm.

4. These samples are 100 ml each and are taken in 150 ml containers.
5. All these samples are prepared in batches since they oxidize in light and natural air.
6. We make sure all the samples are covered with aluminum foils and are placed in darker areas of the lab, just to make sure they don't oxidize fast.
7. To check the readings of transmittance and absorbency, 10 ml of these samples are taken in cuvettes and placed in spectrophotometer for the readings.
8. The spectrophotometer is set for a wavelength of 546 Nano meters and is first calibrated with distilled water.
9. Two runs of distilled water in the beginning helps give better results. Now all the samples are placed in the spectrophotometer and transmittance values displayed on the screen are noted.
10. By hitting the mode knob, we can now take the absorbent values.
11. After every sample, there should be a run of distilled water in between.
12. Now these samples are filled in the viols which are to be placed in the TOC testing machine.
13. The first two viols are filled with distilled water and the rest are filled with the prepared samples in an order.
14. Now these samples are placed in the Autosampler of the TOC testing machine.
15. The furnace is checked, and files are created.
16. The TOC testing machine calculates the Non Purgeable Organic Carbon (NPOC) content present in our samples.
17. This shows how much amount of organic content is present in our sample.

18. All the results of transmittance, absorbance and NPOC are tabulated as before treatment, which are shown in run protocols below.
19. Once all the initial readings are collected, we start with the treatment procedure.
20. The sieved peanut shell is taken, dried and powdered as discussed above. The peanut shell is added to all these samples from 1 gram to 12 grams with an increment of 1 gram.
21. All these samples are taken in batches of 36 and are placed on the platform shaker.
22. The shaker is operated at 100 revolutions per minute for around 3 minutes (fast shaking) and later it is operated at 30 rpm for 30 minutes (slow shaking).
23. This shaking ensures uniform mix of the adsorbent and the dye water.
24. These samples are taken out of the shaker and can rest for one night.
25. Now since the samples rested for ample time, the adsorbent settles at the bottom of the container.
26. Since peanut hull is lighter, it remained fl on the water samples.
27. The liquid which passed through the adsorbent and remained at the top is usually called as the supernatant.
28. This supernatant is now filtered using Whattmann 41 filter papers.
29. After filtration, the samples are all taken in new containers and labelled as samples after treatment.
30. 10 ml of these samples are now taken in cuvettes to test the transmittance and absorbance by placing them in the spectrophotometer.

31. The values of transmittance and absorbance are noted down in the table.

32. Along with the transmittance and absorbance, they are tested for the NPOC values, so they are fi in the viols to be placed in the TOC testing machine.

33. The first two viols are filled with distilled water and the rest are filled with this supernatant liquid from the samples in the same order samples were placed before the treatment.

34. Once the values of NPOC are obtained after treatment, they are compared to check if the treatment was successful.

35. Now all the equipment used were cleared up and run protocols for these samples are tabulated as shown in the section below.

3.5 Run Protocols

1. Table 3.1 to 3.25 are run protocols of this research. The dye solution for all the three dyes made 900 samples.
2. These samples are tabulated and shown below in the form of run protocols.
3. Each table is created based on the concentration of the dye solution and has 36 samples, with 1 dye concentration, 12 dosages of adsorbent and 3 diff t sizes of adsorbent.
4. 9 tables of Victoria Blue B dye samples, with varying concentrations of 40 ppm, 80 ppm, 120 ppm, 160 ppm, 200 ppm, 240 ppm, 280 ppm, 320 ppm and 360 ppm.
5. 9 tables of Congo Red dye samples, with varying concentrations of 20 ppm, 40 ppm, 60 ppm, 80 ppm, 100 ppm, 120 ppm, 140 ppm, 160 ppm and 180 ppm.

6. 7 tables of Direct Blue 15 dye samples, with varying concentrations of 20 ppm, 40 ppm, 60 ppm, 80 ppm, 100 ppm, 120 ppm and 140 ppm.
7. Hence, 324 samples of Victoria Blue B, 324 samples of Congo Red and 252 samples of Direct Blue 15, together makes 900 samples for the study.

Table 3.1: Run Protocol for Victoria Blue B, 40 ppm

runs	dye conc	sieve size	ads dosage
1	40 ppm	640 microns	1g
2	40 ppm	640 microns	2g
3	40 ppm	640 microns	3g
4	40 ppm	640 microns	4g
5	40 ppm	640 microns	5g
6	40 ppm	640 microns	6g
7	40 ppm	640 microns	7g
8	40 ppm	640 microns	8g
9	40 ppm	640 microns	9g
10	40 ppm	640 microns	10g
11	40 ppm	640 microns	11g
12	40 ppm	640 microns	12g
13	40 ppm	420 microns	1g
14	40 ppm	420 microns	2g
15	40 ppm	420 microns	3g
16	40 ppm	420 microns	4g
17	40 ppm	420 microns	5g
18	40 ppm	420 microns	6g
19	40 ppm	420 microns	7g
20	40 ppm	420 microns	8g
21	40 ppm	420 microns	9g
22	40 ppm	420 microns	10g
23	40 ppm	420 microns	11g
24	40 ppm	420 microns	12g
25	40 ppm	<420 microns	1g
26	40 ppm	<420 microns	2g
27	40 ppm	<420 microns	3g
28	40 ppm	<420 microns	4g
29	40 ppm	<420 microns	5g
30	40 ppm	<420 microns	6g
31	40 ppm	<420 microns	7g
32	40 ppm	<420 microns	8g
33	40 ppm	<420 microns	9g
34	40 ppm	<420 microns	10g
35	40 ppm	<420 microns	11g
36	40 ppm	<420 microns	12g

Table 3.2: Run Protocol for Victoria Blue B, 80 ppm

runs	dye conc	sieve size	ads dosage
1	80 ppm	640 microns	1g
2	80 ppm	640 microns	2g
3	80 ppm	640 microns	3g
4	80 ppm	640 microns	4g
5	80 ppm	640 microns	5g
6	80 ppm	640 microns	6g
7	80 ppm	640 microns	7g
8	80 ppm	640 microns	8g
9	80 ppm	640 microns	9g
10	80 ppm	640 microns	10g
11	80 ppm	640 microns	11g
12	80 ppm	640 microns	12g
13	80 ppm	420 microns	1g
14	80 ppm	420 microns	2g
15	80 ppm	420 microns	3g
16	80 ppm	420 microns	4g
17	80 ppm	420 microns	5g
18	80 ppm	420 microns	6g
19	80 ppm	420 microns	7g
20	80 ppm	420 microns	8g
21	80 ppm	420 microns	9g
22	80 ppm	420 microns	10g
23	80 ppm	420 microns	11g
24	80 ppm	420 microns	12g
25	80 ppm	<420 microns	1g
26	80 ppm	<420 microns	2g
27	80 ppm	<420 microns	3g
28	80 ppm	<420 microns	4g
29	80 ppm	<420 microns	5g
30	80 ppm	<420 microns	6g
31	80 ppm	<420 microns	7g
32	80 ppm	<420 microns	8g
33	80 ppm	<420 microns	9g
34	80 ppm	<420 microns	10g
35	80 ppm	<420 microns	11g
36	80 ppm	<420 microns	12g

Table 3.3: Run Protocol for Victoria Blue B, 120 ppm

runs	dye conc	sieve size	ads dosage
1	120 ppm	640 microns	1g
2	120 ppm	640 microns	2g
3	120 ppm	640 microns	3g
4	120 ppm	640 microns	4g
5	120 ppm	640 microns	5g
6	120 ppm	640 microns	6g
7	120 ppm	640 microns	7g
8	120 ppm	640 microns	8g
9	120 ppm	640 microns	9g
10	120 ppm	640 microns	10g
11	120 ppm	640 microns	11g
12	120 ppm	640 microns	12g
13	120 ppm	420 microns	1g
14	120 ppm	420 microns	2g
15	120 ppm	420 microns	3g
16	120 ppm	420 microns	4g
17	120 ppm	420 microns	5g
18	120 ppm	420 microns	6g
19	120 ppm	420 microns	7g
20	120 ppm	420 microns	8g
21	120 ppm	420 microns	9g
22	120 ppm	420 microns	10g
23	120 ppm	420 microns	11g
24	120 ppm	420 microns	12g
25	120 ppm	<420 microns	1g
26	120 ppm	<420 microns	2g
27	120 ppm	<420 microns	3g
28	120 ppm	<420 microns	4g
29	120 ppm	<420 microns	5g
30	120 ppm	<420 microns	6g
31	120 ppm	<420 microns	7g
32	120 ppm	<420 microns	8g
33	120 ppm	<420 microns	9g
34	120 ppm	<420 microns	10g
35	120 ppm	<420 microns	11g
36	120 ppm	<420 microns	12g

Table 3.4: Run Protocol for Victoria Blue B, 160 ppm

runs	dye conc	sieve size	ads dosage
1	160 ppm	640 microns	1g
2	160 ppm	640 microns	2g
3	160 ppm	640 microns	3g
4	160 ppm	640 microns	4g
5	160 ppm	640 microns	5g
6	160 ppm	640 microns	6g
7	160 ppm	640 microns	7g
8	160 ppm	640 microns	8g
9	160 ppm	640 microns	9g
10	160 ppm	640 microns	10g
11	160 ppm	640 microns	11g
12	160 ppm	640 microns	12g
13	160 ppm	420 microns	1g
14	160 ppm	420 microns	2g
15	160 ppm	420 microns	3g
16	160 ppm	420 microns	4g
17	160 ppm	420 microns	5g
18	160 ppm	420 microns	6g
19	160 ppm	420 microns	7g
20	160 ppm	420 microns	8g
21	160 ppm	420 microns	9g
22	160 ppm	420 microns	10g
23	160 ppm	420 microns	11g
24	160 ppm	420 microns	12g
25	160 ppm	<420 microns	1g
26	160 ppm	<420 microns	2g
27	160 ppm	<420 microns	3g
28	160 ppm	<420 microns	4g
29	160 ppm	<420 microns	5g
30	160 ppm	<420 microns	6g
31	160 ppm	<420 microns	7g
32	160 ppm	<420 microns	8g
33	160 ppm	<420 microns	9g
34	160 ppm	<420 microns	10g
35	160 ppm	<420 microns	11g
36	160 ppm	<420 microns	12g

Table 3.5: Run Protocol for Victoria Blue B, 200 ppm

runs	dye conc	sieve size	ads dosage
1	200 ppm	640 microns	1g
2	200 ppm	640 microns	2g
3	200 ppm	640 microns	3g
4	200 ppm	640 microns	4g
5	200 ppm	640 microns	5g
6	200 ppm	640 microns	6g
7	200 ppm	640 microns	7g
8	200 ppm	640 microns	8g
9	200 ppm	640 microns	9g
10	200 ppm	640 microns	10g
11	200 ppm	640 microns	11g
12	200 ppm	640 microns	12g
13	200 ppm	420 microns	1g
14	200 ppm	420 microns	2g
15	200 ppm	420 microns	3g
16	200 ppm	420 microns	4g
17	200 ppm	420 microns	5g
18	200 ppm	420 microns	6g
19	200 ppm	420 microns	7g
20	200 ppm	420 microns	8g
21	200 ppm	420 microns	9g
22	200 ppm	420 microns	10g
23	200 ppm	420 microns	11g
24	200 ppm	420 microns	12g
25	200 ppm	<420 microns	1g
26	200 ppm	<420 microns	2g
27	200 ppm	<420 microns	3g
28	200 ppm	<420 microns	4g
29	200 ppm	<420 microns	5g
30	200 ppm	<420 microns	6g
31	200 ppm	<420 microns	7g
32	200 ppm	<420 microns	8g
33	200 ppm	<420 microns	9g
34	200 ppm	<420 microns	10g
35	200 ppm	<420 microns	11g
36	200 ppm	<420 microns	12g

Table 3.6: Run Protocol for Victoria Blue B, 240 ppm

runs	dye conc	sieve size	ads dosage
1	240 ppm	640 microns	1g
2	240 ppm	640 microns	2g
3	240 ppm	640 microns	3g
4	240 ppm	640 microns	4g
5	240 ppm	640 microns	5g
6	240 ppm	640 microns	6g
7	240 ppm	640 microns	7g
8	240 ppm	640 microns	8g
9	240 ppm	640 microns	9g
10	240 ppm	640 microns	10g
11	240 ppm	640 microns	11g
12	240 ppm	640 microns	12g
13	240 ppm	420 microns	1g
14	240 ppm	420 microns	2g
15	240 ppm	420 microns	3g
16	240 ppm	420 microns	4g
17	240 ppm	420 microns	5g
18	240 ppm	420 microns	6g
19	240 ppm	420 microns	7g
20	240 ppm	420 microns	8g
21	240 ppm	420 microns	9g
22	240 ppm	420 microns	10g
23	240 ppm	420 microns	11g
24	240 ppm	420 microns	12g
25	240 ppm	<420 microns	1g
26	240 ppm	<420 microns	2g
27	240 ppm	<420 microns	3g
28	240 ppm	<420 microns	4g
29	240 ppm	<420 microns	5g
30	240 ppm	<420 microns	6g
31	240 ppm	<420 microns	7g
32	240 ppm	<420 microns	8g
33	240 ppm	<420 microns	9g
34	240 ppm	<420 microns	10g
35	240 ppm	<420 microns	11g
36	240 ppm	<420 microns	12g

Table 3.7: Run Protocol for Victoria Blue B, 280 ppm

runs	dye conc	sieve size	ads dosage
1	280 ppm	640 microns	1g
2	280 ppm	640 microns	2g
3	280 ppm	640 microns	3g
4	280 ppm	640 microns	4g
5	280 ppm	640 microns	5g
6	280 ppm	640 microns	6g
7	280 ppm	640 microns	7g
8	280 ppm	640 microns	8g
9	280 ppm	640 microns	9g
10	280 ppm	640 microns	10g
11	280 ppm	640 microns	11g
12	280 ppm	640 microns	12g
13	280 ppm	420 microns	1g
14	280 ppm	420 microns	2g
15	280 ppm	420 microns	3g
16	280 ppm	420 microns	4g
17	280 ppm	420 microns	5g
18	280 ppm	420 microns	6g
19	280 ppm	420 microns	7g
20	280 ppm	420 microns	8g
21	280 ppm	420 microns	9g
22	280 ppm	420 microns	10g
23	280 ppm	420 microns	11g
24	280 ppm	420 microns	12g
25	280 ppm	<420 microns	1g
26	280 ppm	<420 microns	2g
27	280 ppm	<420 microns	3g
28	280 ppm	<420 microns	4g
29	280 ppm	<420 microns	5g
30	280 ppm	<420 microns	6g
31	280 ppm	<420 microns	7g
32	280 ppm	<420 microns	8g
33	280 ppm	<420 microns	9g
34	280 ppm	<420 microns	10g
35	280 ppm	<420 microns	11g
36	280 ppm	<420 microns	12g

Table 3.8: Run Protocol for Victoria Blue B, 320 ppm

runs	dye conc	sieve size	ads dosage
1	320 ppm	640 microns	1g
2	320 ppm	640 microns	2g
3	320 ppm	640 microns	3g
4	320 ppm	640 microns	4g
5	320 ppm	640 microns	5g
6	320 ppm	640 microns	6g
7	320 ppm	640 microns	7g
8	320 ppm	640 microns	8g
9	320 ppm	640 microns	9g
10	320 ppm	640 microns	10g
11	320 ppm	640 microns	11g
12	320 ppm	640 microns	12g
13	320 ppm	420 microns	1g
14	320 ppm	420 microns	2g
15	320 ppm	420 microns	3g
16	320 ppm	420 microns	4g
17	320 ppm	420 microns	5g
18	320 ppm	420 microns	6g
19	320 ppm	420 microns	7g
20	320 ppm	420 microns	8g
21	320 ppm	420 microns	9g
22	320 ppm	420 microns	10g
23	320 ppm	420 microns	11g
24	320 ppm	420 microns	12g
25	320 ppm	<420 microns	1g
26	320 ppm	<420 microns	2g
27	320 ppm	<420 microns	3g
28	320 ppm	<420 microns	4g
29	320 ppm	<420 microns	5g
30	320 ppm	<420 microns	6g
31	320 ppm	<420 microns	7g
32	320 ppm	<420 microns	8g
33	320 ppm	<420 microns	9g
34	320 ppm	<420 microns	10g
35	320 ppm	<420 microns	11g
36	320 ppm	<420 microns	12g

Table 3.9: Run Protocol for Victoria Blue B, 360 ppm

runs	dye conc	sieve size	ads dosage
1	360 ppm	640 microns	1g
2	360 ppm	640 microns	2g
3	360 ppm	640 microns	3g
4	360 ppm	640 microns	4g
5	360 ppm	640 microns	5g
6	360 ppm	640 microns	6g
7	360 ppm	640 microns	7g
8	360 ppm	640 microns	8g
9	360 ppm	640 microns	9g
10	360 ppm	640 microns	10g
11	360 ppm	640 microns	11g
12	360 ppm	640 microns	12g
13	360 ppm	420 microns	1g
14	360 ppm	420 microns	2g
15	360 ppm	420 microns	3g
16	360 ppm	420 microns	4g
17	360 ppm	420 microns	5g
18	360 ppm	420 microns	6g
19	360 ppm	420 microns	7g
20	360 ppm	420 microns	8g
21	360 ppm	420 microns	9g
22	360 ppm	420 microns	10g
23	360 ppm	420 microns	11g
24	360 ppm	420 microns	12g
25	360 ppm	<420 microns	1g
26	360 ppm	<420 microns	2g
27	360 ppm	<420 microns	3g
28	360 ppm	<420 microns	4g
29	360 ppm	<420 microns	5g
30	360 ppm	<420 microns	6g
31	360 ppm	<420 microns	7g
32	360 ppm	<420 microns	8g
33	360 ppm	<420 microns	9g
34	360 ppm	<420 microns	10g
35	360 ppm	<420 microns	11g
36	360 ppm	<420 microns	12g

Table 3.10: Run Protocol for Congo Red, 20 ppm

runs	**dye conc**	**sieve size**	**ads dosage**
1	20ppm	640 microns	1g
2	20ppm	640 microns	2g
3	20ppm	640 microns	3g
4	20ppm	640 microns	4g
5	20ppm	640 microns	5g
6	20ppm	640 microns	6g
7	20ppm	640 microns	7g
8	20ppm	640 microns	8g
9	20ppm	640 microns	9g
10	20ppm	640 microns	10g
11	20ppm	640 microns	11g
12	20ppm	640 microns	12g
13	20ppm	420 microns	1g
14	20ppm	420 microns	2g
15	20ppm	420 microns	3g
16	20ppm	420 microns	4g
17	20ppm	420 microns	5g
18	20ppm	420 microns	6g
19	20ppm	420 microns	7g
20	20ppm	420 microns	8g
21	20ppm	420 microns	9g
22	20ppm	420 microns	10g
23	20ppm	420 microns	11g
24	20ppm	420 microns	12g
25	20ppm	<420 microns	1g
26	20ppm	<420 microns	2g
27	20ppm	<420 microns	3g
28	20ppm	<420 microns	4g
29	20ppm	<420 microns	5g
30	20ppm	<420 microns	6g
31	20ppm	<420 microns	7g
32	20ppm	<420 microns	8g
33	20ppm	<420 microns	9g
34	20ppm	<420 microns	10g
35	20ppm	<420 m	11g
36	20ppm	<420 m	12g

Table 3.11: Run Protocol for Congo Red, 40 ppm

runs	dye conc	sieve size	ads dosage
1	40 ppm	640 microns	1g
2	40 ppm	640 microns	2g
3	40 ppm	640 microns	3g
4	40 ppm	640 microns	4g
5	40 ppm	640 microns	5g
6	40 ppm	640 microns	6g
7	40 ppm	640 microns	7g
8	40 ppm	640 microns	8g
9	40 ppm	640 microns	9g
10	40 ppm	640 microns	10g
11	40 ppm	640 microns	11g
12	40 ppm	640 microns	12g
13	40 ppm	420 microns	1g
14	40 ppm	420 microns	2g
15	40 ppm	420 microns	3g
16	40 ppm	420 microns	4g
17	40 ppm	420 microns	5g
18	40 ppm	420 microns	6g
19	40 ppm	420 microns	7g
20	40 ppm	420 microns	8g
21	40 ppm	420 microns	9g
22	40 ppm	420 microns	10g
23	40 ppm	420 microns	11g
24	40 ppm	420 microns	12g
25	40 ppm	<420 microns	1g
26	40 ppm	<420 microns	2g
27	40 ppm	<420 microns	3g
28	40 ppm	<420 microns	4g
29	40 ppm	<420 microns	5g
30	40 ppm	<420 microns	6g
31	40 ppm	<420 microns	7g
32	40 ppm	<420 microns	8g
33	40 ppm	<420 microns	9g
34	40 ppm	<420 microns	10g
35	40 ppm	<420 microns	11g
36	40 ppm	<420 microns	12g

Table 3.12: Run Protocol for Congo Red, 60 ppm

runs	dye conc	sieve size	ads dosage
1	60 ppm	640 microns	1g
2	60 ppm	640 microns	2g
3	60 ppm	640 microns	3g
4	60 ppm	640 microns	4g
5	60 ppm	640 microns	5g
6	60 ppm	640 microns	6g
7	60 ppm	640 microns	7g
8	60 ppm	640 microns	8g
9	60 ppm	640 microns	9g
10	60 ppm	640 microns	10g
11	60 ppm	640 microns	11g
12	60 ppm	640 microns	12g
13	60 ppm	420 microns	1g
14	60 ppm	420 microns	2g
15	60 ppm	420 microns	3g
16	60 ppm	420 microns	4g
17	60 ppm	420 microns	5g
18	60 ppm	420 microns	6g
19	60 ppm	420 microns	7g
20	60 ppm	420 microns	8g
21	60 ppm	420 microns	9g
22	60 ppm	420 microns	10g
23	60 ppm	420 microns	11g
24	60 ppm	420 microns	12g
25	60 ppm	<420 microns	1g
26	60 ppm	<420 microns	2g
27	60 ppm	<420 microns	3g
28	60 ppm	<420 microns	4g
29	60 ppm	<420 microns	5g
30	60 ppm	<420 microns	6g
31	60 ppm	<420 microns	7g
32	60 ppm	<420 microns	8g
33	60 ppm	<420 microns	9g
34	60 ppm	<420 microns	10g
35	60 ppm	<420 microns	11g
36	60 ppm	<420 microns	12g

Table 3.13: Run Protocol for Congo Red, 80 ppm

runs	dye conc	sieve size	ads dosage
1	80 ppm	640 microns	1g
2	80 ppm	640 microns	2g
3	80 ppm	640 microns	3g
4	80 ppm	640 microns	4g
5	80 ppm	640 microns	5g
6	80 ppm	640 microns	6g
7	80 ppm	640 microns	7g
8	80 ppm	640 microns	8g
9	80 ppm	640 microns	9g
10	80 ppm	640 microns	10g
11	80 ppm	640 microns	11g
12	80 ppm	640 microns	12g
13	80 ppm	420 microns	1g
14	80 ppm	420 microns	2g
15	80 ppm	420 microns	3g
16	80 ppm	420 microns	4g
17	80 ppm	420 microns	5g
18	80 ppm	420 microns	6g
19	80 ppm	420 microns	7g
20	80 ppm	420 microns	8g
21	80 ppm	420 microns	9g
22	80 ppm	420 microns	10g
23	80 ppm	420 microns	11g
24	80 ppm	420 microns	12g
25	80 ppm	<420 microns	1g
26	80 ppm	<420 microns	2g
27	80 ppm	<420 microns	3g
28	80 ppm	<420 microns	4g
29	80 ppm	<420 microns	5g
30	80 ppm	<420 microns	6g
31	80 ppm	<420 microns	7g
32	80 ppm	<420 microns	8g
33	80 ppm	<420 microns	9g
34	80 ppm	<420 microns	10g
35	80 ppm	<420 microns	11g
36	80 ppm	<420 microns	12g

Table 3.14: Run Protocol for Congo Red, 100 ppm

runs	dye conc	sieve size	ads dosage
1	100 ppm	640 microns	1g
2	100 ppm	640 microns	2g
3	100 ppm	640 microns	3g
4	100 ppm	640 microns	4g
5	100 ppm	640 microns	5g
6	100 ppm	640 microns	6g
7	100 ppm	640 microns	7g
8	100 ppm	640 microns	8g
9	100 ppm	640 microns	9g
10	100 ppm	640 microns	10g
11	100 ppm	640 microns	11g
12	100 ppm	640 microns	12g
13	100 ppm	420 microns	1g
14	100 ppm	420 microns	2g
15	100 ppm	420 microns	3g
16	100 ppm	420 microns	4g
17	100 ppm	420 microns	5g
18	100 ppm	420 microns	6g
19	100 ppm	420 microns	7g
20	100 ppm	420 microns	8g
21	100 ppm	420 microns	9g
22	100 ppm	420 microns	10g
23	100 ppm	420 microns	11g
24	100 ppm	420 microns	12g
25	100 ppm	<420 microns	1g
26	100 ppm	<420 microns	2g
27	100 ppm	<420 microns	3g
28	100 ppm	<420 microns	4g
29	100 ppm	<420 microns	5g
30	100 ppm	<420 microns	6g
31	100 ppm	<420 microns	7g
32	100 ppm	<420 microns	8g
33	100 ppm	<420 microns	9g
34	100 ppm	<420 microns	10g
35	100 ppm	<420 microns	11g
36	100 ppm	<420 microns	12g

Table 3.15: Run Protocol for Congo Red, 120 ppm

runs	**dye conc**	**sieve size**	**ads dosage**
1	120 ppm	640 microns	1g
2	120 ppm	640 microns	2g
3	120 ppm	640 microns	3g
4	120 ppm	640 microns	4g
5	120 ppm	640 microns	5g
6	120 ppm	640 microns	6g
7	120 ppm	640 microns	7g
8	120 ppm	640 microns	8g
9	120 ppm	640 microns	9g
10	120 ppm	640 microns	10g
11	120 ppm	640 microns	11g
12	120 ppm	640 microns	12g
13	120 ppm	420 microns	1g
14	120 ppm	420 microns	2g
15	120 ppm	420 microns	3g
16	120 ppm	420 microns	4g
17	120 ppm	420 microns	5g
18	120 ppm	420 microns	6g
19	120 ppm	420 microns	7g
20	120 ppm	420 microns	8g
21	120 ppm	420 microns	9g
22	120 ppm	420 microns	10g
23	120 ppm	420 microns	11g
24	120 ppm	420 microns	12g
25	120 ppm	<420 microns	1g
26	120 ppm	<420 microns	2g
27	120 ppm	<420 microns	3g
28	120 ppm	<420 microns	4g
29	120 ppm	<420 microns	5g
30	120 ppm	<420 microns	6g
31	120 ppm	<420 microns	7g
32	120 ppm	<420 microns	8g
33	120 ppm	<420 microns	9g
34	120 ppm	<420 microns	10g
35	120 ppm	<420 microns	11g
36	120 ppm	<420 microns	12g

Table 3.16: Run Protocol for Congo Red, 140 ppm

runs	dye conc	sieve size	ads dosage
1	140 ppm	640 microns	1g
2	140 ppm	640 microns	2g
3	140 ppm	640 microns	3g
4	140 ppm	640 microns	4g
5	140 ppm	640 microns	5g
6	140 ppm	640 microns	6g
7	140 ppm	640 microns	7g
8	140 ppm	640 microns	8g
9	140 ppm	640 microns	9g
10	140 ppm	640 microns	10g
11	140 ppm	640 microns	11g
12	140 ppm	640 microns	12g
13	140 ppm	420 microns	1g
14	140 ppm	420 microns	2g
15	140 ppm	420 microns	3g
16	140 ppm	420 microns	4g
17	140 ppm	420 microns	5g
18	140 ppm	420 microns	6g
19	140 ppm	420 microns	7g
20	140 ppm	420 microns	8g
21	140 ppm	420 microns	9g
22	140 ppm	420 microns	10g
23	140 ppm	420 microns	11g
24	140 ppm	420 microns	12g
25	140 ppm	<420 microns	1g
26	140 ppm	<420 microns	2g
27	140 ppm	<420 microns	3g
28	140 ppm	<420 microns	4g
29	140 ppm	<420 microns	5g
30	140 ppm	<420 microns	6g
31	140 ppm	<420 microns	7g
32	140 ppm	<420 microns	8g
33	140 ppm	<420 microns	9g
34	140 ppm	<420 microns	10g
35	140 ppm	<420 microns	11g
36	140 ppm	<420 microns	12g

Table 3.17: Run Protocol for Congo Red, 160 ppm

runs	dye conc	sieve size	ads dosage
1	160 ppm	640 microns	1g
2	160 ppm	640 microns	2g
3	160 ppm	640 microns	3g
4	160 ppm	640 microns	4g
5	160 ppm	640 microns	5g
6	160 ppm	640 microns	6g
7	160 ppm	640 microns	7g
8	160 ppm	640 microns	8g
9	160 ppm	640 microns	9g
10	160 ppm	640 microns	10g
11	160 ppm	640 microns	11g
12	160 ppm	640 microns	12g
13	160 ppm	420 microns	1g
14	160 ppm	420 microns	2g
15	160 ppm	420 microns	3g
16	160 ppm	420 microns	4g
17	160 ppm	420 microns	5g
18	160 ppm	420 microns	6g
19	160 ppm	420 microns	7g
20	160 ppm	420 microns	8g
21	160 ppm	420 microns	9g
22	160 ppm	420 microns	10g
23	160 ppm	420 microns	11g
24	160 ppm	420 microns	12g
25	160 ppm	<420 microns	1g
26	160 ppm	<420 microns	2g
27	160 ppm	<420 microns	3g
28	160 ppm	<420 microns	4g
29	160 ppm	<420 microns	5g
30	160 ppm	<420 microns	6g
31	160 ppm	<420 microns	7g
32	160 ppm	<420 microns	8g
33	160 ppm	<420 microns	9g
34	160 ppm	<420 microns	10g
35	160 ppm	<420 microns	11g
36	160 ppm	<420 microns	12g

Table 3.18: Run Protocol for Direct Blue 15, 20 ppm

runs	dye conc	sieve size	ads dosage
1	20ppm	640 microns	1g
2	20ppm	640 microns	2g
3	20ppm	640 microns	3g
4	20ppm	640 microns	4g
5	20ppm	640 microns	5g
6	20ppm	640 microns	6g
7	20ppm	640 microns	7g
8	20ppm	640 microns	8g
9	20ppm	640 microns	9g
10	20ppm	640 microns	10g
11	20ppm	640 microns	11g
12	20ppm	640 microns	12g
13	20ppm	420 microns	1g
14	20ppm	420 microns	2g
15	20ppm	420 microns	3g
16	20ppm	420 microns	4g
17	20ppm	420 microns	5g
18	20ppm	420 microns	6g
19	20ppm	420 microns	7g
20	20ppm	420 microns	8g
21	20ppm	420 microns	9g
22	20ppm	420 microns	10g
23	20ppm	420 microns	11g
24	20ppm	420 microns	12g
25	20ppm	<420 microns	1g
26	20ppm	<420 microns	2g
27	20ppm	<420 microns	3g
28	20ppm	<420 microns	4g
29	20ppm	<420 microns	5g
30	20ppm	<420 microns	6g
31	20ppm	<420 microns	7g
32	20ppm	<420 microns	8g
33	20ppm	<420 microns	9g
34	20ppm	<420 microns	10g
35	20ppm	<420 m	11g
36	20ppm	<420 m	12g

Table 3.19: Run Protocol for Direct Blue 15, 40 ppm

runs	dye conc	sieve size	ads dosage
1	40 ppm	640 microns	1g
2	40 ppm	640 microns	2g
3	40 ppm	640 microns	3g
4	40 ppm	640 microns	4g
5	40 ppm	640 microns	5g
6	40 ppm	640 microns	6g
7	40 ppm	640 microns	7g
8	40 ppm	640 microns	8g
9	40 ppm	640 microns	9g
10	40 ppm	640 microns	10g
11	40 ppm	640 microns	11g
12	40 ppm	640 microns	12g
13	40 ppm	420 microns	1g
14	40 ppm	420 microns	2g
15	40 ppm	420 microns	3g
16	40 ppm	420 microns	4g
17	40 ppm	420 microns	5g
18	40 ppm	420 microns	6g
19	40 ppm	420 microns	7g
20	40 ppm	420 microns	8g
21	40 ppm	420 microns	9g
22	40 ppm	420 microns	10g
23	40 ppm	420 microns	11g
24	40 ppm	420 microns	12g
25	40 ppm	<420 microns	1g
26	40 ppm	<420 microns	2g
27	40 ppm	<420 microns	3g
28	40 ppm	<420 microns	4g
29	40 ppm	<420 microns	5g
30	40 ppm	<420 microns	6g
31	40 ppm	<420 microns	7g
32	40 ppm	<420 microns	8g
33	40 ppm	<420 microns	9g
34	40 ppm	<420 microns	10g
35	40 ppm	<420 microns	11g
36	40 ppm	<420 microns	12g

Table 3.20: Run Protocol for Direct Blue 15, 60 ppm

runs	dye conc	sieve size	ads dosage
1	60 ppm	640 microns	1g
2	60 ppm	640 microns	2g
3	60 ppm	640 microns	3g
4	60 ppm	640 microns	4g
5	60 ppm	640 microns	5g
6	60 ppm	640 microns	6g
7	60 ppm	640 microns	7g
8	60 ppm	640 microns	8g
9	60 ppm	640 microns	9g
10	60 ppm	640 microns	10g
11	60 ppm	640 microns	11g
12	60 ppm	640 microns	12g
13	60 ppm	420 microns	1g
14	60 ppm	420 microns	2g
15	60 ppm	420 microns	3g
16	60 ppm	420 microns	4g
17	60 ppm	420 microns	5g
18	60 ppm	420 microns	6g
19	60 ppm	420 microns	7g
20	60 ppm	420 microns	8g
21	60 ppm	420 microns	9g
22	60 ppm	420 microns	10g
23	60 ppm	420 microns	11g
24	60 ppm	420 microns	12g
25	60 ppm	<420 microns	1g
26	60 ppm	<420 microns	2g
27	60 ppm	<420 microns	3g
28	60 ppm	<420 microns	4g
29	60 ppm	<420 microns	5g
30	60 ppm	<420 microns	6g
31	60 ppm	<420 microns	7g
32	60 ppm	<420 microns	8g
33	60 ppm	<420 microns	9g
34	60 ppm	<420 microns	10g
35	60 ppm	<420 microns	11g
36	60 ppm	<420 microns	12g

Table 3.21: Run Protocol for Direct Blue 15, 80 ppm

runs	dye conc	sieve size	ads dosage
1	80 ppm	640 microns	1g
2	80 ppm	640 microns	2g
3	80 ppm	640 microns	3g
4	80 ppm	640 microns	4g
5	80 ppm	640 microns	5g
6	80 ppm	640 microns	6g
7	80 ppm	640 microns	7g
8	80 ppm	640 microns	8g
9	80 ppm	640 microns	9g
10	80 ppm	640 microns	10g
11	80 ppm	640 microns	11g
12	80 ppm	640 microns	12g
13	80 ppm	420 microns	1g
14	80 ppm	420 microns	2g
15	80 ppm	420 microns	3g
16	80 ppm	420 microns	4g
17	80 ppm	420 microns	5g
18	80 ppm	420 microns	6g
19	80 ppm	420 microns	7g
20	80 ppm	420 microns	8g
21	80 ppm	420 microns	9g
22	80 ppm	420 microns	10g
23	80 ppm	420 microns	11g
24	80 ppm	420 microns	12g
25	80 ppm	<420 microns	1g
26	80 ppm	<420 microns	2g
27	80 ppm	<420 microns	3g
28	80 ppm	<420 microns	4g
29	80 ppm	<420 microns	5g
30	80 ppm	<420 microns	6g
31	80 ppm	<420 microns	7g
32	80 ppm	<420 microns	8g
33	80 ppm	<420 microns	9g
34	80 ppm	<420 microns	10g
35	80 ppm	<420 microns	11g
36	80 ppm	<420 microns	12g

Table 3.22: Run Protocol for Direct Blue 15, 100 ppm

runs	dye conc	sieve size	ads dosage
1	100 ppm	640 microns	1g
2	100 ppm	640 microns	2g
3	100 ppm	640 microns	3g
4	100 ppm	640 microns	4g
5	100 ppm	640 microns	5g
6	100 ppm	640 microns	6g
7	100 ppm	640 microns	7g
8	100 ppm	640 microns	8g
9	100 ppm	640 microns	9g
10	100 ppm	640 microns	10g
11	100 ppm	640 microns	11g
12	100 ppm	640 microns	12g
13	100 ppm	420 microns	1g
14	100 ppm	420 microns	2g
15	100 ppm	420 microns	3g
16	100 ppm	420 microns	4g
17	100 ppm	420 microns	5g
18	100 ppm	420 microns	6g
19	100 ppm	420 microns	7g
20	100 ppm	420 microns	8g
21	100 ppm	420 microns	9g
22	100 ppm	420 microns	10g
23	100 ppm	420 microns	11g
24	100 ppm	420 microns	12g
25	100 ppm	<420 microns	1g
26	100 ppm	<420 microns	2g
27	100 ppm	<420 microns	3g
28	100 ppm	<420 microns	4g
29	100 ppm	<420 microns	5g
30	100 ppm	<420 microns	6g
31	100 ppm	<420 microns	7g
32	100 ppm	<420 microns	8g
33	100 ppm	<420 microns	9g
34	100 ppm	<420 microns	10g
35	100 ppm	<420 microns	11g
36	100 ppm	<420 microns	12g

Table 3.23: Run Protocol for Direct Blue 15, 120 ppm

runs	dye conc	sieve size	ads dosage
1	120 ppm	640 microns	1g
2	120 ppm	640 microns	2g
3	120 ppm	640 microns	3g
4	120 ppm	640 microns	4g
5	120 ppm	640 microns	5g
6	120 ppm	640 microns	6g
7	120 ppm	640 microns	7g
8	120 ppm	640 microns	8g
9	120 ppm	640 microns	9g
10	120 ppm	640 microns	10g
11	120 ppm	640 microns	11g
12	120 ppm	640 microns	12g
13	120 ppm	420 microns	1g
14	120 ppm	420 microns	2g
15	120 ppm	420 microns	3g
16	120 ppm	420 microns	4g
17	120 ppm	420 microns	5g
18	120 ppm	420 microns	6g
19	120 ppm	420 microns	7g
20	120 ppm	420 microns	8g
21	120 ppm	420 microns	9g
22	120 ppm	420 microns	10g
23	120 ppm	420 microns	11g
24	120 ppm	420 microns	12g
25	120 ppm	<420 microns	1g
26	120 ppm	<420 microns	2g
27	120 ppm	<420 microns	3g
28	120 ppm	<420 microns	4g
29	120 ppm	<420 microns	5g
30	120 ppm	<420 microns	6g
31	120 ppm	<420 microns	7g
32	120 ppm	<420 microns	8g
33	120 ppm	<420 microns	9g
34	120 ppm	<420 microns	10g
35	120 ppm	<420 microns	11g
36	120 ppm	<420 microns	12g

Table 3.24: Run Protocol for Direct Blue 15, 140 ppm

runs	dye conc	sieve size	ads dosage
1	140 ppm	640 microns	1g
2	140 ppm	640 microns	2g
3	140 ppm	640 microns	3g
4	140 ppm	640 microns	4g
5	140 ppm	640 microns	5g
6	140 ppm	640 microns	6g
7	140 ppm	640 microns	7g
8	140 ppm	640 microns	8g
9	140 ppm	640 microns	9g
10	140 ppm	640 microns	10g
11	140 ppm	640 microns	11g
12	140 ppm	640 microns	12g
13	140 ppm	420 microns	1g
14	140 ppm	420 microns	2g
15	140 ppm	420 microns	3g
16	140 ppm	420 microns	4g
17	140 ppm	420 microns	5g
18	140 ppm	420 microns	6g
19	140 ppm	420 microns	7g
20	140 ppm	420 microns	8g
21	140 ppm	420 microns	9g
22	140 ppm	420 microns	10g
23	140 ppm	420 microns	11g
24	140 ppm	420 microns	12g
25	140 ppm	<420 microns	1g
26	140 ppm	<420 microns	2g
27	140 ppm	<420 microns	3g
28	140 ppm	<420 microns	4g
29	140 ppm	<420 microns	5g
30	140 ppm	<420 microns	6g
31	140 ppm	<420 microns	7g
32	140 ppm	<420 microns	8g
33	140 ppm	<420 microns	9g
34	140 ppm	<420 microns	10g
35	140 ppm	<420 microns	11g
36	140 ppm	<420 microns	12g

CHAPTER IV

RESULTS AND DISCUSSIONS

1. There is a total of 900 samples which are presented in the form of tables and figures in the appendix.
2. There is a total of 25 tables. They are, 9 tables of Victoria Blue B dye samples, with varying concentrations of 40 ppm, 80 ppm, 120 ppm, 160 ppm, 200 ppm, 240 ppm, 280 ppm, 320 ppm and 360 ppm.
3. Nine tables of Congo Red dye samples, with varying concentrations of 20 ppm, 40 ppm, 60 ppm, 80 ppm, 100 ppm, 120 ppm, 140 ppm, 160 ppm and 180 ppm.
4. 7 tables of Direct Blue 15 dye samples, with varying concentrations of 20 ppm, 40 ppm, 60 ppm, 80 ppm, 100 ppm, 120 ppm and 140 ppm.
5. A total of 324 samples of Victoria Blue B, 324 samples of Congo Red and 252 samples of Direct Blue 15, makes 900 samples for the study.

4.1 Results

1. Maximum efficiency of color removal is observed for smaller particle size because of its larger surface area and minimum efficiency of color removal was observed for larger particle size because of its comparatively smaller surface area.

2. Since the molecular weight depends on the number of molecules or atoms attached together, lower molecular weight compounds have less complex structure and it ap- plies to the dyes used.
3. Lower molecular weight dyes have less complex structure and are hence easy to break, which are easy to treat compared to the higher molecular weight dyes.
4. Maximum transmittance after treatment was observed for Victoria Blue B dye at a dye concentration of 40 ppm when 12 g of peanut hull (particle size less than 420 microns) was used.
5. Minimum transmittance after treatment was observed for Direct Blue 15 dye at a dye concentration of 140 ppm when 1 g of peanut hull (particle size over 640 microns) was used.

4.2 Absorbance and Transmittance

1. The lowest transmittance for Victoria Blue B before treatment is 37% and highest transmittance is 54%.
2. The maximum transmittance attained by Victoria Blue B dye wastewater of 40 mg/l after treatment is 85% as shown in Figure 4.1.
3. The adsorbent dosage was 12 g for 100 ml wastewater sample and the adsorbent size is less than 420 microns.
4. The minimum transmittance attained by Victoria Blue B dye wastewater of 360 mg/l after treatment is 50% as shown in Figure 4.2.
5. The adsorbent dosage was 1 g for 100 ml wastewater sample and the adsorbent size is larger than 640 microns.

6. The lowest transmittance for Congo Red before treatment is 31% and highest transmittance is 48%.
7. The maximum transmittance attained by Congo Red dye wastewater of 20 mg/l after treatment is 78% as shown in Figure 4.3.
8. The adsorbent dosage was 12 g for 100 ml wastewater sample and the adsorbent size is less than 420 microns.
9. The minimum transmittance attained by Congo Red dye wastewater of 180 mg/l after treatment is 49% as shown in Figure 4.4.
10. The adsorbent dosage was 1 g for 100 ml wastewater sample and the adsorbent size is larger than 640 microns.
11. The lowest transmittance for Direct Blue 15 before treatment is 20% and highest transmittance is 35%.
12. The maximum transmittance attained by Direct Blue 15 dye wastewater of 20 mg/l after treatment is 60% as shown in Figure 4.5.
13. The adsorbent dosage was 12 g for 100 ml wastewater sample and the adsorbent size is less than 420 microns.
14. The minimum transmittance attained by Direct Blue 15 dye wastewater of 140 mg/l after treatment is 40% as shown in Figure 4.6.
15. The adsorbent dosage was 1 g for 100 ml wastewater sample and the adsorbent size is larger than 640 microns.

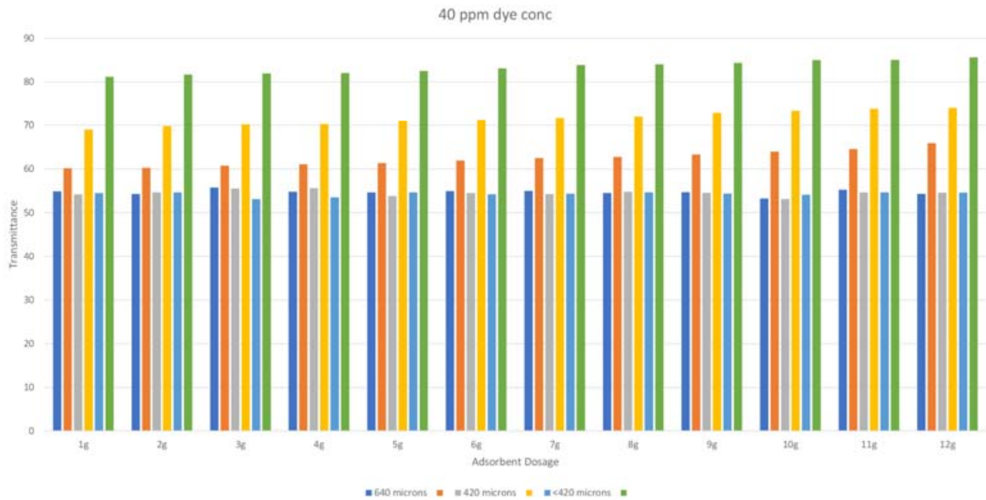

Figure 4.1: Results of Victoria Blue B dye of 40 ppm dye concentration showing maximum transmittance

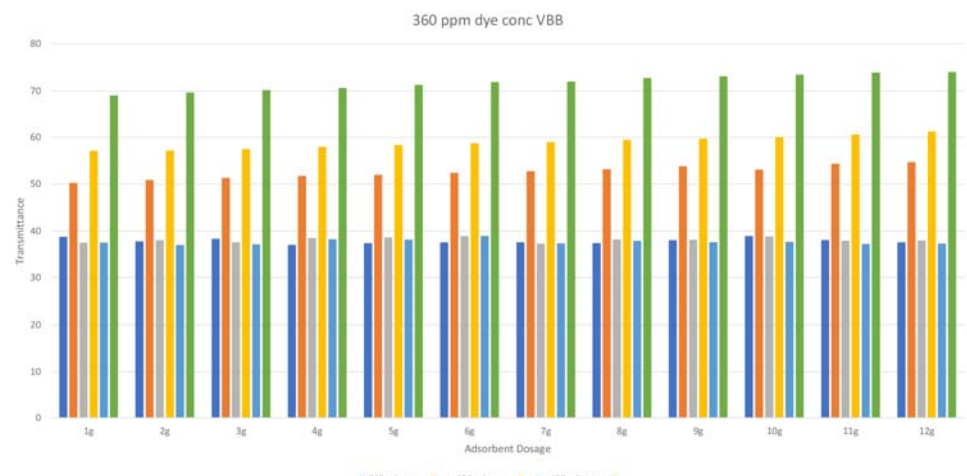

Figure 4.2: Results of Victoria Blue B dye of 360 ppm dye concentration showing minimum transmittance

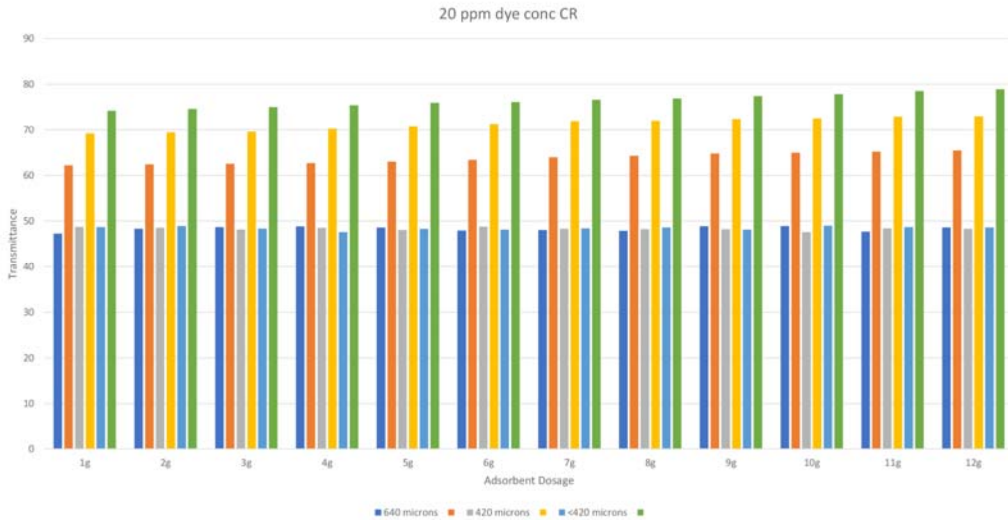

Figure 4.3: Results of Congo Red dye of 20 ppm dye concentration showing maximum transmittance

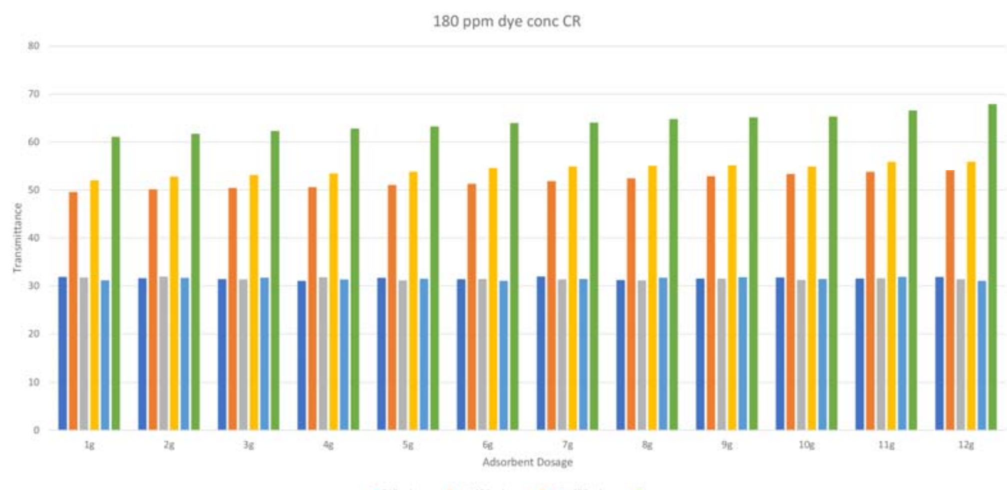

Figure 4.4: Results of Congo Red dye of 180 ppm dye concentration showing minimum transmittance

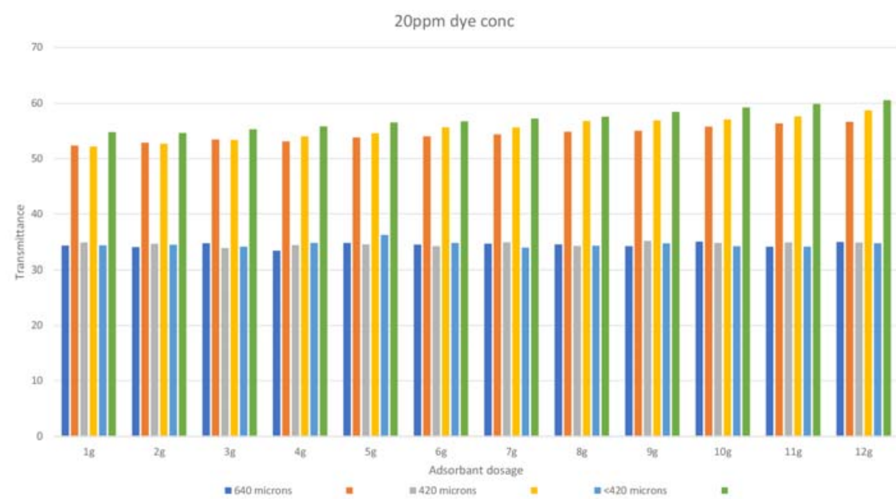

Figure 4.5: Results of Direct Blue 15 dye of 20 ppm dye concentration showing maximum transmittance

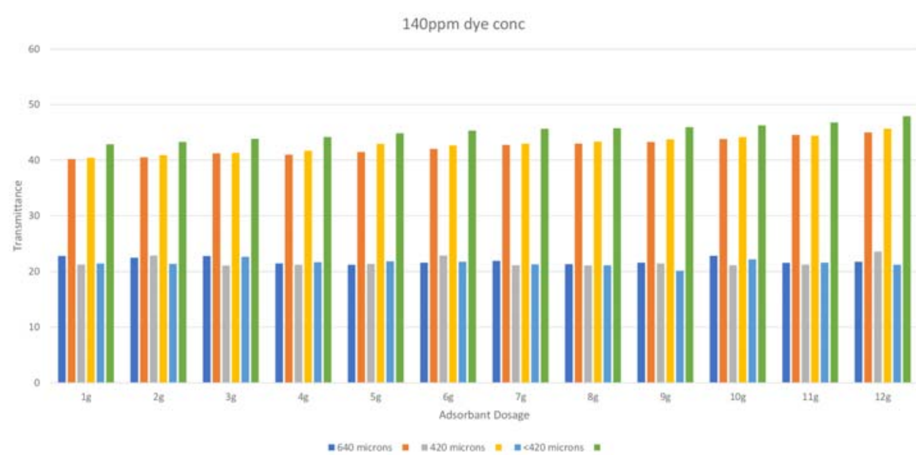

Figure 4.6: Results of Direct Blue 15 dye of 140 ppm dye concentration showing minimum transmittance

4.3 pH and NPOC

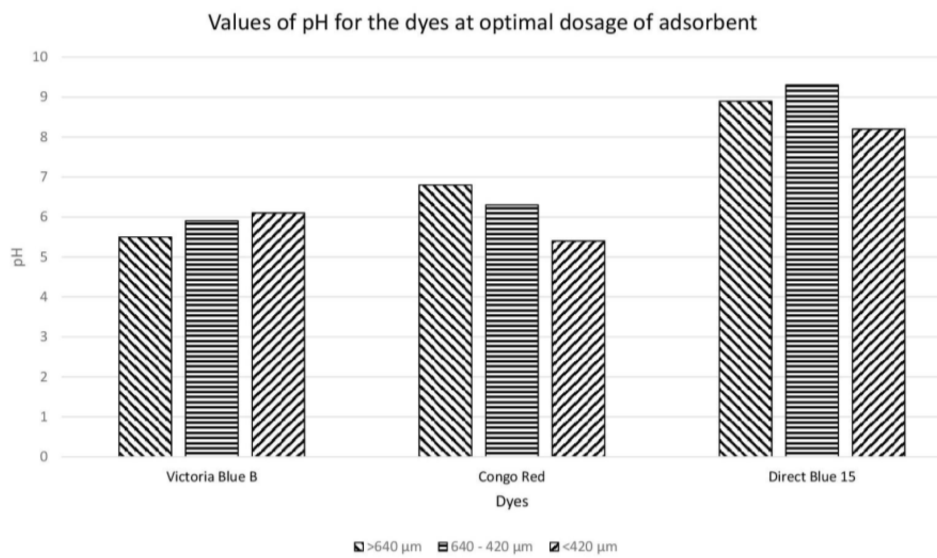

Figure 4.7: pH for Victoria Blue B, Congo Red and Direct Blue 15 at optimal dosage of peanut hull

pH values at an optimal dosage of 10 grams of peanut hull was calculated which shows the acidity of Victoria Blue B dye was more than the Congo Red dye, which was more than the Direct Blue 15.

NPOC values shows that the Total Organic Carbon content was low for particle size less than 420 microns and gradually increased for particle size greater than 640 microns.

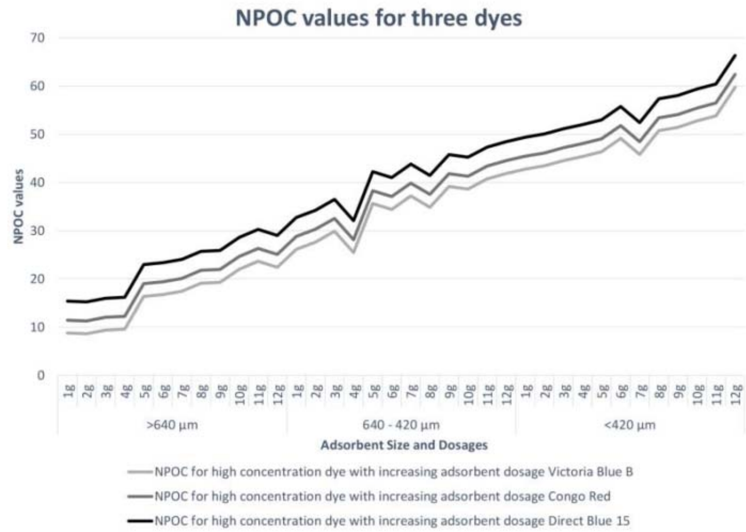

Figure 4.8: graph showing TOC values for Victoria Blue B, Congo Red and Direct Blue 15

4.4 Adsorption Isotherms

Adsorption is a process that occurs at the interface of two or more states. Gas over liquid and gas over solid are gaseous adsorption and liquid over solid is called condensate adsorption. The process of Adsorption is usually studied through graphs known as adsorption isotherm. It is the graph between the amounts of adsorbate adsorbed on the surface of adsorbent and pressure at constant temperature. There are three main theories to plot the adsorption isotherms and they are Linear, Freundlich and Langmuir theories [9]. The data collected in the experimental procedure is being used to estimate the models of Adsorption isotherms.

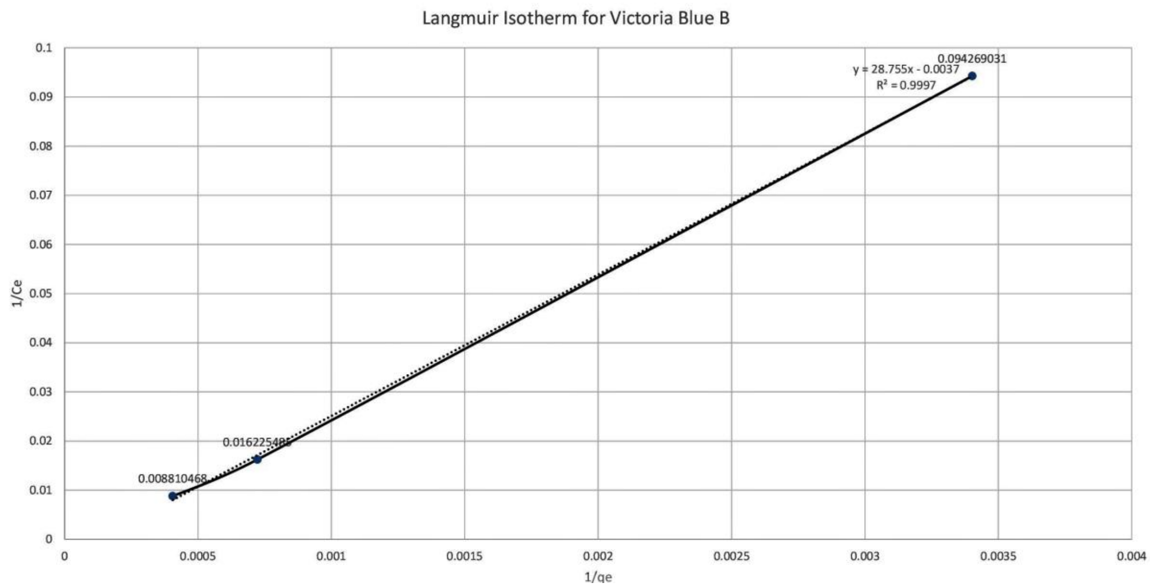

Figure 4.9: Langmuir isotherm model for Victoria Blue B at the optimum dosage of 10gms, Eq: y = 28.755 x - 0.0037 with value of sq.R = 0.9997

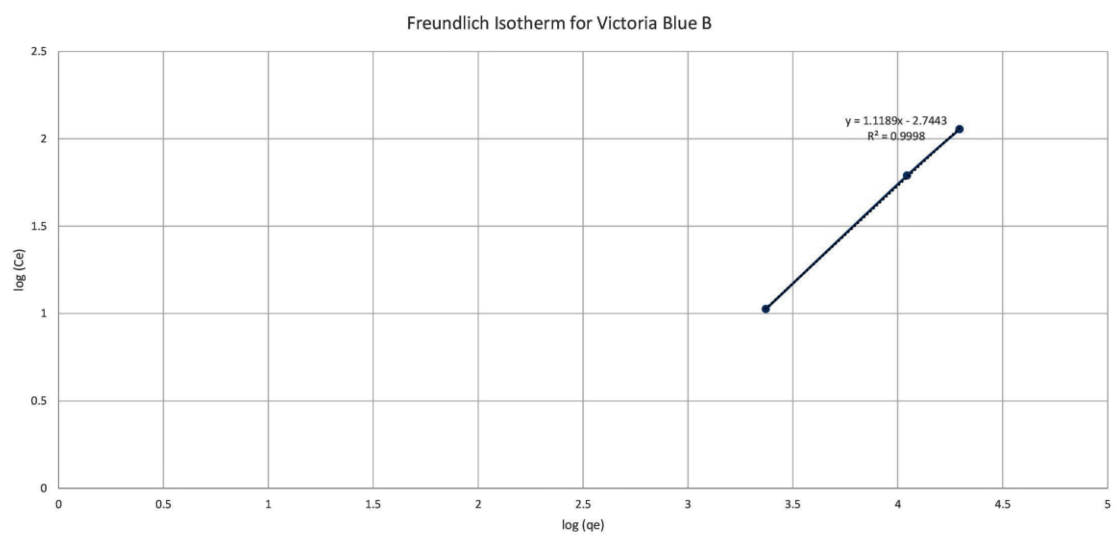

Figure 4.10: Freundlich isotherm model is the best fi for Victoria Blue B at the optimum dosage of 10 gms, Eq: y = 1.1189 x - 2.7443 with value of sq.R = 0.9998

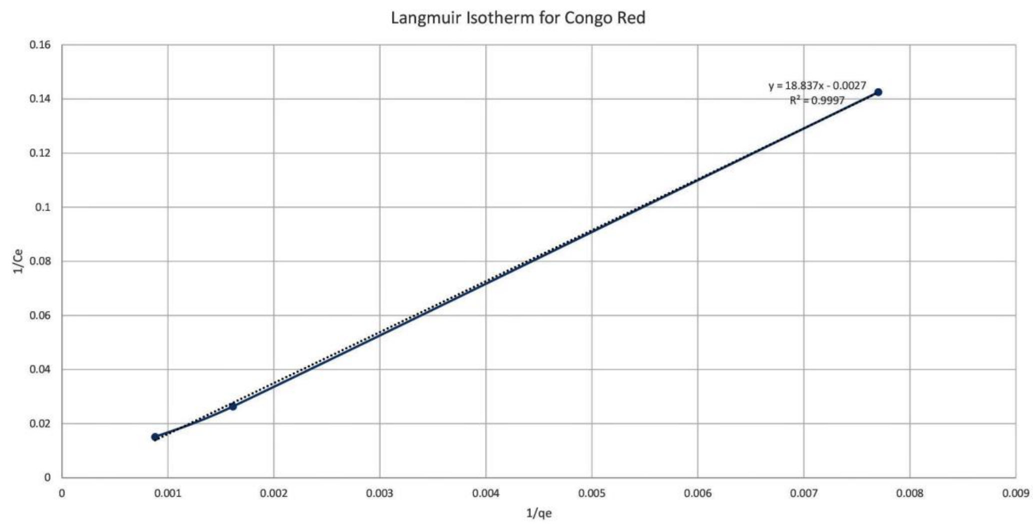

Figure 4.11: Langmuir isotherm model is the best fi for Congo Red at the optimum dosage of 10 gms, Eq: y = 18.837 x - 0.0027 with value of sq.R = 0.9997

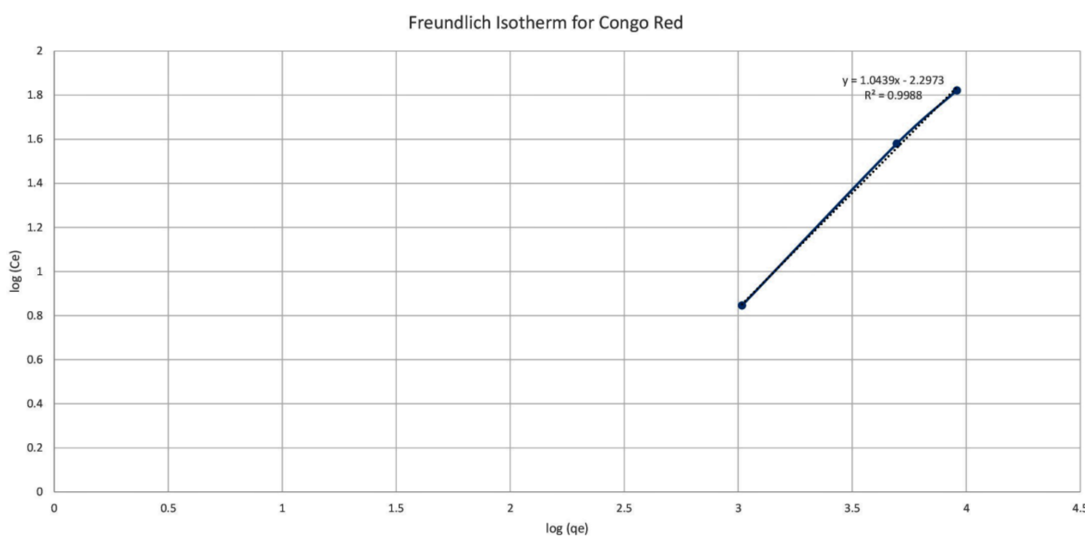

Figure 4.12: Freundlich isotherm model for Congo Red at the optimum dosage of 10 gms, Eq: y = 1.0439 x - 2.2973 with value of sq.R = 0.9988

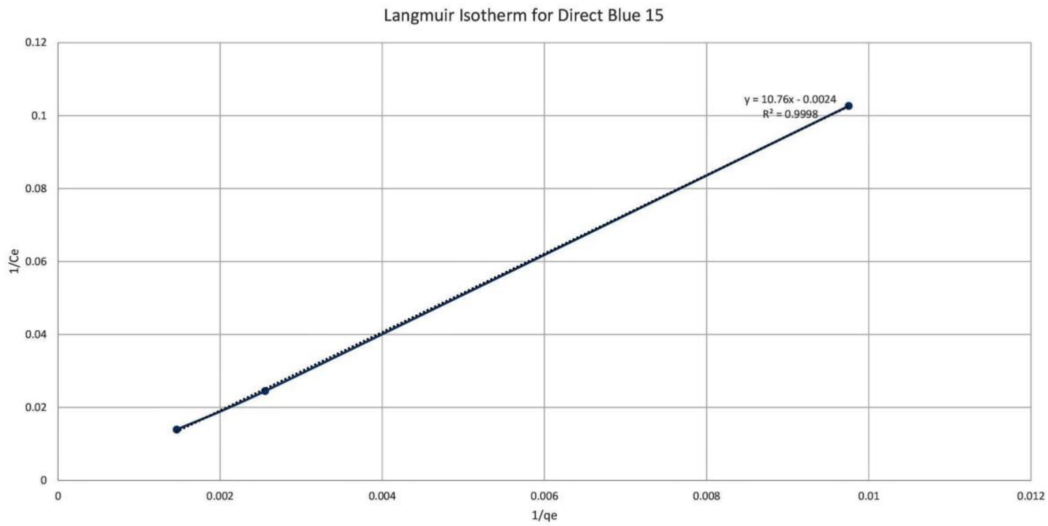

Figure 4.13: Langmuir isotherm model for Direct Blue 15 at the optimum dosage of 10 gms, Eq: y = 10.76 x - 0.0024 with value of sq.R = 0.9998

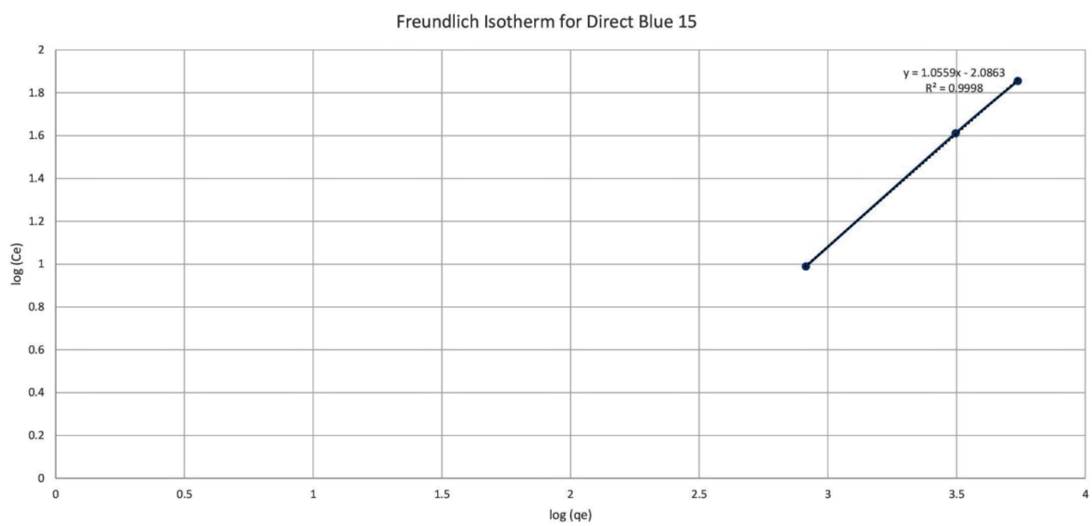

Figure 4.14: Freundlich isotherm model for Direct Blue 15 at the optimum dosage of 10 gms, Eq: y = 1.0559 x - 2.0863 with value of sq.R = 0.9998

CHAPTER V

CONCLUSIONS

The conclusions and recommendations for future research are discussed below in the following sections.

5.1 Conclusion

The following conclusions are obtained from this research study.

1. The maximum efficiency of color removal was found as the size of the peanut hull decreased and then the efficiency slowly decreased as the dye concentration increased. Similarly, there was high efficiency of color removal for powdered peanut hull and the efficiency increased with the decrease in dye concentration.
2. Maximum efficiency of color removal was obtained with Victoria Blue B and minimum efficiency of color removal was obtained with Direct Blue 15 among three dyes.
3. The lowest transmittance for Victoria Blue B before treatment is 37% and highest transmittance is 54%.
4. The maximum transmittance attained by Victoria Blue B dye wastewater of 20 mg/l after treatment is 85%. The adsorbent dosage was 12 g for 100 ml wastewater sample and the adsorbent size is less than 420 microns.

The minimum transmittance attained by Victoria Blue B dye wastewater of 360 mg/l after treatment is 50%. The adsorbent dosage was 1 g for 100 ml wastewater sample and the adsorbent size is larger than 640 microns.

5. The lowest transmittance for Congo Red before treatment is 31% and highest transmittance is 48%.
6. The maximum transmittance attained by Congo Red dye wastewater of 20 mg/l after treatment is 78%. The adsorbent dosage was 12 g for 100 ml wastewater sample and the adsorbent size is less than 420 microns. The minimum transmittance attained by Congo Red dye wastewater of 180 mg/l after treatment is 49%.
7. The adsorbent dosage was 1 g for 100 ml wastewater sample and the adsorbent size is larger than 640 microns.
8. The lowest transmittance for Direct Blue 15 before treatment is 20% and highest transmittance is 35%.
9. The maximum transmittance attained by Direct Blue 15 dye wastewater of 20 mg/l after treatment is 60%. The adsorbent dosage was 12 g for 100 ml wastewater sample and the adsorbent size is less than 420 microns. The minimum transmittance attained by Direct Blue 15 dye wastewater of 140 mg/l after treatment is 40%. The adsorbent dosage was 1 g for 100 ml wastewater sample and the adsorbent size is larger than 640 microns.

5.2 Engineering Significance

This research can be applied to the real world dye wastewater treatment. Since the adsorbent used for the treatment is low in cost, the treatment cost will be comparatively low than the traditional activated carbon. The treatment method is easy and time efficient than the coagulation or electro-coagulation methods since there is no need to add any other chemicals.

5.3 Recommendations for Future Research

Here are few recommendations for the researches in future.

1. New ideas to use natural dyes over artificial dyes. This will help reduce the usage of synthetic dyes.
2. Creative techniques that will limit the cost of natural dyes over the synthetic dyes. Once we fi natural dyes cheaper than the synthetic, we tend to shift to natural dyes.
3. Focus on pollution reduction techniques. Dyes released into land and water cause much more harm than we imagine.
4. More ideas involving reuse of treated dye waste water. This will automatically have a check on the waste water generated from all the industries.
5. Development of more ideas on how to use the by-products generated. this helps reduce the amount of wastes generated.
6. Study of different dyes to have more information about how to treat a particular dye.
7. Focus on developing methods and models based on the type of the dye. Design the methods specific to the type of the dye and adsorbents used to remove the dye. For example, incineration is a technique not suitable for dyes with more Sulfur and Nitrogen since their incineration generates more oxides, when released directly into atmosphere without treating for reduction of sulfur and nitrogen causes more harm.

8. Development of new methods to limit the cost spent for recycling the hazardous products.
9. Focus on more low-cost adsorbents.
10. Focus on disposal techniques of both the dye and the dye-mixed adsorbent. This is because the dyes we see in our daily life are mostly hazardous or toxic and their disposal is one main point to be considered.

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APPENDIX A: TABLES

Table 6.1: Absorbance and transmittance values of Victoria Blue B, 40ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	40ppm	640 m	1g	0.260	0.221	54.9	60.16
2	40ppm	640 m	2g	0.265	0.220	54.27	60.24
3	40ppm	640 m	3g	0.254	0.216	55.77	60.75
4	40ppm	640 m	4g	0.261	0.214	54.81	61.07
5	40ppm	640 m	5g	0.262	0.212	54.64	61.35
6	40ppm	640 m	6g	0.260	0.208	54.92	61.92
7	40ppm	640 m	7g	0.260	0.204	54.99	62.48
8	40ppm	640 m	8g	0.264	0.203	54.51	62.73
9	40ppm	640 m	9g	0.262	0.199	54.69	63.28
10	40ppm	640 m	10g	0.274	0.194	53.23	63.97
11	40ppm	640 m	11g	0.258	0.190	55.26	64.56
12	40ppm	640 m	12g	0.265	0.181	54.3	65.87
13	40ppm	420 m	1g	0.266	0.161	54.19	69.02
14	40ppm	420 m	2g	0.262	0.156	54.68	69.78
15	40ppm	420 m	3g	0.255	0.154	55.53	70.19
16	40ppm	420 m	4g	0.255	0.153	55.6	70.26
17	40ppm	420 m	5g	0.269	0.149	53.8	70.91
18	40ppm	420 m	6g	0.263	0.147	54.52	71.24
19	40ppm	420 m	7g	0.266	0.145	54.26	71.69
20	40ppm	420 m	8g	0.261	0.142	54.8	72.06
21	40ppm	420 m	9g	0.263	0.138	54.53	72.84
22	40ppm	420 m	10g	0.274	0.135	53.15	73.33
23	40ppm	420 m	11g	0.262	0.132	54.65	73.84
24	40ppm	420 m	12g	0.263	0.131	54.6	74.02
25	40ppm	<420 m	1g	0.264	0.091	54.48	81.15
26	40ppm	<420 m	2g	0.262	0.088	54.64	81.67
27	40ppm	<420 m	3g	0.275	0.087	53.1	81.93
28	40ppm	<420 m	4g	0.272	0.086	53.49	82.04
29	40ppm	<420 m	5g	0.262	0.083	54.67	82.53
30	40ppm	<420 m	6g	0.266	0.080	54.2	83.11
31	40ppm	<420 m	7g	0.265	0.076	54.35	83.87
32	40ppm	<420 m	8g	0.262	0.076	54.66	84.02
33	40ppm	<420 m	9g	0.265	0.074	54.38	84.35
34	40ppm	<420 m	10g	0.267	0.071	54.11	84.97
35	40ppm	<420 m	11g	0.262	0.070	54.68	85.03
36	40ppm	<420 m	12g	0.263	0.067	54.6	85.62

Table 6.2: Absorbance and transmittance values of Victoria Blue B, 80ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	80 ppm	640 m	1g	0.283	0.234	52.08	58.29
2	80 ppm	640 m	2g	0.276	0.231	52.94	58.76
3	80 ppm	640 m	3g	0.283	0.229	52.13	59.01
4	80 ppm	640 m	4g	0.277	0.227	52.86	59.29
5	80 ppm	640 m	5g	0.282	0.220	52.19	60.24
6	80 ppm	640 m	6g	0.281	0.217	52.37	60.71
7	80 ppm	640 m	7g	0.280	0.212	52.51	61.38
8	80 ppm	640 m	8g	0.283	0.208	52.09	61.97
9	80 ppm	640 m	9g	0.277	0.205	52.82	62.31
10	80 ppm	640 m	10g	0.287	0.207	51.65	62.04
11	80 ppm	640 m	11g	0.280	0.201	52.53	62.88
12	80 ppm	640 m	12g	0.288	0.194	51.58	63.97
13	80 ppm	420 m	1g	0.290	0.172	51.23	67.24
14	80 ppm	420 m	2g	0.277	0.167	52.85	68.09
15	80 ppm	420 m	3g	0.282	0.161	52.28	68.97
16	80 ppm	420 m	4g	0.283	0.158	52.13	69.44
17	80 ppm	420 m	5g	0.284	0.156	52.04	69.86
18	80 ppm	420 m	6g	0.277	0.153	52.81	70.29
19	80 ppm	420 m	7g	0.289	0.150	51.42	70.85
20	80 ppm	420 m	8g	0.290	0.147	51.25	71.34
21	80 ppm	420 m	9g	0.279	0.145	52.57	71.58
22	80 ppm	420 m	10g	0.279	0.141	52.61	72.31
23	80 ppm	420 m	11g	0.277	0.137	52.84	72.92
24	80 ppm	420 m	12g	0.276	0.136	52.98	73.07
25	80 ppm	<420 m	1g	0.283	0.112	52.12	77.19
26	80 ppm	<420 m	2g	0.277	0.109	52.84	77.83
27	80 ppm	<420 m	3g	0.276	0.107	52.91	78.24
28	80 ppm	<420 m	4g	0.279	0.103	52.62	78.97
29	80 ppm	<420 m	5g	0.278	0.102	52.71	79.15
30	80 ppm	<420 m	6g	0.290	0.098	51.32	79.88
31	80 ppm	<420 m	7g	0.283	0.096	52.17	80.25
32	80 ppm	<420 m	8g	0.289	0.093	51.45	80.73
33	80 ppm	<420 m	9g	0.278	0.089	52.78	81.43
34	80 ppm	<420 m	10g	0.278	0.087	52.76	81.92
35	80 ppm	<420 m	11g	0.282	0.084	52.24	82.43
36	80 ppm	<420 m	12g	0.279	0.081	52.63	83.01

Table 6.3: Absorbance and transmittance values of Victoria Blue B, 120ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	120ppm	640 m	1g	0.297	0.250	50.49	56.21
2	120ppm	640 m	2g	0.296	0.245	50.62	56.89
3	120ppm	640 m	3g	0.307	0.239	49.34	57.65
4	120ppm	640 m	4g	0.296	0.243	50.57	57.2
5	120ppm	640 m	5g	0.298	0.232	50.36	58.56
6	120ppm	640 m	6g	0.299	0.231	50.2	58.71
7	120ppm	640 m	7g	0.307	0.227	49.36	59.24
8	120ppm	640 m	8g	0.309	0.220	49.11	60.25
9	120ppm	640 m	9g	0.303	0.212	49.74	61.34
10	120ppm	640 m	10g	0.301	0.208	49.95	61.98
11	120ppm	640 m	11g	0.293	0.207	50.93	62.13
12	120ppm	640 m	12g	0.316	0.198	48.29	63.34
13	120ppm	420 m	1g	0.306	0.184	49.41	65.41
14	120ppm	420 m	2g	0.308	0.182	49.17	65.83
15	120ppm	420 m	3g	0.297	0.178	50.43	66.41
16	120ppm	420 m	4g	0.295	0.179	50.75	66.29
17	120ppm	420 m	5g	0.307	0.173	49.34	67.14
18	120ppm	420 m	6g	0.304	0.169	49.68	67.83
19	120ppm	420 m	7g	0.296	0.165	50.61	68.35
20	120ppm	420 m	8g	0.296	0.162	50.6	68.92
21	120ppm	420 m	9g	0.303	0.160	49.75	69.17
22	120ppm	420 m	10g	0.308	0.159	49.23	69.34
23	120ppm	420 m	11g	0.302	0.153	49.9	70.29
24	120ppm	420 m	12g	0.304	0.153	49.64	70.32
25	120ppm	<420 m	1g	0.310	0.129	49.03	74.25
26	120ppm	<420 m	2g	0.307	0.126	49.35	74.81
27	120ppm	<420 m	3g	0.307	0.121	49.3	75.67
28	120ppm	<420 m	4g	0.302	0.119	49.85	76.01
29	120ppm	<420 m	5g	0.307	0.115	49.37	76.82
30	120ppm	<420 m	6g	0.302	0.113	49.84	77.15
31	120ppm	<420 m	7g	0.299	0.112	50.23	77.24
32	120ppm	<420 m	8g	0.307	0.106	49.31	78.31
33	120ppm	<420 m	9g	0.308	0.101	49.25	79.24
34	120ppm	<420 m	10g	0.299	0.096	50.27	80.16
35	120ppm	<420 m	11g	0.294	0.092	50.79	80.87
36	120ppm	<420 m	12g	0.294	0.090	50.78	81.25

Table 6.4: Absorbance and transmittance values of Victoria Blue B, 160ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	160ppm	640 m	1g	0.318	0.258	48.13	55.18
2	160ppm	640 m	2g	0.317	0.257	48.23	55.33
3	160ppm	640 m	3g	0.311	0.252	48.87	55.93
4	160ppm	640 m	4g	0.315	0.247	48.39	56.61
5	160ppm	640 m	5g	0.313	0.243	48.65	57.09
6	160ppm	640 m	6g	0.317	0.243	48.15	57.11
7	160ppm	640 m	7g	0.314	0.238	48.49	57.81
8	160ppm	640 m	8g	0.313	0.230	48.67	58.82
9	160ppm	640 m	9g	0.314	0.230	48.54	58.89
10	160ppm	640 m	10g	0.317	0.227	48.2	59.25
11	160ppm	640 m	11g	0.318	0.225	48.11	59.53
12	160ppm	640 m	12g	0.319	0.217	48.02	60.62
13	160ppm	420 m	1g	0.308	0.196	49.17	63.75
14	160ppm	420 m	2g	0.315	0.195	48.47	63.86
15	160ppm	420 m	3g	0.316	0.193	48.36	64.15
16	160ppm	420 m	4g	0.306	0.188	49.42	64.89
17	160ppm	420 m	5g	0.321	0.186	47.73	65.1
18	160ppm	420 m	6g	0.316	0.181	48.33	65.99
19	160ppm	420 m	7g	0.317	0.180	48.17	66.14
20	160ppm	420 m	8g	0.317	0.178	48.19	66.43
21	160ppm	420 m	9g	0.315	0.173	48.44	67.19
22	160ppm	420 m	10g	0.321	0.167	47.78	68.08
23	160ppm	420 m	11g	0.321	0.160	47.79	69.13
24	160ppm	420 m	12g	0.310	0.158	48.95	69.43
25	160ppm	<420 m	1g	0.314	0.106	48.56	78.43
26	160ppm	<420 m	2g	0.311	0.103	48.84	78.96
27	160ppm	<420 m	3g	0.316	0.101	48.28	79.21
28	160ppm	<420 m	4g	0.312	0.099	48.8	79.68
29	160ppm	<420 m	5g	0.313	0.099	48.61	79.54
30	160ppm	<420 m	6g	0.314	0.097	48.52	80.04
31	160ppm	<420 m	7g	0.313	0.095	48.64	80.41
32	160ppm	<420 m	8g	0.311	0.092	48.85	80.93
33	160ppm	<420 m	9g	0.315	0.091	48.44	81.17
34	160ppm	<420 m	10g	0.308	0.088	49.15	81.64
35	160ppm	<420 m	11g	0.313	0.087	48.65	81.86
36	160ppm	<420 m	12g	0.313	0.086	48.68	82.03

Table 6.5: Absorbance and transmittance values of Victoria Blue B, 200ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	200ppm	640 m	1g	0.330	0.260	46.76	54.96
2	200ppm	640 m	2g	0.339	0.259	45.8	55.12
3	200ppm	640 m	3g	0.344	0.257	45.27	55.37
4	200ppm	640 m	4g	0.341	0.250	45.56	56.19
5	200ppm	640 m	5g	0.333	0.245	46.44	56.94
6	200ppm	640 m	6g	0.341	0.242	45.62	57.28
7	200ppm	640 m	7g	0.330	0.241	46.75	57.46
8	200ppm	640 m	8g	0.336	0.240	46.13	57.53
9	200ppm	640 m	9g	0.340	0.236	45.76	58.04
10	200ppm	640 m	10g	0.343	0.230	45.35	58.86
11	200ppm	640 m	11g	0.338	0.228	45.93	59.09
12	200ppm	640 m	12g	0.342	0.218	45.49	60.5
13	200ppm	420 m	1g	0.338	0.209	45.94	61.78
14	200ppm	420 m	2g	0.341	0.208	45.58	61.93
15	200ppm	420 m	3g	0.338	0.207	45.97	62.06
16	200ppm	420 m	4g	0.340	0.203	45.73	62.69
17	200ppm	420 m	5g	0.341	0.198	45.56	63.41
18	200ppm	420 m	6g	0.341	0.194	45.63	63.96
19	200ppm	420 m	7g	0.334	0.193	46.31	64.18
20	200ppm	420 m	8g	0.344	0.191	45.25	64.39
21	200ppm	420 m	9g	0.338	0.188	45.91	64.87
22	200ppm	420 m	10g	0.339	0.186	45.83	65.18
23	200ppm	420 m	11g	0.339	0.182	45.79	65.76
24	200ppm	420 m	12g	0.344	0.180	45.34	66.01
25	200ppm	<420 m	1g	0.345	0.125	45.23	75.03
26	200ppm	<420 m	2g	0.343	0.123	45.44	75.42
27	200ppm	<420 m	3g	0.338	0.120	45.87	75.85
28	200ppm	<420 m	4g	0.339	0.120	45.78	75.93
29	200ppm	<420 m	5g	0.340	0.117	45.73	76.43
30	200ppm	<420 m	6g	0.339	0.117	45.79	76.31
31	200ppm	<420 m	7g	0.341	0.111	45.61	77.46
32	200ppm	<420 m	8g	0.343	0.109	45.4	77.8
33	200ppm	<420 m	9g	0.341	0.108	45.57	77.94
34	200ppm	<420 m	10g	0.345	0.106	45.23	78.31
35	200ppm	<420 m	11g	0.343	0.104	45.42	78.64
36	200ppm	<420 m	12g	0.342	0.100	45.48	79.43

Table 6.6: Absorbance and transmittance values of Victoria Blue B, 240ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	240ppm	640 m	1g	0.350	0.268	44.71	53.98
2	240ppm	640 m	2g	0.353	0.267	44.34	54.04
3	240ppm	640 m	3g	0.346	0.261	45.12	54.85
4	240ppm	640 m	4g	0.348	0.256	44.87	55.47
5	240ppm	640 m	5g	0.355	0.249	44.15	56.31
6	240ppm	640 m	6g	0.349	0.246	44.74	56.78
7	240ppm	640 m	7g	0.341	0.243	45.62	57.13
8	240ppm	640 m	8g	0.349	0.241	44.8	57.46
9	240ppm	640 m	9g	0.360	0.231	43.65	58.77
10	240ppm	640 m	10g	0.362	0.230	43.47	58.94
11	240ppm	640 m	11g	0.350	0.228	44.63	59.12
12	240ppm	640 m	12g	0.352	0.224	44.48	59.75
13	240ppm	420 m	1g	0.354	0.212	44.3	61.34
14	240ppm	420 m	2g	0.349	0.209	44.75	61.86
15	240ppm	420 m	3g	0.350	0.206	44.68	62.16
16	240ppm	420 m	4g	0.355	0.201	44.16	62.94
17	240ppm	420 m	5g	0.350	0.199	44.67	63.28
18	240ppm	420 m	6g	0.349	0.197	44.81	63.51
19	240ppm	420 m	7g	0.353	0.193	44.39	64.06
20	240ppm	420 m	8g	0.352	0.188	44.51	64.89
21	240ppm	420 m	9g	0.356	0.186	44.06	65.11
22	240ppm	420 m	10g	0.354	0.183	44.28	65.68
23	240ppm	420 m	11g	0.348	0.178	44.87	66.3
24	240ppm	420 m	12g	0.357	0.177	43.94	66.54
25	240ppm	<420 m	1g	0.353	0.135	44.32	73.34
26	240ppm	<420 m	2g	0.350	0.131	44.71	73.94
27	240ppm	<420 m	3g	0.358	0.127	43.87	74.59
28	240ppm	<420 m	4g	0.360	0.125	43.63	74.92
29	240ppm	<420 m	5g	0.352	0.123	44.48	75.33
30	240ppm	<420 m	6g	0.355	0.120	44.2	75.86
31	240ppm	<420 m	7g	0.353	0.117	44.33	76.39
32	240ppm	<420 m	8g	0.354	0.114	44.21	76.92
33	240ppm	<420 m	9g	0.351	0.112	44.58	77.31
34	240ppm	<420 m	10g	0.351	0.110	44.57	77.65
35	240ppm	<420 m	11g	0.350	0.108	44.63	78.02
36	240ppm	<420 m	12g	0.353	0.106	44.34	78.41

Table 6.7: Absorbance and transmittance values of Victoria Blue B, 280ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	280ppm	640 m	1g	0.370	0.228	42.69	59.16
2	280ppm	640 m	2g	0.372	0.224	42.5	59.74
3	280ppm	640 m	3g	0.368	0.221	42.89	60.05
4	280ppm	640 m	4g	0.369	0.221	42.76	60.18
5	280ppm	640 m	5g	0.371	0.215	42.57	60.94
6	280ppm	640 m	6g	0.367	0.214	42.98	61.07
7	280ppm	640 m	7g	0.376	0.209	42.11	61.84
8	280ppm	640 m	8g	0.371	0.207	42.6	62.15
9	280ppm	640 m	9g	0.374	0.203	42.26	62.69
10	280ppm	640 m	10g	0.366	0.199	43.05	63.28
11	280ppm	640 m	11g	0.366	0.197	43.01	63.54
12	280ppm	640 m	12g	0.369	0.194	42.79	63.96
13	280ppm	420 m	1g	0.368	0.186	42.87	65.17
14	280ppm	420 m	2g	0.372	0.182	42.5	65.84
15	280ppm	420 m	3g	0.370	0.179	42.63	66.24
16	280ppm	420 m	4g	0.369	0.175	42.79	66.87
17	280ppm	420 m	5g	0.368	0.173	42.84	67.13
18	280ppm	420 m	6g	0.376	0.168	42.03	67.96
19	280ppm	420 m	7g	0.374	0.166	42.28	68.21
20	280ppm	420 m	8g	0.376	0.163	42.07	68.72
21	280ppm	420 m	9g	0.370	0.159	42.64	69.34
22	280ppm	420 m	10g	0.366	0.158	43.07	69.55
23	280ppm	420 m	11g	0.375	0.153	42.14	70.3
24	280ppm	420 m	12g	0.370	0.152	42.68	70.49
25	280ppm	<420 m	1g	0.369	0.147	42.77	71.23
26	280ppm	<420 m	2g	0.368	0.143	42.86	71.94
27	280ppm	<420 m	3g	0.371	0.142	42.54	72.14
28	280ppm	<420 m	4g	0.368	0.139	42.81	72.65
29	280ppm	<420 m	5g	0.369	0.134	42.79	73.41
30	280ppm	<420 m	6g	0.377	0.131	41.98	73.98
31	280ppm	<420 m	7g	0.373	0.129	42.34	74.22
32	280ppm	<420 m	8g	0.368	0.125	42.83	74.95
33	280ppm	<420 m	9g	0.374	0.125	42.24	75.06
34	280ppm	<420 m	10g	0.369	0.120	42.72	75.91
35	280ppm	<420 m	11g	0.373	0.119	42.4	76.04
36	280ppm	<420 m	12g	0.373	0.114	42.39	76.83

Table 6.8: Absorbance and transmittance values of Victoria Blue B, 320ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	320ppm	640 m	1g	0.388	0.283	40.91	52.17
2	320ppm	640 m	2g	0.392	0.279	40.58	52.62
3	320ppm	640 m	3g	0.405	0.276	39.32	52.96
4	320ppm	640 m	4g	0.407	0.274	39.18	53.15
5	320ppm	640 m	5g	0.402	0.269	39.59	53.84
6	320ppm	640 m	6g	0.404	0.268	39.47	53.96
7	320ppm	640 m	7g	0.400	0.267	39.83	54.07
8	320ppm	640 m	8g	0.398	0.263	39.96	54.63
9	320ppm	640 m	9g	0.404	0.258	39.45	55.2
10	320ppm	640 m	10g	0.401	0.254	39.7	55.71
11	320ppm	640 m	11g	0.393	0.251	40.44	56.09
12	320ppm	640 m	12g	0.405	0.250	39.31	56.27
13	320ppm	420 m	1g	0.408	0.208	39.1	61.89
14	320ppm	420 m	2g	0.406	0.205	39.24	62.31
15	320ppm	420 m	3g	0.399	0.202	39.93	62.78
16	320ppm	420 m	4g	0.400	0.199	39.83	63.17
17	320ppm	420 m	5g	0.404	0.197	39.45	63.49
18	320ppm	420 m	6g	0.398	0.195	39.96	63.84
19	320ppm	420 m	7g	0.398	0.192	39.99	64.32
20	320ppm	420 m	8g	0.408	0.188	39.05	64.87
21	320ppm	420 m	9g	0.398	0.186	39.96	65.19
22	320ppm	420 m	10g	0.402	0.183	39.67	65.63
23	320ppm	420 m	11g	0.406	0.181	39.23	65.9
24	320ppm	420 m	12g	0.401	0.177	39.72	66.47
25	320ppm	<420 m	1g	0.404	0.147	39.48	71.21
26	320ppm	<420 m	2g	0.393	0.145	40.48	71.68
27	320ppm	<420 m	3g	0.407	0.144	39.14	71.77
28	320ppm	<420 m	4g	0.403	0.141	39.56	72.36
29	320ppm	<420 m	5g	0.404	0.138	39.45	72.72
30	320ppm	<420 m	6g	0.405	0.137	39.34	72.98
31	320ppm	<420 m	7g	0.404	0.135	39.41	73.24
32	320ppm	<420 m	8g	0.403	0.132	39.55	73.85
33	320ppm	<420 m	9g	0.396	0.129	40.2	74.33
34	320ppm	<420 m	10g	0.406	0.126	39.25	74.79
35	320ppm	<420 m	11g	0.399	0.125	39.93	75.06
36	320ppm	<420 m	12g	0.400	0.122	39.8	75.48

Table 6.9: Absorbance and transmittance values of Victoria Blue B, 360ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	360ppm	640 m	1g	0.411	0.299	38.79	50.22
2	360ppm	640 m	2g	0.423	0.294	37.8	50.84
3	360ppm	640 m	3g	0.416	0.290	38.39	51.31
4	360ppm	640 m	4g	0.431	0.286	37.07	51.72
5	360ppm	640 m	5g	0.427	0.284	37.43	51.95
6	360ppm	640 m	6g	0.425	0.281	37.6	52.38
7	360ppm	640 m	7g	0.424	0.278	37.63	52.72
8	360ppm	640 m	8g	0.426	0.275	37.46	53.14
9	360ppm	640 m	9g	0.419	0.269	38.08	53.8
10	360ppm	640 m	10g	0.410	0.275	38.93	53.05
11	360ppm	640 m	11g	0.419	0.265	38.1	54.29
12	360ppm	640 m	12g	0.424	0.262	37.64	54.67
13	360ppm	420 m	1g	0.426	0.243	37.53	57.09
14	360ppm	420 m	2g	0.420	0.243	38.06	57.16
15	360ppm	420 m	3g	0.425	0.240	37.61	57.48
16	360ppm	420 m	4g	0.415	0.237	38.49	57.92
17	360ppm	420 m	5g	0.413	0.234	38.66	58.34
18	360ppm	420 m	6g	0.409	0.231	38.95	58.72
19	360ppm	420 m	7g	0.428	0.229	37.33	58.96
20	360ppm	420 m	8g	0.417	0.226	38.24	59.41
21	360ppm	420 m	9g	0.419	0.224	38.15	59.68
22	360ppm	420 m	10g	0.411	0.222	38.84	60.01
23	360ppm	420 m	11g	0.421	0.218	37.95	60.59
24	360ppm	420 m	12g	0.420	0.213	37.98	61.23
25	360ppm	<420 m	1g	0.425	0.161	37.55	69.07
26	360ppm	<420 m	2g	0.431	0.157	37.04	69.65
27	360ppm	<420 m	3g	0.430	0.154	37.18	70.19
28	360ppm	<420 m	4g	0.417	0.151	38.3	70.65
29	360ppm	<420 m	5g	0.418	0.147	38.21	71.32
30	360ppm	<420 m	6g	0.409	0.143	38.96	71.94
31	360ppm	<420 m	7g	0.427	0.142	37.39	72.06
32	360ppm	<420 m	8g	0.421	0.138	37.92	72.8
33	360ppm	<420 m	9g	0.424	0.136	37.66	73.15
34	360ppm	<420 m	10g	0.424	0.134	37.71	73.53
35	360ppm	<420 m	11g	0.429	0.131	37.25	73.96
36	360ppm	<420 m	12g	0.428	0.130	37.34	74.08

Table 6.10: Absorbance and transmittance values of Congo Red, 20ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	20ppm	640 m	1g	0.326	0.206	47.26	62.21
2	20ppm	640 m	2g	0.316	0.205	48.32	62.43
3	20ppm	640 m	3g	0.313	0.204	48.67	62.56
4	20ppm	640 m	4g	0.311	0.203	48.83	62.71
5	20ppm	640 m	5g	0.313	0.200	48.59	63.04
6	20ppm	640 m	6g	0.320	0.198	47.91	63.42
7	20ppm	640 m	7g	0.318	0.194	48.04	63.97
8	20ppm	640 m	8g	0.320	0.192	47.88	64.31
9	20ppm	640 m	9g	0.311	0.188	48.85	64.82
10	20ppm	640 m	10g	0.311	0.187	48.92	64.96
11	20ppm	640 m	11g	0.322	0.186	47.68	65.23
12	20ppm	640 m	12g	0.313	0.184	48.6	65.47
13	20ppm	420 m	1g	0.312	0.160	48.73	69.23
14	20ppm	420 m	2g	0.314	0.158	48.54	69.44
15	20ppm	420 m	3g	0.317	0.157	48.16	69.59
16	20ppm	420 m	4g	0.314	0.153	48.53	70.25
17	20ppm	420 m	5g	0.318	0.150	48.05	70.82
18	20ppm	420 m	6g	0.312	0.147	48.77	71.32
19	20ppm	420 m	7g	0.316	0.143	48.31	71.91
20	20ppm	420 m	8g	0.317	0.142	48.22	72.04
21	20ppm	420 m	9g	0.317	0.140	48.19	72.39
22	20ppm	420 m	10g	0.322	0.139	47.61	72.54
23	20ppm	420 m	11g	0.315	0.137	48.38	72.93
24	20ppm	420 m	12g	0.316	0.137	48.29	73.01
25	20ppm	<420 m	1g	0.313	0.130	48.67	74.19
26	20ppm	<420 m	2g	0.311	0.127	48.92	74.62
27	20ppm	<420 m	3g	0.316	0.125	48.35	75.04
28	20ppm	<420 m	4g	0.322	0.123	47.61	75.41
29	20ppm	<420 m	5g	0.316	0.119	48.28	75.96
30	20ppm	<420 m	6g	0.318	0.119	48.13	76.12
31	20ppm	<420 m	7g	0.315	0.116	48.4	76.63
32	20ppm	<420 m	8g	0.314	0.114	48.58	76.89
33	20ppm	<420 m	9g	0.318	0.111	48.09	77.42
34	20ppm	<420 m	10g	0.310	0.109	48.98	77.85
35	20ppm	<420 m	11g	0.313	0.105	48.67	78.53
36	20ppm	<420 m	12g	0.313	0.103	48.62	78.94

Table 6.11: Absorbance and transmittance values of Congo Red, 40ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	40ppm	640 m	1g	0.331	0.226	46.67	59.43
2	40ppm	640 m	2g	0.329	0.222	46.89	59.92
3	40ppm	640 m	3g	0.329	0.222	46.93	60.04
4	40ppm	640 m	4g	0.335	0.221	46.21	60.17
5	40ppm	640 m	5g	0.330	0.218	46.75	60.53
6	40ppm	640 m	6g	0.333	0.215	46.5	60.94
7	40ppm	640 m	7g	0.335	0.212	46.22	61.32
8	40ppm	640 m	8g	0.336	0.209	46.18	61.75
9	40ppm	640 m	9g	0.332	0.208	46.56	61.9
10	40ppm	640 m	10g	0.333	0.205	46.48	62.42
11	40ppm	640 m	11g	0.331	0.202	46.66	62.83
12	40ppm	640 m	12g	0.334	0.198	46.32	63.33
13	40ppm	420 m	1g	0.333	0.166	46.43	68.24
14	40ppm	420 m	2g	0.331	0.162	46.7	68.89
15	40ppm	420 m	3g	0.330	0.160	46.76	69.11
16	40ppm	420 m	4g	0.331	0.159	46.68	69.37
17	40ppm	420 m	5g	0.329	0.155	46.91	69.94
18	40ppm	420 m	6g	0.336	0.154	46.12	70.21
19	40ppm	420 m	7g	0.331	0.152	46.63	70.48
20	40ppm	420 m	8g	0.330	0.149	46.82	70.93
21	40ppm	420 m	9g	0.332	0.148	46.51	71.05
22	40ppm	420 m	10g	0.337	0.145	46.07	71.59
23	40ppm	420 m	11g	0.331	0.142	46.64	72.18
24	40ppm	420 m	12g	0.332	0.138	46.58	72.76
25	40ppm	<420 m	1g	0.332	0.140	46.57	72.49
26	40ppm	<420 m	2g	0.334	0.138	46.39	72.86
27	40ppm	<420 m	3g	0.334	0.135	46.32	73.34
28	40ppm	<420 m	4g	0.333	0.131	46.44	73.94
29	40ppm	<420 m	5g	0.336	0.127	46.15	74.59
30	40ppm	<420 m	6g	0.325	0.125	47.31	74.92
31	40ppm	<420 m	7g	0.328	0.123	46.98	75.33
32	40ppm	<420 m	8g	0.332	0.120	46.57	75.86
33	40ppm	<420 m	9g	0.332	0.117	46.59	76.39
34	40ppm	<420 m	10g	0.334	0.114	46.35	76.92
35	40ppm	<420 m	11g	0.335	0.112	46.23	77.31
36	40ppm	<420 m	12g	0.331	0.110	46.69	77.65

Table 6.12: Absorbance and transmittance values of Congo Red, 60ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	60ppm	640 m	1g	0.350	0.241	44.67	57.42
2	60ppm	640 m	2g	0.348	0.237	44.89	57.91
3	60ppm	640 m	3g	0.351	0.235	44.53	58.27
4	60ppm	640 m	4g	0.354	0.231	44.23	58.79
5	60ppm	640 m	5g	0.354	0.228	44.21	59.11
6	60ppm	640 m	6g	0.351	0.223	44.58	59.83
7	60ppm	640 m	7g	0.348	0.219	44.83	60.34
8	60ppm	640 m	8g	0.347	0.216	44.98	60.78
9	60ppm	640 m	9g	0.353	0.213	44.32	61.22
10	60ppm	640 m	10g	0.353	0.209	44.34	61.84
11	60ppm	640 m	11g	0.347	0.205	44.95	62.35
12	60ppm	640 m	12g	0.350	0.201	44.67	62.97
13	60ppm	420 m	1g	0.351	0.208	44.58	61.98
14	60ppm	420 m	2g	0.347	0.207	44.93	62.13
15	60ppm	420 m	3g	0.353	0.198	44.38	63.34
16	60ppm	420 m	4g	0.349	0.184	44.75	65.41
17	60ppm	420 m	5g	0.354	0.182	44.23	65.83
18	60ppm	420 m	6g	0.351	0.178	44.61	66.41
19	60ppm	420 m	7g	0.351	0.179	44.54	66.29
20	60ppm	420 m	8g	0.347	0.173	44.93	67.14
21	60ppm	420 m	9g	0.351	0.169	44.61	67.83
22	60ppm	420 m	10g	0.357	0.165	43.97	68.35
23	60ppm	420 m	11g	0.350	0.162	44.68	68.92
24	60ppm	420 m	12g	0.354	0.160	44.23	69.17
25	60ppm	<420 m	1g	0.351	0.153	44.59	70.25
26	60ppm	<420 m	2g	0.347	0.149	44.98	70.93
27	60ppm	<420 m	3g	0.349	0.148	44.76	71.1
28	60ppm	<420 m	4g	0.348	0.145	44.91	71.58
29	60ppm	<420 m	5g	0.355	0.142	44.17	72.06
30	60ppm	<420 m	6g	0.349	0.137	44.82	72.87
31	60ppm	<420 m	7g	0.350	0.135	44.67	73.35
32	60ppm	<420 m	8g	0.355	0.131	44.16	73.94
33	60ppm	<420 m	9g	0.349	0.129	44.82	74.27
34	60ppm	<420 m	10g	0.347	0.127	44.95	74.56
35	60ppm	<420 m	11g	0.355	0.125	44.15	75.03
36	60ppm	<420 m	12g	0.353	0.121	44.31	75.64

Table 6.13: Absorbance and transmittance values of Congo Red, 80ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	80ppm	640 m	1g	0.378	0.250	41.85	56.19
2	80ppm	640 m	2g	0.377	0.249	41.93	56.31
3	80ppm	640 m	3g	0.379	0.246	41.76	56.78
4	80ppm	640 m	4g	0.376	0.243	42.04	57.13
5	80ppm	640 m	5g	0.379	0.241	41.83	57.46
6	80ppm	640 m	6g	0.376	0.231	42.1	58.77
7	80ppm	640 m	7g	0.373	0.230	42.36	58.94
8	80ppm	640 m	8g	0.378	0.228	41.87	59.12
9	80ppm	640 m	9g	0.369	0.224	42.73	59.75
10	80ppm	640 m	10g	0.376	0.218	42.08	60.55
11	80ppm	640 m	11g	0.380	0.212	41.65	61.34
12	80ppm	640 m	12g	0.371	0.209	42.53	61.86
13	80ppm	420 m	1g	0.368	0.221	42.89	60.15
14	80ppm	420 m	2g	0.381	0.210	41.61	61.73
15	80ppm	420 m	3g	0.386	0.206	41.09	62.27
16	80ppm	420 m	4g	0.374	0.202	42.22	62.81
17	80ppm	420 m	5g	0.375	0.197	42.14	63.59
18	80ppm	420 m	6g	0.384	0.194	41.31	63.96
19	80ppm	420 m	7g	0.380	0.191	41.68	64.39
20	80ppm	420 m	8g	0.373	0.187	42.4	64.96
21	80ppm	420 m	9g	0.388	0.186	40.94	65.18
22	80ppm	420 m	10g	0.375	0.184	42.13	65.42
23	80ppm	420 m	11g	0.378	0.182	41.88	65.83
24	80ppm	420 m	12g	0.383	0.179	41.42	66.19
25	80ppm	<420 m	1g	0.375	0.163	42.2	68.72
26	80ppm	<420 m	2g	0.373	0.159	42.33	69.34
27	80ppm	<420 m	3g	0.381	0.158	41.62	69.55
28	80ppm	<420 m	4g	0.361	0.153	43.55	70.3
29	80ppm	<420 m	5g	0.384	0.152	41.29	70.49
30	80ppm	<420 m	6g	0.394	0.147	40.4	71.23
31	80ppm	<420 m	7g	0.373	0.143	42.32	71.94
32	80ppm	<420 m	8g	0.376	0.142	42.1	72.08
33	80ppm	<420 m	9g	0.382	0.139	41.52	72.65
34	80ppm	<420 m	10g	0.380	0.134	41.67	73.41
35	80ppm	<420 m	11g	0.373	0.131	42.39	73.98
36	80ppm	<420 m	12g	0.373	0.129	42.35	74.22

Table 6.14: Absorbance and transmittance values of Congo Red, 100ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	100pm	640 m	1g	0.390	0.254	40.74	55.76
2	100pm	640 m	2g	0.391	0.251	40.69	56.11
3	100pm	640 m	3g	0.389	0.247	40.85	56.63
4	100pm	640 m	4g	0.395	0.245	40.24	56.84
5	100pm	640 m	5g	0.390	0.243	40.7	57.09
6	100pm	640 m	6g	0.395	0.243	40.23	57.16
7	100pm	640 m	7g	0.391	0.240	40.64	57.48
8	100pm	640 m	8g	0.396	0.237	40.18	57.92
9	100pm	640 m	9g	0.397	0.234	40.06	58.34
10	100pm	640 m	10g	0.395	0.231	40.3	58.72
11	100pm	640 m	11g	0.396	0.231	40.21	58.69
12	100pm	640 m	12g	0.394	0.226	40.33	59.42
13	100pm	420 m	1g	0.389	0.229	40.87	58.96
14	100pm	420 m	2g	0.387	0.229	40.98	59.04
15	100pm	420 m	3g	0.389	0.224	40.86	59.69
16	100pm	420 m	4g	0.395	0.221	40.24	60.16
17	100pm	420 m	5g	0.393	0.216	40.48	60.83
18	100pm	420 m	6g	0.394	0.213	40.35	61.27
19	100pm	420 m	7g	0.389	0.212	40.85	61.35
20	100pm	420 m	8g	0.398	0.209	40.04	61.81
21	100pm	420 m	9g	0.397	0.201	40.07	62.88
22	100pm	420 m	10g	0.392	0.200	40.53	63.1
23	100pm	420 m	11g	0.396	0.195	40.21	63.82
24	100pm	420 m	12g	0.390	0.192	40.75	64.33
25	100pm	<420 m	1g	0.389	0.182	40.8	65.84
26	100pm	<420 m	2g	0.395	0.179	40.26	66.24
27	100pm	<420 m	3g	0.398	0.175	40.01	66.87
28	100pm	<420 m	4g	0.387	0.173	40.99	67.13
29	100pm	<420 m	5g	0.388	0.168	40.93	67.96
30	100pm	<420 m	6g	0.391	0.166	40.61	68.21
31	100pm	<420 m	7g	0.398	0.163	40.04	68.72
32	100pm	<420 m	8g	0.392	0.159	40.53	69.34
33	100pm	<420 m	9g	0.393	0.158	40.45	69.55
34	100pm	<420 m	10g	0.393	0.149	40.47	70.91
35	100pm	<420 m	11g	0.397	0.147	40.06	71.34
36	100pm	<420 m	12g	0.390	0.140	40.72	72.46

Table 6.15: Absorbance and transmittance values of Congo Red, 120ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	120ppm	640 m	1g	0.403	0.272	39.57	53.47
2	120ppm	640 m	2g	0.399	0.265	39.9	54.35
3	120ppm	640 m	3g	0.398	0.260	39.95	54.96
4	120ppm	640 m	4g	0.402	0.259	39.62	55.12
5	120ppm	640 m	5g	0.402	0.257	39.63	55.37
6	120ppm	640 m	6g	0.401	0.250	39.7	56.19
7	120ppm	640 m	7g	0.399	0.245	39.88	56.94
8	120ppm	640 m	8g	0.414	0.242	38.54	57.28
9	120ppm	640 m	9g	0.402	0.241	39.65	57.46
10	120ppm	640 m	10g	0.413	0.240	38.64	57.53
11	120ppm	640 m	11g	0.414	0.236	38.51	58.04
12	120ppm	640 m	12g	0.400	0.232	39.82	58.66
13	120ppm	420 m	1g	0.400	0.230	39.84	58.93
14	120ppm	420 m	2g	0.418	0.227	38.2	59.24
15	120ppm	420 m	3g	0.403	0.225	39.55	59.63
16	120ppm	420 m	4g	0.408	0.221	39.04	60.12
17	120ppm	420 m	5g	0.409	0.219	38.97	60.35
18	120ppm	420 m	6g	0.400	0.216	39.81	60.87
19	120ppm	420 m	7g	0.400	0.214	39.8	61.15
20	120ppm	420 m	8g	0.401	0.212	39.73	61.42
21	120ppm	420 m	9g	0.406	0.209	39.26	61.78
22	120ppm	420 m	10g	0.418	0.207	38.17	62.07
23	120ppm	420 m	11g	0.411	0.205	38.79	62.36
24	120ppm	420 m	12g	0.412	0.203	38.72	62.59
25	120ppm	<420 m	1g	0.399	0.201	39.93	62.94
26	120ppm	<420 m	2g	0.405	0.199	39.4	63.28
27	120ppm	<420 m	3g	0.419	0.197	38.13	63.51
28	120ppm	<420 m	4g	0.401	0.193	39.69	64.06
29	120ppm	<420 m	5g	0.409	0.188	39.03	64.89
30	120ppm	<420 m	6g	0.412	0.186	38.72	65.11
31	120ppm	<420 m	7g	0.418	0.183	38.22	65.68
32	120ppm	<420 m	8g	0.399	0.178	39.91	66.3
33	120ppm	<420 m	9g	0.401	0.177	39.68	66.54
34	120ppm	<420 m	10g	0.409	0.171	39.02	67.43
35	120ppm	<420 m	11g	0.411	0.164	38.81	68.56
36	120ppm	<420 m	12g	0.416	0.155	38.4	69.95

Table 6.16: Absorbance and transmittance values of Congo Red, 140ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	140ppm	640 m	1g	0.445	0.282	35.91	52.18
2	140ppm	640 m	2g	0.451	0.277	35.39	52.86
3	140ppm	640 m	3g	0.453	0.274	35.27	53.24
4	140ppm	640 m	4g	0.456	0.268	35.02	53.93
5	140ppm	640 m	5g	0.449	0.266	35.56	54.16
6	140ppm	640 m	6g	0.450	0.261	35.51	54.89
7	140ppm	640 m	7g	0.448	0.257	35.63	55.31
8	140ppm	640 m	8g	0.447	0.254	35.71	55.74
9	140ppm	640 m	9g	0.446	0.249	35.82	56.38
10	140ppm	640 m	10g	0.445	0.247	35.91	56.56
11	140ppm	640 m	11g	0.454	0.239	35.13	57.72
12	140ppm	640 m	12g	0.452	0.237	35.33	57.91
13	140ppm	420 m	1g	0.448	0.251	35.64	56.14
14	140ppm	420 m	2g	0.448	0.245	35.62	56.83
15	140ppm	420 m	3g	0.452	0.242	35.3	57.22
16	140ppm	420 m	4g	0.455	0.239	35.11	57.64
17	140ppm	420 m	5g	0.448	0.237	35.61	57.91
18	140ppm	420 m	6g	0.451	0.235	35.38	58.25
19	140ppm	420 m	7g	0.445	0.231	35.93	58.71
20	140ppm	420 m	8g	0.448	0.230	35.62	58.9
21	140ppm	420 m	9g	0.453	0.229	35.2	59.04
22	140ppm	420 m	10g	0.449	0.226	35.58	59.43
23	140ppm	420 m	11g	0.446	0.223	35.78	59.82
24	140ppm	420 m	12g	0.447	0.219	35.72	60.41
25	140ppm	<420 m	1g	0.444	0.188	35.98	64.86
26	140ppm	<420 m	2g	0.450	0.185	35.49	65.26
27	140ppm	<420 m	3g	0.452	0.183	35.34	65.63
28	140ppm	<420 m	4g	0.455	0.180	35.1	66.14
29	140ppm	<420 m	5g	0.455	0.175	35.06	66.91
30	140ppm	<420 m	6g	0.452	0.173	35.32	67.21
31	140ppm	<420 m	7g	0.446	0.169	35.83	67.78
32	140ppm	<420 m	8g	0.450	0.165	35.48	68.32
33	140ppm	<420 m	9g	0.448	0.161	35.62	68.97
34	140ppm	<420 m	10g	0.450	0.159	35.47	69.34
35	140ppm	<420 m	11g	0.445	0.156	35.93	69.86
36	140ppm	<420 m	12g	0.445	0.152	35.87	70.52

Table 6.17: Absorbance and transmittance values of Congo Red, 160ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	160ppm	640 m	1g	0.459	0.300	34.72	50.14
2	160ppm	640 m	2g	0.460	0.296	34.67	50.63
3	160ppm	640 m	3g	0.465	0.293	34.24	50.95
4	160ppm	640 m	4g	0.464	0.290	34.38	51.28
5	160ppm	640 m	5g	0.461	0.285	34.58	51.85
6	160ppm	640 m	6g	0.465	0.283	34.29	52.07
7	160ppm	640 m	7g	0.465	0.279	34.28	52.64
8	160ppm	640 m	8g	0.466	0.274	34.16	53.15
9	160ppm	640 m	9g	0.461	0.272	34.58	53.48
10	160ppm	640 m	10g	0.460	0.269	34.71	53.81
11	160ppm	640 m	11g	0.461	0.267	34.56	54.06
12	160ppm	640 m	12g	0.479	0.261	33.19	54.88
13	160ppm	420 m	1g	0.470	0.250	33.87	56.21
14	160ppm	420 m	2g	0.460	0.245	34.67	56.89
15	160ppm	420 m	3g	0.461	0.239	34.61	57.65
16	160ppm	420 m	4g	0.462	0.243	34.53	57.2
17	160ppm	420 m	5g	0.464	0.232	34.34	58.56
18	160ppm	420 m	6g	0.461	0.231	34.61	58.71
19	160ppm	420 m	7g	0.456	0.227	34.98	59.24
20	160ppm	420 m	8g	0.459	0.220	34.76	60.25
21	160ppm	420 m	9g	0.463	0.212	34.42	61.34
22	160ppm	420 m	10g	0.457	0.208	34.93	61.98
23	160ppm	420 m	11g	0.464	0.207	34.32	62.13
24	160ppm	420 m	12g	0.465	0.198	34.27	63.34
25	160ppm	<420 m	1g	0.464	0.194	34.36	64.03
26	160ppm	<420 m	2g	0.466	0.191	34.21	64.45
27	160ppm	<420 m	3g	0.465	0.186	34.26	65.13
28	160ppm	<420 m	4g	0.457	0.182	34.94	65.74
29	160ppm	<420 m	5g	0.462	0.179	34.52	66.21
30	160ppm	<420 m	6g	0.464	0.174	34.38	66.93
31	160ppm	<420 m	7g	0.466	0.173	34.2	67.15
32	160ppm	<420 m	8g	0.462	0.169	34.52	67.83
33	160ppm	<420 m	9g	0.458	0.166	34.82	68.22
34	160ppm	<420 m	10g	0.460	0.163	34.64	68.78
35	160ppm	<420 m	11g	0.462	0.159	34.51	69.42
36	160ppm	<420 m	12g	0.459	0.155	34.79	69.99

Table 6.18: Absorbance and transmittance values of Congo Red, 180ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	180ppm	640 m	1g	0.496	0.305	31.88	49.58
2	180ppm	640 m	2g	0.500	0.300	31.6	50.17
3	180ppm	640 m	3g	0.503	0.297	31.42	50.46
4	180ppm	640 m	4g	0.508	0.296	31.02	50.63
5	180ppm	640 m	5g	0.499	0.292	31.67	51.06
6	180ppm	640 m	6g	0.503	0.290	31.4	51.32
7	180ppm	640 m	7g	0.495	0.285	31.98	51.85
8	180ppm	640 m	8g	0.506	0.280	31.21	52.47
9	180ppm	640 m	9g	0.501	0.276	31.53	52.93
10	180ppm	640 m	10g	0.498	0.273	31.77	53.36
11	180ppm	640 m	11g	0.501	0.269	31.54	53.79
12	180ppm	640 m	12g	0.497	0.267	31.84	54.08
13	180ppm	420 m	1g	0.498	0.284	31.76	52.05
14	180ppm	420 m	2g	0.496	0.277	31.94	52.84
15	180ppm	420 m	3g	0.504	0.274	31.35	53.17
16	180ppm	420 m	4g	0.497	0.272	31.83	53.49
17	180ppm	420 m	5g	0.507	0.269	31.15	53.82
18	180ppm	420 m	6g	0.503	0.263	31.44	54.61
19	180ppm	420 m	7g	0.504	0.260	31.35	54.93
20	180ppm	420 m	8g	0.507	0.259	31.14	55.07
21	180ppm	420 m	9g	0.501	0.258	31.52	55.19
22	180ppm	420 m	10g	0.505	0.260	31.23	54.91
23	180ppm	420 m	11g	0.501	0.253	31.57	55.88
24	180ppm	420 m	12g	0.503	0.252	31.38	55.93
25	180ppm	<420 m	1g	0.506	0.214	31.19	61.12
26	180ppm	<420 m	2g	0.499	0.209	31.67	61.74
27	180ppm	<420 m	3g	0.499	0.205	31.73	62.31
28	180ppm	<420 m	4g	0.504	0.202	31.32	62.84
29	180ppm	<420 m	5g	0.502	0.199	31.48	63.27
30	180ppm	<420 m	6g	0.508	0.194	31.06	63.95
31	180ppm	<420 m	7g	0.502	0.193	31.46	64.06
32	180ppm	<420 m	8g	0.499	0.188	31.71	64.81
33	180ppm	<420 m	9g	0.497	0.186	31.83	65.15
34	180ppm	<420 m	10g	0.502	0.185	31.45	65.32
35	180ppm	<420 m	11g	0.496	0.177	31.89	66.59
36	180ppm	<420 m	12g	0.508	0.168	31.04	67.93

Table 6.19: Absorbance and transmittance values of Direct Blue 15, 20ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	20ppm	640 m	1g	0.465	0.281	34.3	52.35
2	20ppm	640 m	2g	0.468	0.277	34.01	52.89
3	20ppm	640 m	3g	0.460	0.272	34.71	53.46
4	20ppm	640 m	4g	0.477	0.275	33.38	53.09
5	20ppm	640 m	5g	0.459	0.269	34.77	53.81
6	20ppm	640 m	6g	0.463	0.267	34.45	54.03
7	20ppm	640 m	7g	0.461	0.265	34.63	54.37
8	20ppm	640 m	8g	0.462	0.261	34.49	54.86
9	20ppm	640 m	9g	0.466	0.259	34.18	55.03
10	20ppm	640 m	10g	0.456	0.254	34.99	55.78
11	20ppm	640 m	11g	0.468	0.249	34.07	56.36
12	20ppm	640 m	12g	0.457	0.247	34.92	56.65
13	20ppm	420 m	1g	0.458	0.282	34.84	52.18
14	20ppm	420 m	2g	0.461	0.278	34.6	52.69
15	20ppm	420 m	3g	0.470	0.273	33.86	53.35
16	20ppm	420 m	4g	0.464	0.267	34.38	54.02
17	20ppm	420 m	5g	0.462	0.263	34.51	54.57
18	20ppm	420 m	6g	0.466	0.255	34.17	55.65
19	20ppm	420 m	7g	0.457	0.255	34.89	55.63
20	20ppm	420 m	8g	0.466	0.246	34.21	56.79
21	20ppm	420 m	9g	0.454	0.245	35.13	56.92
22	20ppm	420 m	10g	0.459	0.243	34.77	57.09
23	20ppm	420 m	11g	0.458	0.239	34.86	57.63
24	20ppm	420 m	12g	0.458	0.231	34.83	58.72
25	20ppm	<420 m	1g	0.465	0.261	34.31	54.77
26	20ppm	<420 m	2g	0.463	0.262	34.42	54.64
27	20ppm	<420 m	3g	0.467	0.257	34.09	55.31
28	20ppm	<420 m	4g	0.459	0.253	34.76	55.83
29	20ppm	<420 m	5g	0.441	0.248	36.2	56.52
30	20ppm	<420 m	6g	0.459	0.246	34.76	56.75
31	20ppm	<420 m	7g	0.470	0.242	33.92	57.24
32	20ppm	<420 m	8g	0.465	0.240	34.27	57.59
33	20ppm	<420 m	9g	0.460	0.233	34.68	58.45
34	20ppm	<420 m	10g	0.467	0.227	34.14	59.24
35	20ppm	<420 m	11g	0.467	0.223	34.09	59.85
36	20ppm	<420 m	12g	0.460	0.218	34.71	60.57

Table 6.20: Absorbance and transmittance values of Direct Blue 15, 40ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	40ppm	640 m	1g	0.483	0.299	32.86	50.19
2	40ppm	640 m	2g	0.490	0.293	32.38	50.92
3	40ppm	640 m	3g	0.488	0.289	32.5	51.37
4	40ppm	640 m	4g	0.495	0.286	31.97	51.76
5	40ppm	640 m	5g	0.487	0.279	32.61	52.57
6	40ppm	640 m	6g	0.494	0.276	32.05	52.96
7	40ppm	640 m	7g	0.488	0.279	32.51	52.6
8	40ppm	640 m	8g	0.494	0.277	32.04	52.84
9	40ppm	640 m	9g	0.491	0.273	32.32	53.38
10	40ppm	640 m	10g	0.483	0.268	32.87	53.91
11	40ppm	640 m	11g	0.499	0.264	31.71	54.45
12	40ppm	640 m	12g	0.489	0.260	32.44	54.94
13	40ppm	420 m	1g	0.493	0.302	32.15	49.93
14	40ppm	420 m	2g	0.504	0.301	31.32	50.02
15	40ppm	420 m	3g	0.493	0.299	32.17	50.26
16	40ppm	420 m	4g	0.484	0.294	32.78	50.79
17	40ppm	420 m	5g	0.488	0.289	32.5	51.37
18	40ppm	420 m	6g	0.482	0.286	32.97	51.76
19	40ppm	420 m	7g	0.492	0.282	32.23	52.28
20	40ppm	420 m	8g	0.483	0.279	32.92	52.61
21	40ppm	420 m	9g	0.495	0.271	31.98	53.56
22	40ppm	420 m	10g	0.484	0.268	32.79	53.97
23	40ppm	420 m	11g	0.504	0.267	31.32	54.09
24	40ppm	420 m	12g	0.486	0.260	32.67	54.92
25	40ppm	<420 m	1g	0.489	0.281	32.4	52.37
26	40ppm	<420 m	2g	0.493	0.277	32.16	52.8
27	40ppm	<420 m	3g	0.484	0.274	32.78	53.26
28	40ppm	<420 m	4g	0.491	0.270	32.31	53.74
29	40ppm	<420 m	5g	0.491	0.267	32.29	54.13
30	40ppm	<420 m	6g	0.484	0.264	32.84	54.42
31	40ppm	<420 m	7g	0.506	0.258	31.17	55.17
32	40ppm	<420 m	8g	0.485	0.253	32.76	55.83
33	40ppm	<420 m	9g	0.493	0.246	32.13	56.76
34	40ppm	<420 m	10g	0.488	0.244	32.48	57.04
35	40ppm	<420 m	11g	0.485	0.237	32.71	57.91
36	40ppm	<420 m	12g	0.486	0.235	32.68	58.26

Table 6.21: Absorbance and transmittance values of Direct Blue 15, 60ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	60ppm	640 m	1g	0.513	0.320	30.71	47.83
2	60ppm	640 m	2g	0.509	0.317	30.97	48.25
3	60ppm	640 m	3g	0.524	0.311	29.92	48.83
4	60ppm	640 m	4g	0.519	0.309	30.27	49.07
5	60ppm	640 m	5g	0.522	0.304	30.06	49.69
6	60ppm	640 m	6g	0.513	0.299	30.68	50.26
7	60ppm	640 m	7g	0.508	0.293	31.05	50.95
8	60ppm	640 m	8g	0.518	0.288	30.36	51.57
9	60ppm	640 m	9g	0.520	0.291	30.18	51.14
10	60ppm	640 m	10g	0.511	0.286	30.86	51.74
11	60ppm	640 m	11g	0.504	0.281	31.35	52.34
12	60ppm	640 m	12g	0.513	0.276	30.72	52.97
13	60ppm	420 m	1g	0.512	0.319	30.79	47.93
14	60ppm	420 m	2g	0.505	0.318	31.27	48.07
15	60ppm	420 m	3g	0.520	0.311	30.19	48.89
16	60ppm	420 m	4g	0.515	0.307	30.53	49.34
17	60ppm	420 m	5g	0.524	0.303	29.91	49.78
18	60ppm	420 m	6g	0.520	0.300	30.2	50.16
19	60ppm	420 m	7g	0.513	0.295	30.72	50.69
20	60ppm	420 m	8g	0.521	0.292	30.11	51.01
21	60ppm	420 m	9g	0.516	0.284	30.45	51.96
22	60ppm	420 m	10g	0.513	0.283	30.68	52.17
23	60ppm	420 m	11g	0.508	0.278	31.02	52.76
24	60ppm	420 m	12g	0.511	0.271	30.86	53.58
25	60ppm	<420 m	1g	0.501	0.300	31.54	50.09
26	60ppm	<420 m	2g	0.505	0.293	31.25	50.98
27	60ppm	<420 m	3g	0.511	0.290	30.81	51.23
28	60ppm	<420 m	4g	0.515	0.286	30.52	51.71
29	60ppm	<420 m	5g	0.514	0.284	30.63	52.03
30	60ppm	<420 m	6g	0.513	0.278	30.7	52.75
31	60ppm	<420 m	7g	0.514	0.274	30.61	53.18
32	60ppm	<420 m	8g	0.516	0.269	30.5	53.79
33	60ppm	<420 m	9g	0.495	0.265	31.96	54.34
34	60ppm	<420 m	10g	0.521	0.262	30.16	54.68
35	60ppm	<420 m	11g	0.522	0.256	30.07	55.5
36	60ppm	<420 m	12g	0.514	0.250	30.64	56.17

Table 6.22: Absorbance and transmittance values of Direct Blue 15, 80ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	80ppm	640 m	1g	0.549	0.337	28.25	45.98
2	80ppm	640 m	2g	0.527	0.336	29.69	46.17
3	80ppm	640 m	3g	0.550	0.329	28.16	46.85
4	80ppm	640 m	4g	0.538	0.328	28.97	47.03
5	80ppm	640 m	5g	0.549	0.325	28.22	47.36
6	80ppm	640 m	6g	0.545	0.319	28.49	47.94
7	80ppm	640 m	7g	0.551	0.317	28.14	48.15
8	80ppm	640 m	8g	0.543	0.313	28.62	48.69
9	80ppm	640 m	9g	0.547	0.309	28.37	49.07
10	80ppm	640 m	10g	0.543	0.304	28.63	49.68
11	80ppm	640 m	11g	0.530	0.301	29.52	49.99
12	80ppm	640 m	12g	0.554	0.298	27.94	50.32
13	80ppm	420 m	1g	0.547	0.338	28.36	45.88
14	80ppm	420 m	2g	0.543	0.336	28.61	46.14
15	80ppm	420 m	3g	0.539	0.330	28.91	46.73
16	80ppm	420 m	4g	0.548	0.317	28.32	48.16
17	80ppm	420 m	5g	0.543	0.311	28.61	48.89
18	80ppm	420 m	6g	0.550	0.310	28.19	49.02
19	80ppm	420 m	7g	0.542	0.305	28.73	49.54
20	80ppm	420 m	8g	0.526	0.303	29.79	49.81
21	80ppm	420 m	9g	0.547	0.300	28.38	50.17
22	80ppm	420 m	10g	0.537	0.295	29.03	50.74
23	80ppm	420 m	11g	0.534	0.287	29.25	51.66
24	80ppm	420 m	12g	0.547	0.284	28.41	52.03
25	80ppm	<420 m	1g	0.540	0.314	28.83	48.55
26	80ppm	<420 m	2g	0.541	0.310	28.79	48.97
27	80ppm	<420 m	3g	0.549	0.306	28.23	49.42
28	80ppm	<420 m	4g	0.545	0.303	28.5	49.81
29	80ppm	<420 m	5g	0.548	0.301	28.33	50.06
30	80ppm	<420 m	6g	0.551	0.300	28.13	50.17
31	80ppm	<420 m	7g	0.551	0.294	28.09	50.84
32	80ppm	<420 m	8g	0.546	0.291	28.44	51.19
33	80ppm	<420 m	9g	0.523	0.287	29.97	51.63
34	80ppm	<420 m	10g	0.549	0.280	28.24	52.44
35	80ppm	<420 m	11g	0.550	0.276	28.16	52.96
36	80ppm	<420 m	12g	0.545	0.268	28.52	53.94

Table 6.23: Absorbance and transmittance values of Direct Blue 15, 100ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	100pm	640 m	1g	0.556	0.360	27.77	43.64
2	100pm	640 m	2g	0.570	0.356	26.89	44.05
3	100pm	640 m	3g	0.564	0.350	27.3	44.63
4	100pm	640 m	4g	0.565	0.344	27.24	45.26
5	100pm	640 m	5g	0.566	0.338	27.18	45.89
6	100pm	640 m	6g	0.569	0.336	26.98	46.12
7	100pm	640 m	7g	0.568	0.330	27.05	46.74
8	100pm	640 m	8g	0.572	0.326	26.81	47.21
9	100pm	640 m	9g	0.557	0.320	27.71	47.83
10	100pm	640 m	10g	0.554	0.316	27.95	48.26
11	100pm	640 m	11g	0.571	0.310	26.84	48.95
12	100pm	640 m	12g	0.575	0.309	26.62	49.08
13	100pm	420 m	1g	0.556	0.353	27.81	44.31
14	100pm	420 m	2g	0.585	0.352	26.03	44.45
15	100pm	420 m	3g	0.559	0.347	27.59	44.93
16	100pm	420 m	4g	0.570	0.346	26.91	45.12
17	100pm	420 m	5g	0.555	0.341	27.87	45.63
18	100pm	420 m	6g	0.580	0.338	26.29	45.97
19	100pm	420 m	7g	0.560	0.335	27.55	46.28
20	100pm	420 m	8g	0.555	0.330	27.84	46.74
21	100pm	420 m	9g	0.562	0.329	27.42	46.93
22	100pm	420 m	10g	0.558	0.325	27.66	47.28
23	100pm	420 m	11g	0.553	0.320	27.98	47.86
24	100pm	420 m	12g	0.561	0.315	27.5	48.41
25	100pm	<420 m	1g	0.563	0.325	27.37	47.3
26	100pm	<420 m	2g	0.561	0.323	27.48	47.49
27	100pm	<420 m	3g	0.582	0.318	26.2	48.04
28	100pm	<420 m	4g	0.582	0.311	26.17	48.82
29	100pm	<420 m	5g	0.556	0.309	27.78	49.13
30	100pm	<420 m	6g	0.575	0.304	26.62	49.64
31	100pm	<420 m	7g	0.553	0.302	27.98	49.92
32	100pm	<420 m	8g	0.566	0.300	27.19	50.16
33	100pm	<420 m	9g	0.545	0.295	28.49	50.72
34	100pm	<420 m	10g	0.568	0.293	27.06	50.95
35	100pm	<420 m	11g	0.566	0.290	27.18	51.24
36	100pm	<420 m	12g	0.570	0.284	26.92	51.96

Table 6.24: Absorbance and transmittance values of Direct Blue 15, 120ppm

runs	dye conc	sieve size	ads dosage	Absorbance BT	AT	Transmittance BT	AT
1	120ppm	640 m	1g	0.624	0.375	23.79	42.21
2	120ppm	640 m	2g	0.633	0.369	23.3	42.79
3	120ppm	640 m	3g	0.627	0.365	23.62	43.14
4	120ppm	640 m	4g	0.610	0.360	24.54	43.65
5	120ppm	640 m	5g	0.613	0.357	24.36	43.98
6	120ppm	640 m	6g	0.622	0.356	23.87	44.06
7	120ppm	640 m	7g	0.621	0.352	23.95	44.48
8	120ppm	640 m	8g	0.615	0.347	24.26	44.93
9	120ppm	640 m	9g	0.626	0.345	23.68	45.17
10	120ppm	640 m	10g	0.607	0.341	24.71	45.62
11	120ppm	640 m	11g	0.612	0.337	24.43	46.03
12	120ppm	640 m	12g	0.603	0.335	24.94	46.22
13	120ppm	420 m	1g	0.604	0.375	24.89	42.14
14	120ppm	420 m	2g	0.616	0.369	24.22	42.75
15	120ppm	420 m	3g	0.620	0.366	23.97	43.01
16	120ppm	420 m	4g	0.612	0.359	24.45	43.76
17	120ppm	420 m	5g	0.610	0.357	24.52	43.94
18	120ppm	420 m	6g	0.627	0.355	23.59	44.18
19	120ppm	420 m	7g	0.617	0.353	24.17	44.34
20	120ppm	420 m	8g	0.624	0.348	23.78	44.87
21	120ppm	420 m	9g	0.609	0.345	24.63	45.21
22	120ppm	420 m	10g	0.629	0.341	23.52	45.63
23	120ppm	420 m	11g	0.615	0.338	24.29	45.92
24	120ppm	420 m	12g	0.620	0.336	23.98	46.14
25	120ppm	<420 m	1g	0.635	0.364	23.15	43.28
26	120ppm	<420 m	2g	0.612	0.358	24.44	43.84
27	120ppm	<420 m	3g	0.615	0.355	24.29	44.15
28	120ppm	<420 m	4g	0.619	0.352	24.06	44.49
29	120ppm	<420 m	5g	0.633	0.348	23.29	44.83
30	120ppm	<420 m	6g	0.632	0.344	23.34	45.27
31	120ppm	<420 m	7g	0.604	0.340	24.86	45.71
32	120ppm	<420 m	8g	0.625	0.333	23.73	46.45
33	120ppm	<420 m	9g	0.606	0.329	24.8	46.93
34	120ppm	<420 m	10g	0.603	0.325	24.92	47.28
35	120ppm	<420 m	11g	0.629	0.320	23.51	47.81
36	120ppm	<420 m	12g	0.630	0.317	23.45	48.16

Table 6.25: Absorbance and transmittance values of Direct Blue 15, 140ppm

runs	dye conc	sieve size	Ads Dose	Absorbance BT	AT	Transmittance BT	AT
1	140ppm	640 m	1g	0.642	0.396	22.78	40.18
2	140ppm	640 m	2g	0.649	0.393	22.46	40.49
3	140ppm	640 m	3g	0.643	0.385	22.75	41.21
4	140ppm	640 m	4g	0.669	0.388	21.44	40.96
5	140ppm	640 m	5g	0.674	0.383	21.18	41.43
6	140ppm	640 m	6g	0.666	0.377	21.57	42.01
7	140ppm	640 m	7g	0.660	0.369	21.9	42.72
8	140ppm	640 m	8g	0.671	0.367	21.32	42.96
9	140ppm	640 m	9g	0.666	0.364	21.58	43.25
10	140ppm	640 m	10g	0.642	0.359	22.81	43.78
11	140ppm	640 m	11g	0.666	0.351	21.56	44.52
12	140ppm	640 m	12g	0.663	0.347	21.72	44.97
13	140ppm	420 m	1g	0.673	0.393	21.24	40.42
14	140ppm	420 m	2g	0.641	0.388	22.85	40.91
15	140ppm	420 m	3g	0.677	0.384	21.04	41.27
16	140ppm	420 m	4g	0.673	0.380	21.21	41.64
17	140ppm	420 m	5g	0.670	0.367	21.37	42.91
18	140ppm	420 m	6g	0.641	0.370	22.87	42.63
19	140ppm	420 m	7g	0.676	0.367	21.1	42.94
20	140ppm	420 m	8g	0.676	0.363	21.08	43.32
21	140ppm	420 m	9g	0.669	0.359	21.42	43.74
22	140ppm	420 m	10g	0.676	0.355	21.11	44.16
23	140ppm	420 m	11g	0.673	0.353	21.23	44.38
24	140ppm	420 m	12g	0.628	0.340	23.57	45.66
25	140ppm	<420 m	1g	0.669	0.368	21.42	42.83
26	140ppm	<420 m	2g	0.670	0.364	21.37	43.27
27	140ppm	<420 m	3g	0.645	0.358	22.64	43.84
28	140ppm	<420 m	4g	0.665	0.355	21.65	44.16
29	140ppm	<420 m	5g	0.661	0.349	21.81	44.82
30	140ppm	<420 m	6g	0.663	0.344	21.73	45.29
31	140ppm	<420 m	7g	0.672	0.341	21.27	45.64
32	140ppm	<420 m	8g	0.676	0.340	21.09	45.73
33	140ppm	<420 m	9g	0.696	0.338	20.12	45.91
34	140ppm	<420 m	10g	0.654	0.335	22.18	46.24
35	140ppm	<420 m	11g	0.666	0.330	21.58	46.76
36	140ppm	<420 m	12g	0.674	0.320	21.2	47.89

Table 6.26: pH values for Victoria Blue B, Congo Red and Direct Blue 15 at an optimal dosage of 10 grams

Adsorbent Size	Victoria Blue B	Congo Red	Direct Blue 15
>640 microns	5.5	6.8	8.9
640 - 420 microns	5.9	6.3	9.3
<420 microns	6.1	5.4	8.2

Table 6.27: Values of NPOC for Victoria Blue B, Congo Red and Direct Blue 15 for adsorbent size >640 microns

Ads Size	Ads Dosage	Victoria Blue B	Congo Red	Direct Blue 15
>640	1g	8.76	11.42	15.37
>640	2g	8.62	11.28	15.23
>640	3g	9.37	12.03	15.98
>640	4g	9.57	12.23	16.18
>640	5g	16.36	19.02	22.97
>640	6g	16.74	19.4	23.35
>640	7g	17.43	20.09	24.04
>640	8g	19.11	21.77	25.72
>640	9g	19.29	21.95	25.9
>640	10g	21.98	24.64	28.59
>640	11g	23.66	26.32	30.27
>640	12g	22.42	25.08	29.03

Table 6.28: Values of NPOC for Victoria Blue B, Congo Red and Direct Blue 15 for adsorbent size 640 - 420 microns

Ads Size	Ads Dosage	Victoria Blue B	Congo Red	Direct Blue 15
640 - 420	1g	26.14	28.8	32.75
640 - 420	2g	27.63	30.29	34.24
640 - 420	3g	29.87	32.53	36.48
640 - 420	4g	25.47	28.13	32.08
640 - 420	5g	35.63	38.29	42.24
640 - 420	6g	34.42	37.08	41.03
640 - 420	7g	37.21	39.87	43.82
640 - 420	8g	34.87	37.53	41.48
640 - 420	9g	39.17	41.83	45.78
640 - 420	10g	38.63	41.29	45.24
640 - 420	11g	40.74	43.4	47.35
640 - 420	12g	41.87	44.53	48.48

Table 6.29: Values of NPOC for Victoria Blue B, Congo Red and Direct Blue 15 for adsorbent size <420 microns

Ads Size	**Ads Dosage**	**Victoria Blue B**	**Congo Red**	**Direct Blue 15**
<420	1g	42.79	45.45	49.4
<420	2g	43.46	46.12	50.07
<420	3g	44.55	47.21	51.16
<420	4g	45.41	48.07	52.02
<420	5g	46.39	49.05	53
<420	6g	49.15	51.81	55.76
<420	7g	45.81	48.47	52.42
<420	8g	50.76	53.42	57.37
<420	9g	51.45	54.11	58.06
<420	10g	52.78	55.44	59.39
<420	11g	53.84	56.5	60.45
<420	12g	59.77	62.43	66.38

Table 6.30: Adsorption Isotherm for Victoria Blue B

Dye Conc	Final Conc	qe	1/qe	1/Ce	qe	log(qe)	log(Ce)
Low 40ppm	10.61	293.92	0.00340	0.094	2351.36	3.371	1.025
Med 200 ppm	61.63	1383.68	0.000723	0.016	11069.48	4.044	1.789
High 360ppm	113.50	2464.986	0.000406	0.008	19719.8	4.294	2.055

Table 6.31: Adsorption Isotherm for Congo Red

Dye Conc	Final Conc	qe	1/qe	1/Ce	qe	log(qe)	log(Ce)
Low 20ppm	7.02	129.84	0.007702	0.142	1038.72	3.016	0.846
Med 100 ppm	38.00	619.992	0.001613	0.026	4959.93	3.695	1.579
High 180ppm	66.27	1137.32	0.000879	0.015	9098.55	3.958	1.821

Table 6.32: Adsorption Isotherm for Direct Blue 15

Dye Conc	Final Conc	qe	1/qe	1/Ce	qe	log(qe)	log(Ce)
Low 20ppm	9.74	102.563	0.00975	0.102	820.51	2.914	0.988
Med 80 ppm	40.84	391.594	0.002554	0.024	3132.75	3.495	1.611
High 140ppm	71.70	682.954	0.001464	0.013	5463.64	3.737	1.855

APPENDIX B: FIGURES

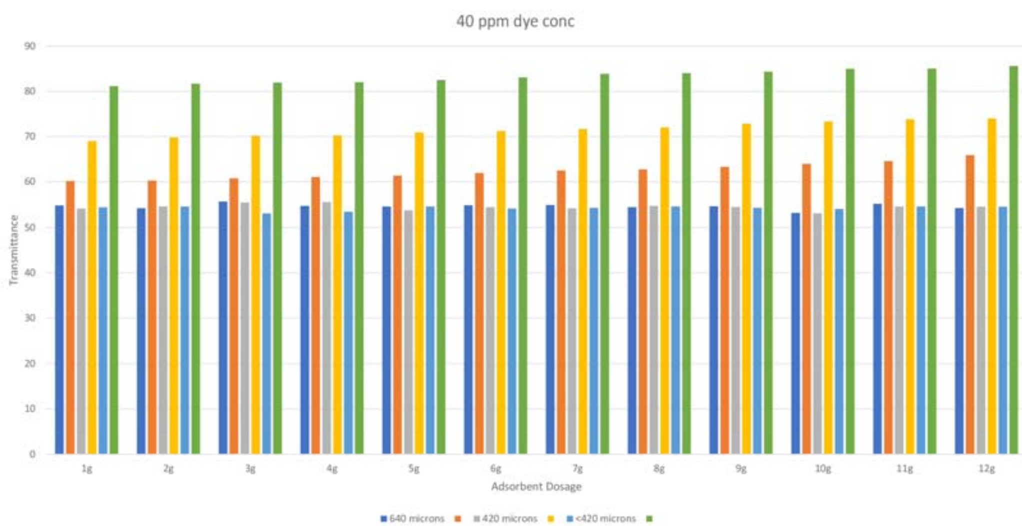

Figure 7.1: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 40 ppm

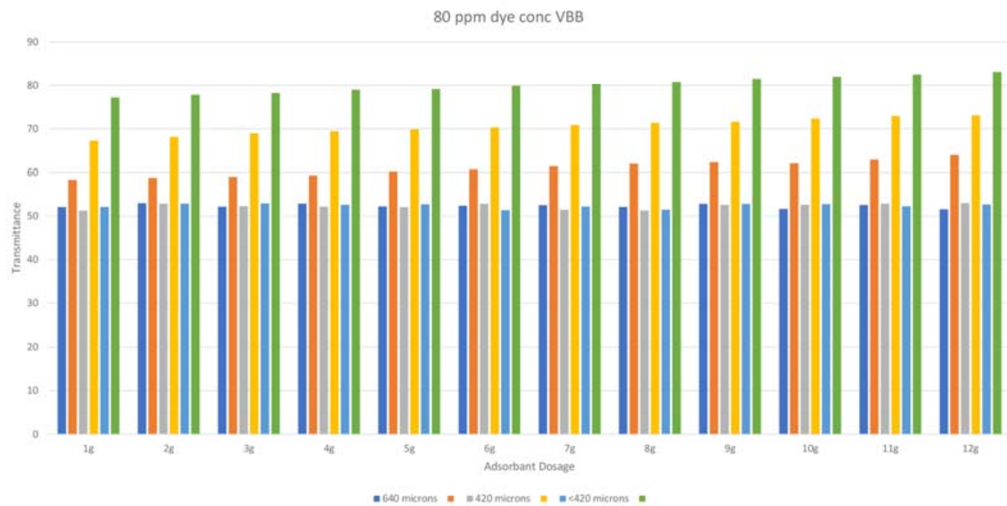

Figure 7.2: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 80 ppm

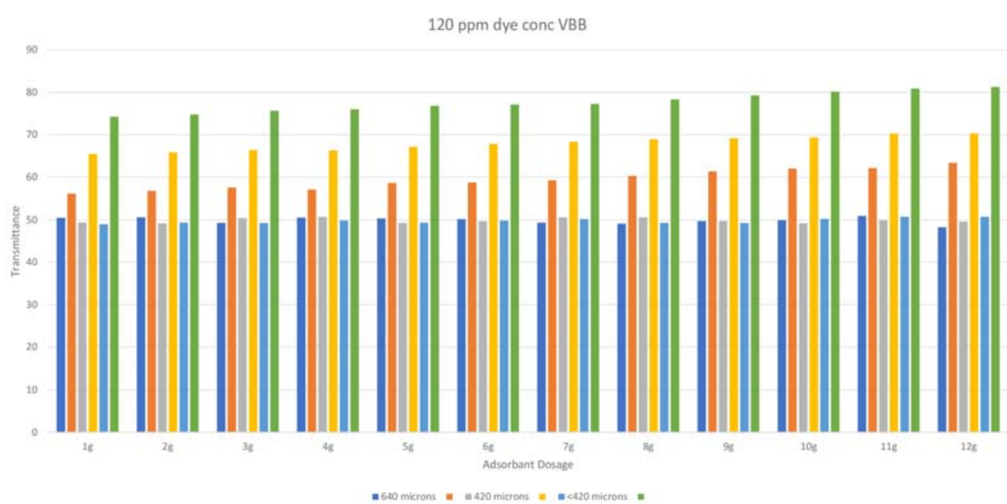

Figure 7.3: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 120 ppm

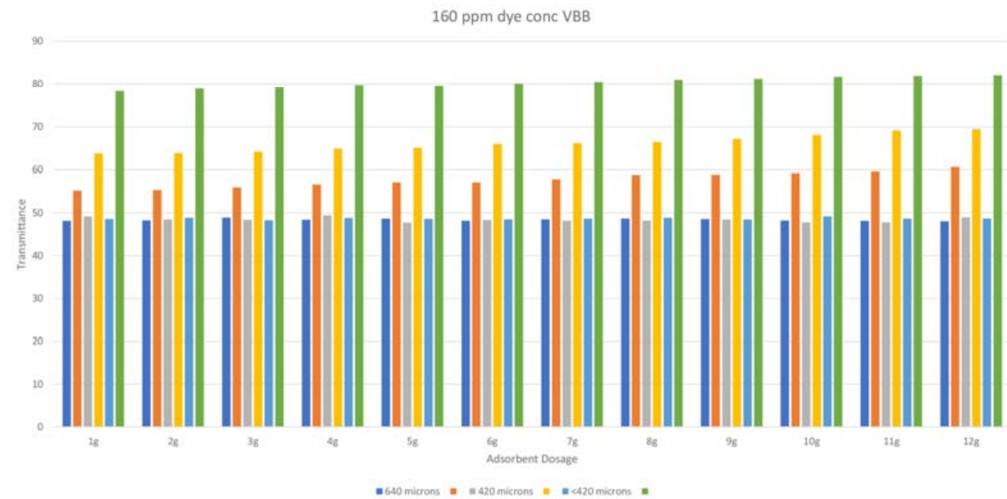

Figure 7.4: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 160 ppm

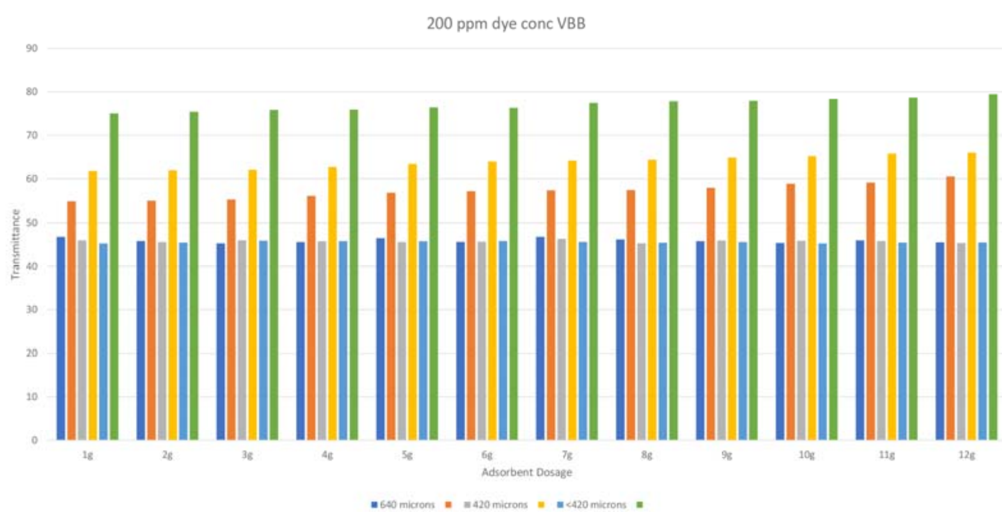

Figure 7.5: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 200 ppm

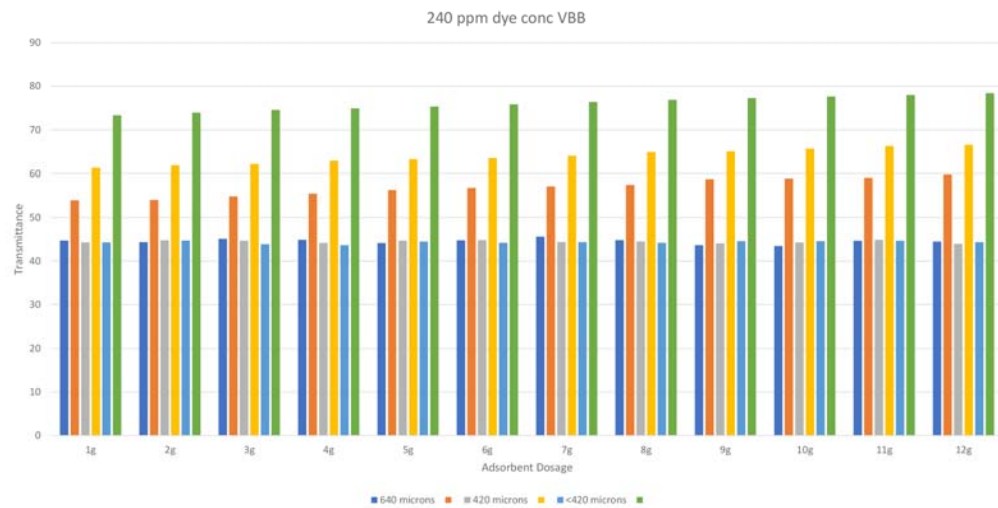

Figure 7.6: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 240 ppm

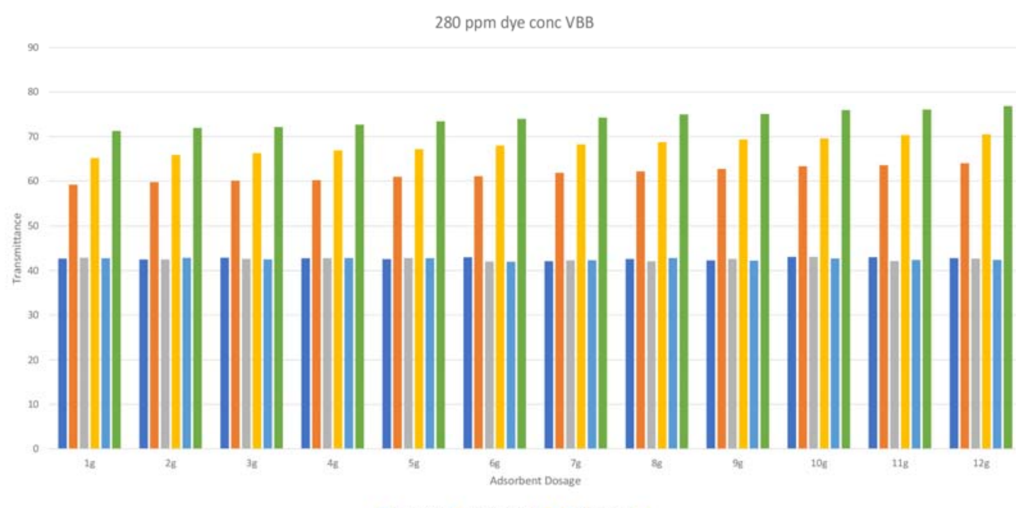

Figure 7.7: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 280 ppm

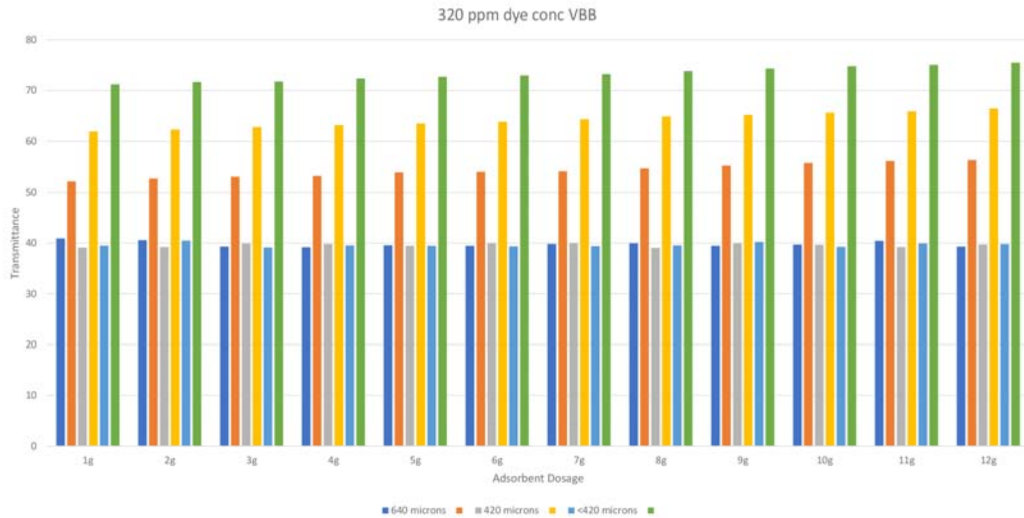

Figure 7.8: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 320 ppm

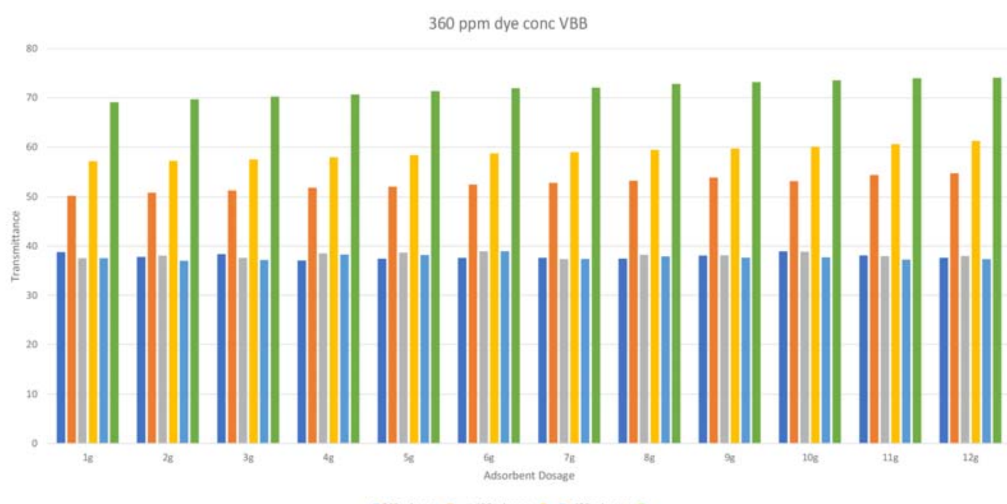

Figure 7.9: Transmittance vs Adsorbent Size and Dosage for Victoria Blue B, 360 ppm

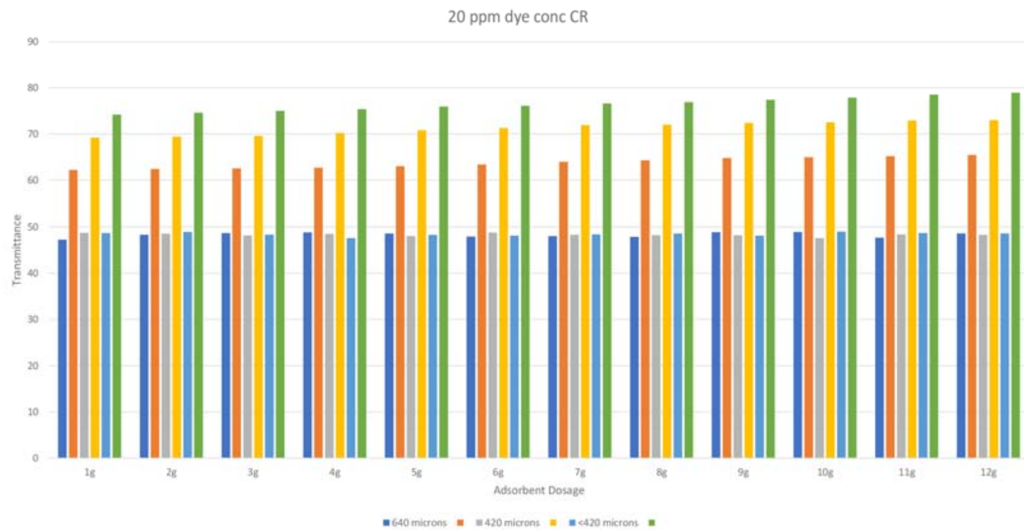

Figure 7.10: Transmittance vs Adsorbent Size and Dosage for Congo Red, 20 ppm

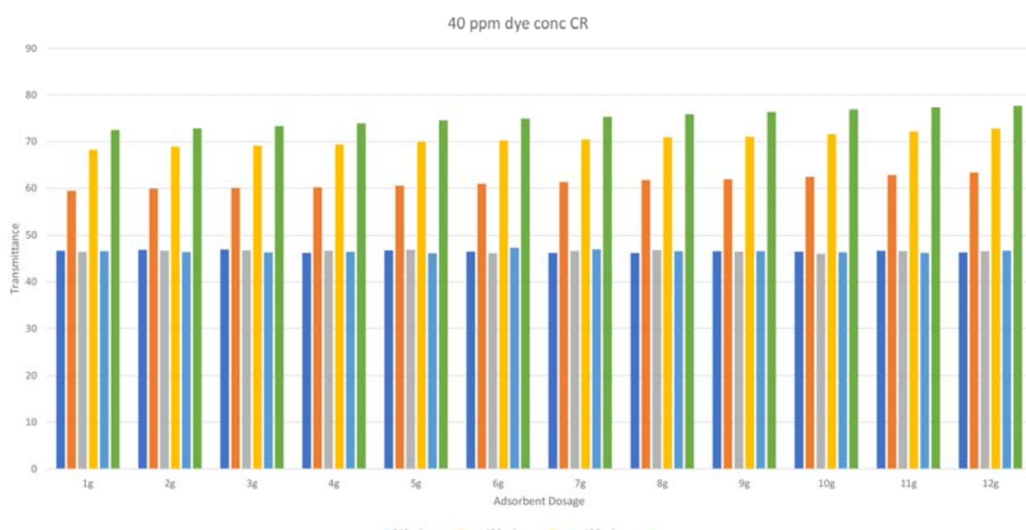

Figure 7.11: Transmittance vs Adsorbent Size and Dosage for Congo Red, 40 ppm

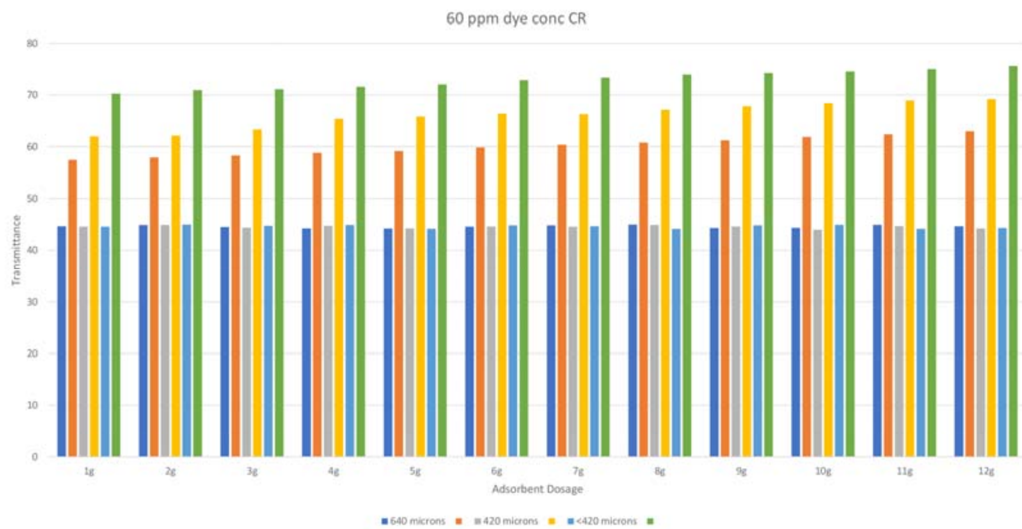

Figure 7.12: Transmittance vs Adsorbent Size and Dosage for Congo Red, 60 ppm

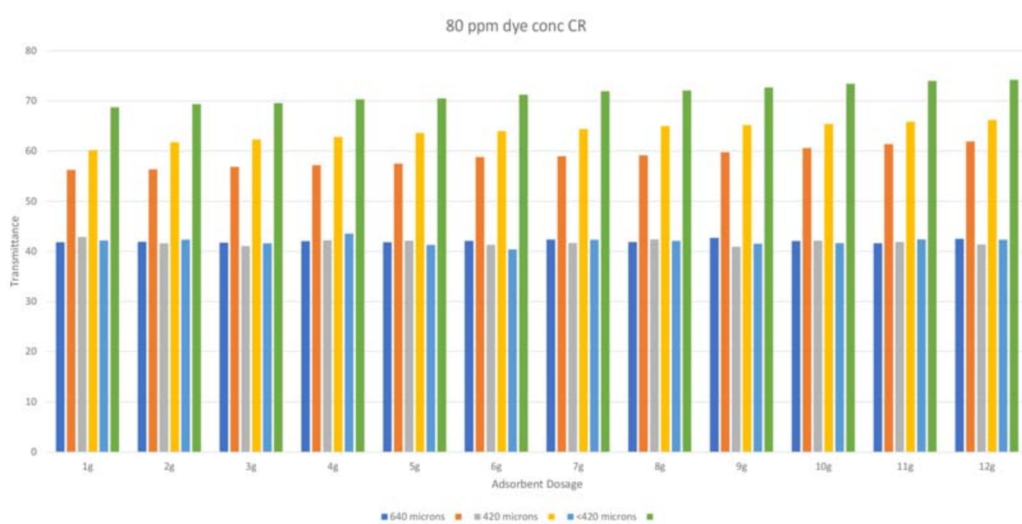

Figure 7.13: Transmittance vs Adsorbent Size and Dosage for Congo Red, 80 ppm

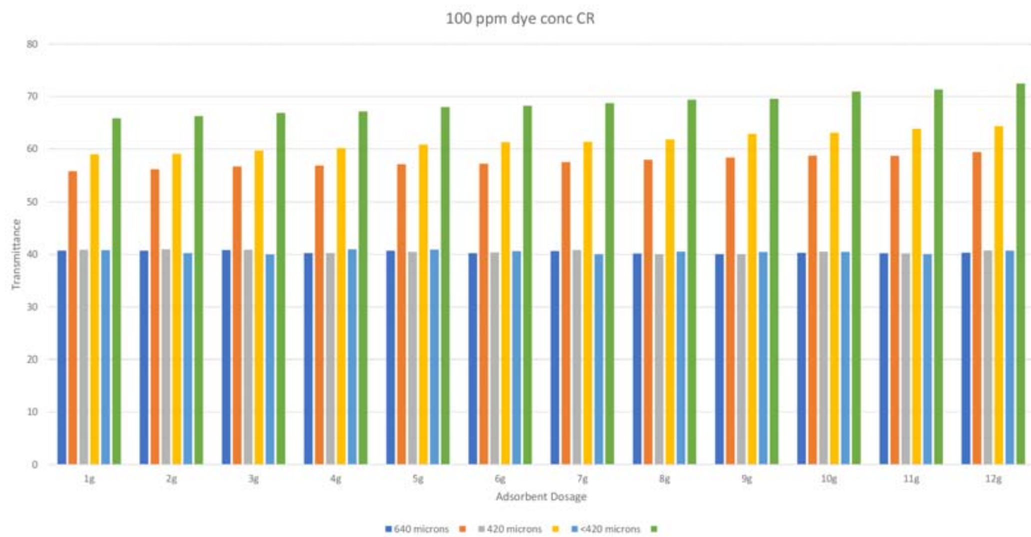

Figure 7.14: Transmittance vs Adsorbent Size and Dosage for Congo Red, 100 ppm

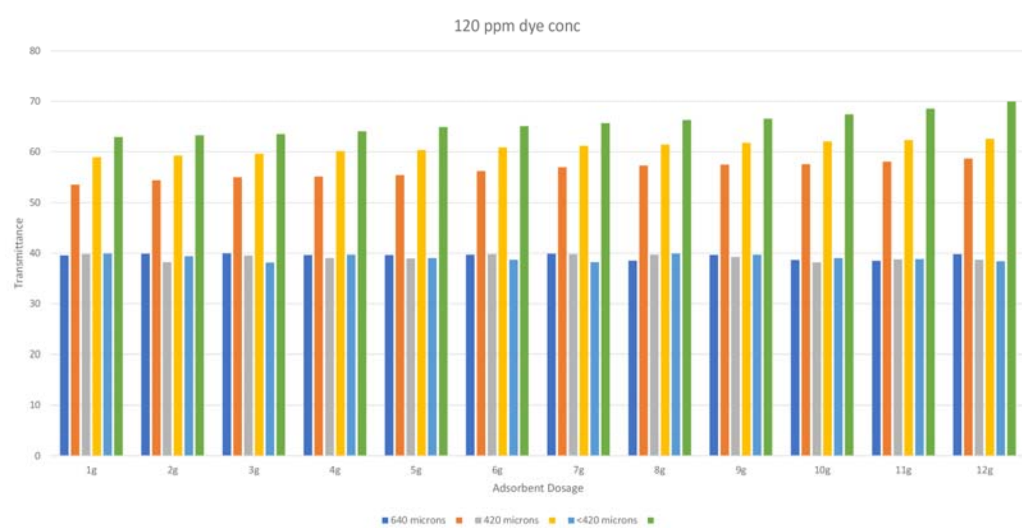

Figure 7.15: Transmittance vs Adsorbent Size and Dosage for Congo Red, 120 ppm

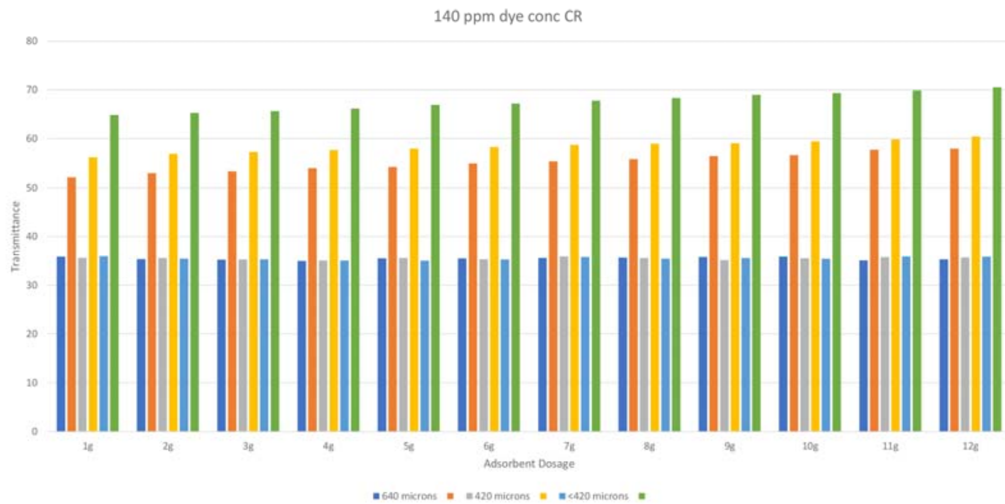

Figure 7.16: Transmittance vs Adsorbent Size and Dosage for Congo Red, 140 ppm

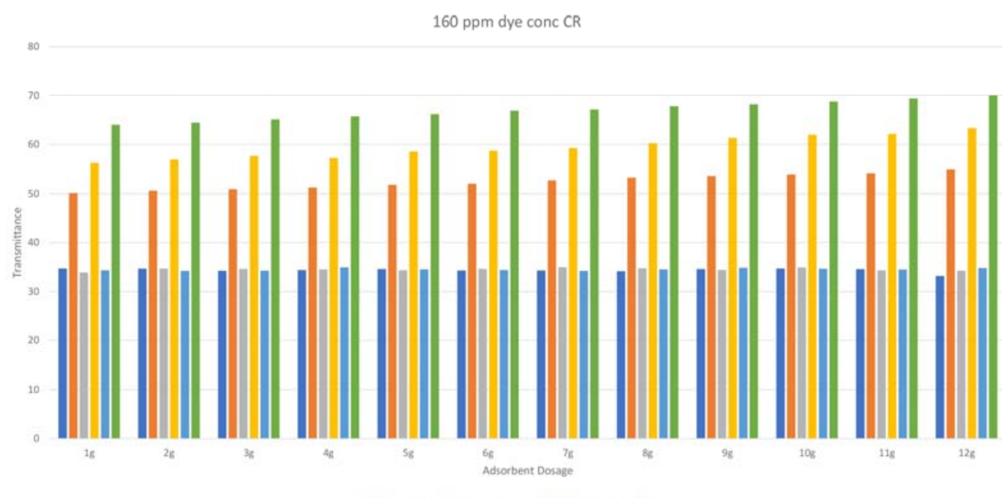

Figure 7.17: Transmittance vs Adsorbent Size and Dosage for Congo Red, 160 ppm

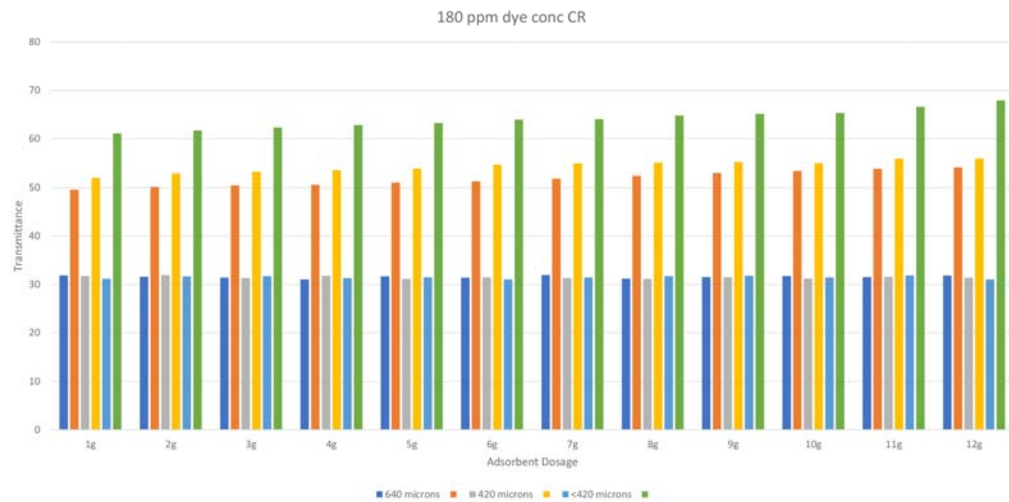

Figure 7.18: Transmittance vs Adsorbent Size and Dosage for Congo Red, 180 ppm

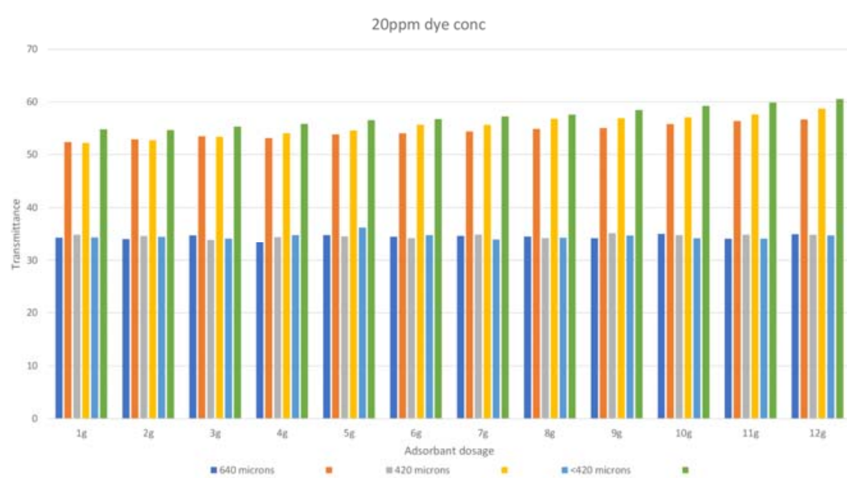

Figure 7.19: Transmittance vs Adsorbent Size and Dosage for Direct Blue 15, 20 ppm

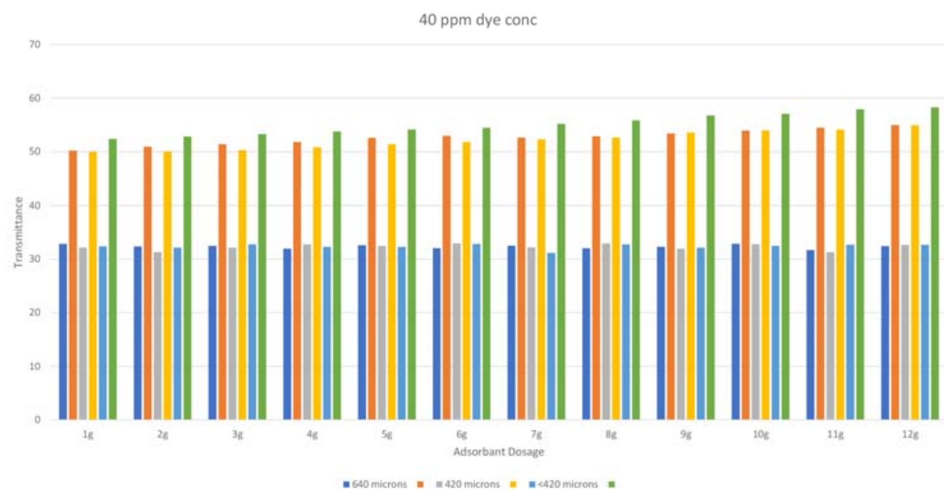

Figure 7.20: Transmittance vs Adsorbent Size and Dosage for Direct Blue 15, 40 ppm

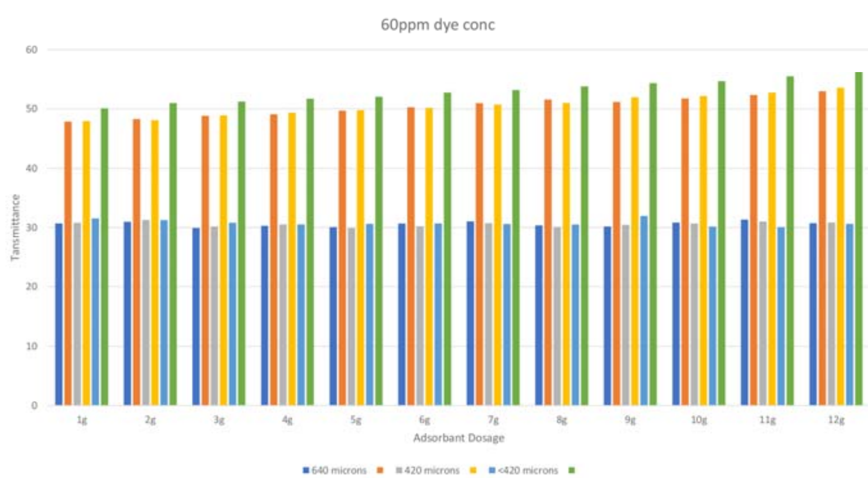

Figure 7.21: Transmittance vs Adsorbent Size and Dosage for Direct Blue 15, 60 ppm

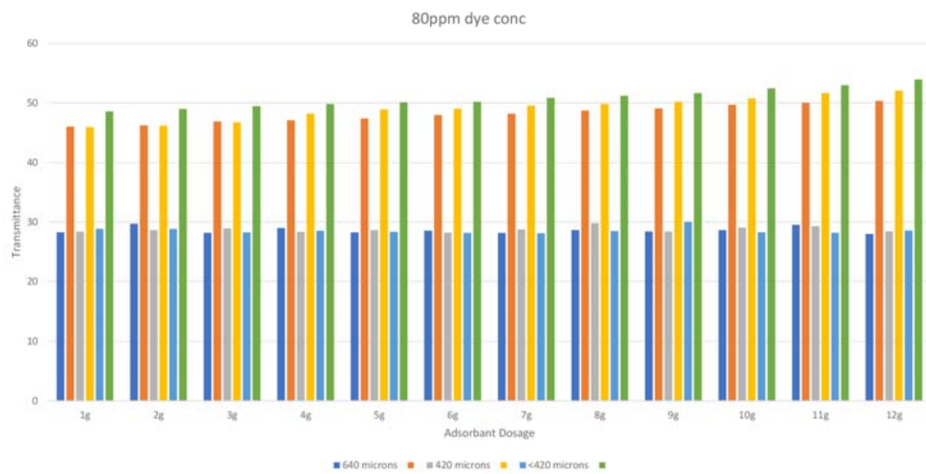

Figure 7.22: Transmittance vs Adsorbent Size and Dosage for Direct Blue 15, 80 ppm

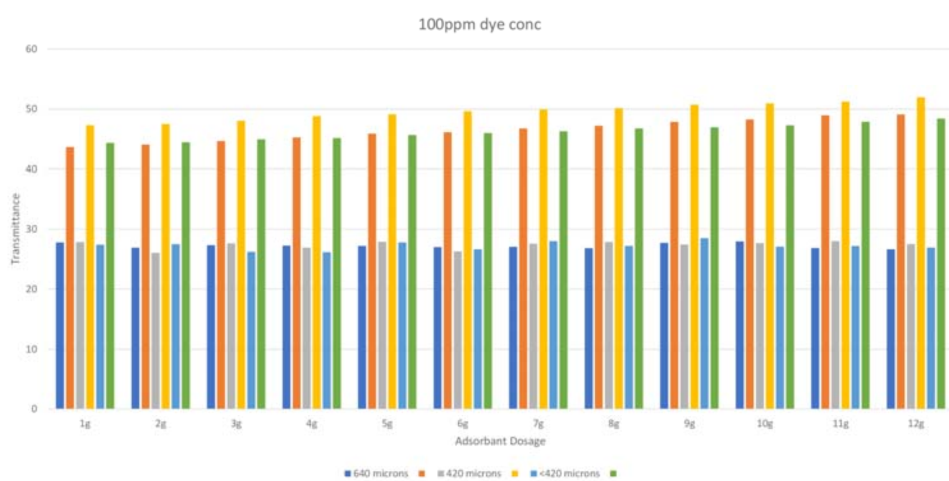

Figure 7.23: Transmittance vs Adsorbent Size and Dosage for Direct Blue 15, 100 ppm

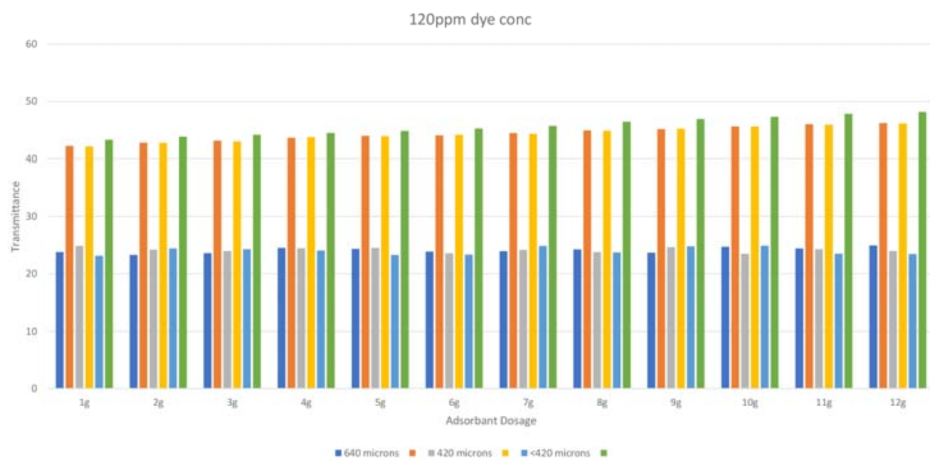

Figure 7.24: Transmittance vs Adsorbent Size and Dosage for Direct Blue 15, 120 ppm

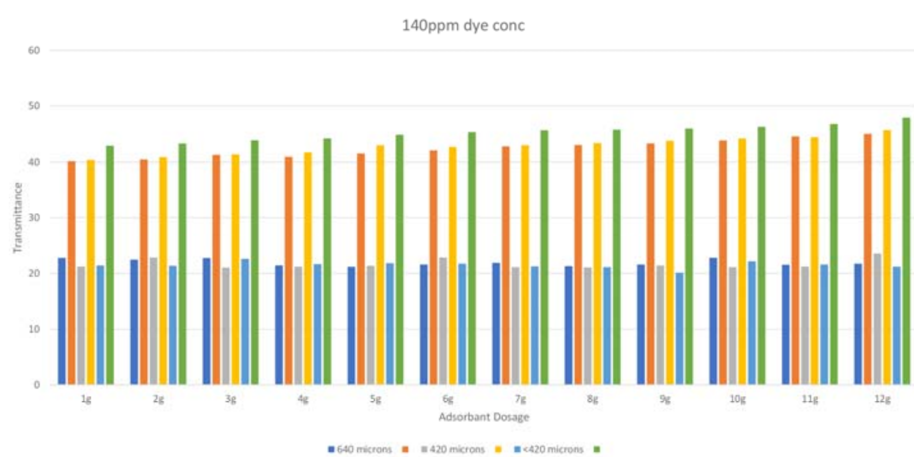

Figure 7.25: Transmittance vs Adsorbent Size and Dosage for Direct Blue 15, 140 ppm

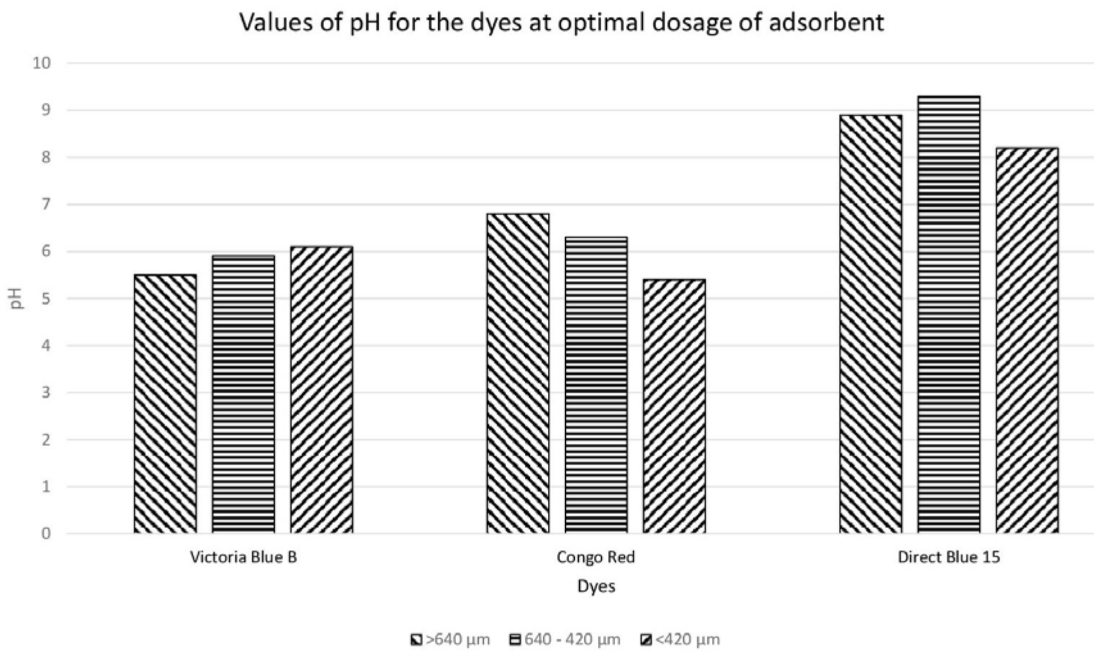

Figure 7.26: graph showing pH for Victoria Blue B, Congo Red and Direct Blue 15 at optimal dosage of peanut hull, after treatment

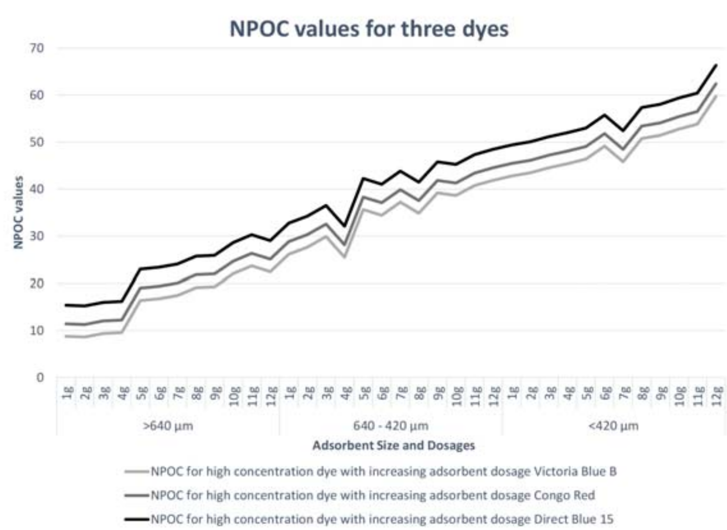

Figure 7.27: graph showing TOC values for Victoria Blue B, Congo Red and Direct Blue 15

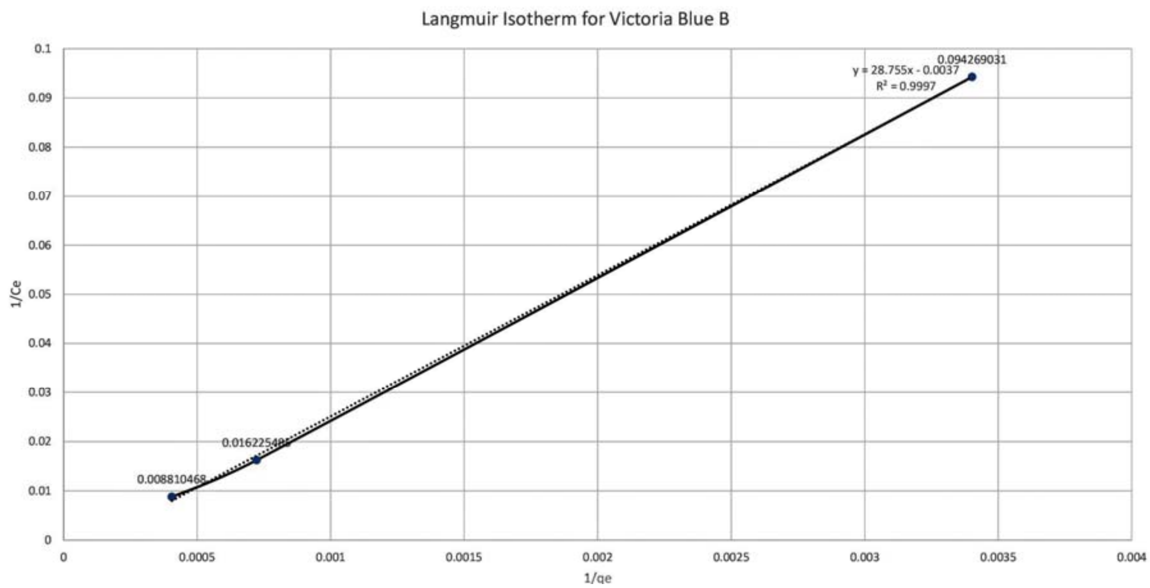

Figure 7.28: Langmuir Isotherm for Victoria Blue B

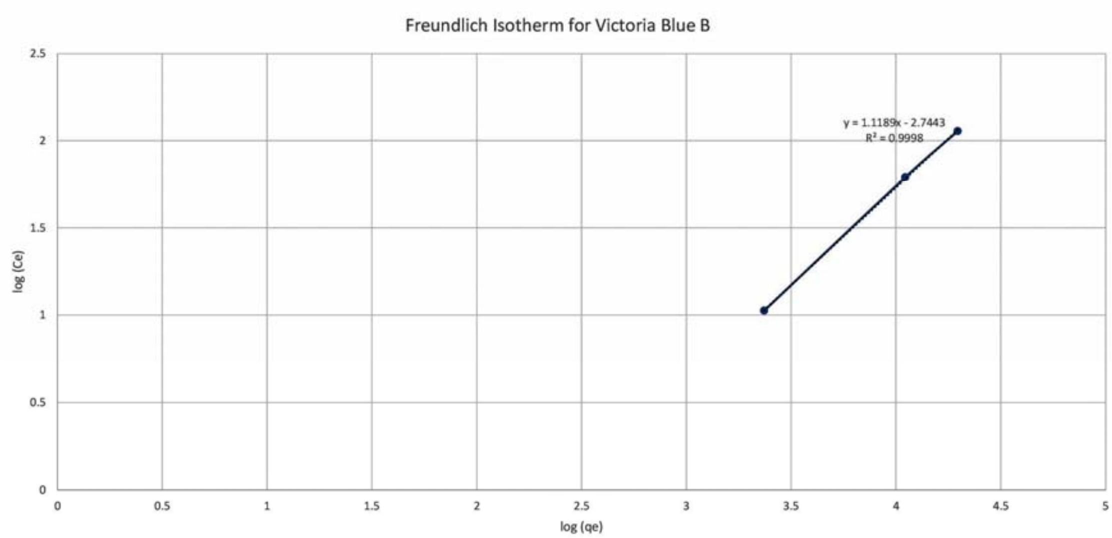

Figure 7.29: Freundlich Isotherm for Victoria Blue B

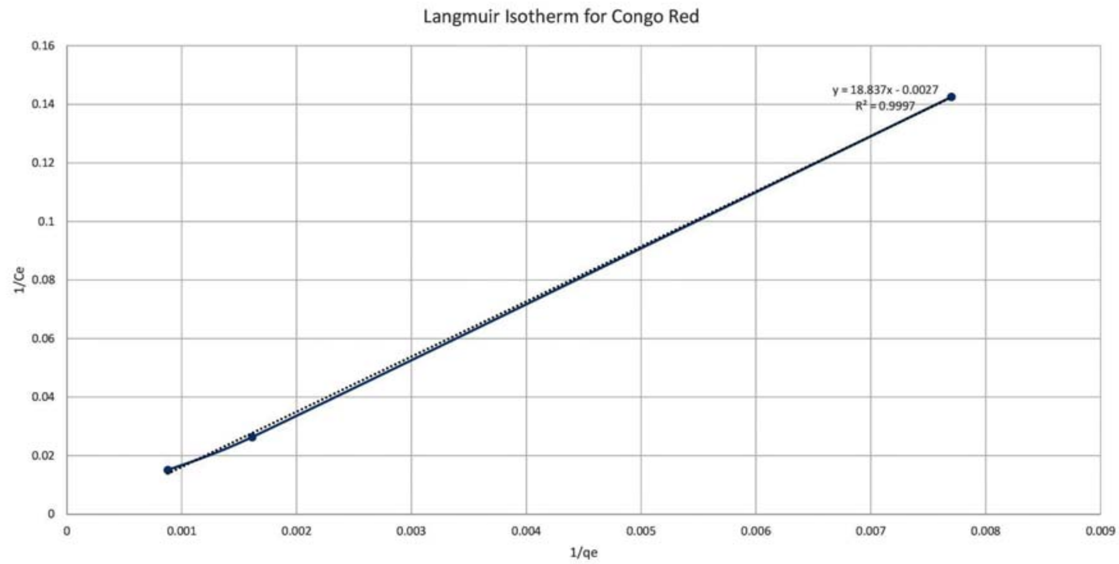

Figure 7.30: Langmuir Isotherm for Congo Red

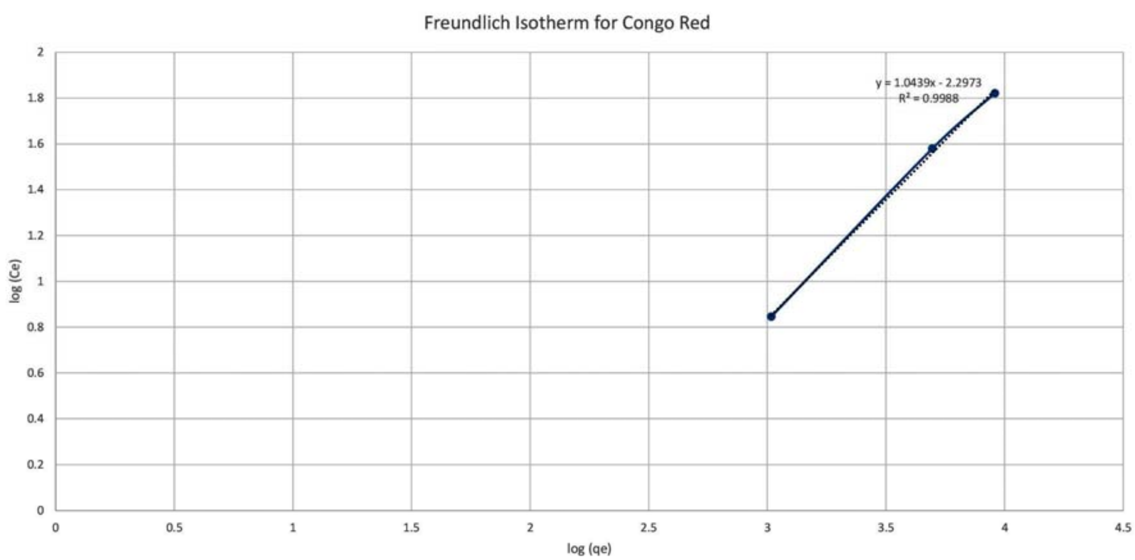

Figure 7.31: Freundlich Isotherm for Congo Red

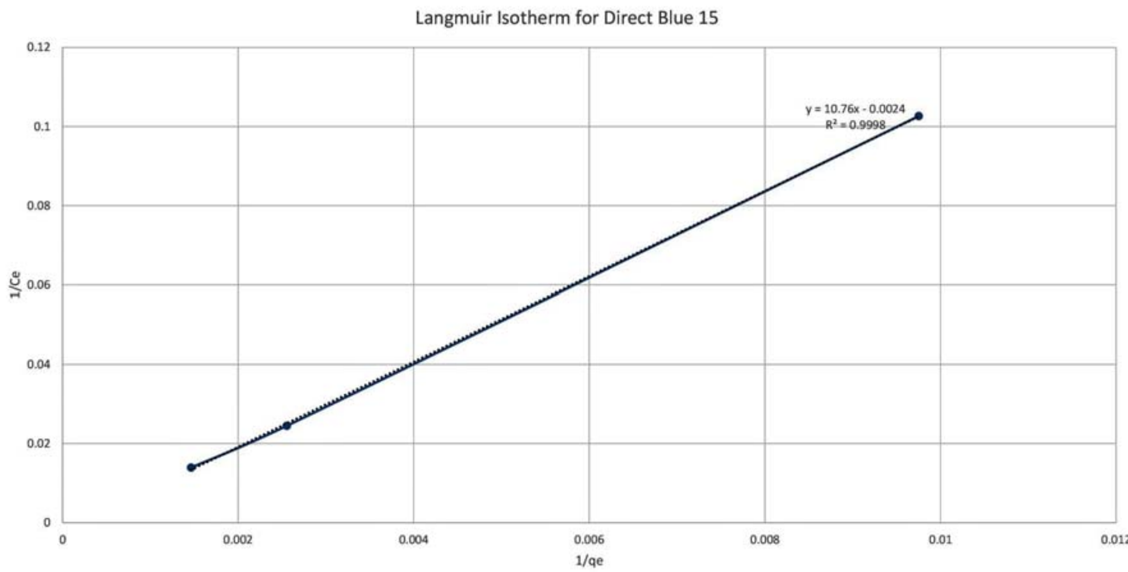

Figure 7.32: Langmuir Isotherm for Victoria Blue B

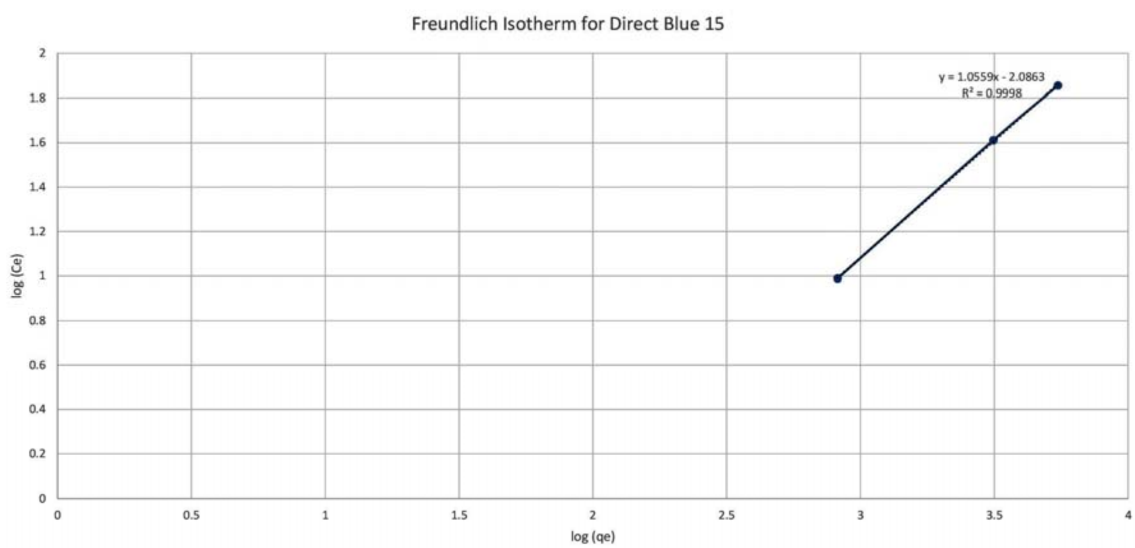

Figure 7.33: Freundlich Isotherm for Victoria Blue B