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# Color Removal and Treatment of Dye and Sugar Waste Water Using Low Cost Adsorbents

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# COLOR REMOVAL AND TREATMENT OF DYE AND SUGAR WASTE WATER USING LOW COST ADSORBENTS

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# DEDICATION

This thesis is dedicated to the God, my parents, and future generations.

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COLOR REMOVAL AND TREATMENT OF DYE AND SUGAR WASTE WATER USING LOW COST ADSORBENTS

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## ABSTRACT

This study was undertaken to determine the treatment of wastewater from dye and sugar industry for removal of color. This specific treatment consists of adsorption using low cost adsorbents and micro filtration using whatman-41 micro filters. Considerations of this treatment process is to take the samples using batch adsorption and avoid coagulation with further dilution. Numerous runs were made with the ideal waste samples prepared in the laboratory.

As a first step in the study different dyes were considered using different concentrations of sugar wastewater. Samples were treated with three different low-cost adsorbents.

These treated samples using low cost adsorbents and can be discharge into surface water through municipal sewage.

**Key words:** Dye wastewater, Sugar wastewater, Adsorption, Absorbance, Transmittance, Micro filtration, Low cost adsorbents.

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**CHAPTER I**

**INTRODUCTION**

## 1.1 Introduction

Sugar is the most essential substrate in human diet. The consumption of sugar is increasing in daily life in this emerging world. More than 115 countries are producing sugar in the world (1). The United States is the fifth largest produces and fifth largest consumer of sugar in the world. From 1789 United States government continued to provide the support for the domestic sugar industries. The s1ugar cane and sugar beets are the two main sources from which sugar is produced (1). Sugar is used in candies, soft drinks, cakes, beverages, ice creams and many other food products. Sugar industry requires massive amounts of water to produce sugar. Many types of pollution loads were released in the form of solid, liquid, and gaseous states. Chemicals such as $Ca(OH)_2$, $H_3PO_4$, $CO_2$, $SO_2$, NaOH, $Na_2CO_3$, HCL were used in the sugar industry to produce sugar and pre-treatment of wastes (2).

The disposal of untreated waste water from the sugar industry is the major environmental problem. This waste water contains significant amounts of TDS and TSS (3). This water is not useful for irrigation purpose. If disposed on land the rate of infiltration decreases due to the increase in BOD, TDS and TSS. The increase in TSS causes salt deposition which leads to decrease in soil porosity. Similarly, higher TDS contents is not favorable for the crop growth (4). It shows the typical environmental pollution caused by the sugar waste water.

Dye is a colored aromatic compound used to impart its color on different substrates. They may be organic or inorganic dyes. In United States, Dye additives are used textiles, foods, cosmetics, drugs, and medical devices. Dyes are classified in several ways (5,6). Their classification is based on source of materials, chromophore, nuclear structure, and industrial classification. Depending on source of materials they are classified into natural dyes and synthetic dyes. Depending on chromophore they are classified into Nitro and Nitroso Dyes, Azo Dyes, Triaryl methane, anthraquinone dyes, Indigo dyes. Depending on nuclear structure they are classified into anionic and cationic dyes. According to industrial classification they are classified into protein textile dyes, cellulose textile dyes, synthetic textile dyes. Cellulose textile dyes are classified into direct dyes, vat dyes, basic dyes, fiber reactive dyes. Protein textile dyes are again classified into acid dyes, mordant dyes. Synthetic textile dyes are again classified into disperse dyes and solvent dyes.

The dyes used in this treatment are Naphthol Green B which comes under Industrial dyes, Acid Orange 74 which comes under Protein textile dyes, Disperse Blue 14 comes under Synthetic textile dyes (7,8).

**1.2 Objectives**

The following are the main objectives of this project:

1) To remove color from the combined dye and sugar waste water.

2) Identification of non-purgeable organic carbon using Shimadzu TOC analyzer.

3) Determining the absorbance and transmittance of the wastewater after treating through adsorption and micro-filtration using Carolina spectrophotometer with a fixed wavelength 545 nm as a visible range.

# CHAPTER II

# LITERATURE REVIEW

## 2.1. Dyes

Dye is a coloring compound which imparts its color to other organic or inorganic substances. Before invention of synthetic dyes all coloring substances were extracted from the plant materials like seeds, leaves, roots, barks and also from the shellfish. The synthetic dyes were accidentally discovered by an English chemist William Perkins. The synthetic dyes were mostly prepared from the derivatives of coal-tar (9).

## 2.2. Classification of Dyes

The dyes are classified based on the following characteristics:

1.Source of materials

2.Chromophore

3.Nuclear structure

4.Industrial classification.

### *2.2.1. Source of Materials Classification*

This is a common classification of dyes in which dyes are classified from the source which they are made. Dyes are mainly classified into two types base on their sources (10).

*1.Natural dyes*. Coloring materials are used by the humans from their early stages for food, clothing and housing in two stages. One is covering with the pigment which is known as painting and second with the covering of whole mass known as dyeing. Materials used for the painting are usually made from the colored rocks and minerals. Materials used for dyeing are usually made from the animal and plant extractions. In both ways they are from the natural sources. So, they are called as Natural dyes (11).

*2.Synthetic dyes.*

Synthetic dyes are derived from the organic and inorganic compounds. These are generally manufactured in the dye industries from the chemicals. They are further classified into 14 distinct categories in terms of industrial scenes (12,13). They are Directs, Sulphur, Vat dyes, Organic pigments, Reactive, Dispersed dyes, Acid dyes, Azoic dyes, Basic dyes, Oxidation dyes, Developed dyes, Mordant dyes, Optical, Solvent dyes.

### ***2.2.2. Chromophore Classification***

Depending on chromophore they are classified into

1.Nitro and Nitroso Dyes - Nitro dyes are based on $-No_2$ nitro functional group and Nitroso dyes are based on -N=O nitroso functional group.

2.Azo Dyes - These are based on-N=N- azo structure.

3.Triaryl methane - These are based on triphenyl methane.

4.Anthraquinone dyes - These are derivatives of anthraquinone >C=O and >C=C.

5. Indigo dyes - These are organic dyes based on carbonyl chromophore.

### ***2.2.3. Nuclear Structure Classification***

Depending on nuclear structure they are classified into

1.Anionic

2.Cationic dyes

### *2.2.4. Industrial Classification*

According to industrial classification they are classified into

*1.Protein textile dyes.*

*a. Acid dyes* - Acidic dyes are highly water soluble and have better light fastness than basic dyes. They contain sulphonic acid groups, which are usually present as sodium sulphonate salts. These increase solubility in water and give the dye molecules a negative charge (14). In an acidic solution, the -NH2 functionalities of the fibers are protonated to give a positive charge: -NH3+. This charge interacts with the negative dye charge, allowing the formation of ionic interactions. As well as this, Van-der-Waals bonds, dipolar bonds, and hydrogen bonds are formed between dye and fiber. As a group, acid dyes can be divided into two sub-groups: acid-leveling or acid-milling (14).

*b. Mordant dyes* - Mordant is a Latin word meaning 'to bite'. Mordants act as 'fixing agents' to improve the color fastness of some acid dyes, which have the ability to form complexes with metal ions. Mordants are usually metal salts; alum was commonly used for ancient dyes, but there is an enormous range of other metallic salt mordants available. Each one gives an assorted color with any particular dye, by forming an insoluble complex with the dye molecules (14). Chromium salts such as sodium or potassium dichromate are commonly used now for synthetic mordant dyes. (18) The diagrams below show C.I. Mordant Black 1 with and without a chromium (III) ion. Chromium (III) forms 6-coordinate complexes, so two Mordant Black molecules would attach to one ion. Only one is shown below for clarity.

*2.Cellulose textile dyes.*

*a. Direct dyes* - The name 'direct dye' alludes to the fact that these dyes do not require any form of 'fixing' (14). They are almost always azo dyes, with some similarities to acid dyes. They also have sulphurated functionality, but in this case, it is only to improve solubility, as the negative charges on dye and fiber will repel each other (14).

*b. Vat dyes* - Vat dyes are a good example of the cross-over between dyes and pigments. Large, planar, and often containing multi-ring systems, vat dyes come exclusively from the carbonyl class of dyes. The ring systems of the vat dyes help to strengthen the Van-der-Waals forces between dye and fiber. Vat dyes are insoluble in water but may become solubilized by alkali reduction. For this reason, they tend not to contain many other functional groups which may be vulnerable to oxidation or reduction (15).

*c. Basic dyes* - Basic dyes possess cationic functional groups such as -NR3+ or =NR2+. The name 'basic dye' refers to when these dyes were still used to dye wool in an alkaline bath. Protein in basic conditions develops a negative charge as the -COOH groups are deprotonated to give -COO-Basic dyes perform poorly on natural fibers but work very well on acrylics. A general structure of an acrylic type polymer is shown below. It is simplified and doesn't show any anionic groups which are often present (15).

*d. Fiber reactive dyes* - A fiber-reactive dye will form a covalent bond with the appropriate textile functionality. This is of great interest, since, once attached, they are very difficult to remove. Early fiber-reactive dyes; The first fiber-reactive dyes were designed for cellulose fibers, and they are still used mostly in this way. There are also commercially available fiber-reactive dyes for protein and polyamide fibers. In theory, fiber-reactive dyes have been developed for other fibers, but these are not yet practical commercially (16).

*3.Synthetic textile dyes.*

*a. Disperse dyes* - Disperse dyes have low solubility in water, but they can interact with the polyester chains by forming dispersed particles. Their main use is the dyeing of polyesters, and they find minor use dyeing cellulose acetates and polyamides. The general structure of disperse dyes is small, planar and non-ionic, with attached polar functional groups like -NO2 and -CN. The shape makes it easier for the dye to slide between the tightly-packed polymer chains, and the polar groups improve the water solubility, improve the dipolar bonding between dye and polymer and affect the color of the dye. However, their small size means that disperse dyes are quite volatile and tend to sublime out of the polymer at sufficiently high temperatures (16).

*b. Solvent dyes* - Dyes are generally defined along the lines of being colored, aromatic compounds that can ionize. One class of dyes is an exception to this. These colors are applied by dissolving in the target, which is invariably a lipid or non-polar solvent (16).

The Color Index uses this as a classification and naming system. Each dye is named according to the pattern: – solvent + base color + number

These dyes are thereby specifically identified as dyes of the stated color, and whose primary mechanism of staining is by dissolving in the target. Note that this is a functional and color classification. It contains no chemical information; neither does it imply that dyes with similar names, but unique numbers are in any way related. It should also be noted that the classification refers to the primary mechanism of staining. Other mechanisms may also be possible but are rare.

The dyes used in this treatment are Naphthol Green B which comes under Industrial dyes, Acid Orange 74 which comes under Protein textile dyes, Disperse Blue 14 comes under Synthetic textile dyes (16).

**2.3. Naphthol Green B**

The C.I. (Color Index) number is 10020 with C.I. name is acid green 1. It comes under the class of nitroso with acidic ionization. It is very soluble in aqueous solution. Its molecular formula is $(C_{10}H_5NO_5SNa)_3Fe$ with formula weight 878.79. This dye is a lake, in which the mordant metal is ferric iron. However, the iron appears to play no part in staining tissues. The unlocked dye is Naphthol green Y, C.I. 10005. Attachment to tissues is through the sulphonic group. The dye is therefore an acid dye, but it is rarely used for staining tissues (17).

**2.4. Acid Orange 74**

Acid orange 74 has C.I. number 18745 with molecular structure of single azo, metal complexes. Its molecular formula is $C_{16}H_{12}N_5NaO_7S$ with 441.35 formula weight. It is an orange, dark brown powder. It is soluble in water for orange, soluble in ethanol, slightly soluble in soluble fiber element. The strong sulfuric acid to dark yellow, diluted into orange; In 10% of sodium hydroxide solution for orange (18). It is used for wool, polyamide fiber and silk dyeing and printing directly, also used in leather and electrochemical aluminum color. Especially for the influential product and the wool carpet dyeing.

**2.5. Disperse Blue 14**

It is with C.I. number 61500 and C.I. name Disperse blue 14. Its molecular structure is anthraquinones. Its molecular formula is $C_{16}H_{14}N_2O_2$ with molecular weight 266.29. bright blue. Blue powder (19). Soluble in acetone, glacial acetic acid, the difficulties, pyridine, and toluene. The strong sulfuric acid to red light brown. Used for polyester, vinegar, and polyamide fiber dyeing, also can be used to transfer printing. And is fit for manufacturing fireworks, hair color components. Can also be used in such of surface coloring and plastic.

**2.6. Sugar Waste Water**

Sugar processing wastewater has a high content of organic material and subsequently a high biochemical oxygen demand $(BOD)_2$, particularly because of the presence of sugars and organic material arriving with the beet or cane (20). Wastewater resulting from the washing of incoming raw materials may also contain crop pests, pesticide residues, and pathogens (20).

## 2.7. Parameters

The spectrometric parameters of dye waste water are absorbance and transmittance. For the distilled water the absorbance and transmittance values are 0 ad 100% respectively (21). It implies that the distilled water has maximum transmittance capacity of ultraviolet radiation and minimum absorbance capacity which is nearly zero. That is the reason because it is considered as the standard measure to calibrate the spectrophotometry (21).

### *2.7.1. Transmittance*

Transmittance (T) is a measurement of how much light passes through a substance. The higher the amount of light that passes through, the larger the transmittance (22). Transmittance is defined as the ratio of the intensity of incident light: intensity of transmitted light i.e. if the intensity of incident light is I. and the intensity of transmitted light is I, then

$$T = \frac{I}{I.}$$

At times, this fraction may be represented as a percentage, where it is called the percentage transmittance (%T).

### *2.7.2. Absorbance*

Absorbance (A) is defined as:

$$A = \log_{10}\left(\frac{1}{T}\right)$$

Consequently, the absorbance can also be given in terms of the percentage transmittance:

$$A = 2 - \log_{10}(\%T).$$

According to Beer-Lambert law, the absorbance of light, as it passes through a solution, is directly proportional to the path length of light through the material (l) and the concentration (c).

So, we can write,

A= €lc

where € is a constant called the molar absorptivity (4). This constant has a specific value for a given substance, provided the temperature of the substance and the wavelength of light passed through it are kept unchanged.

This is an extremely useful relationship which allows concentrations of unknown solutions to be found by measuring the absorbance of light through a sample.

***2.7.3. Non-Purgeable Organic Carbon***

All the carbon present after the sample has been acidified and purged with purified air to remove inorganic carbon. Note that volatile organics will be lost during the purging. It is common but incorrect, for laboratories to measure NPOC, but report it as TOC. In our machine for the addition method, the parameters POC and NPOC are measured. The TOC is then calculated. Measurement of the non-purgeable organic compounds, after POC analysis using catalytic combustion at 680°C and subsequent determination of the resulting carbon dioxide using NDIR detection.

The TOC is calculated via addition: TOC = POC + NPOC.

For the direct or NPOC method, it is assumed that the sample does not contain any significant amounts of volatile or purgeable organic compounds (23). According to this assumption, the TOC is directly determined as NPOC.

Acidification of the sample using a mineral acid (for instance HCL) to a pH < 2, whereby carbonates and hydrogen carbonates are completely converted to carbon dioxide. The carbon dioxide is removed from the sample solution via a spare gas (24). Direct NPOC measurement (like TC measurement) via oxidation to $CO_2$. Subsequent NDIR detection.

The TOC corresponds to the NPOC:

TOC = NPOC

## 2.8. Wastewater Treatment Methods

There are many methods to treat the dye wastewater. There many physio-chemical treatment methods such as adsorption, coagulation, flocculation, biological treatment, electro chemical oxidation etc. In this research me are mainly concentrating on combined method of adsorption and micro filtration (25).

### *2.8.1. Adsorption*

Adsorption is a surface phenomenon with common mechanism for organic and inorganic pollutants removal. When a solution containing absorbable solute comes into contact with a solid with a highly porous surface structure, liquid–solid intermolecular forces of attraction cause some of the solute molecules from the solution to be concentrated or deposited at the solid surface. The solute retained (on the solid surface) in adsorption processes is called adsorbate, whereas, the solid on which it is retained is called as an adsorbent. This surface accumulation of adsorbate on adsorbent is called adsorption. This creation of an adsorbed phase having a composition different from that of the bulk fluid phase forms the basis of separation by adsorption technology (26).

### *2.8.2. Micro-filtration*

Micro-filtration (or MF for short) is one of the pressure-driven membrane processes in the series micro-filtration, ultra-filtration (UF), nano-filtration (NF) and reverse osmosis (RO). The micro-filtration process uses a membrane – a simple permeable material – which, in the case of micro-filtration, only allows particles smaller than 0.1 microns to pass through it. The micro-filtration membrane can consist of various materials like, for example, polysulfide, polyvinyl difluoride (PVDF), polyether sulfone (PES), ZrO2 and carbon. The pore size varies between 0.1

and 5 microns. Because the pores are large compared to other mentioned filtration techniques, pressure – needed to send the liquid through a micro-filter membrane – is limited to 0.1 to 3 bar (27).

# CHAPTER III

# MATERIALS AND METHODS

## 3.1 Dyes

The dyes used in the experiments are:

1. Naphthol Green B

2. Acid Orange 74

3. Disperse Blue 14

## 3.2 Adsorbents

The following coagulants were used to study the color removal using coagulation with the dyes mentioned above:

1. Activated Carbon (DARCO, Grade HDC)

2. Peanut Hull

3.Orange Peel

## 3.3 Equipment

*1. Weighing balance (OHAUS PA1502)*

This machine consists of a metal base with ABS top housing with stainless steel pan. It also has up-front level indicator with integral weigh below the hook. It is equipped with security bracket and calibration lock along with full housing in-use cover. The maximum capacity of the machine is 1,510g with reliability of 0.01g. The pan size is 7.1 inch (180mm) with no applicable internal calibration. Auxiliary display model is available as an accessory. The communication used is RS232 with LCD display. the linearity is ±0.02g with minimum weight USP 20g and stabilization time of 2sec. It can be used in the environment conditions between 10˚C - 30˚C and 80%RH (27).

*2. Spectrophotometer (Carolina #65-3303)*

This spectrophotometer is easy to operate. It consists of a nob to set the wavelength in the units of nanometer. Button 1 helps to blank the standard. It displays both absorbance and % transmittance to using the mode bottom to toggle between them. The absorbance accuracy check is ±2% at 1A. accepts 10mm test tube or 10mm square cuvette. The wavelength range is 335 – 1000mm with spectral bandpass 20nm. The wavelength accuracy is ±2 nm and wavelength repeatability is ± 1 nm. The stray radiant energy of < 0.5% T at 340 and 400nm with 0-125 T & 0-2.0 Abs. The photometric accuracy of ± 2.0% T. the power requirements are 115/230 V ± 10%, 60/50 Hz (28).

*3. Innova 2300 - Platform Shaker, 115 V 60 CV AC*

It consists of triple–eccentric counter balanced drive in cast iron housing which provides vibration. It shakes between 25-500rpm with 2.5cm orbit and 25-300rpm with 5.1cm orbit. Speed can be controlled and displayed in increments of 1rpm. It has a timer 0.1-0.99h along with the audible and visual alarms. The platform size is 76 cm x 46 cm and requires power of 120 V, 50/60 Hz (28,29).

*4. TOC analyzer (Shimadzu TOC-L)*

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

*5. Fisher Oven 200 SERIES (Model 230F)*

It is a conventional benchtop laboratory oven with adjustable height interior shelf for additional flexibility. It works with 115VAC, 50/60Hz. It has a regulator to control the temperature with a LED light indicator (31).

### 3.4 Method

The treatment method starts with the preparation of mother samples of the selected dyes. First weigh the dye using Weighing balance (OHAUS PA1502) with ±0.01g precision. Prepare mother samples of the three dyes with 1000ppm and of volume 1000ml in a glass jar by adding the measured dye to a 1000ml. Stir it thoroughly with a glass stirrer. Cover it immediately with the silver foils to prevent it from oxidizing. Then prepare 4 different concentrations of 3dyes each by taking the samples from the mother samples in different glass jars. 50ppm, 100ppm, 150ppm, 200ppm for the Naphthol Green B, Acid Orange 74 and 250ppm, 500ppm, 750ppm, 100ppm for Disperse Blue 14. Fill each concentration of dye in 78 vails of 100ml maximum capacity up to 50ml in it. Then prepare the sugar wastewater mother samples in the laboratory of 1000ppm. Then prepare 6 different concentrations of sugar wastewater from the mother samples of 100ppm, 200ppm, 300ppm, 400ppm, 500ppm, 600ppm. Add 50ml of 6 different concentrations of sugar wastewater solutions to the vails half filled with dye samples.

Then calculate the absorbance and transmittance values for the samples before treatment using the Spectrophotometer (Carolina #65-3303) and tabulate the values.

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

Plot the graphs between the transmittance vs adsorbent dosage for before and after treatment. Similarly, for all the adsorbents used and compare the efficiencies.

**3.5 Run Protocols**

Table 1 to Table 12 are the tables of run protocols for this research study. The parameters which are varied in this research consists of type of dyes and concentration of dye wastewater and concentration of sugar wastewater, type of adsorbent and dosage of adsorbent.

### *3.5.1 Dyes for Activated Carbon*

Table 1. Run protocol for low concentration dye treated with activated carbon

| **Run order** | **Dye concentration (ppm)** | **Adsorbent concentration (g)** | **Sugar Waste water concentration (ppm)** |
|---|---|---|---|
| 1 | 50 | 0.5 | 100 |
| 2 | 50 | 1 | 100 |
| 3 | 50 | 1.5 | 100 |
| 4 | 50 | 2 | 100 |
| 5 | 50 | 0.5 | 200 |
| 6 | 50 | 1 | 200 |
| 7 | 50 | 1.5 | 200 |
| 8 | 50 | 2 | 200 |
| 9 | 50 | 0.5 | 300 |
| 10 | 50 | 1 | 300 |
| 11 | 50 | 1.5 | 300 |
| 12 | 50 | 2 | 300 |
| 13 | 50 | 0.5 | 400 |
| 14 | 50 | 1 | 400 |
| 15 | 50 | 1.5 | 400 |
| 16 | 50 | 2 | 400 |
| 17 | 50 | 0.5 | 500 |
| 18 | 50 | 1 | 500 |
| 19 | 50 | 1.5 | 500 |
| 20 | 50 | 2 | 500 |
| 21 | 50 | 0.5 | 600 |
| 22 | 50 | 1 | 600 |
| 23 | 50 | 1.5 | 600 |
| 24 | 50 | 2 | 600 |

Table 2. Run protocol for lower medium concentration dye treated with activated carbon

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

Table 3. Run protocol for upper medium concentration dye treated with activated carbon

| **Run order** | **Dye concentration (ppm)** | **Adsorbent concentration (g)** | **Sugar Waste water concentration (ppm)** |
|---|---|---|---|
| | | | |
| 1 | 150 | 0.5 | 100 |
| 2 | 150 | 1 | 100 |
| 3 | 150 | 1.5 | 100 |
| 4 | 150 | 2 | 100 |
| 5 | 150 | 0.5 | 200 |
| 6 | 150 | 1 | 200 |
| 7 | 150 | 1.5 | 200 |
| 8 | 150 | 2 | 200 |
| 9 | 150 | 0.5 | 300 |
| 10 | 150 | 1 | 300 |
| 11 | 150 | 1.5 | 300 |
| 12 | 150 | 2 | 300 |
| 13 | 150 | 0.5 | 400 |
| 14 | 150 | 1 | 400 |
| 15 | 150 | 1.5 | 400 |
| 16 | 150 | 2 | 400 |
| 17 | 150 | 0.5 | 500 |
| 18 | 150 | 1 | 500 |
| 19 | 150 | 1.5 | 500 |
| 20 | 150 | 2 | 500 |
| 21 | 150 | 0.5 | 600 |
| 22 | 150 | 1 | 600 |
| 23 | 150 | 1.5 | 600 |
| 24 | 150 | 2 | 600 |

Table 4. Run protocols for high concentration dye treated with activated carbon

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

### 3.5.2 Dyes for Orange Peel

Table 5. Run protocol for low concentration dye treated with orange peel

| Run order | Dye concentration (ppm) | Adsorbent concentration (g) | Sugar Waste water concentration (ppm) |
|---|---|---|---|
| | | | |
| 1 | 50 | 0.5 | 100 |
| 2 | 50 | 1 | 100 |
| 3 | 50 | 1.5 | 100 |
| 4 | 50 | 2 | 100 |
| 5 | 50 | 0.5 | 200 |
| 6 | 50 | 1 | 200 |
| 7 | 50 | 1.5 | 200 |
| 8 | 50 | 2 | 200 |
| 9 | 50 | 0.5 | 300 |
| 10 | 50 | 1 | 300 |
| 11 | 50 | 1.5 | 300 |
| 12 | 50 | 2 | 300 |
| 13 | 50 | 0.5 | 400 |
| 14 | 50 | 1 | 400 |
| 15 | 50 | 1.5 | 400 |
| 16 | 50 | 2 | 400 |
| 17 | 50 | 0.5 | 500 |
| 18 | 50 | 1 | 500 |
| 19 | 50 | 1.5 | 500 |
| 20 | 50 | 2 | 500 |
| 21 | 50 | 0.5 | 600 |
| 22 | 50 | 1 | 600 |
| 23 | 50 | 1.5 | 600 |
| 24 | 50 | 2 | 600 |

Table 6. Run protocol for lower medium concentration dye treated with orange peel

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

Table 7. Run protocol for upper medium concentration dye treated with orange peel

| **Run order** | **Dye concentration (ppm)** | **Adsorbent concentration (g)** | **Sugar Waste water concentration (ppm)** |
|---|---|---|---|
| | | | |
| 1 | 150 | 0.5 | 100 |
| 2 | 150 | 1 | 100 |
| 3 | 150 | 1.5 | 100 |
| 4 | 150 | 2 | 100 |
| 5 | 150 | 0.5 | 200 |
| 6 | 150 | 1 | 200 |
| 7 | 150 | 1.5 | 200 |
| 8 | 150 | 2 | 200 |
| 9 | 150 | 0.5 | 300 |
| 10 | 150 | 1 | 300 |
| 11 | 150 | 1.5 | 300 |
| 12 | 150 | 2 | 300 |
| 13 | 150 | 0.5 | 400 |
| 14 | 150 | 1 | 400 |
| 15 | 150 | 1.5 | 400 |
| 16 | 150 | 2 | 400 |
| 17 | 150 | 0.5 | 500 |
| 18 | 150 | 1 | 500 |
| 19 | 150 | 1.5 | 500 |
| 20 | 150 | 2 | 500 |
| 21 | 150 | 0.5 | 600 |
| 22 | 150 | 1 | 600 |
| 23 | 150 | 1.5 | 600 |
| 24 | 150 | 2 | 600 |

Table 8. Run protocol for high concentration dye treated with orange peel

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

### *3.5.3. Dyes for Peanut Hull*

Table 9. Run protocol for low concentration dye treated with peanut hull

| **Run order** | **Dye concentration (ppm)** | **Adsorbent concentration** | **Sugar Waste water concentration (ppm)** |
|---|---|---|---|
| | | | |
| 1 | 50 | 3327 µm - 2380µm | 100 |
| 2 | 50 | 2380 µm - 2362 µm | 100 |
| 3 | 50 | 2362 µm - 600 µm | 100 |
| 4 | 50 | 600 µm - 425 µm | 100 |
| 5 | 50 | < 425 µm | 100 |
| 6 | 50 | 3327 µm - 2380µm | 200 |
| 7 | 50 | 2380 µm - 2362 µm | 200 |
| 8 | 50 | 2362 µm - 600 µm | 200 |
| 9 | 50 | 600 µm - 425 µm | 200 |
| 10 | 50 | < 425 µm | 200 |
| 11 | 50 | 3327 µm - 2380µm | 300 |
| 12 | 50 | 2380 µm - 2362 µm | 300 |
| 13 | 50 | 2362 µm - 600 µm | 300 |
| 14 | 50 | 600 µm - 425 µm | 300 |
| 15 | 50 | < 425 µm | 300 |
| 16 | 50 | 3327 µm - 2380µm | 400 |
| 17 | 50 | 2380 µm - 2362 µm | 400 |
| 18 | 50 | 2362 µm - 600 µm | 400 |
| 19 | 50 | 600 µm - 425 µm | 400 |
| 20 | 50 | < 425 µm | 400 |
| 21 | 50 | 3327 µm - 2380µm | 500 |
| 22 | 50 | 2380 µm - 2362 µm | 500 |
| 23 | 50 | 2362 µm - 600 µm | 500 |
| 24 | 50 | 600 µm - 425 µm | 500 |
| 25 | 50 | < 425 µm | 500 |
| 26 | 50 | 3327 µm - 2380µm | 600 |
| 27 | 50 | 2380 µm - 2362 µm | 600 |
| 28 | 50 | 2362 µm - 600 µm | 600 |
| 29 | 50 | 600 µm - 425 µm | 600 |
| 30 | 50 | < 425 µm | 600 |

Table 10. Run protocol for lower medium concentration dye treated with peanut hull

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

Table 11. Run protocol for upper medium concentration dye treated with peanut hull

| **Run order** | **Dye concentration (ppm)** | **Adsorbent concentration** | **Sugar Waste water concentration (ppm)** |
|---|---|---|---|
| | | | |
| 1 | 150 | 3327 µm - 2380µm | 100 |
| 2 | 150 | 2380 µm - 2362 µm | 100 |
| 3 | 150 | 2362 µm - 600 µm | 100 |
| 4 | 150 | 600 µm - 425 µm | 100 |
| 5 | 150 | < 425 µm | 100 |
| 6 | 150 | 3327 µm - 2380µm | 200 |
| 7 | 150 | 2380 µm - 2362 µm | 200 |
| 8 | 150 | 2362 µm - 600 µm | 200 |
| 9 | 150 | 600 µm - 425 µm | 200 |
| 10 | 150 | < 425 µm | 200 |
| 11 | 150 | 3327 µm - 2380µm | 300 |
| 12 | 150 | 2380 µm - 2362 µm | 300 |
| 13 | 150 | 2362 µm - 600 µm | 300 |
| 14 | 150 | 600 µm - 425 µm | 300 |
| 15 | 150 | < 425 µm | 300 |
| 16 | 150 | 3327 µm - 2380µm | 400 |
| 17 | 150 | 2380 µm - 2362 µm | 400 |
| 18 | 150 | 2362 µm - 600 µm | 400 |
| 19 | 150 | 600 µm - 425 µm | 400 |
| 20 | 150 | < 425 µm | 400 |
| 21 | 150 | 3327 µm - 2380µm | 500 |
| 22 | 150 | 2380 µm - 2362 µm | 500 |
| 23 | 150 | 2362 µm - 600 µm | 500 |
| 24 | 150 | 600 µm - 425 µm | 500 |
| 25 | 150 | < 425 µm | 500 |
| 26 | 150 | 3327 µm - 2380µm | 600 |
| 27 | 150 | 2380 µm - 2362 µm | 600 |
| 28 | 150 | 2362 µm - 600 µm | 600 |
| 29 | 150 | 600 µm - 425 µm | 600 |
| 30 | 150 | < 425 µm | 600 |

Table12. Run protocol for high concentration dye treated with peanut hull

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

# CHAPTER IV

# RESULTS AND DISCUSSIONS

## 4.1 Results

The following are the results of all runs (936), which are presented in the Appendix A and B.

1. Appendix A are the tables of all runs

2. Appendix B are the figures of all runs

The observations are compared, and the results are tabulated to interpret the performance and behavior of the low-cost adsorbents with four different dosages for activated carbon and orange peel powder (0.5gm, 1gm, 1.5gm, 2gm) and peanut hull at five different sieve sizes (3327 µm -2380 µm, 2380 µm - 2362 µm, 2362 µm - 600 µm, 600 µm - 425 µm, < 425 µm) with 4 different dosages of dyes low, lower medium, upper medium, high and six concentrations of sugar water (100ppm, 200ppm, 300ppm, 400ppm, 500ppm, 600ppm). The values of absorbance and transmittance are observed and recorded before and after the treatment.

**Note:** Hereafter, the terms BT, AT listed in the table indicates before treatment and after treatment of batch adsorption of sugar waste water samples and $\alpha$, $\beta$, $\gamma$, $\delta$, $\varepsilon$ in the tables indicates (3327-2380) µm, (2380-2362) µm, (2362-600) µm, (600-425) µm, < 425 µm size of peanut hull retained. The following tables in the results and discussion tells the transmittance of different dyes with sugar wastewater at optimum size and dosage of adsorbent.

Table 13. Transmittance of Naphthol Green B at optimum size and dosage

| Dye concentration | Transmittance (%) for different adsorbents | | |
|---|---|---|---|
| | **Activated Carbon** | **Orange Peel** | **Peanut Hull** |
| Low Concentration | 96.72 | 83.12 | 76.98 |
| Lower Medium Concentration | 95.11 | 74.12 | 67.56 |
| Upper Medium Concentration | 94.08 | 71.96 | 64.53 |
| High Concentration | 93.17 | 67.98 | 60.94 |

The table above represent the transmittance after treatment with three different adsorbents which is used to describe the relationship between the transmittance and varying dye (Naphthol Green B) concentration with three different low-cost adsorbents (Activated Carbon, Orange Peel, Peanut Hull) for the various wastewater samples. We can observe that the transmittance decreases from 96.72% to 93.17% with the increase in dye concentration from low to high when treated with activated carbon. Similarly, we can observe that the transmittance decreases from 83.12% to 67.98% & 76.98% to 60.94% with the increase in dye concentration from low to high when treated with Orange Peel and Peanut Hull respectively.

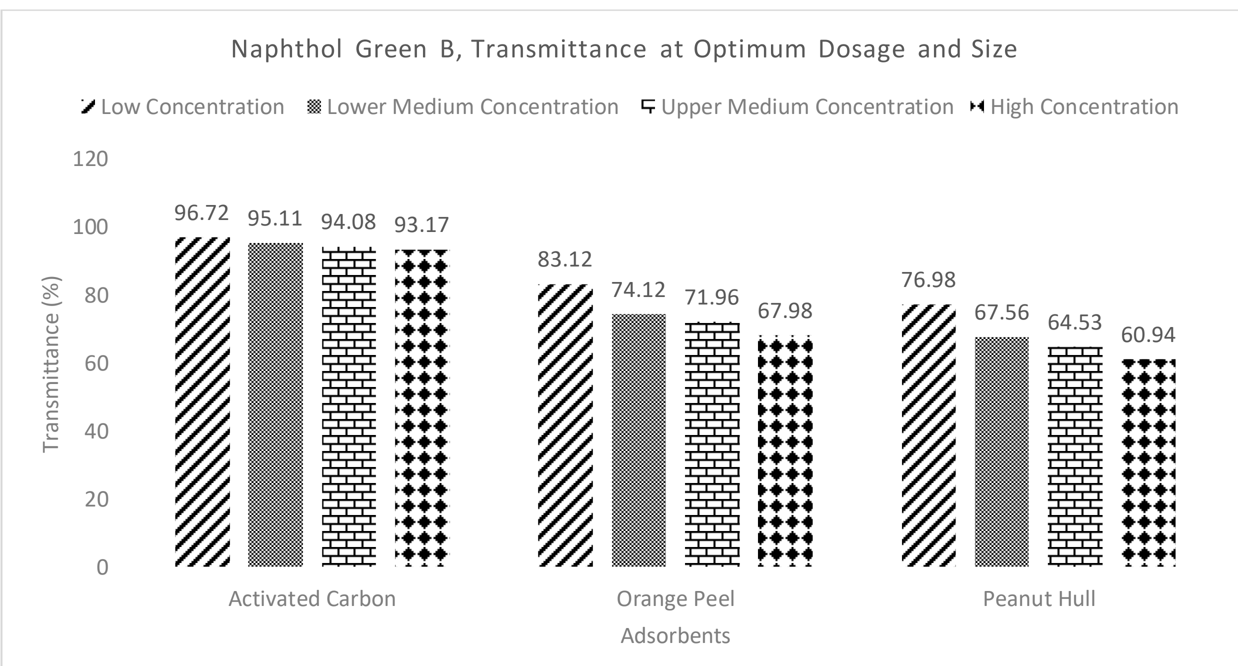


Figure 1. Transmittance of Naphthol Green B at optimum adsorbent size and dosage

Table 14. Transmittance of Acid Orange 74 at optimum size and dosage

| Dye concentration | Transmittance (%) for different adsorbents | | |
|---|---|---|---|
| | **Activated Carbon** | **Orange Peel** | **Peanut Hull** |
| Low Concentration | 95.76 | 82.03 | 74.03 |
| Lower Medium Concentration | 93.98 | 80.24 | 71.09 |
| Upper Medium Concentration | 94.07 | 76.87 | 66.77 |
| High Concentration | 92.05 | 71.67 | 53.27 |

The table above represents the transmittance after treatment with three different adsorbents is used to describe the relationship between the transmittance and varying dye (Acid Orange 74) concentration with three different low-cost adsorbents (Activated Carbon, Orange Peel, Peanut Hull) for the various wastewater samples. We can observe that the transmittance decreases from 95.76% to 92.05% with the increase in dye concentration from low to high when treated with activated carbon. Similarly, we can observe that the transmittance decreases from 82.03% to 71.67% & 74.03% to 53.27% with the increase in dye concentration from low to high when treated with Orange Peel and Peanut Hull respectively.

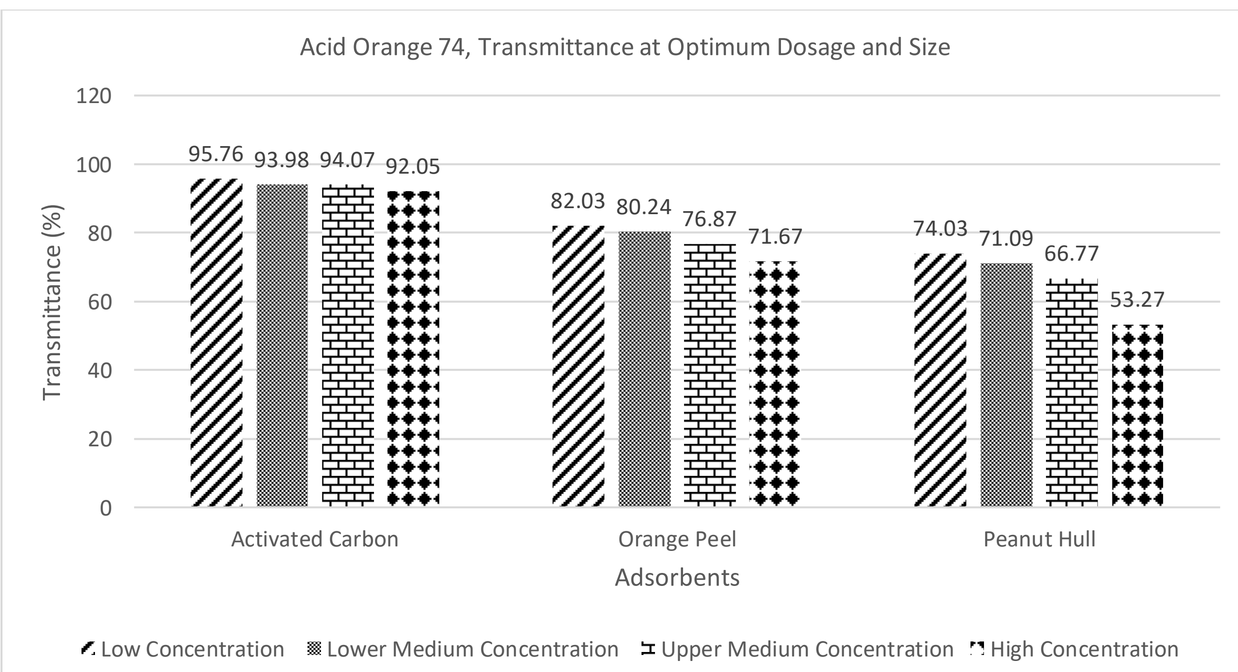


Figure 2. Transmittance of Acid Orange 74 at optimum adsorbent size and dosage

Table 15. Transmittance of Disperse Blue 14 at optimum size and dosage

| Dye concentration | Transmittance (%) for different adsorbents | | |
|---|---|---|---|
| | **Activated Carbon** | **Orange Peel** | **Peanut Hull** |
| Low Concentration | 98.86 | 97.83 | 78.67 |
| Lower Medium Concentration | 98.92 | 95.97 | 75.37 |
| Upper Medium Concentration | 97.17 | 93.16 | 76.03 |
| High Concentration | 95.63 | 90.01 | 72.24 |

The table above represents the transmittance after treatment with three different adsorbents is used to describe the relationship between the transmittance and varying dye (Disperse Blue 14) concentration with three different low-cost adsorbents (Activated Carbon, Orange Peel, Peanut Hull) for the various wastewater samples. We can observe that the transmittance decreases from 98.86% to 95.63% with the increase in dye concentration from low to high when treated with activated carbon. Similarly, we can observe that the transmittance decreases from 97.83% to 90.01% & 78.67% to 72.24% with the increase in dye concentration from low to high when treated with Orange Peel and Peanut Hull respectively.

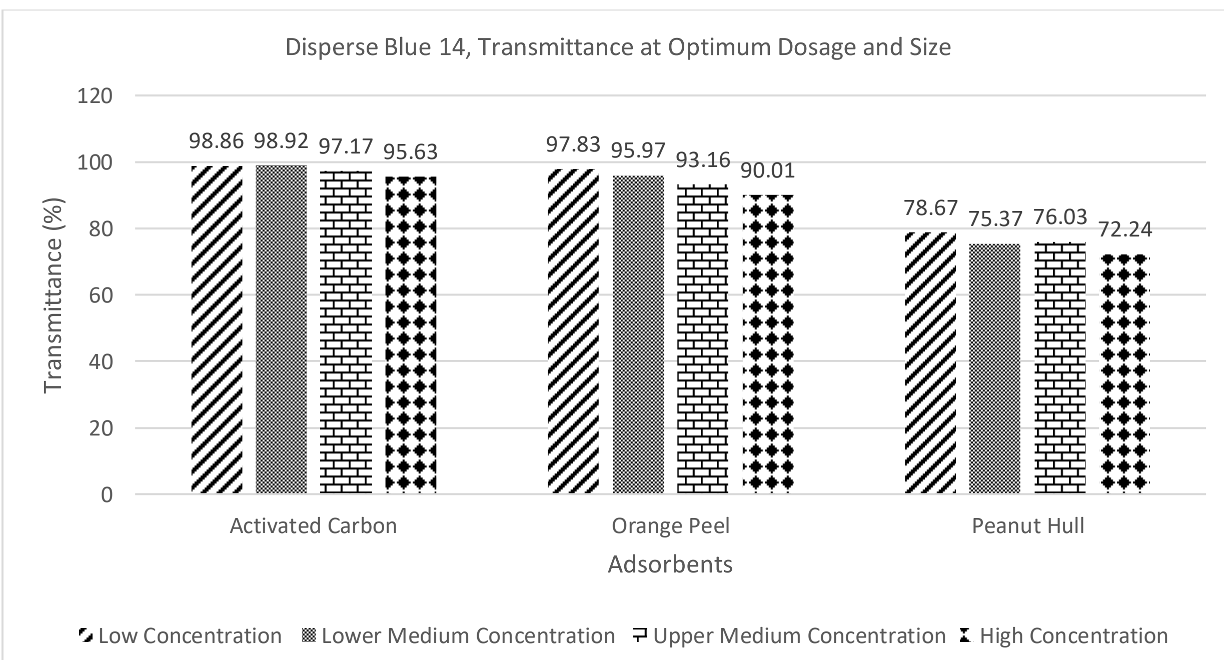


Figure 3. Transmittance of Disperse Blue 14 at optimum adsorbent size and dosage.

Table 16. NPOC of Naphthol Green B with increasing sugar wastewater concentration.

| Sugar wastewater concentration | NPOC for high concentration Naphthol Green B (200 ppm) with increasing sugar wastewater concentration (mg/l) | | |
|---|---|---|---|
| | Activated Carbon | Orange Peel | Peanut Hull |
| 100ppm Sugar Wastewater | 9.76 | 10.62 | 12.47 |
| | 8.62 | 10.91 | 12.83 |
| | 8.37 | 11.28 | 13.42 |
| | 8.57 | 11.74 | 13.91 |
| 200ppm Sugar Wastewater | 15.36 | 16.51 | 18.24 |
| | 15.74 | 16.96 | 18.79 |
| | 15.43 | 16.26 | 19.18 |
| | 16.11 | 17.73 | 19.92 |
| 300ppm Sugar Wastewater | 18.29 | 19.13 | 23.47 |
| | 17.98 | 19.43 | 23.69 |
| | 17.66 | 20.27 | 24.84 |
| | 16.42 | 20.76 | 26.91 |
| 400ppm Sugar Wastewater | 22.14 | 24.36 | 27.88 |
| | 21.63 | 24.83 | 28.43 |
| | 20.87 | 25.12 | 28.76 |
| | 23.47 | 25.63 | 29.38 |
| 500ppm Sugar Wastewater | 27.63 | 29.26 | 32.01 |
| | 26.42 | 29.17 | 32.78 |
| | 23.21 | 30.24 | 33.11 |
| | 26.87 | 30.75 | 33.54 |
| 600ppm Sugar Wastewater | 32.17 | 33.43 | 36.41 |
| | 31.63 | 33.78 | 36.95 |
| | 30.74 | 34.12 | 37.08 |
| | 29.87 | 35.06 | 37.86 |

The above table represent the NPOC after treatment with three different adsorbents which is used to describe the relationship between the NPOC and varying sugar wastewater concentration with three different low-cost adsorbents (Activated Carbon, Orange Peel, Peanut Hull) for high Naphthol Green B concentration. We can observe that wastewater treated with peanut hull has the high NPOC value of 37.86 mg/l, orange peel and activated carbon has NPOC value of 35.06 mg/l and 32.17 mg/l respectively. We can also observe that the NPOC values increases with increase in sugar wastewater concentration from 100ppm to 600ppm.

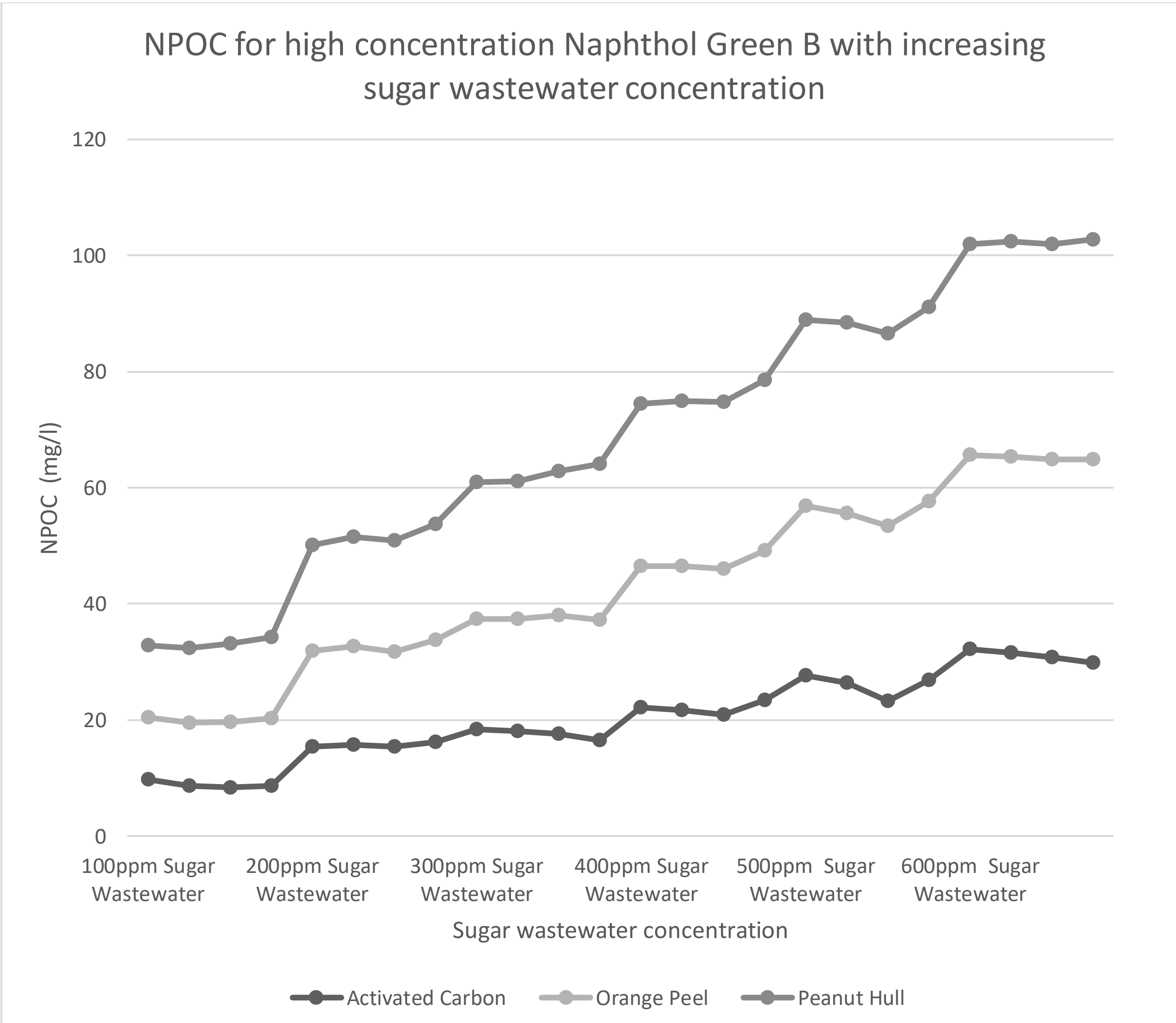


Figure 4. Comparison of NPOC at high concentration Naphthol Green B

Table 17. NPOC of Acid Orange 74 with increasing sugar wastewater concentration.

| Sugar wastewater concentration | NPOC for high concentration Acid Orange 74 (200 ppm) with increasing sugar wastewater concentration (mg/l) | | |
|---|---|---|---|
| | Activated Carbon | Orange Peel | Peanut Hull |
| 100ppm Sugar Wastewater | 10.43 | 12.36 | 14.24 |
| | 10.91 | 12.91 | 14.97 |
| | 11.11 | 13.42 | 15.01 |
| | 11.38 | 14.04 | 15.33 |
| 200ppm Sugar Wastewater | 20.27 | 22.34 | 25.67 |
| | 19.98 | 22.67 | 26.42 |
| | 20.14 | 23.01 | 26.91 |
| | 20.75 | 24.04 | 27.02 |
| 300ppm Sugar Wastewater | 28.42 | 30.24 | 31.24 |
| | 27.23 | 30.78 | 31.41 |
| | 28.51 | 31.32 | 32.07 |
| | 28.79 | 31.76 | 32.42 |
| 400ppm Sugar Wastewater | 31.24 | 34.27 | 37.91 |
| | 31.97 | 34.39 | 38.36 |
| | 32.36 | 35.12 | 38.74 |
| | 32.64 | 35.67 | 39.18 |
| 500ppm Sugar Wastewater | 39.16 | 42.16 | 44.83 |
| | 40.23 | 42.21 | 45.14 |
| | 40.71 | 43.03 | 45.72 |
| | 39.28 | 43.24 | 47.85 |
| 600ppm Sugar Wastewater | 45.28 | 48.13 | 51.98 |
| | 45.91 | 49.18 | 52.06 |
| | 46.36 | 49.33 | 52.48 |
| | 47.12 | 50.16 | 53.51 |

The above table represent the NPOC after treatment with three different adsorbents which is used to describe the relationship between the NPOC and varying sugar wastewater concentration with three different low-cost adsorbents (Activated Carbon, Orange Peel, Peanut Hull) for high Acid Orange 74 concentration. We can observe that wastewater treated with peanut hull has the high NPOC value of 53.51 mg/l, orange peel and activated carbon has NPOC value of 50.16 mg/l and 47.12 mg/l respectively. We can also observe that the NPOC values increases with increase in sugar wastewater concentration from 100ppm to 600ppm.

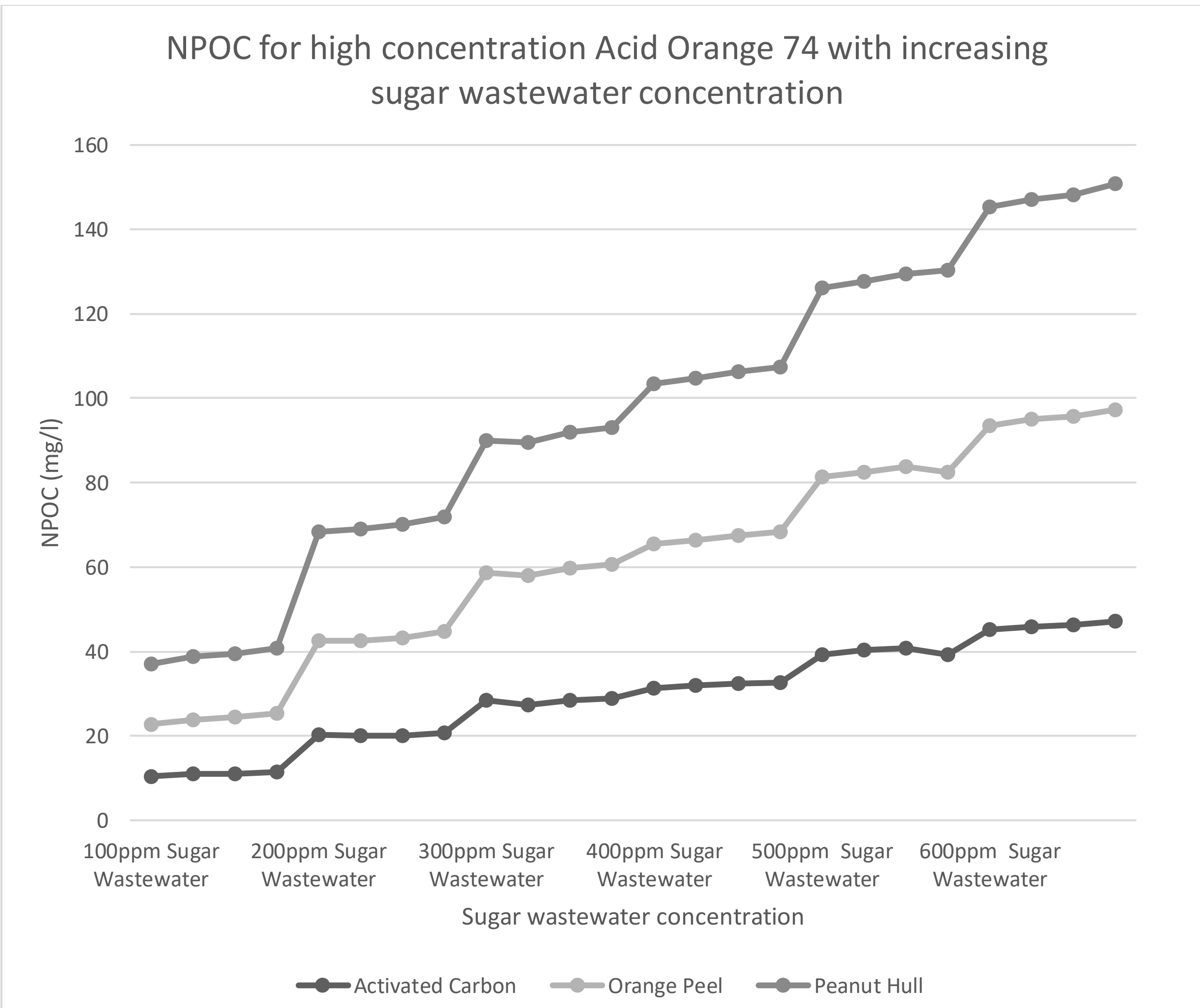


Figure 5. Comparison of NPOC at high concentration Acid Orange 74

Table 18. NPOC of Disperse Blue 14 with increasing sugar wastewater concentration.

| Sugar wastewater concentration | NPOC for high concentration Disperse Blue 14 (1000 ppm) with increasing sugar wastewater concentration (mg/l) | | |
|---|---|---|---|
| | Activated Carbon | Orange Peel | Peanut Hull |
| 100ppm Sugar Wastewater | 8.25 | 9.78 | 12.96 |
| | 9.31 | 10.82 | 13.42 |
| | 10.76 | 11.25 | 14.22 |
| | 10.82 | 12.34 | 15.02 |
| 200ppm Sugar Wastewater | 18.11 | 21.55 | 22.36 |
| | 19.64 | 22.12 | 24.39 |
| | 20.38 | 23.45 | 24.51 |
| | 20.49 | 20.65 | 25.03 |
| 300ppm Sugar Wastewater | 25.46 | 28.58 | 30.15 |
| | 26.23 | 27.01 | 31.25 |
| | 26.75 | 29.45 | 30.67 |
| | 27.02 | 30.64 | 31.98 |
| 400ppm Sugar Wastewater | 31.41 | 33.68 | 36.36 |
| | 31.76 | 34.67 | 36.59 |
| | 32.48 | 36.49 | 37.44 |
| | 32.87 | 37.52 | 37.76 |
| 500ppm Sugar Wastewater | 30.14 | 40.21 | 42.33 |
| | 31.26 | 41.32 | 43.21 |
| | 32.36 | 43.09 | 43.86 |
| | 33.47 | 44.36 | 44.21 |
| 600ppm Sugar Wastewater | 43.47 | 56.22 | 59.33 |
| | 44.62 | 53.29 | 57.61 |
| | 45.14 | 56.39 | 60.37 |
| | 46.78 | 57.9 | 60.84 |

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

**4.2 Results of pH**

The results we achieved for the Naphthol green B, Acid Orange 74, Disperse Blue 14 are (6.5, 7.2, 8.3), (5.9, 5.5, 5.7) and (7.6, 8.1, 6.8) when treated with activated carbon, orange peel, peanut hull respectively at their optimum dosages. The pH factor is very important in the adsorption process especially for dye adsorption. The pH of a medium will control the magnitude of electrostatic charges which are imparted by the ionized dye molecules. Consequently, the rate of adsorption will vary with the pH of an aqueous medium. Generally, at low pH solution, the percentage of dye removal will decrease for cationic dye adsorption, while for anionic dyes the percentage of dye removal will increase. In contrast, at a high pH solution the percentage of dye removal will increase for cationic dye adsorption and decrease for anionic dye adsorption. For cationic dyes, lower adsorption of dye at acidic pH is probably due to the presence of excess H+ ions competing with the cation groups on the dye for adsorption sites.

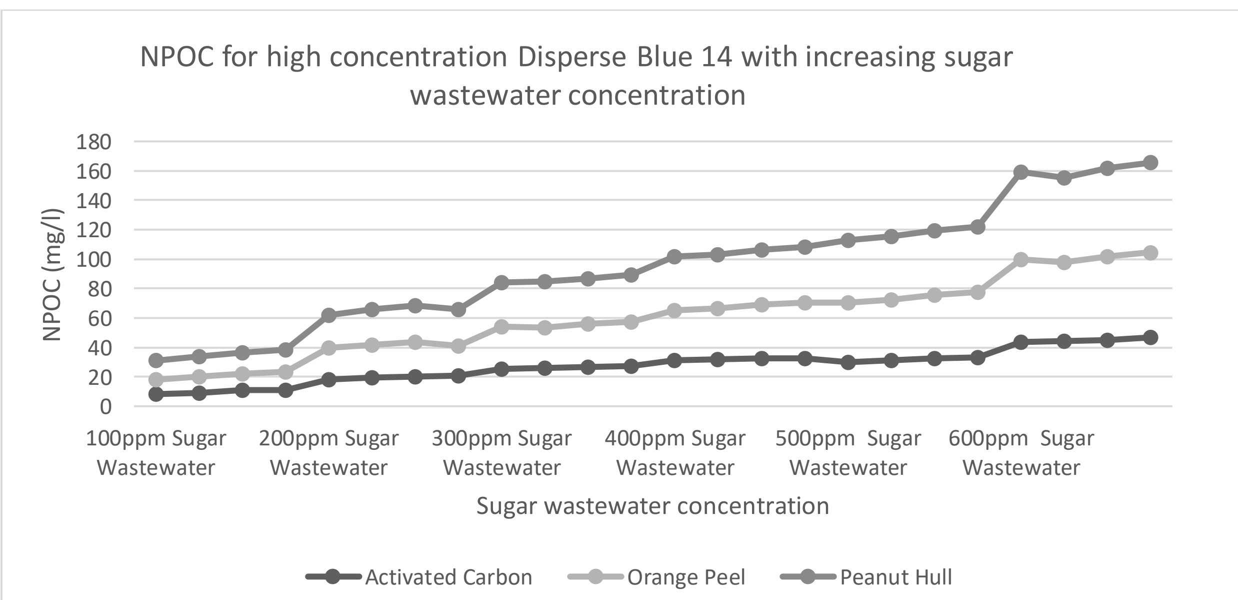


Figure 6. Comparison of NPOC at high concentration Disperse Blue 14

**4.3 Results of Isotherms**

Results of isotherms are represented from figure 43 to figure 60 in Appendix B.

Langmuir isotherm model has the best fit for Naphthol Green B at the optimum dosage of low-cost adsorbents with linear equation: y = 483.15x – 0.0047 with coefficient: 0.00207 and Coefficient of determination $R^2 = 0.9825$.

Freundlich isotherm model has the best fit for Acid Orange 74 at the optimum dosage of low-cost adsorbents with linear equation: y = 0.8395x – 1.4178 with coefficient: 1.1911 and Coefficient of determination $R^2 = 0.9904$.

Langmuir isotherm model has the best fit for Disperse Blue 14 at the optimum dosage of low-cost adsorbents with linear equation: y = 492.94x – 0.0102 with coefficient: 0.00203 and Coefficient of determination $R^2 = 0.9981$.

**4.4. Effects of Parameters on Color Removal**

Transmittance and absorbance are the two major parameters which are effectively used to distinguish the level of color removal. The maximum transmittance and minimum absorbance represents the high efficiency of color removal. pH is another factor that is considered but as this treatment method is territory treatment method pH doesn’t affect much. As the experiment are conducted in laboratories constant temperature is maintained. The NPOC depends on the organic carbon present in the wastewater. Lower the NPOC represents higher the treatment efficiency.

# CHAPTER V

# CONCLUSIONS

## 5.1. Conclusions

The following conclusions are derived from this study:

1. Disperse Blue 14 had highest transmittance of 97.83% and 78.67% after treatment with orange peel and peanut hull respectively.

2. Naphthol Green B and Acid Orange 74 had the transmittance values 83.12%, 76.98% and 82.03%, 74.23% after treatment orange peel and peanut hull respectively.

3. Peanut Hull had the highest transmittance of 78.67%, 76.98% and 74.03% with <425µm size at 100mg/L for Disperse Blue 14, Naphthol Green B, Acid Orange 74 respectively.

4. Orange Peel had the highest transmittance of 97.83%, 83.12% and 82.03% with 2gm dosage for Disperse Blue 14, Naphthol Green B, Acid Orange 74 respectively.

5. The values of transmittance after treatment with PAC is taken as the datum for the comparison of values after treatment with Orange peel and Peanut hull.

6. The successive treatment of dye waste water combined with sugar waste water involving adsorption and micro-filtration is found to be one of the efficient 1combination.

7. Peanut hull had highest NPOC values of 60.84 mg/l, 53.51 mg/l, 37.86 mg/l after the treatment

of high concentration Disperse Blue 14, Acid Orange 74 and Naphthol Green B mixed with 600 ppm of sugar wastewater respectively.

8. Orange peel had NPOC values of 57.9 mg/l, 50.16 mg/l, 35.06 mg/l after the treatment of high concentration Disperse Blue 14, Acid Orange 74 and Naphthol Green B mixed with 600 ppm of sugar wastewater respectively.

**5.2. Significance and Application**

This study shows significant relationship between the dye wastewater samples mixed with sugar wastewater and adsorbent-microfiltration method. As the conventional method to treat the dye waste water requires high capital and operating costs, this treatment method using low cost adsorbents is one of the economical way of treatment. The combined approach allows better achievement of decolorization efficiency along with reduced treatment costs. Moreover, 10 states, Georgia, Texas, Alabama, Florida, North Carolina, South Carolina, Virginia, Oklahoma, New Mexico grows the 99% of the peanut crop in USA. This implies the availability of the peanut hull is adequate. California, Texas, Arizona are higher at the production of oranges. These indicates significant amount of low cost adsorbents that are available in United States.

**5.3. Recommendations for Future Research**

1. This research gives an insight on dealing with the complex wastes.

2. Adsorption must be studied with different adsorbents and more binary combinations of wastewater effluents from point and non-point sources.

3. Conducting experiments with different dyes will help to identify the range of treatment capacity of low cost adsorbents.

4. Recommended research on micro-filters with various pore sizes can give the optimum filtration capacity for different dyes.

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## APPENDIX A : TABLES

Table 19. Transmittance of Naphthol Green B (200 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 42.32 | 92.62 | 39.28 | 89.15 | 36.15 | 85.28 | 33.42 | 79.68 | 31.24 | 76.91 | 28.15 | 69.4 |
| **1gm** | 42.19 | 92.51 | 38.62 | 89.92 | 35.62 | 85.62 | 33.85 | 80.02 | 30.98 | 76.1 | 29.62 | 70.12 |
| **1.5gm** | 39.47 | 92.69 | 38.91 | 90.02 | 36.44 | 85.97 | 32.92 | 80.15 | 31.01 | 76.98 | 28.88 | 70.78 |
| **2gm** | 42.88 | 93.17 | 39.17 | 90.88 | 36.79 | 86.56 | 33.01 | 81.01 | 31.11 | 77.56 | 29.02 | 71.02 |

Table 20. Transmittance of Naphthol Green B (150 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 57.28 | 93.14 | 54.16 | 90.64 | 50.81 | 87.35 | 47.83 | 83.91 | 43.29 | 79.83 | 39.63 | 76.48 |
| **1gm** | 57.39 | 93.65 | 54.23 | 90.79 | 51.2 | 87.64 | 47.95 | 84.24 | 43.37 | 80.25 | 39.74 | 76.86 |
| **1.5gm** | 57.56 | 93.96 | 54.64 | 90.93 | 51.64 | 87.86 | 48.04 | 84.63 | 43.86 | 80.71 | 39.35 | 76.93 |
| **2gm** | 57.63 | 94.08 | 54.72 | 91.28 | 51.75 | 88.12 | 48.17 | 84.78 | 43.93 | 80.98 | 38.85 | 77.59 |

Table 21. Transmittance of Naphthol Green B (100 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 62.53 | 94.32 | 58.56 | 90.11 | 56.12 | 87.64 | 51.23 | 85.31 | 47.54 | 83.14 | 45.88 | 79.62 |
| **1gm** | 62.44 | 94.66 | 58.12 | 90.23 | 56.36 | 87.91 | 51.11 | 85.62 | 48.23 | 83.72 | 46.34 | 79.91 |
| **1.5gm** | 61.98 | 94.93 | 57.32 | 90.98 | 55.13 | 88.24 | 50.2 | 86.11 | 48.11 | 84.13 | 45.54 | 80.15 |
| **2gm** | 62.02 | 95.11 | 58.98 | 91.34 | 56.92 | 88.67 | 50.43 | 86.25 | 47.93 | 84.76 | 46.13 | 80.83 |

Table 22. Transmittance of Naphthol Green B (50 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 70.25 | 95.68 | 66.21 | 92.85 | 63.94 | 88.95 | 60.82 | 83.74 | 58.01 | 79.83 | 56.57 | 75.31 |
| **1gm** | 70.34 | 95.92 | 66.4 | 93.14 | 62.56 | 89.12 | 60.15 | 84.06 | 59.23 | 79.41 | 57.11 | 75.82 |
| **1.5gm** | 69.98 | 96.13 | 66.14 | 93.53 | 63.62 | 89.56 | 59.92 | 84.5 | 59.66 | 80.25 | 56.23 | 76.34 |
| **2gm** | 70.16 | 96.72 | 65.92 | 94.01 | 63.87 | 90.01 | 60.8 | 84.92 | 58.52 | 80.91 | 57.51 | 76.91 |

Table 23. Transmittance of Naphthol Green B (200 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 42.32 | 67.14 | 39.28 | 64.32 | 36.15 | 60.07 | 33.42 | 58.21 | 31.24 | 52.88 | 28.15 | 50.02 |
| **1gm** | 42.19 | 67.19 | 38.62 | 64.64 | 35.62 | 60.66 | 33.85 | 58.42 | 30.98 | 52.95 | 29.62 | 50.84 |
| **1.5gm** | 39.47 | 67.62 | 38.91 | 64.92 | 36.44 | 60.72 | 32.92 | 58.68 | 31.01 | 53.01 | 28.88 | 50.56 |
| **2gm** | 42.88 | 67.98 | 39.17 | 65.01 | 36.79 | 61.09 | 33.01 | 59.11 | 31.11 | 53.13 | 29.02 | 51.19 |

Table 24. Transmittance of Naphthol Green B (150 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 57.28 | 71.48 | 54.16 | 68.92 | 50.81 | 65.87 | 47.83 | 62.12 | 43.29 | 59.69 | 39.63 | 56.23 |
| **1gm** | 57.39 | 71.7 | 54.23 | 68.99 | 51.2 | 65.94 | 47.95 | 62.48 | 43.37 | 59.74 | 39.74 | 56.28 |
| **1.5gm** | 57.56 | 71.83 | 54.64 | 69.26 | 51.64 | 66.05 | 48.04 | 62.93 | 43.86 | 59.87 | 39.35 | 56.71 |
| **2gm** | 57.63 | 71.96 | 54.72 | 69.53 | 51.75 | 66.73 | 48.17 | 63.12 | 43.93 | 60.02 | 38.85 | 57.09 |

Table 25. Transmittance of Naphthol Green B (100 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 62.53 | 73.48 | 58.56 | 70.16 | 56.12 | 67.72 | 51.23 | 65.16 | 47.54 | 62.78 | 45.88 | 59.97 |
| **1gm** | 62.44 | 73.79 | 58.12 | 70.54 | 56.36 | 67.88 | 51.11 | 65.19 | 48.23 | 62.96 | 46.34 | 59.98 |
| **1.5gm** | 61.98 | 73.86 | 57.32 | 70.78 | 55.13 | 67.95 | 50.2 | 65.62 | 48.11 | 63.7 | 45.54 | 60.76 |
| **2gm** | 62.02 | 74.12 | 58.98 | 71.02 | 56.92 | 68.62 | 50.43 | 66.01 | 47.93 | 63.81 | 46.13 | 60.82 |

Table 26. Transmittance of Naphthol Green B (50 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 70.25 | 82.17 | 66.21 | 79.61 | 63.94 | 76.83 | 60.82 | 74.19 | 58.01 | 71.37 | 56.57 | 68.72 |
| **1gm** | 70.34 | 82.43 | 66.4 | 79.78 | 62.56 | 76.92 | 60.15 | 74.68 | 59.23 | 71.58 | 57.11 | 68.91 |
| **1.5gm** | 69.98 | 82.86 | 66.14 | 79.95 | 63.62 | 77.18 | 59.92 | 74.96 | 59.66 | 71.84 | 56.23 | 70.67 |
| **2gm** | 70.16 | 83.12 | 65.92 | 80.16 | 63.87 | 77.64 | 60.8 | 75.14 | 58.52 | 72.12 | 57.51 | 70.99 |

Table 27. Transmittance of Naphthol Green B (200 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **2gm, α** | 42.32 | 59.71 | 39.28 | 56.18 | 36.15 | 53.97 | 33.42 | 48.62 | 31.24 | 45.43 | 28.15 | 42.98 |
| **2gm, β** | 42.19 | 59.26 | 38.62 | 56.25 | 35.62 | 53.15 | 33.85 | 48.51 | 30.98 | 45.75 | 29.62 | 42.72 |
| **2gm, γ** | 39.47 | 60.68 | 38.91 | 56.67 | 36.44 | 54.02 | 32.92 | 48.9 | 31.01 | 45.93 | 28.88 | 43.11 |
| **2gm, δ** | 42.88 | 60.72 | 39.17 | 56.79 | 36.79 | 54.19 | 33.01 | 49.11 | 31.11 | 46.07 | 29.02 | 43.28 |
| **2gm, ε** | 41.61 | 60.94 | 38.92 | 57.18 | 35.79 | 54.68 | 34.15 | 49.6 | 32.66 | 46.14 | 28.98 | 43.76 |

Table 28. Transmittance of Naphthol Green B (150 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| 2gm, α | 57.28 | 63.8 | 54.16 | 59.62 | 50.81 | 56.18 | 47.83 | 53.29 | 43.29 | 49.86 | 39.63 | 46.92 |
| 2gm, β | 57.39 | 63.94 | 54.23 | 59.95 | 51.2 | 56.29 | 47.95 | 53.62 | 43.37 | 49.95 | 39.74 | 46.97 |
| 2gm, γ | 57.56 | 64.16 | 54.64 | 60.16 | 51.64 | 56.32 | 48.04 | 53.84 | 43.86 | 50.17 | 39.35 | 47.62 |
| 2gm, δ | 57.63 | 64.28 | 54.72 | 60.27 | 51.75 | 56.74 | 48.17 | 54.02 | 43.93 | 50.28 | 38.85 | 47.84 |
| 2gm, ε | 57.14 | 64.53 | 53.92 | 60.36 | 50.98 | 56.81 | 48.25 | 54.13 | 44.02 | 50.59 | 38.17 | 48.09 |

Table 29. Transmittance of Naphthol Green B (100 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| 2gm, α | 62.53 | 65.25 | 58.56 | 61.43 | 56.12 | 58.15 | 51.23 | 54.38 | 47.54 | 50.06 | 45.88 | 48.21 |
| 2gm, β | 62.44 | 66.02 | 58.12 | 61.55 | 56.36 | 58.71 | 51.11 | 54.72 | 48.23 | 50.71 | 46.34 | 48.56 |
| 2gm, γ | 61.98 | 66.51 | 57.32 | 62.72 | 55.13 | 58.85 | 50.2 | 54.89 | 48.11 | 50.97 | 45.54 | 48.79 |
| 2gm, δ | 62.02 | 67.24 | 58.98 | 61.98 | 56.92 | 59.12 | 50.43 | 54.97 | 47.93 | 51.05 | 46.13 | 49.11 |
| 2gm, ε | 61.55 | 67.56 | 57.66 | 62.03 | 55.92 | 59.86 | 50.87 | 55.24 | 46.91 | 51.42 | 45.29 | 50.25 |

Table 30. Transmittance of Naphthol Green B (50 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| 2gm, α | 70.25 | 75.23 | 66.21 | 71.64 | 63.94 | 68.45 | 60.82 | 63.29 | 58.01 | 60.15 | 56.57 | 58.76 |
| 2gm, β | 70.34 | 75.91 | 66.4 | 71.77 | 62.56 | 68.6 | 60.15 | 63.25 | 58.23 | 60.96 | 57.11 | 59.17 |
| 2gm, γ | 69.98 | 76.24 | 66.14 | 72.56 | 63.62 | 69.14 | 59.92 | 63.91 | 58.66 | 60.27 | 56.23 | 58.62 |
| 2gm, δ | 70.16 | 76.38 | 65.92 | 72.89 | 63.87 | 69.76 | 60.8 | 64.24 | 58.52 | 60.71 | 57.51 | 58.83 |
| 2gm, ε | 69.42 | 76.98 | 66.74 | 73.13 | 64.02 | 70.04 | 60.23 | 64.73 | 58.06 | 61.98 | 56.92 | 59.11 |

Table 31. Transmittance of Acid Orange 74 (200 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 13.49 | 91.36 | 10.48 | 87.12 | 7.58 | 85.69 | 4.39 | 81.76 | 2.11 | 79.31 | 1.92 | 77.15 |
| **1gm** | 13.27 | 91.67 | 10.12 | 87.62 | 7.65 | 85.71 | 4.56 | 81.83 | 2.67 | 79.67 | 1.18 | 78.15 |
| **1.5gm** | 13.65 | 91.98 | 10.38 | 88.11 | 7.82 | 85.89 | 4.67 | 81.93 | 2.02 | 79.92 | 1.67 | 77.98 |
| **2gm** | 14.02 | 92.05 | 10.97 | 88.32 | 8.11 | 86.01 | 5.85 | 82.07 | 3.01 | 79.97 | 1.34 | 78.24 |

Table 32. Transmittance of Acid Orange 74 (150 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 28.13 | 93.42 | 24.11 | 90.21 | 19.46 | 88.02 | 15.22 | 85.31 | 12.07 | 83.25 | 9.18 | 79.26 |
| **1gm** | 28.79 | 93.64 | 24.65 | 90.72 | 19.72 | 88.46 | 15.28 | 85.62 | 12.24 | 83.48 | 9.24 | 79.29 |
| **1.5gm** | 28.91 | 93.98 | 24.97 | 90.81 | 19.98 | 88.95 | 15.75 | 85.72 | 12.79 | 83.73 | 9.37 | 79.86 |
| **2gm** | 29.24 | 94.07 | 25.02 | 91.24 | 20.01 | 89.78 | 16.11 | 86.01 | 12.83 | 84.21 | 8.85 | 79.92 |

Table 33. Transmittance of Acid Orange 74 (100 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 44.52 | 94.23 | 40.11 | 91.62 | 36.94 | 88.36 | 32.82 | 86.12 | 28.54 | 83.38 | 23.12 | 80.32 |
| **1gm** | 44.68 | 94.98 | 40.53 | 91.98 | 37.21 | 88.96 | 33.09 | 86.78 | 29.05 | 84.07 | 23.56 | 80.97 |
| **1.5gm** | 45.03 | 95.06 | 41.24 | 92.08 | 37.46 | 89.26 | 33.28 | 87.56 | 29.61 | 84.73 | 23.98 | 81.44 |
| **2gm** | 45.97 | 95.76 | 41.87 | 92.76 | 38.01 | 89.79 | 33.97 | 87.89 | 29.98 | 85.11 | 24.08 | 81.97 |

Table 34. Transmittance of Acid Orange 74 (50 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 13.49 | 70.02 | 10.48 | 65.13 | 7.58 | 62.07 | 4.39 | 57.89 | 2.11 | 53.15 | 1.92 | 49.68 |
| **1gm** | 13.27 | 70.24 | 10.12 | 65.15 | 7.65 | 62.09 | 4.56 | 57.96 | 2.67 | 53.67 | 1.18 | 49.79 |
| **1.5gm** | 13.65 | 70.91 | 10.38 | 66.02 | 7.82 | 62.84 | 4.67 | 58.72 | 2.02 | 53.78 | 1.67 | 50.76 |
| **2gm** | 14.02 | 71.67 | 10.97 | 66.71 | 8.11 | 62.91 | 5.85 | 58.85 | 3.01 | 54.01 | 1.34 | 50.23 |

Table 35. Transmittance of Acid Orange 74 (200 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 28.13 | 76.02 | 24.11 | 73.15 | 19.46 | 69.81 | 15.22 | 65.62 | 12.07 | 63.11 | 9.18 | 60.73 |
| **1gm** | 28.79 | 76.41 | 24.65 | 73.54 | 19.72 | 69.87 | 15.28 | 65.78 | 12.24 | 63.72 | 9.24 | 60.95 |
| **1.5gm** | 28.91 | 76.63 | 24.97 | 73.91 | 19.98 | 69.94 | 15.75 | 65.94 | 12.79 | 63.96 | 9.37 | 61.7 |
| **2gm** | 29.24 | 76.87 | 25.02 | 74.07 | 20.01 | 70.61 | 16.11 | 66.38 | 12.83 | 64.17 | 8.85 | 61.61 |

Table 36. Transmittance of Acid Orange 74 (150 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 35.16 | 79.45 | 30.27 | 75.42 | 26.84 | 71.29 | 23.29 | 68.64 | 18.62 | 65.12 | 12.14 | 61.89 |
| **1gm** | 35.19 | 79.49 | 30.31 | 75.53 | 26.41 | 71.91 | 23.17 | 68.79 | 18.17 | 65.31 | 12.69 | 61.93 |
| **1.5gm** | 35.06 | 79.87 | 30.62 | 75.68 | 27.09 | 72.04 | 23.84 | 68.93 | 18.24 | 65.46 | 12.15 | 62.24 |
| **2gm** | 35.24 | 80.24 | 29.45 | 76.01 | 26.84 | 72.32 | 23.49 | 69.17 | 18.63 | 65.72 | 11.97 | 62.47 |

Table 38. Transmittance of Acid Orange 74 (50 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 44.52 | 81.27 | 40.11 | 78.62 | 36.94 | 75.03 | 32.82 | 69.15 | 28.54 | 65.82 | 23.12 | 63.27 |
| **1gm** | 44.68 | 81.44 | 40.53 | 78.71 | 37.21 | 75.67 | 33.09 | 69.61 | 29.05 | 65.76 | 23.56 | 63.11 |
| **1.5gm** | 45.03 | 81.92 | 41.24 | 78.98 | 37.46 | 75.72 | 33.28 | 70.02 | 29.61 | 65.91 | 23.98 | 63.78 |
| **2gm** | 45.97 | 82.03 | 41.87 | 79.05 | 38.01 | 76.31 | 33.97 | 70.31 | 29.98 | 66.07 | 24.08 | 64.01 |

Table 39. Transmittance of Acid Orange 74 (200 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | BT | BT | AT | BT | AT | BT | AT |
| **2gm, α** | 13.49 | 52.17 | 10.48 | 46.72 | 7.58 | 43.81 | 4.39 | 39.28 | 2.11 | 36.15 | 1.92 | 33.29 |
| **2gm, β** | 13.27 | 52.25 | 10.12 | 46.91 | 7.65 | 43.92 | 4.56 | 39.6 | 2.67 | 36.42 | 1.18 | 33.64 |
| **2gm, γ** | 13.65 | 52.34 | 10.38 | 47.28 | 7.82 | 44.71 | 4.67 | 39.71 | 2.02 | 36.47 | 1.67 | 33.72 |
| **2gm, δ** | 14.02 | 52.98 | 10.97 | 47.35 | 8.11 | 44.79 | 5.85 | 40.32 | 3.01 | 36.85 | 1.34 | 34.13 |
| **2gm, ε** | 14.62 | 53.27 | 10.41 | 47.64 | 8.27 | 44.83 | 5.94 | 40.54 | 3.14 | 37.13 | 1.56 | 34.28 |

Table 40. Transmittance of Acid Orange 74 (150 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **2gm, α** | 28.13 | 65.15 | 24.11 | 62.34 | 19.46 | 59.73 | 15.22 | 56.02 | 12.07 | 52.19 | 9.18 | 48.07 |
| **2gm, β** | 28.79 | 65.72 | 24.65 | 62.39 | 19.72 | 59.78 | 15.28 | 56.37 | 12.24 | 53.12 | 9.24 | 48.38 |
| **2gm, γ** | 28.91 | 65.98 | 24.97 | 62.72 | 19.98 | 60.29 | 15.75 | 56.64 | 12.79 | 53.17 | 9.37 | 48.65 |
| **2gm, δ** | 29.24 | 66.24 | 25.02 | 62.94 | 20.01 | 60.48 | 16.11 | 56.91 | 12.83 | 53.62 | 8.85 | 48.92 |
| **2gm, ε** | 28.71 | 66.77 | 25.67 | 63.17 | 20.23 | 60.9 | 15.97 | 57.88 | 12.65 | 53.69 | 8.34 | 49.01 |

Table 41. Transmittance of Acid Orange 74 (100 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **2gm, α** | 35.16 | 70.56 | 30.27 | 67.28 | 26.84 | 63.11 | 23.29 | 60.46 | 18.62 | 57.29 | 12.14 | 53.28 |
| **2gm, β** | 35.19 | 70.69 | 30.31 | 67.34 | 26.41 | 63.27 | 23.17 | 60.54 | 18.17 | 57.34 | 12.69 | 53.39 |
| **2gm, γ** | 35.06 | 70.78 | 30.62 | 67.56 | 27.09 | 63.46 | 23.84 | 60.73 | 18.24 | 57.49 | 12.15 | 53.64 |
| **2gm, δ** | 35.24 | 70.94 | 29.45 | 67.72 | 26.84 | 63.81 | 23.49 | 60.92 | 18.63 | 57.88 | 11.97 | 54.01 |
| **2gm, ε** | 35.17 | 71.09 | 29.28 | 67.83 | 26.97 | 64.16 | 24.08 | 61.18 | 18.74 | 58.04 | 12.11 | 54.28 |

Table 42. Transmittance of Acid Orange 74 (50 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **2gm, α** | 44.52 | 73.24 | 40.11 | 70.17 | 36.94 | 66.28 | 32.82 | 64.13 | 28.54 | 60.35 | 23.12 | 57.97 |
| **2gm, β** | 44.68 | 73.87 | 40.53 | 70.34 | 37.21 | 66.92 | 33.09 | 64.47 | 29.05 | 60.72 | 23.56 | 57.68 |
| **2gm, γ** | 45.03 | 73.15 | 41.24 | 70.47 | 37.46 | 66.78 | 33.28 | 64.92 | 29.61 | 60.86 | 23.98 | 58.15 |
| **2gm, δ** | 45.97 | 73.98 | 41.87 | 71.29 | 38.01 | 67.15 | 33.97 | 65.78 | 29.98 | 61.29 | 24.08 | 58.29 |
| **2gm, ε** | 45.15 | 74.03 | 41.56 | 71.47 | 37.87 | 67.34 | 32.91 | 65.89 | 28.72 | 61.36 | 24.69 | 58.62 |

Table 43. Transmittance of Disperse Blue 14 (1000 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 66.32 | 95.32 | 63.21 | 94.12 | 60.81 | 93.62 | 58.27 | 92.52 | 55.31 | 91.51 | 53.12 | 90.17 |
| **1gm** | 66.15 | 95.39 | 63.29 | 94.24 | 60.9 | 93.99 | 58.54 | 92.67 | 55.11 | 92.01 | 53.18 | 90.29 |
| **1.5gm** | 66.27 | 95.46 | 63.2 | 94.35 | 60.76 | 94.03 | 58.63 | 92.69 | 55.34 | 92.14 | 53.97 | 90.84 |
| **2gm** | 66.58 | 95.63 | 63.15 | 94.67 | 60.82 | 94.17 | 58.72 | 92.98 | 55.37 | 92.37 | 53.64 | 91.17 |

Table 44. Transmittance of Disperse Blue 14 (750 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| 0.5gm | 71.24 | 97.27 | 68.26 | 96.12 | 65.31 | 95.65 | 62.38 | 94.24 | 60.11 | 93.23 | 57.16 | 92.17 |
| 1gm | 71.35 | 97.34 | 68.15 | 96.34 | 66.03 | 95.74 | 62.54 | 94.33 | 60.19 | 93.67 | 58.34 | 92.19 |
| 1.5gm | 71.67 | 97.56 | 68.24 | 96.67 | 66.11 | 95.81 | 62.83 | 94.45 | 60.03 | 93.72 | 57.65 | 92.78 |
| 2gm | 71.72 | 97.17 | 67.97 | 96.88 | 65.96 | 95.93 | 63.07 | 94.78 | 59.93 | 94.03 | 57.88 | 92.97 |

Table 45. Transmittance of Disperse Blue 14 (500 ppm) with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| 0.5gm | 82.15 | 98.24 | 79.24 | 97.03 | 76.17 | 96.45 | 73.29 | 95.33 | 70.04 | 94.11 | 68.27 | 93.67 |
| 1gm | 82.24 | 98.56 | 79.35 | 97.27 | 76.25 | 96.56 | 73.33 | 95.42 | 70.15 | 94.26 | 69.15 | 93.69 |
| 1.5gm | 82.39 | 98.71 | 79.51 | 97.54 | 76.38 | 96.77 | 73.01 | 95.54 | 69.87 | 94.38 | 68.21 | 93.73 |
| 2gm | 82.68 | 98.86 | 79.77 | 97.81 | 77.71 | 96.98 | 73.05 | 95.79 | 70.34 | 94.6 | 68.76 | 94.01 |

Table 46. Transmittance of Disperse Blue 14 (250 ppm)with activated carbon

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| 0.5gm | 77.12 | 98.15 | 74.27 | 97.36 | 70.24 | 95.39 | 67.17 | 94.35 | 64.32 | 93.88 | 61.83 | 92.46 |
| 1gm | 77.23 | 98.24 | 74.18 | 97.45 | 69.98 | 95.35 | 67.73 | 94.67 | 64.35 | 93.91 | 61.72 | 92.51 |
| 1.5gm | 77.02 | 98.71 | 74.92 | 97.53 | 70.25 | 95.72 | 67.54 | 94.69 | 64.48 | 94.15 | 61.98 | 92.67 |
| 2gm | 77.15 | 98.92 | 74.15 | 97.78 | 70.21 | 95.98 | 67.46 | 95.02 | 64.71 | 94.34 | 62.01 | 92.98 |

Table 47. Transmittance of Disperse Blue 14 (1000 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 66.32 | 89.76 | 63.21 | 88.15 | 60.81 | 87.24 | 58.27 | 86.18 | 55.31 | 85.07 | 53.12 | 83.24 |
| **1gm** | 66.15 | 89.85 | 63.29 | 88.87 | 60.9 | 87.37 | 58.54 | 86.62 | 55.11 | 85.12 | 53.18 | 83.46 |
| **1.5gm** | 66.27 | 89.92 | 63.2 | 89.02 | 60.76 | 87.48 | 58.63 | 86.97 | 55.34 | 85.29 | 53.97 | 83.58 |
| **2gm** | 66.58 | 90.01 | 63.15 | 89.29 | 60.82 | 87.91 | 58.72 | 87.16 | 55.37 | 85.81 | 53.64 | 83.73 |

Table 48. Transmittance of Disperse Blue 14 (750 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 71.24 | 92.86 | 68.26 | 91.62 | 65.31 | 90.48 | 62.38 | 89.63 | 60.11 | 88.44 | 57.16 | 87.15 |
| **1gm** | 71.35 | 92.91 | 68.15 | 91.68 | 66.03 | 90.57 | 62.54 | 89.76 | 60.19 | 88.63 | 58.34 | 87.34 |
| **1.5gm** | 71.67 | 92.98 | 68.24 | 91.92 | 66.11 | 90.69 | 62.83 | 89.95 | 60.03 | 88.86 | 57.65 | 87.49 |
| **2gm** | 71.72 | 93.16 | 67.97 | 92.09 | 65.96 | 90.87 | 63.07 | 90.02 | 59.93 | 89.18 | 57.88 | 88.01 |

Table 49. Transmittance of Disperse Blue 14 (500 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **0.5gm** | 77.12 | 95.48 | 74.27 | 94.12 | 70.24 | 93.29 | 67.17 | 91.96 | 64.32 | 90.08 | 61.83 | 89.99 |
| **1gm** | 77.23 | 95.56 | 74.18 | 94.38 | 69.98 | 93.58 | 67.73 | 92.19 | 64.35 | 90.82 | 61.72 | 89.86 |
| **1.5gm** | 77.02 | 95.81 | 74.92 | 94.39 | 70.25 | 93.73 | 67.54 | 92.27 | 64.48 | 91.09 | 61.98 | 90.15 |
| **2gm** | 77.15 | 95.97 | 74.15 | 94.99 | 70.21 | 94.09 | 67.46 | 92.56 | 64.71 | 91.16 | 62.01 | 90.21 |

Table 50. Transmittance of Disperse Blue 14 (250 ppm) with orange peel

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **0.5gm** | 82.15 | 97.26 | 79.24 | 96.14 | 76.17 | 95.07 | 73.29 | 94.11 | 70.04 | 93.24 | 68.27 | 91.17 |
| **1gm** | 82.24 | 97.34 | 79.35 | 96.35 | 76.25 | 95.18 | 73.33 | 94.37 | 70.15 | 93.37 | 69.15 | 91.89 |
| **1.5gm** | 82.39 | 97.56 | 79.51 | 96.81 | 76.38 | 95.29 | 73.01 | 94.92 | 69.87 | 93.78 | 68.21 | 92.21 |
| **2gm** | 82.68 | 97.83 | 79.77 | 97.02 | 77.71 | 95.88 | 73.05 | 95.18 | 70.34 | 93.94 | 68.76 | 92.43 |

Table 51. Transmittance of Disperse Blue 14 (1000 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **2gm, α** | 66.32 | 71.63 | 63.21 | 68.39 | 60.81 | 66.16 | 58.27 | 63.28 | 55.31 | 59.17 | 53.12 | 58.24 |
| **2gm, β** | 66.15 | 71.78 | 63.29 | 68.73 | 60.9 | 66.25 | 58.54 | 63.37 | 55.11 | 59.28 | 53.18 | 58.37 |
| **2gm, γ** | 66.27 | 71.92 | 63.2 | 69.21 | 60.76 | 66.57 | 58.63 | 63.49 | 55.34 | 59.37 | 53.97 | 58.63 |
| **2gm, δ** | 66.58 | 72.03 | 63.15 | 69.34 | 60.82 | 66.98 | 58.72 | 63.52 | 55.37 | 59.46 | 53.64 | 58.74 |
| **2gm, ε** | 67.39 | 72.24 | 62.14 | 69.45 | 61.03 | 67.05 | 59.15 | 63.84 | 55.49 | 59.85 | 53.96 | 58.95 |

Table 52. Transmittance of Disperse Blue 14 (750 ppm) with peanut hull

| Absorbent Dosage | Transmittance (%) values with varying concentration of sugar wastewater | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100ppm of Sugar wasterwater | | 200ppm of Sugar wasterwater | | 300ppm of Sugar wasterwater | | 400ppm of Sugar wasterwater | | 500ppm of Sugar wasterwater | | 600ppm of Sugar wasterwater | |
| | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT | BT | AT |
| **2gm, α** | 71.24 | 75.16 | 68.26 | 73.29 | 65.31 | 71.28 | 62.38 | 69.66 | 60.11 | 66.12 | 57.16 | 63.28 |
| **2gm, β** | 71.35 | 75.24 | 68.15 | 73.42 | 66.03 | 71.62 | 62.54 | 69.73 | 60.19 | 66.39 | 58.34 | 63.29 |
| **2gm, γ** | 71.67 | 75.37 | 68.24 | 73.57 | 66.11 | 71.93 | 62.83 | 69.88 | 60.03 | 66.53 | 57.65 | 63.42 |
| **2gm, δ** | 71.72 | 75.92 | 67.97 | 73.3 | 65.96 | 72.09 | 63.07 | 70.21 | 59.93 | 66.83 | 57.88 | 63.57 |
| **2gm, ε** | 72.01 | 76.03 | 68.42 | 73.92 | 65.16 | 72.16 | 63.29 | 70.36 | 59.15 | 67.06 | 57.62 | 63.81 |

Table 53. Transmittance of Disperse Blue 14 (500 ppm) with peanut hull

| **Absorbent Dosage** | **Transmittance (%) values with varying concentration of sugar wastewater** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **100ppm of Sugar wasterwater** | | **200ppm of Sugar wasterwater** | | **300ppm of Sugar wasterwater** | | **400ppm of Sugar wasterwater** | | **500ppm of Sugar wasterwater** | | **600ppm of Sugar wasterwater** | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **2gm, α** | 77.12 | 74.28 | 74.27 | 72.91 | 70.24 | 69.1 | 67.17 | 65.76 | 64.32 | 63.29 | 61.83 | 60.16 |
| **2gm, β** | 77.23 | 74.39 | 74.18 | 72.98 | 69.98 | 69.43 | 67.73 | 65.83 | 64.35 | 63.42 | 61.72 | 60.24 |
| **2gm, γ** | 77.02 | 74.86 | 74.92 | 73.07 | 70.25 | 69.64 | 67.54 | 65.88 | 64.48 | 63.58 | 61.98 | 60.38 |
| **2gm, δ** | 77.15 | 75.24 | 74.15 | 73.16 | 70.21 | 69.88 | 67.46 | 65.92 | 64.71 | 63.91 | 62.01 | 60.55 |
| **2gm, ε** | 77.13 | 75.37 | 74.03 | 73.25 | 70.8 | 69.91 | 67.84 | 66.13 | 65.02 | 63.74 | 61.66 | 61.08 |

Table 54. Transmittance of Disperse Blue 14 (250 ppm) with peanut hull

| **Absorbent Dosage** | **Transmittance (%) values with varying concentration of sugar wastewater** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **100ppm of Sugar wasterwater** | | **200ppm of Sugar wasterwater** | | **300ppm of Sugar wasterwater** | | **400ppm of Sugar wasterwater** | | **500ppm of Sugar wasterwater** | | **600ppm of Sugar wasterwater** | |
| | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** | **BT** | **AT** |
| **2gm, α** | 82.15 | 78.29 | 79.24 | 77.46 | 76.17 | 75.69 | 73.29 | 72.62 | 70.04 | 69.17 | 68.27 | 67.82 |
| **2gm, β** | 82.24 | 78.36 | 79.35 | 77.52 | 76.25 | 75.72 | 73.33 | 72.85 | 70.15 | 69.21 | 69.15 | 67.91 |
| **2gm, γ** | 82.39 | 78.42 | 79.51 | 77.83 | 76.38 | 75.83 | 73.01 | 72.93 | 69.87 | 69.26 | 68.21 | 67.97 |
| **2gm, δ** | 82.68 | 78.9 | 79.77 | 77.91 | 77.71 | 75.95 | 73.05 | 72.97 | 70.34 | 69.38 | 68.76 | 68.03 |
| **2gm, ε** | 82.64 | 78.67 | 79.28 | 78.06 | 76.97 | 75.98 | 73.24 | 73.01 | 70.69 | 69.54 | 68.78 | 68.17 |

## APPENDIX B : FIGURES

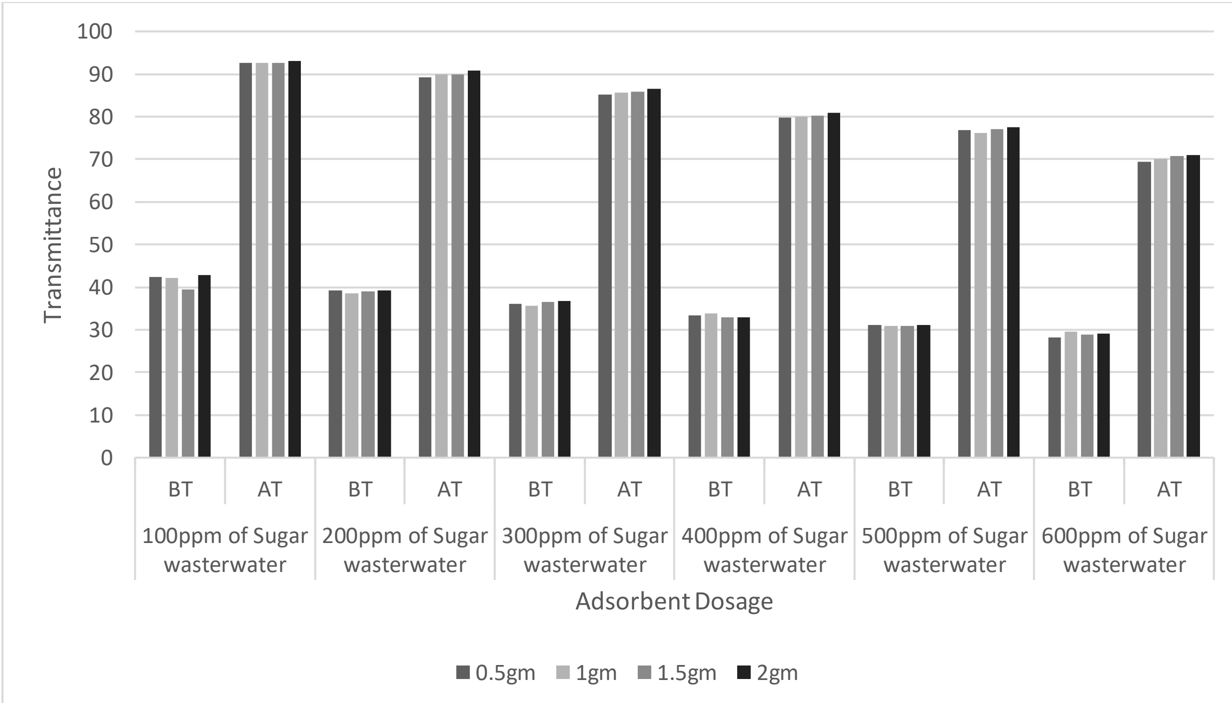


Figure 7. Transmittance of Naphthol Green B (200 ppm) with activated carbon

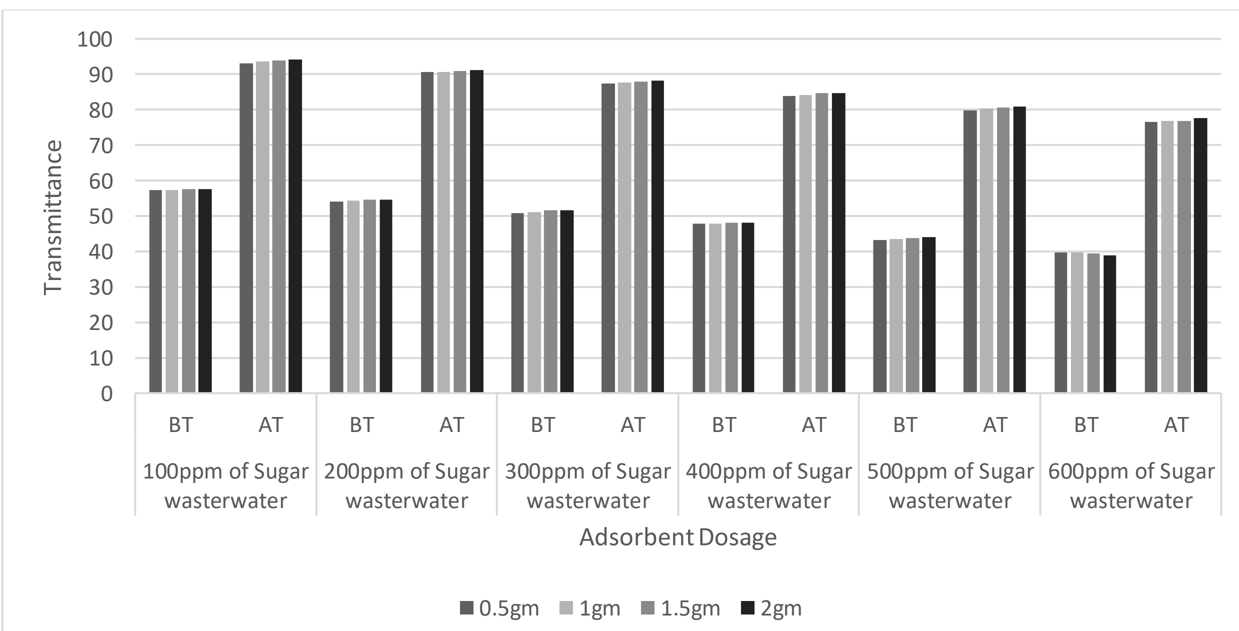


Figure 8. Transmittance of Naphthol Green B (150 ppm) with activated carbon

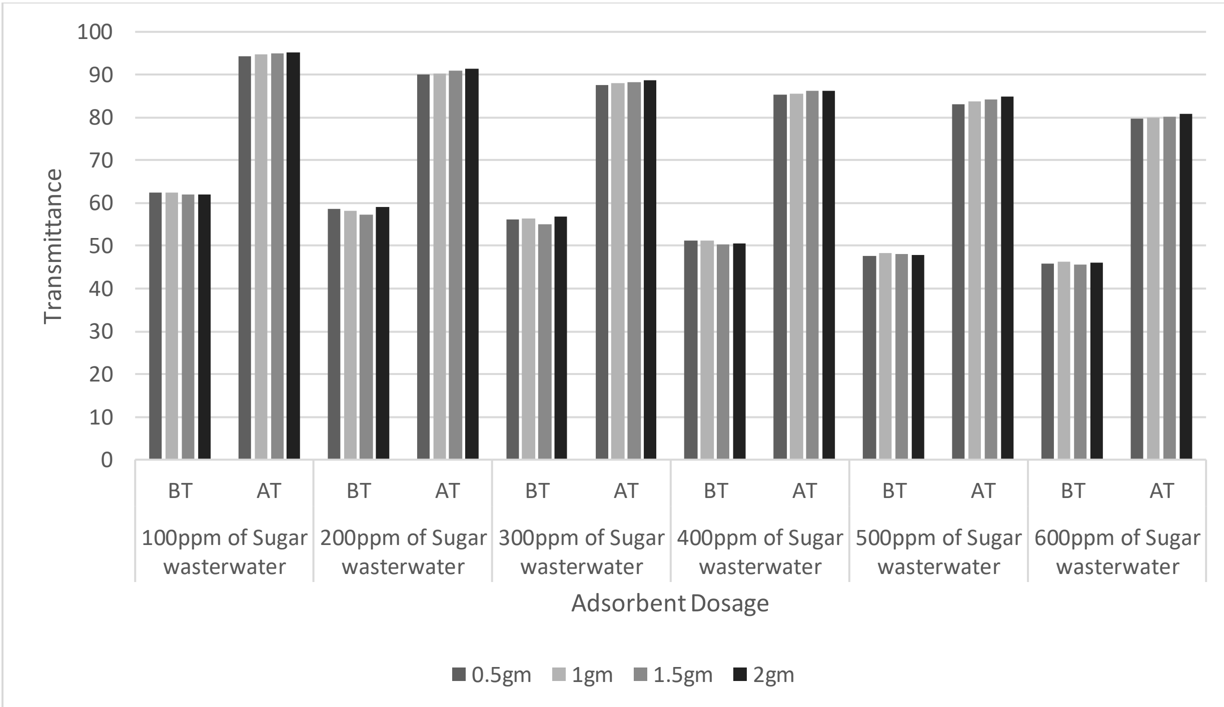


Figure 9. Transmittance of Naphthol Green B (100 ppm) with activated carbon

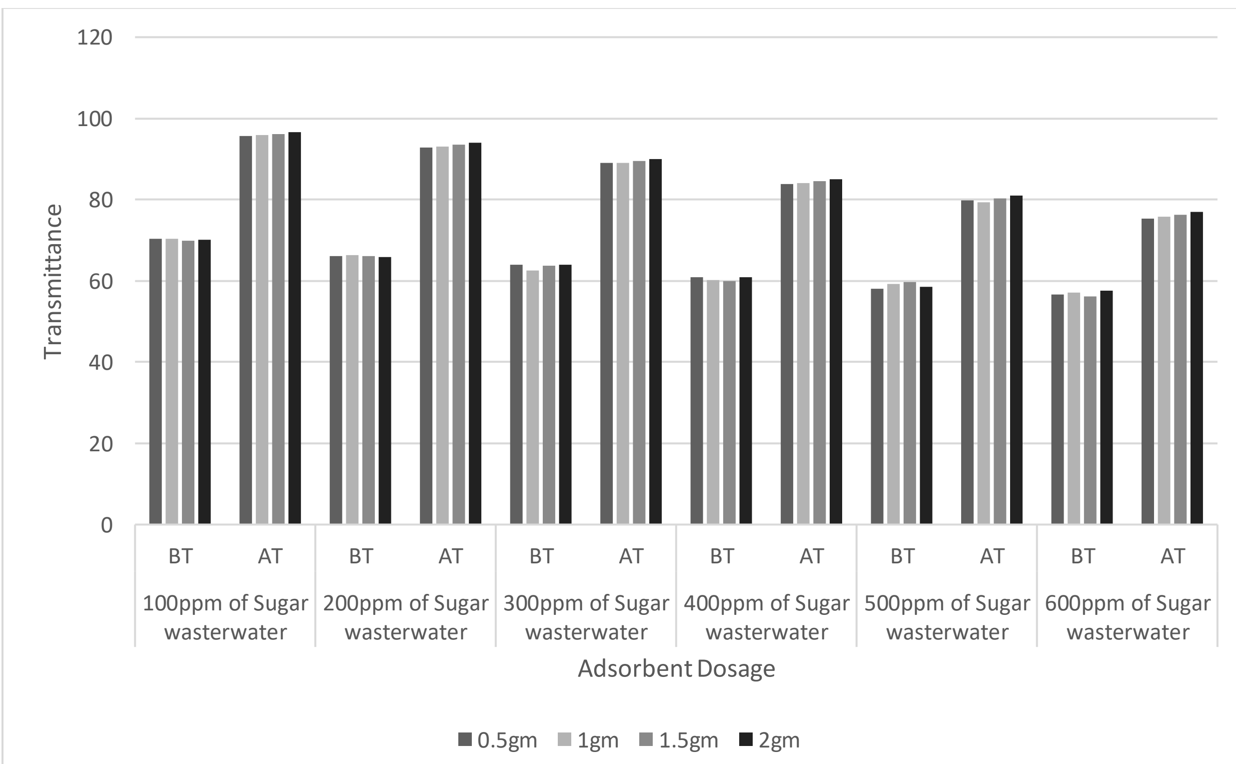


Figure 10. Transmittance of Naphthol Green B (50 ppm) with activated carbon

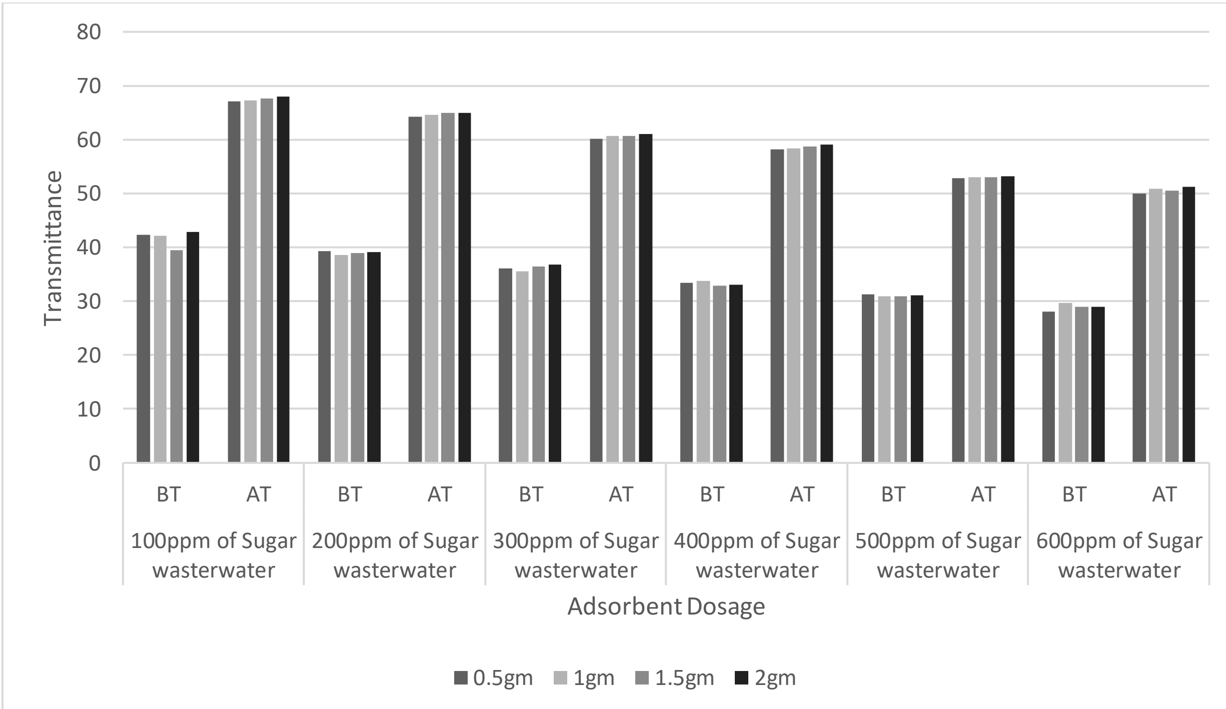


Figure 11. Transmittance of Naphthol Green B (200 ppm) with orange peel

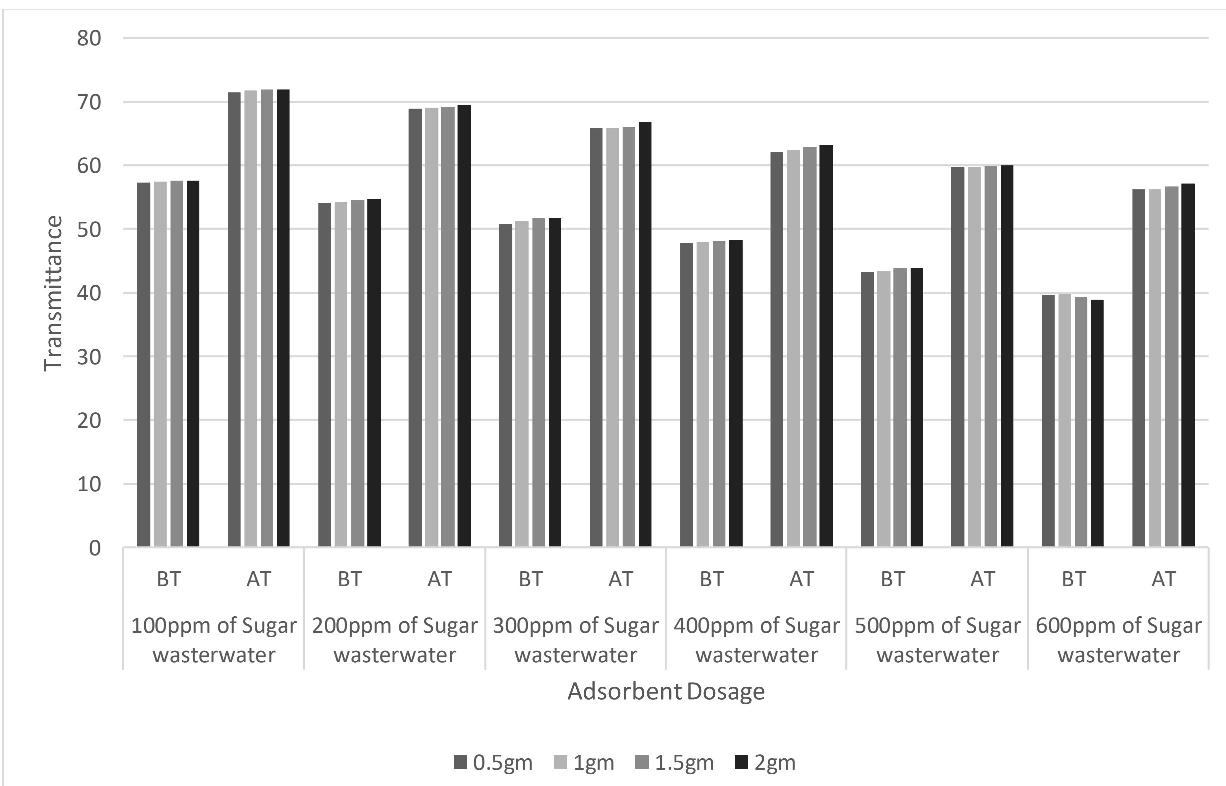


Figure 12. Transmittance of Naphthol Green B (150 ppm) with orange peel

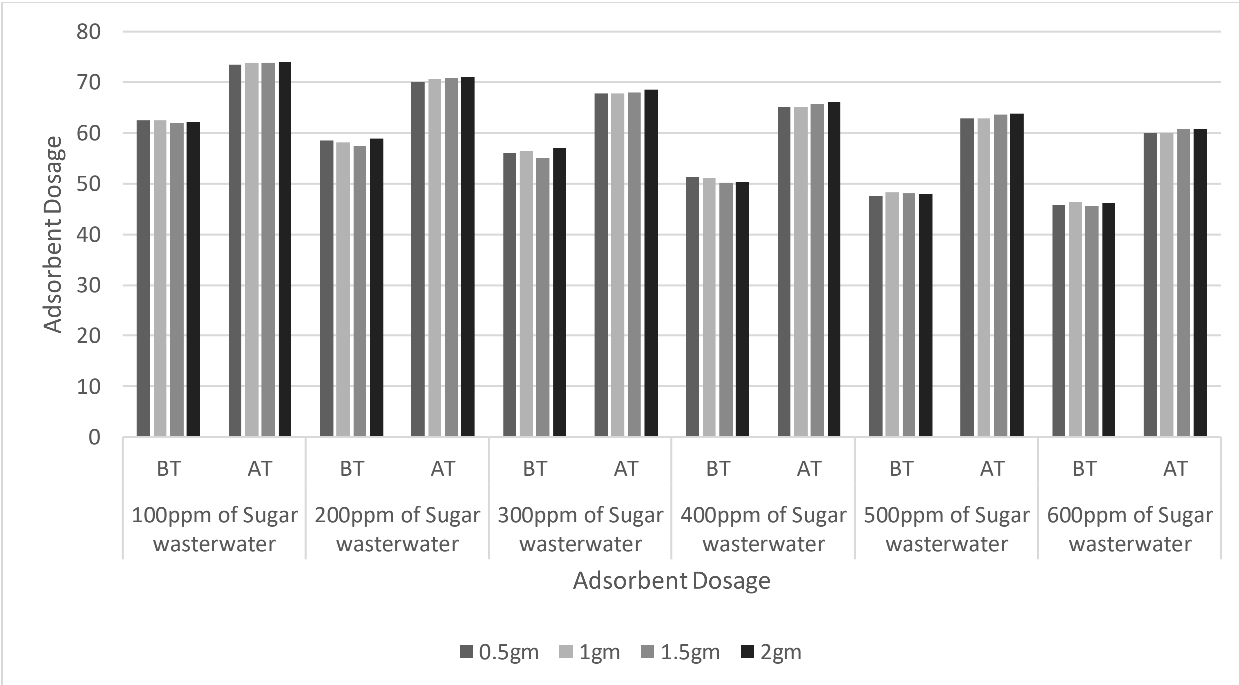


Figure 13. Transmittance of Naphthol Green B (100 ppm) with orange peel

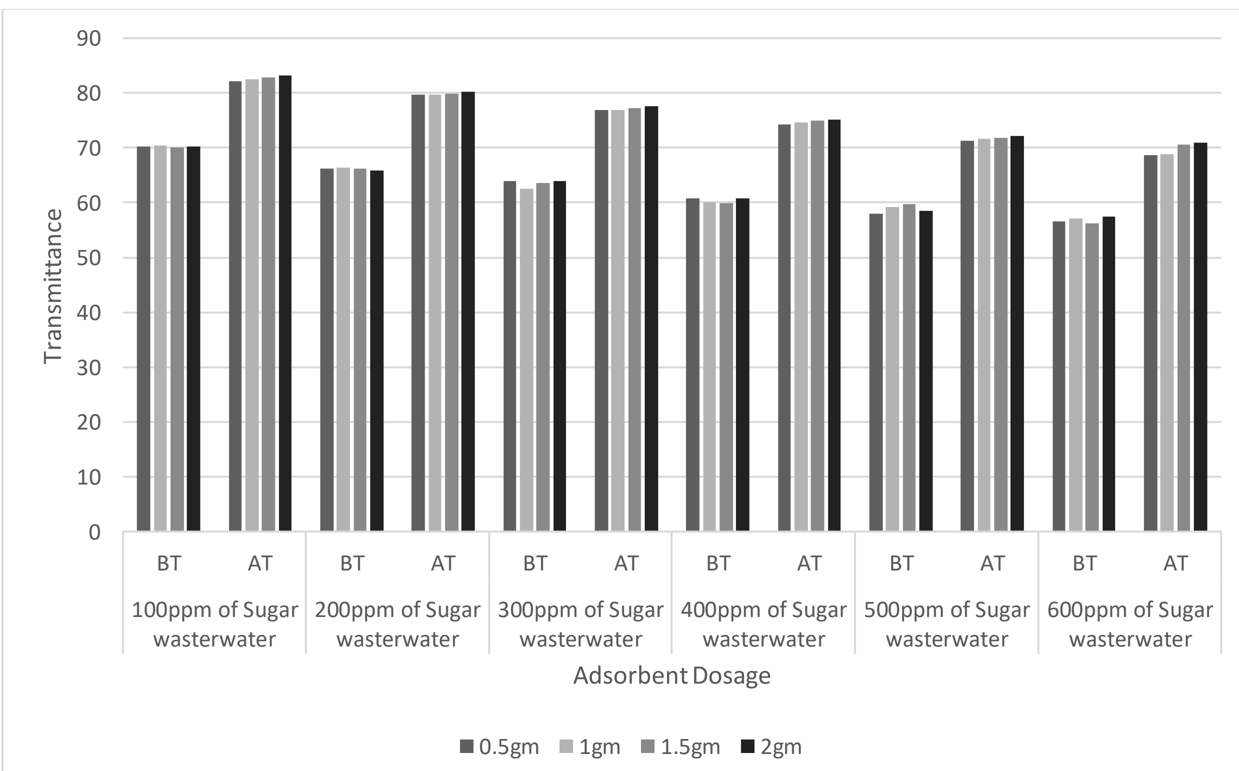


Figure 14. Transmittance of Naphthol Green B (50 ppm) with orange peel

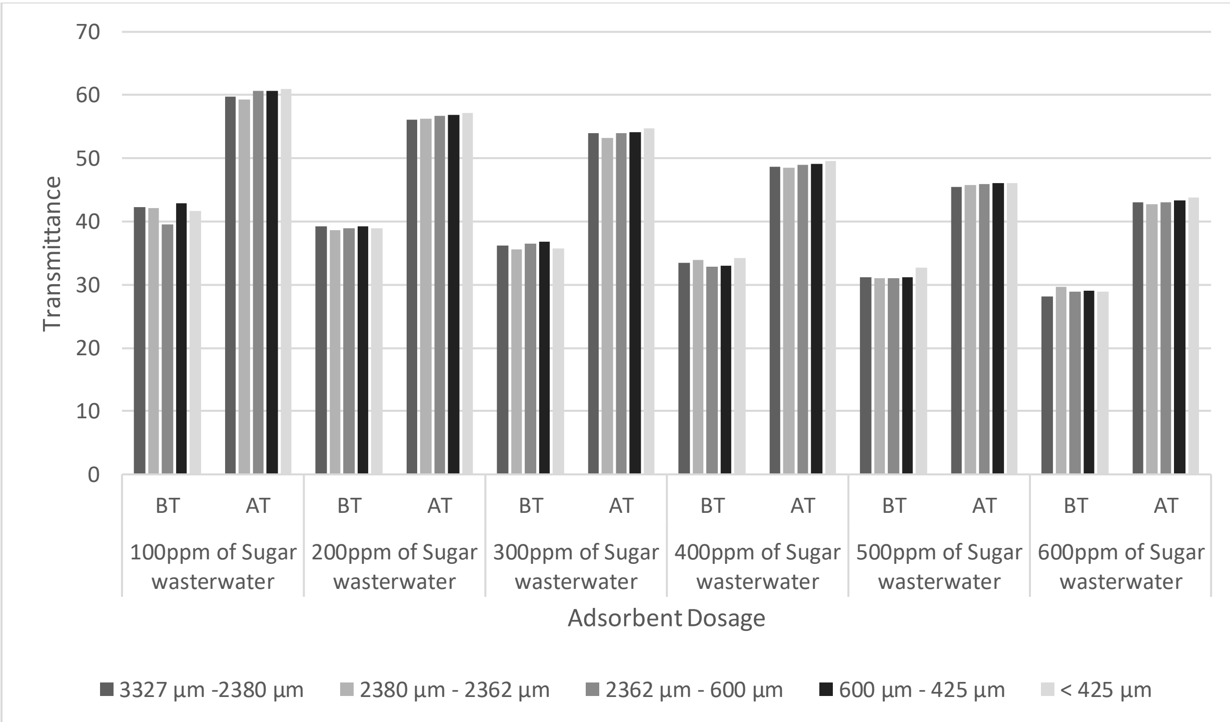


Figure 15. Transmittance of Naphthol Green B (200 ppm) with peanut hull

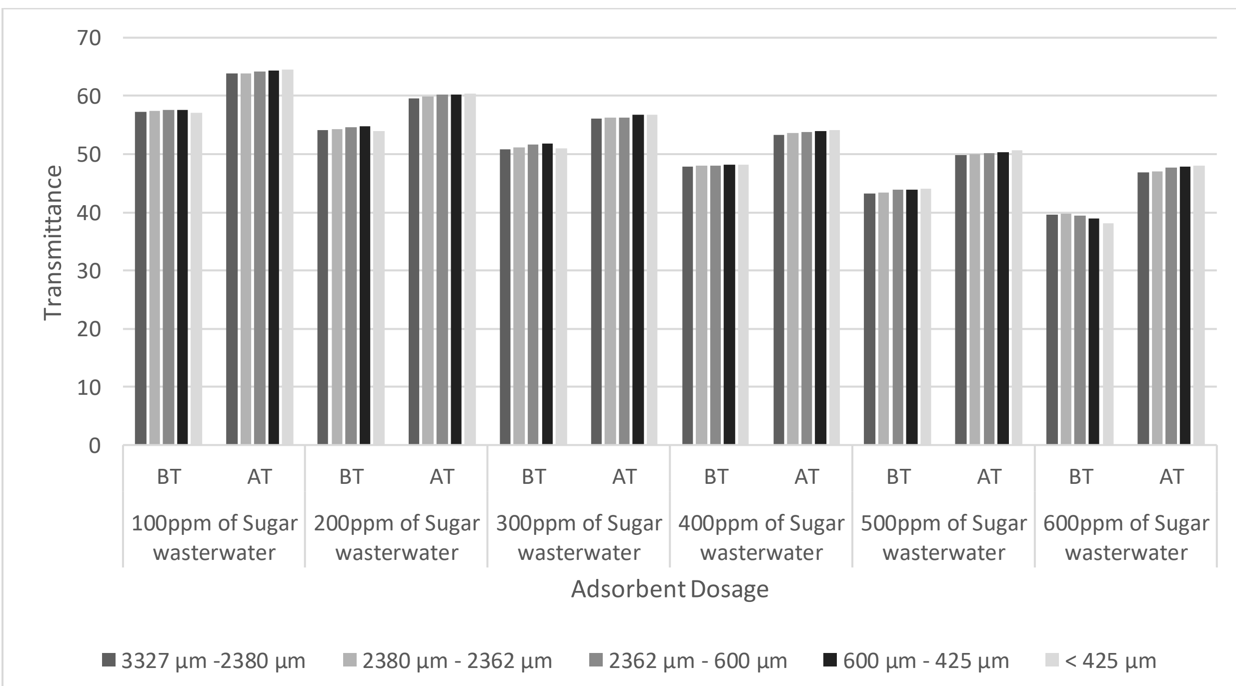


Figure 16. Transmittance of Naphthol Green B (150 ppm) with peanut hull

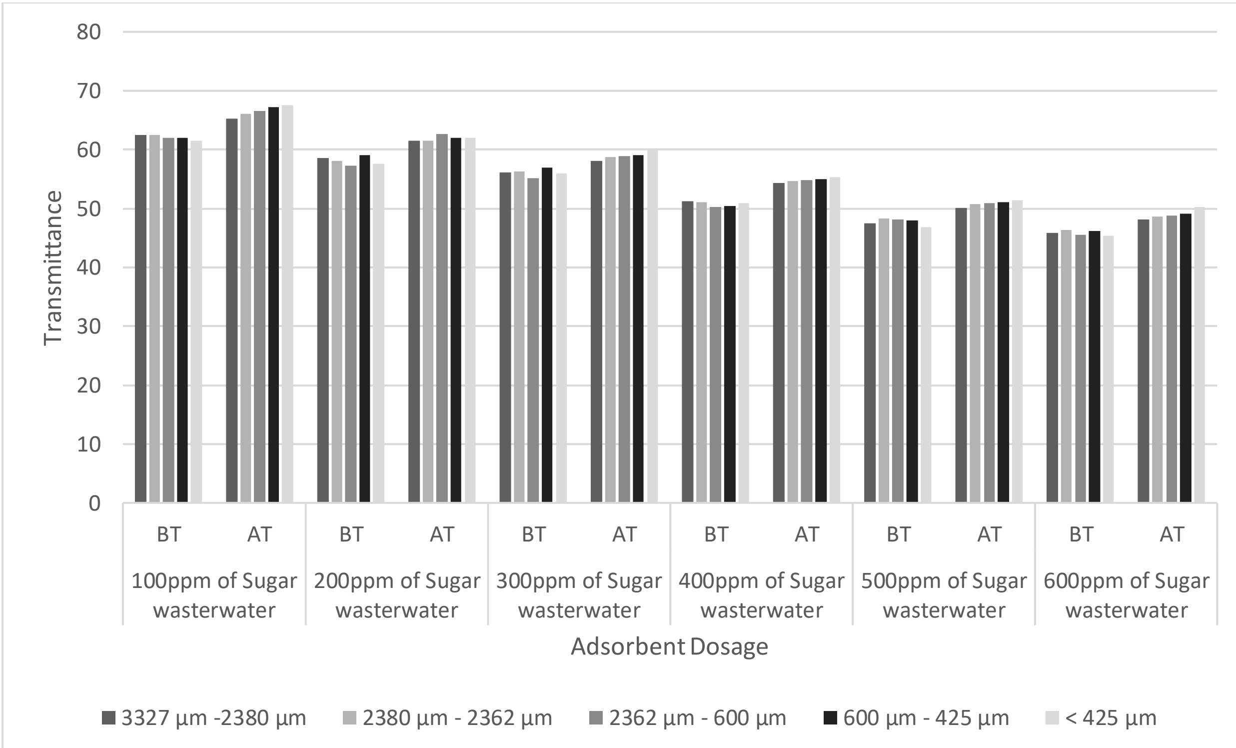


Figure 17. Transmittance of Naphthol Green B (100 ppm) with peanut hull

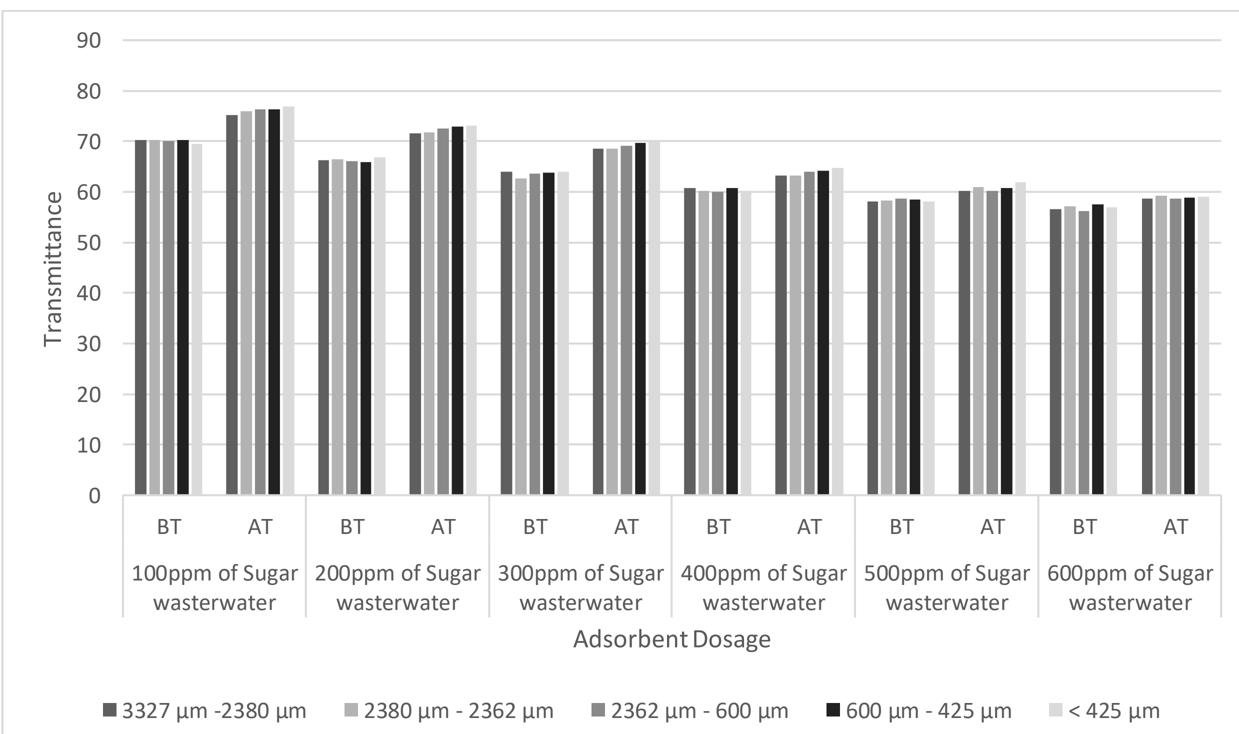


Figure 18. Transmittance of Naphthol Green B (50 ppm) with peanut hull

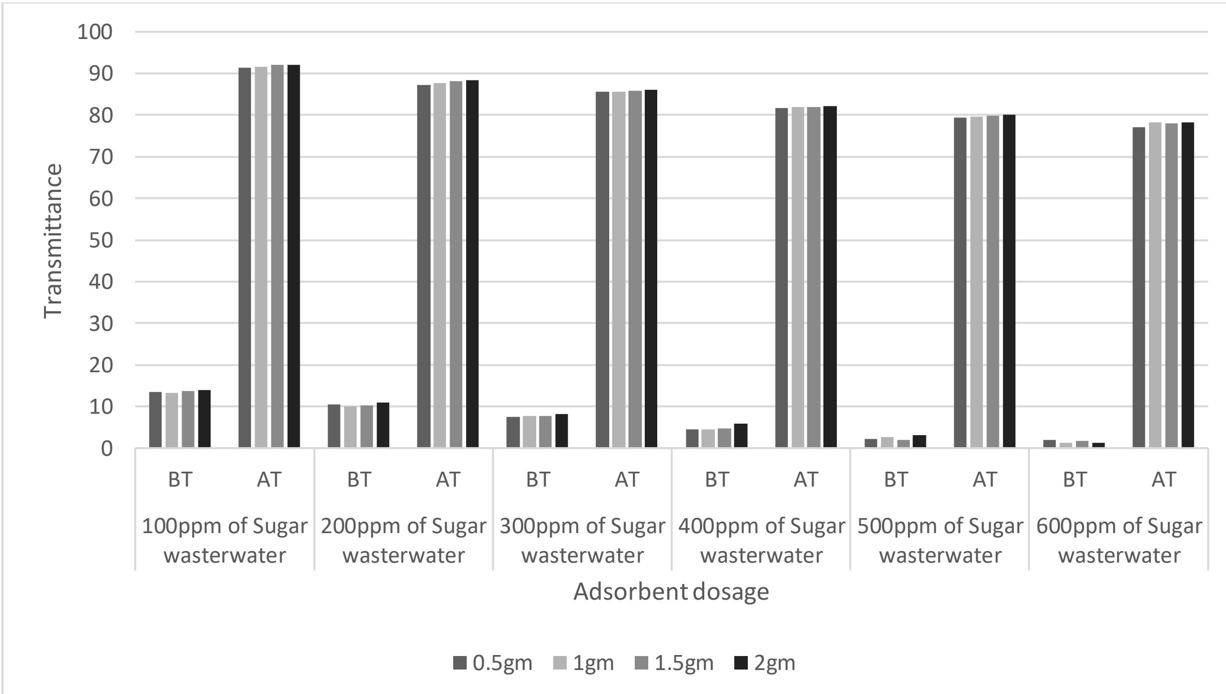


Figure 19. Transmittance of Acid Orange 74 (200 ppm) with activated carbon

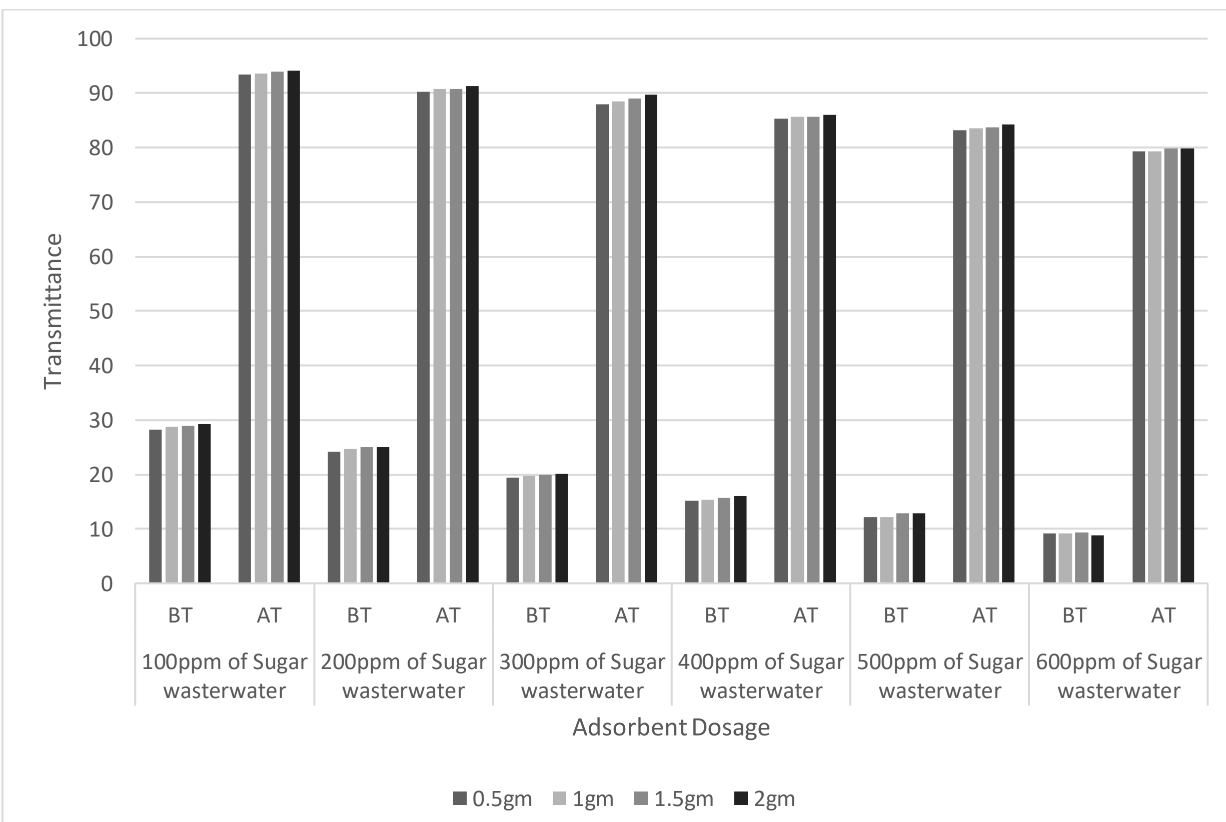


Figure 20. Transmittance of Acid Orange 74 (150 ppm) with activated carbon

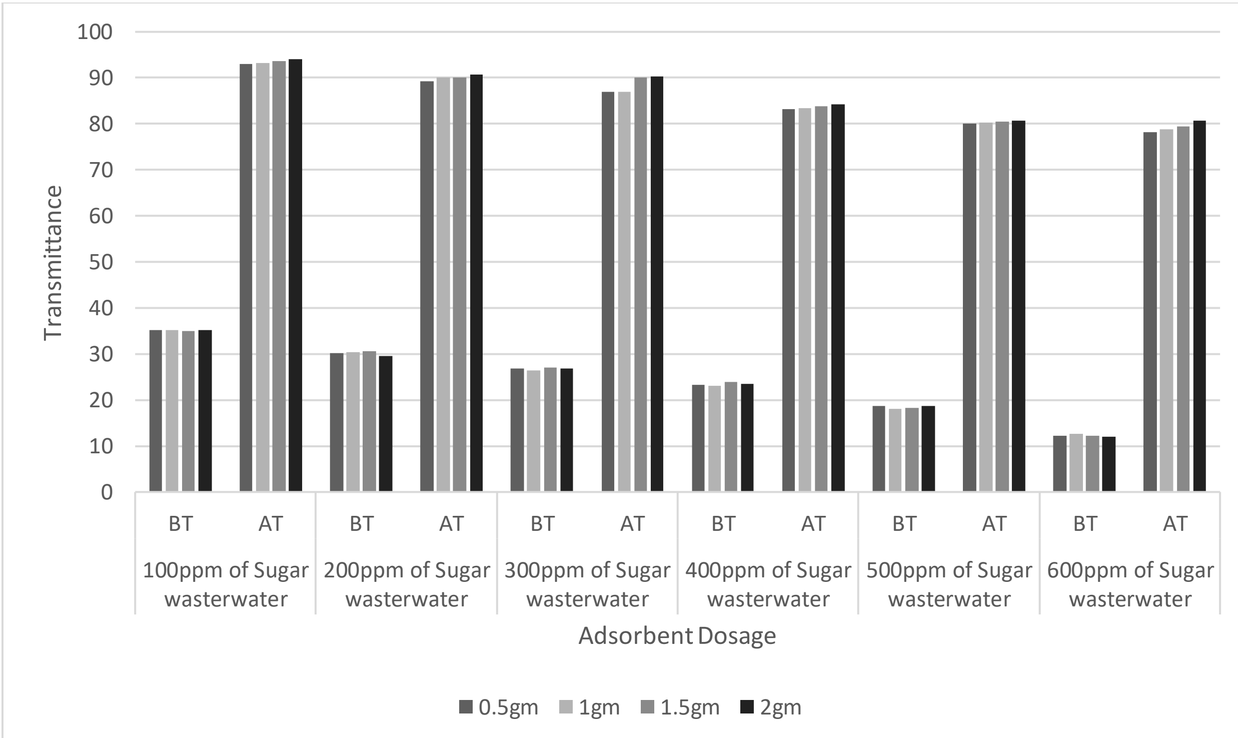


Figure 21. Transmittance of Acid Orange 74 (100 ppm) with activated carbon

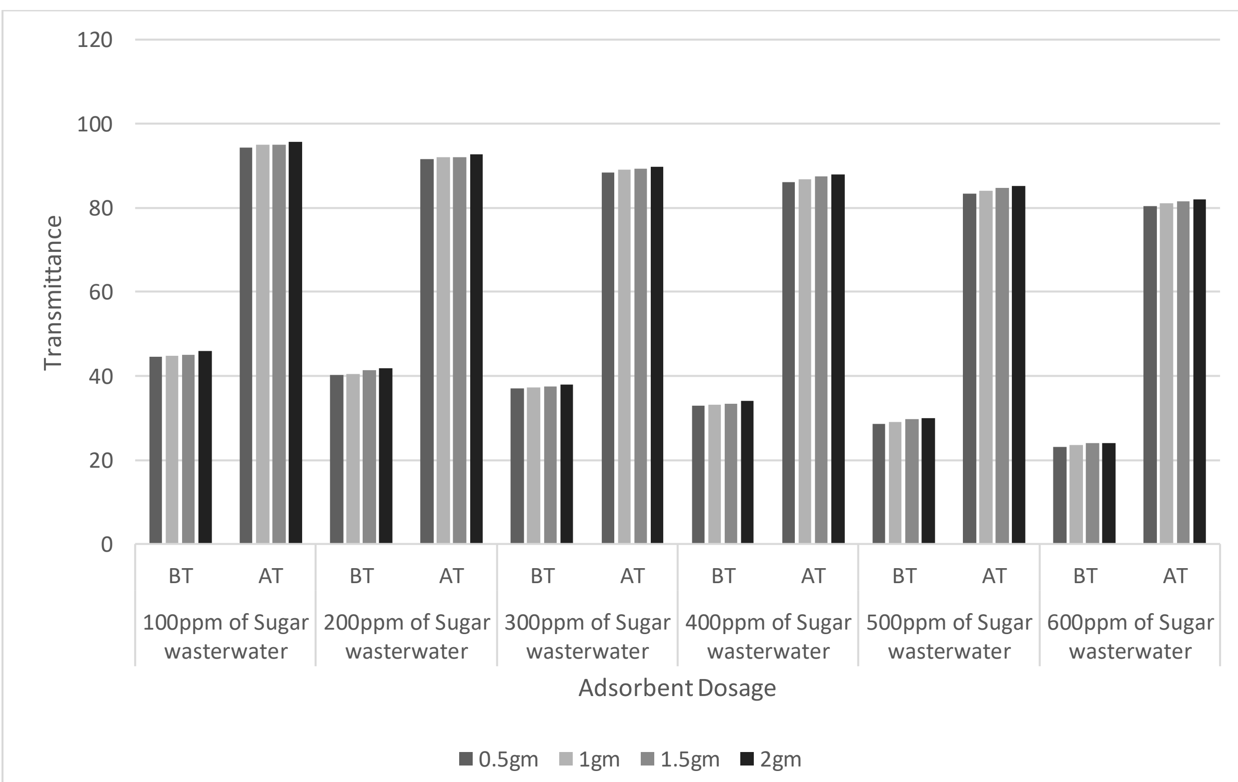


Figure 22. Transmittance of Acid Orange 74 (50 ppm) with activated carbon

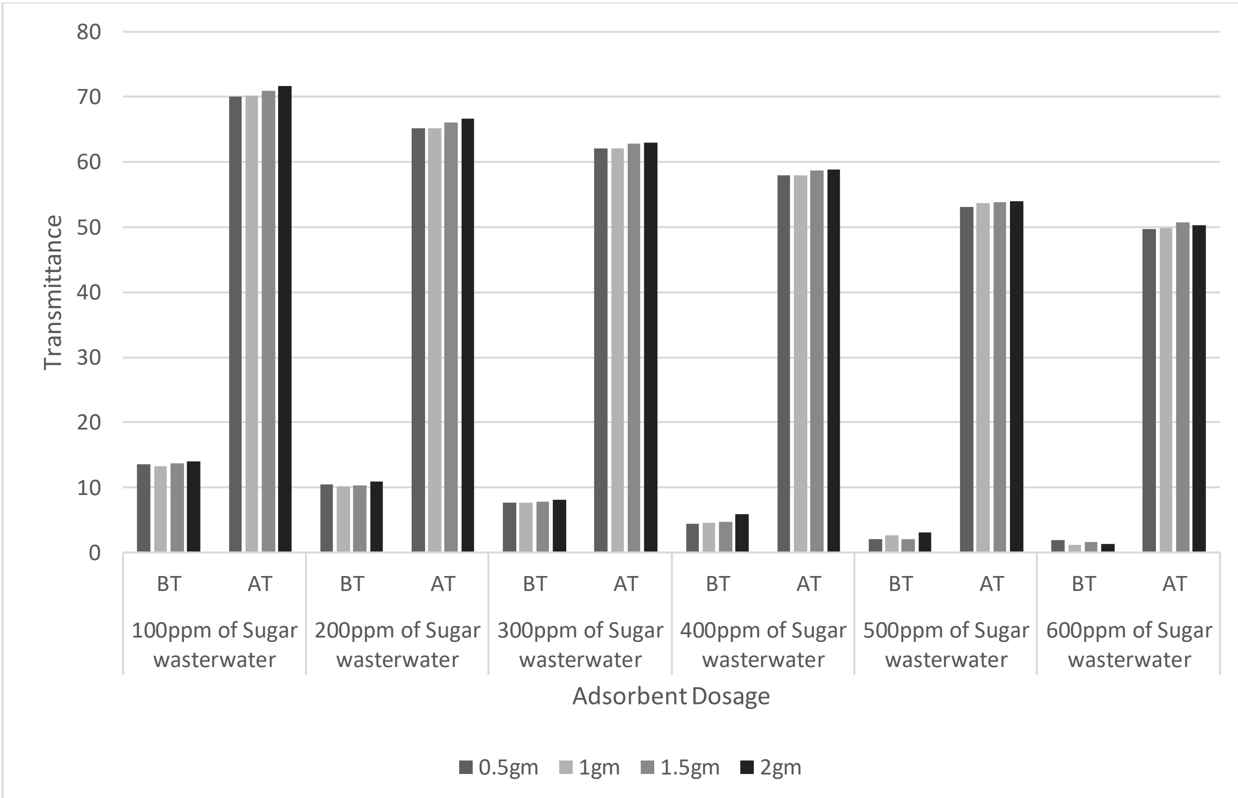


Figure 23. Transmittance of Acid Orange 74 (200 ppm) with orange peel

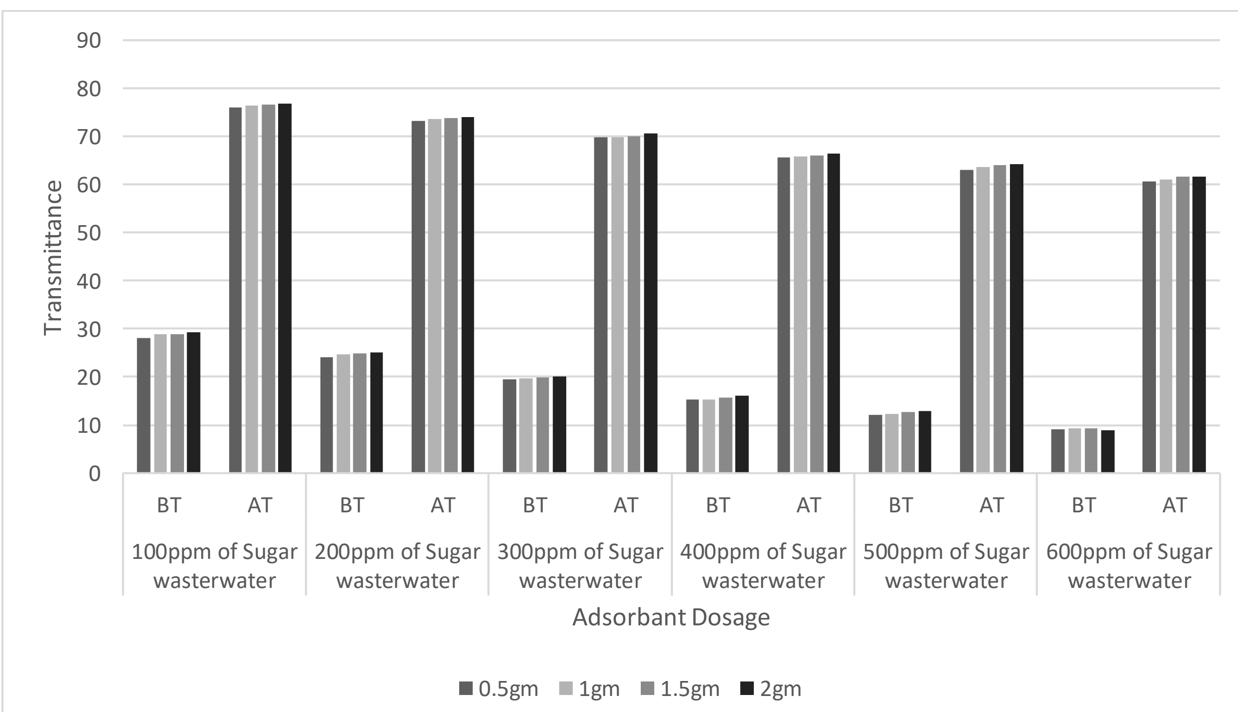


Figure 24. Transmittance of Acid Orange 74 (150 ppm) with orange peel

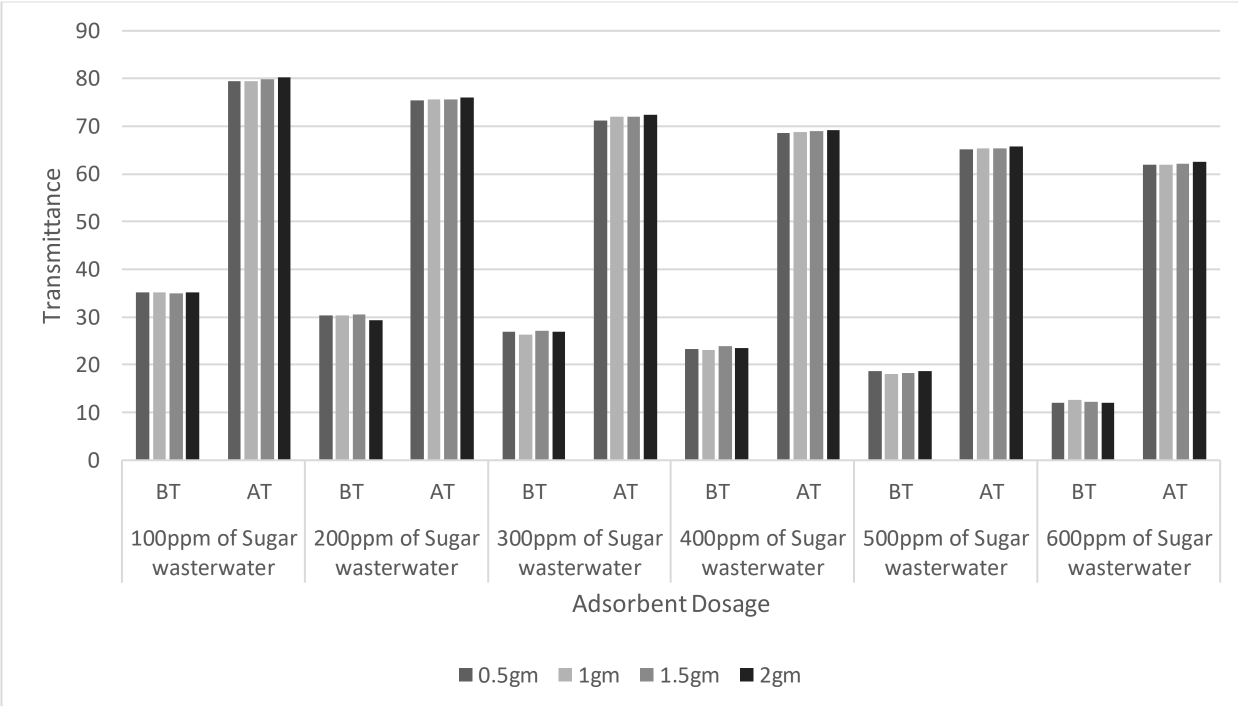


Figure 25. Transmittance of Acid Orange 74 (100 ppm) with orange peel

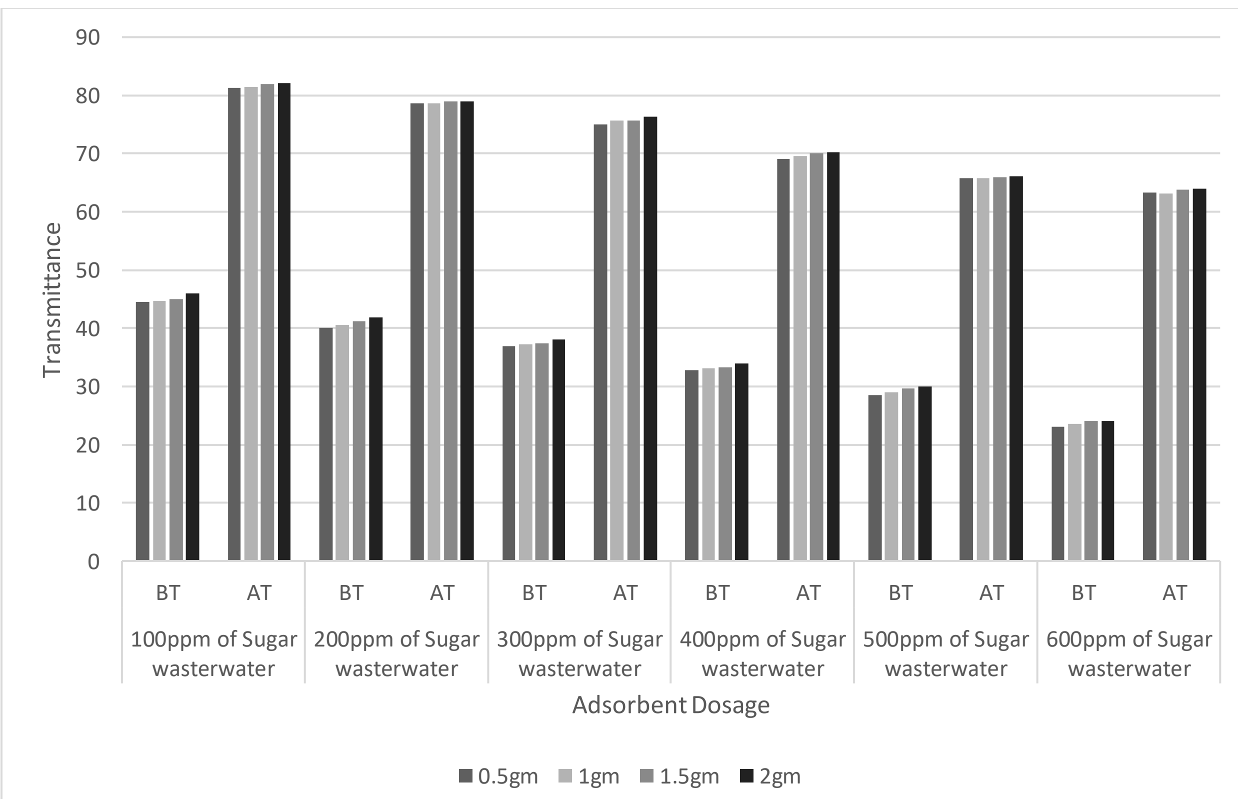


Figure 26. Transmittance of Acid Orange 74 (50 ppm) with orange peel

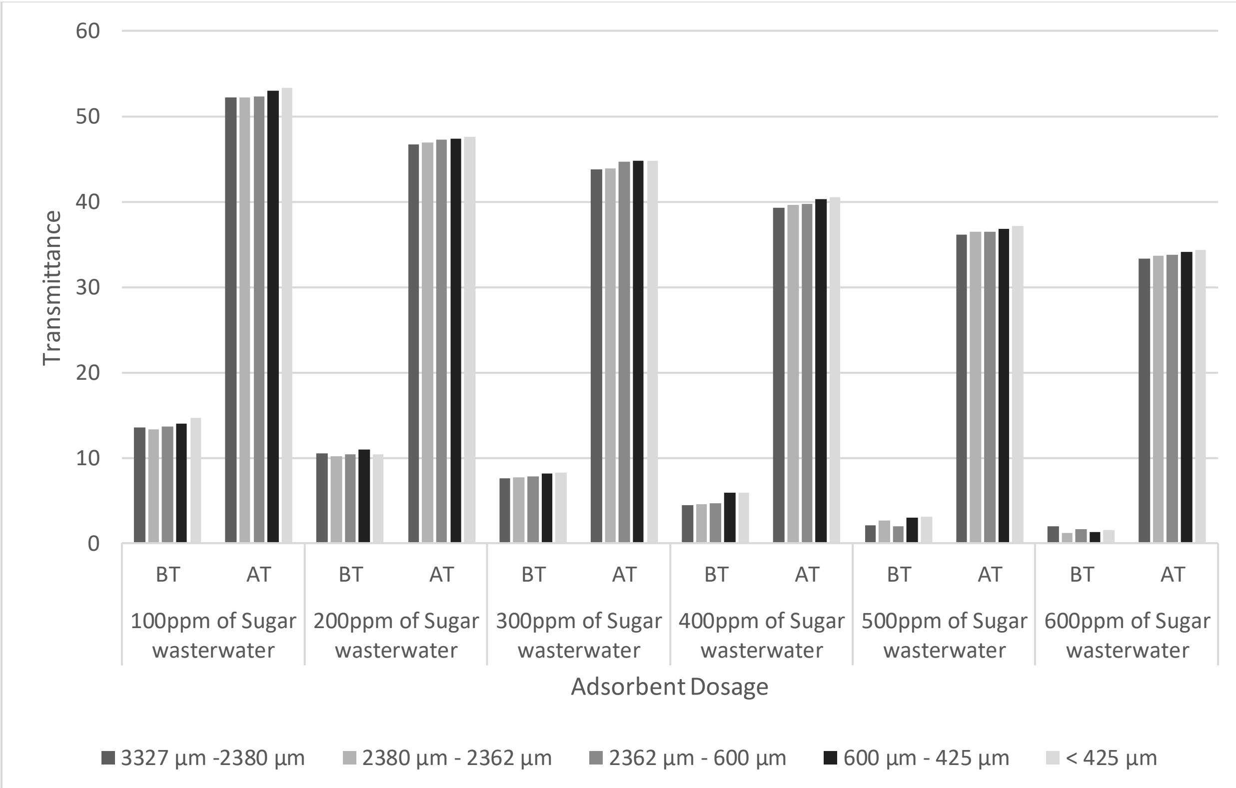


Figure 27. Transmittance of Acid Orange 74 (200 ppm) with peanut hull

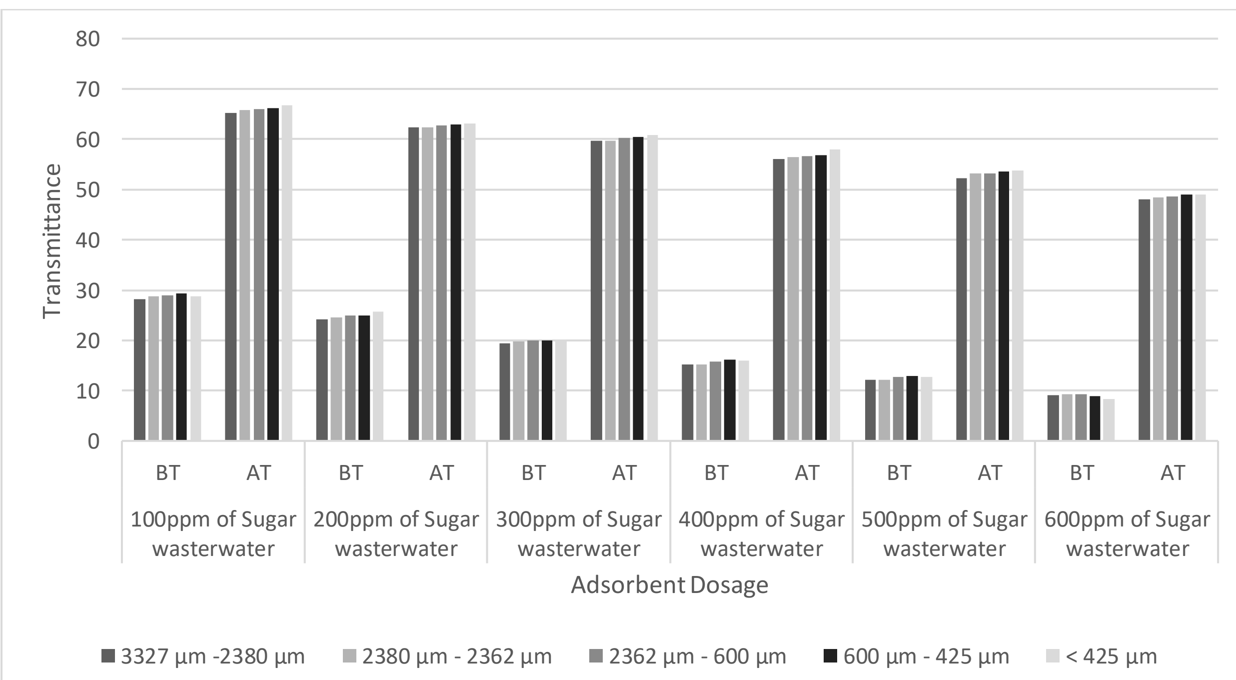


Figure 28. Transmittance of Acid Orange 74 (150 ppm) with peanut hull

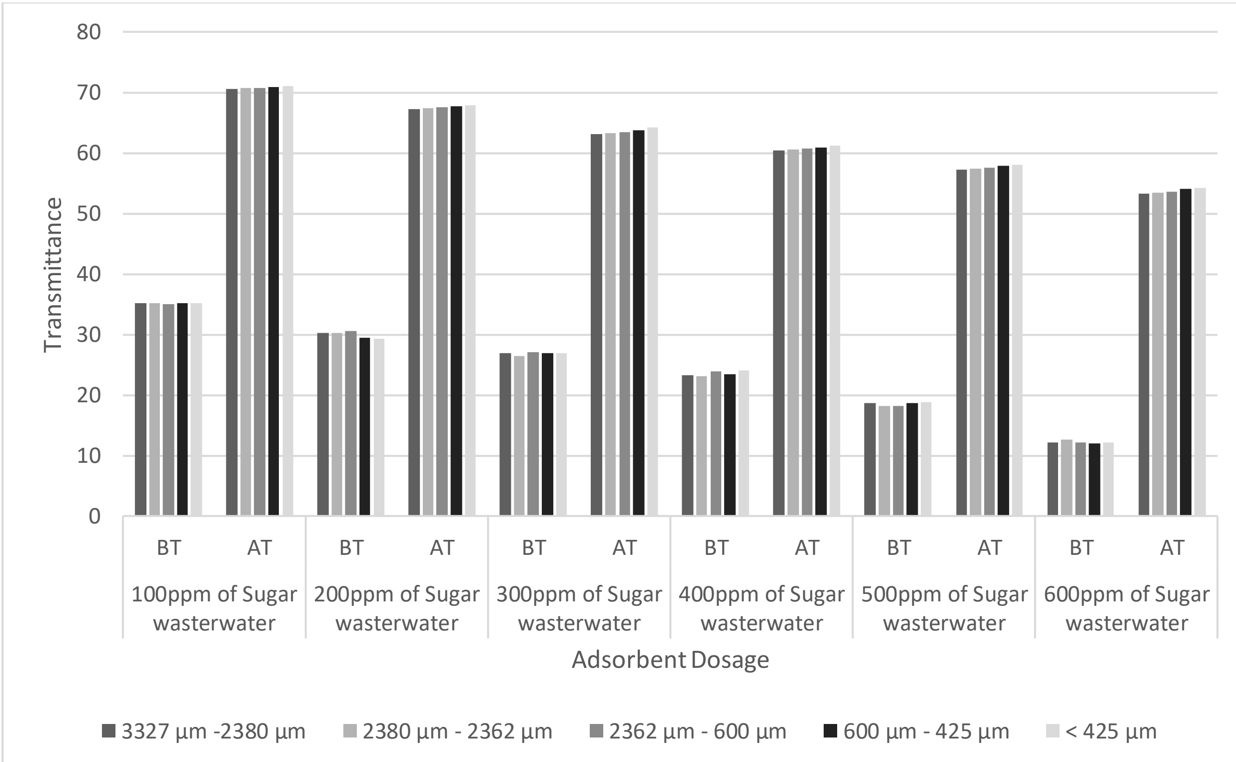


Figure 29. Transmittance of Acid Orange 74 (100 ppm) with peanut hull

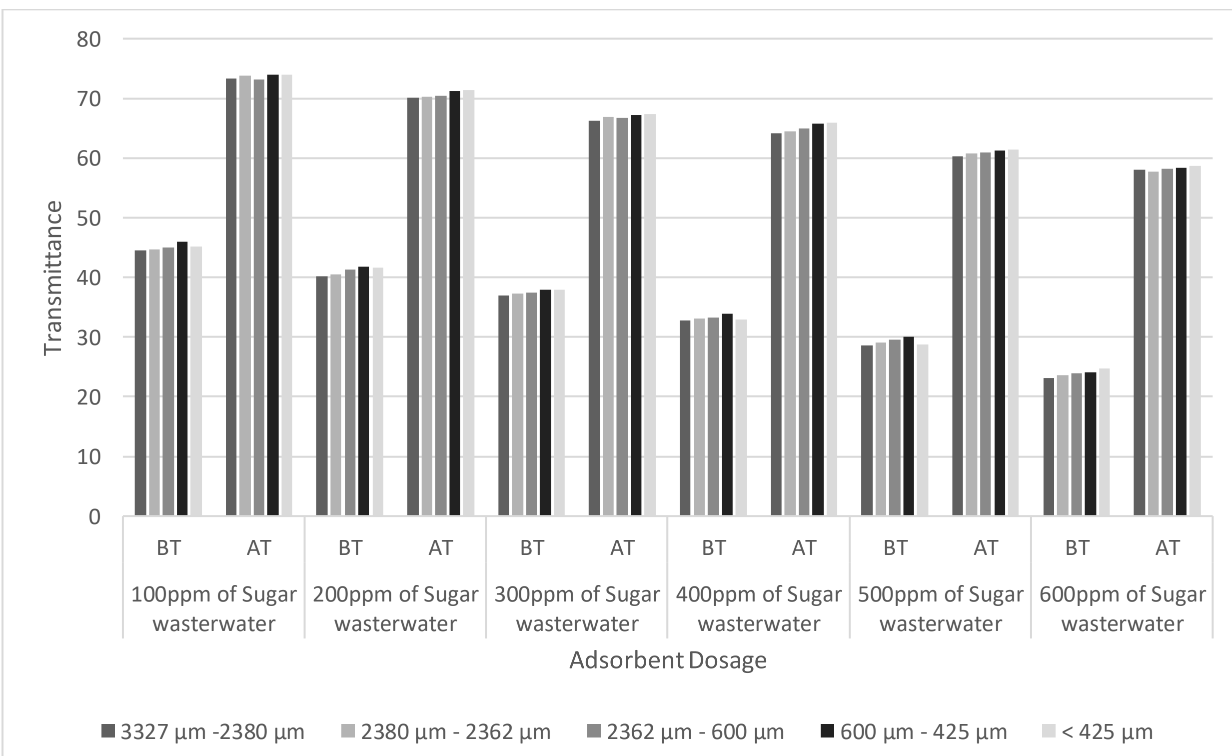


Figure 30. Transmittance of Acid Orange 74 (50 ppm) with peanut hull

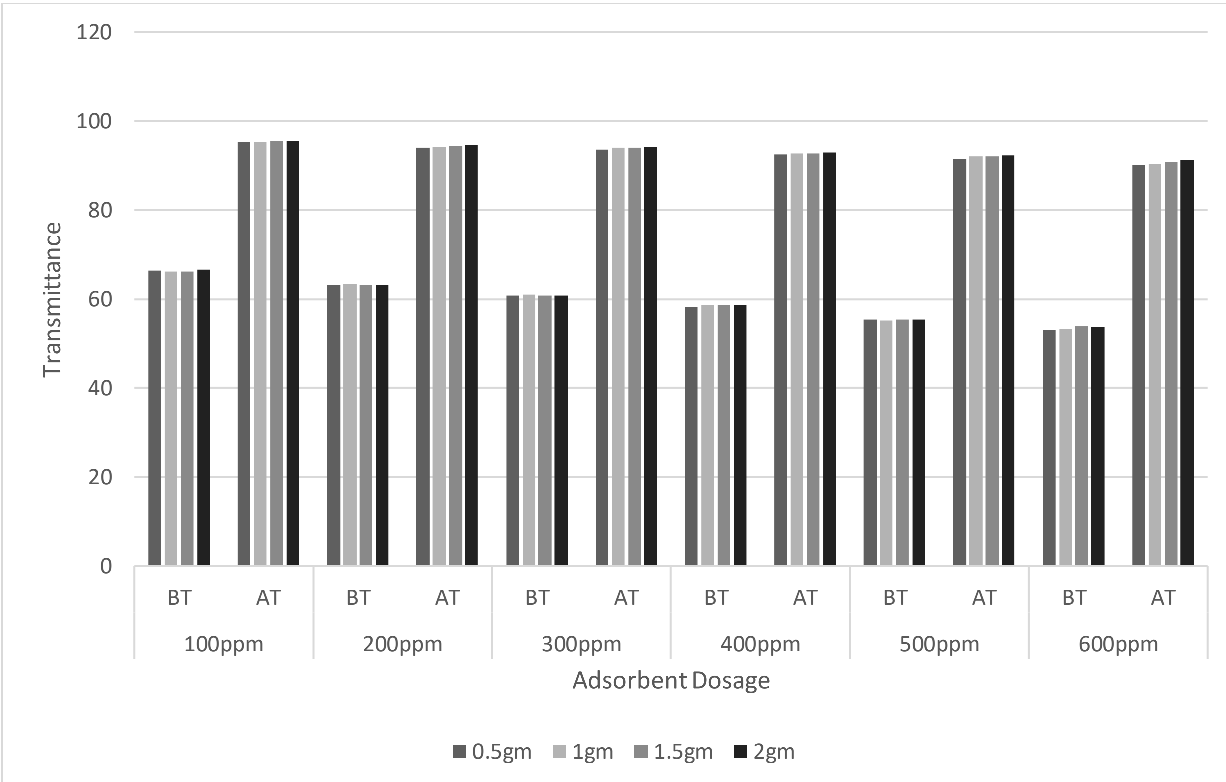


Figure 31. Transmittance of Disperse Blue 14 (1000 ppm) with activated carbon

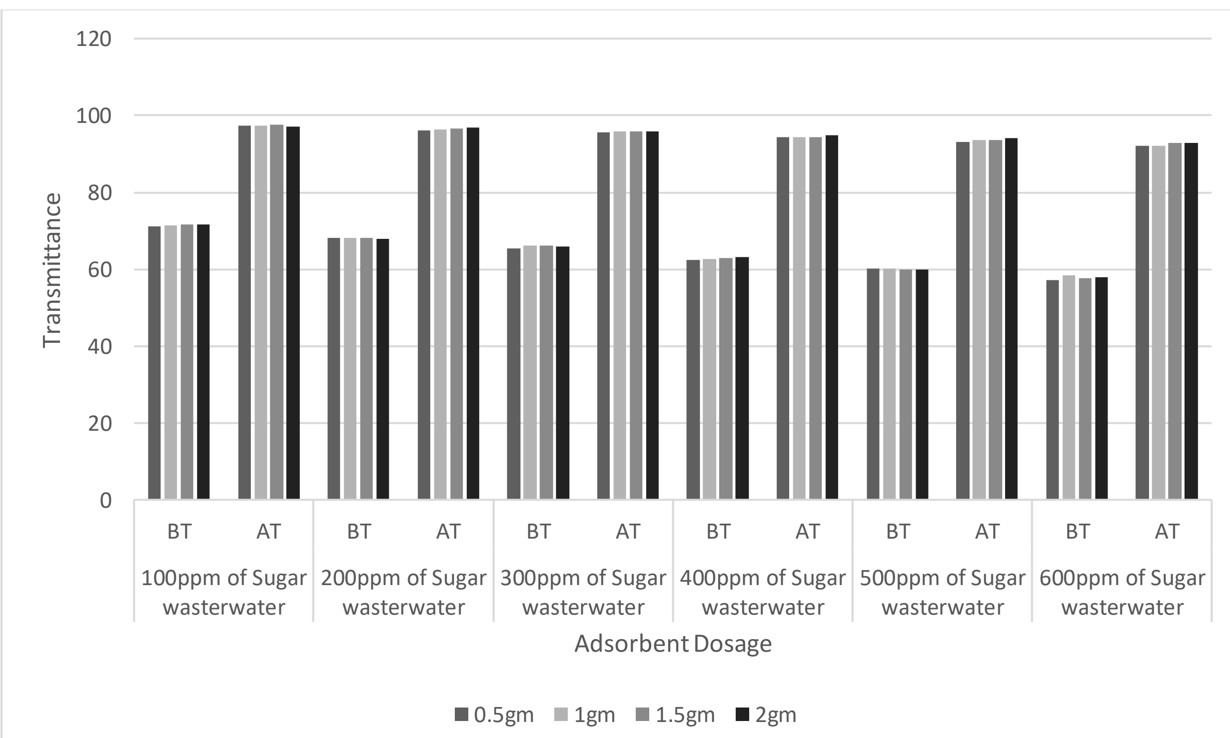


Figure 32. Transmittance of Disperse Blue 14 (750 ppm) with activated carbon

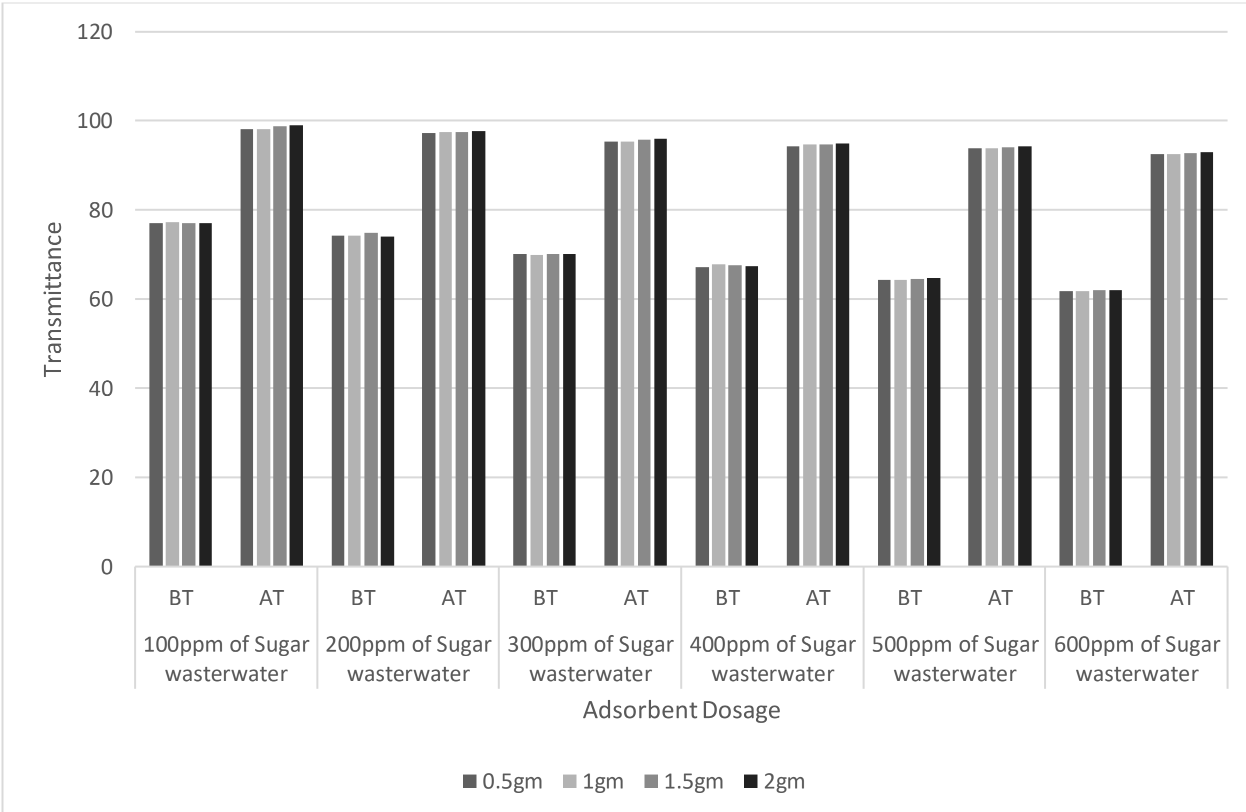


Figure 33. Transmittance of Disperse Blue 14 (500 ppm) with activated carbon

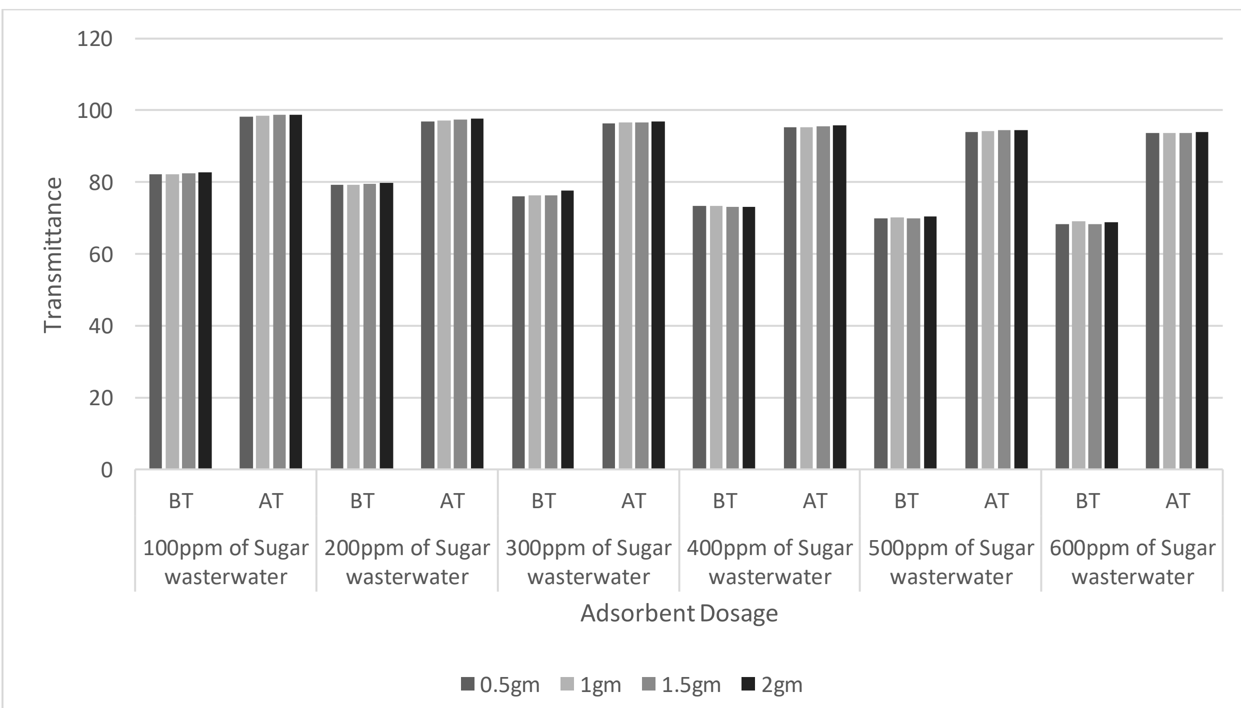


Figure 34. Transmittance of Disperse Blue 14 (250 ppm) with activated carbon

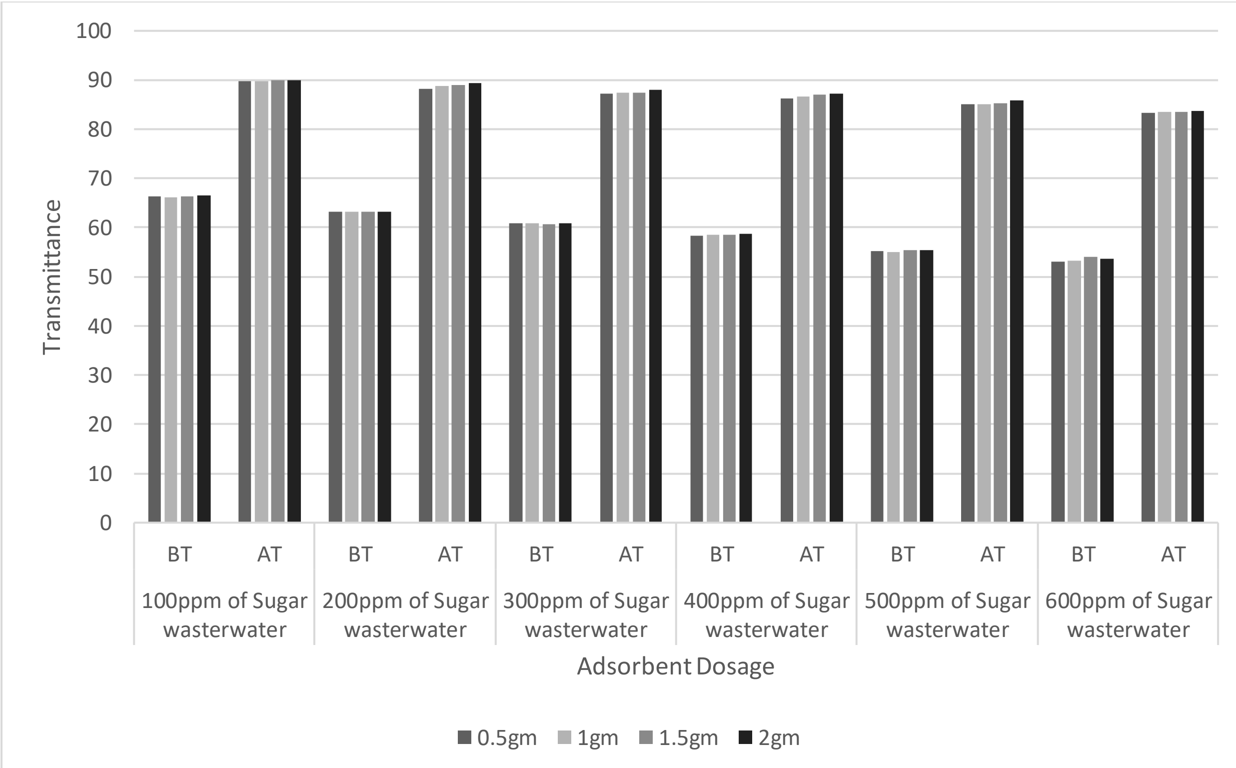


Figure 35. Transmittance of Disperse Blue 14 (1000 ppm) with orange peel

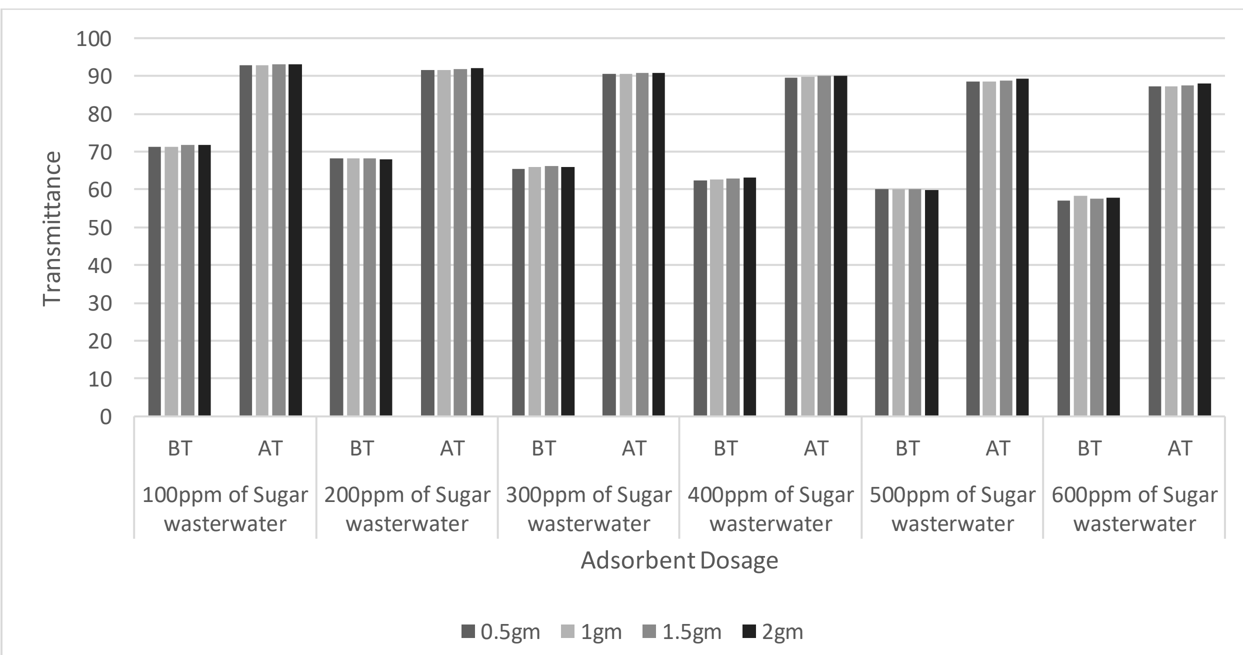


Figure 36. Transmittance of Disperse Blue 14 (750 ppm) with orange peel

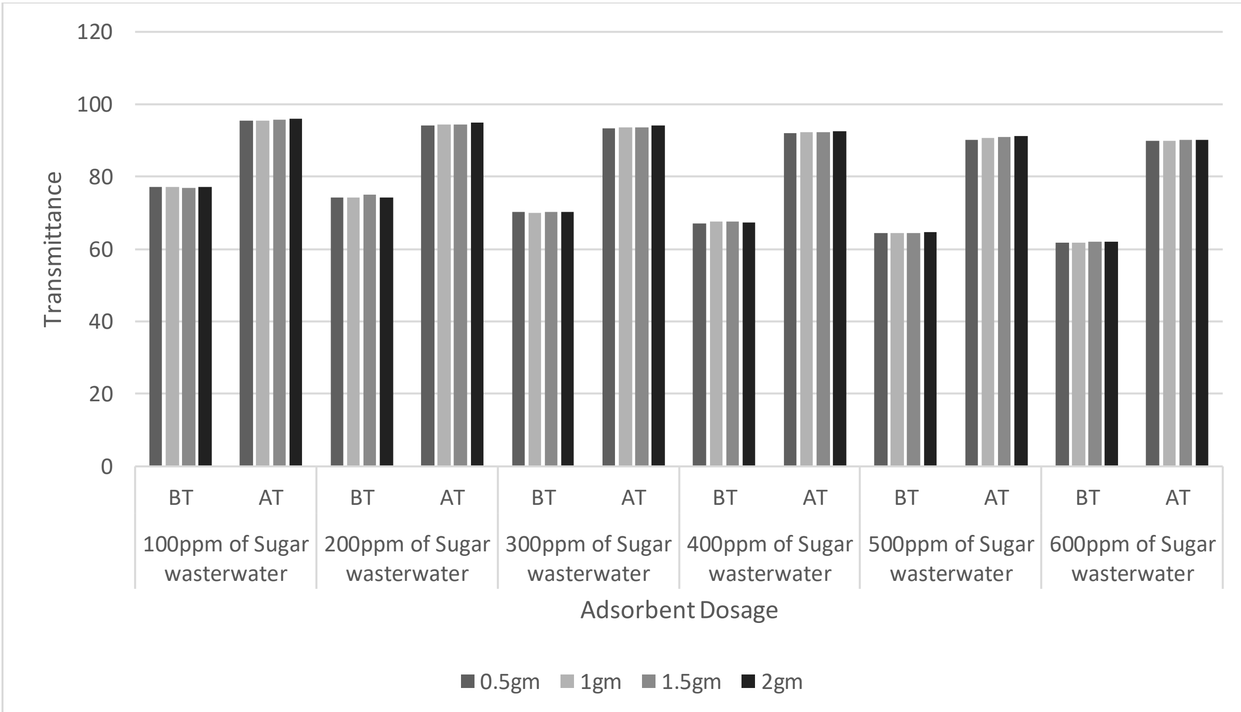


Figure 37. Transmittance of Disperse Blue 14 (500 ppm) with orange peel

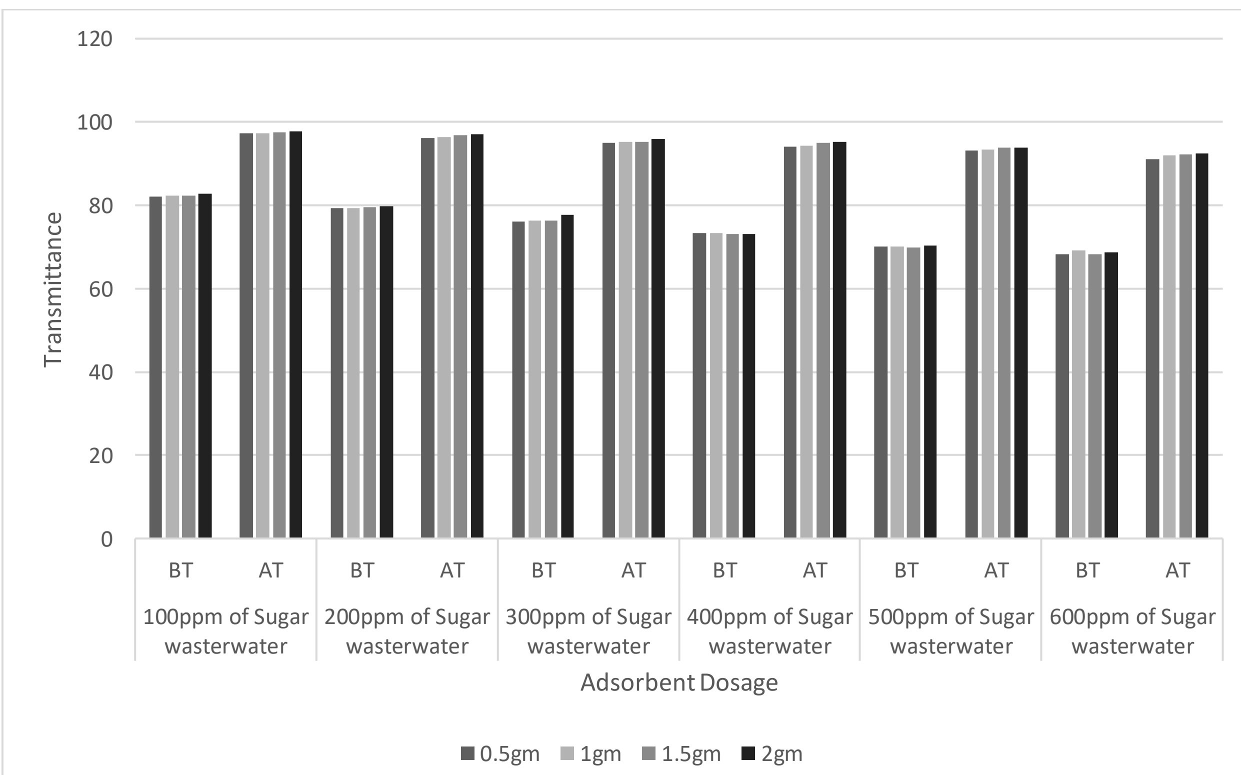


Figure 38. Transmittance of Disperse Blue 14 (250 ppm) with orange peel

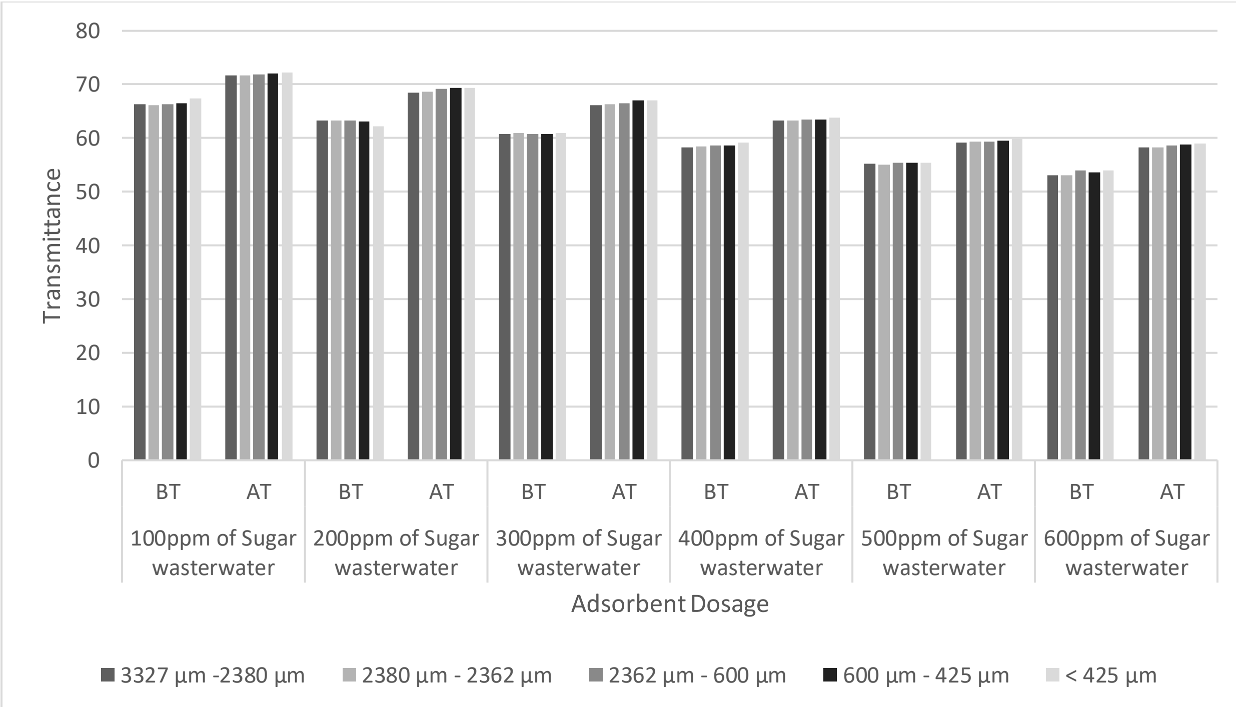


Figure 39. Transmittance of Disperse Blue 14 (1000 ppm) with peanut hull

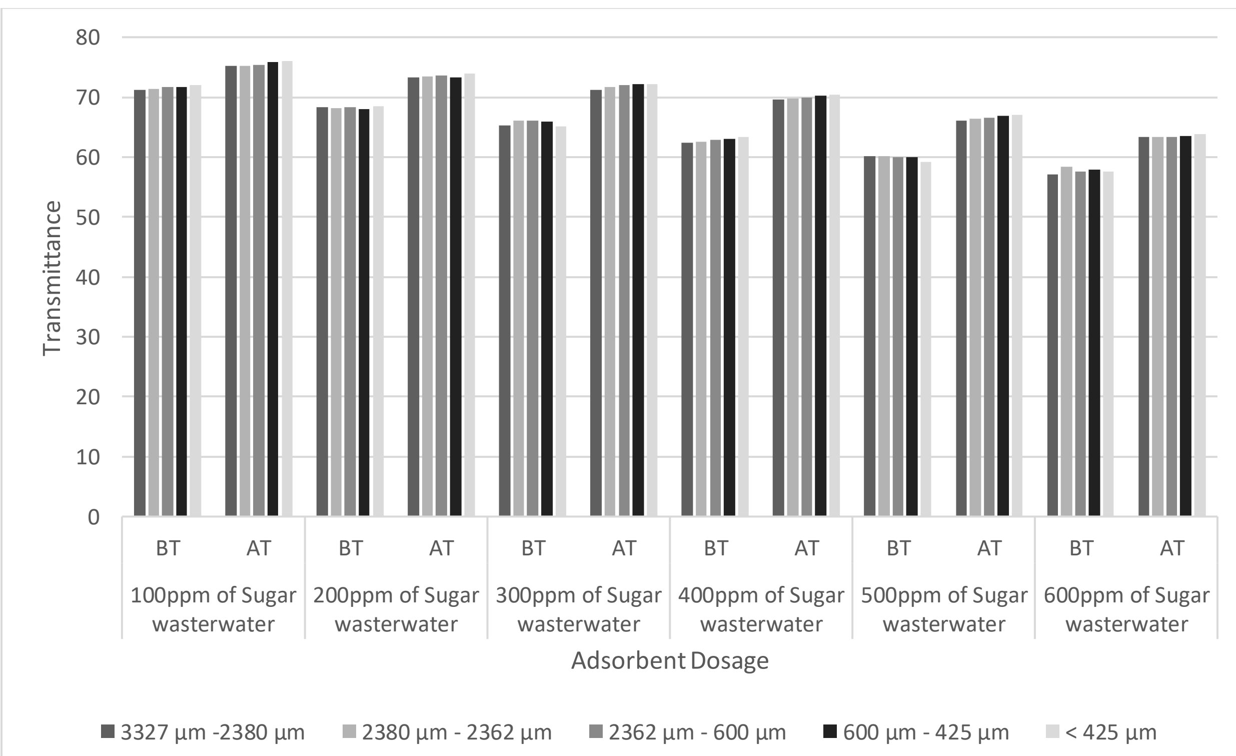


Figure 40. Transmittance of Disperse Blue 14 (750 ppm) with peanut hull

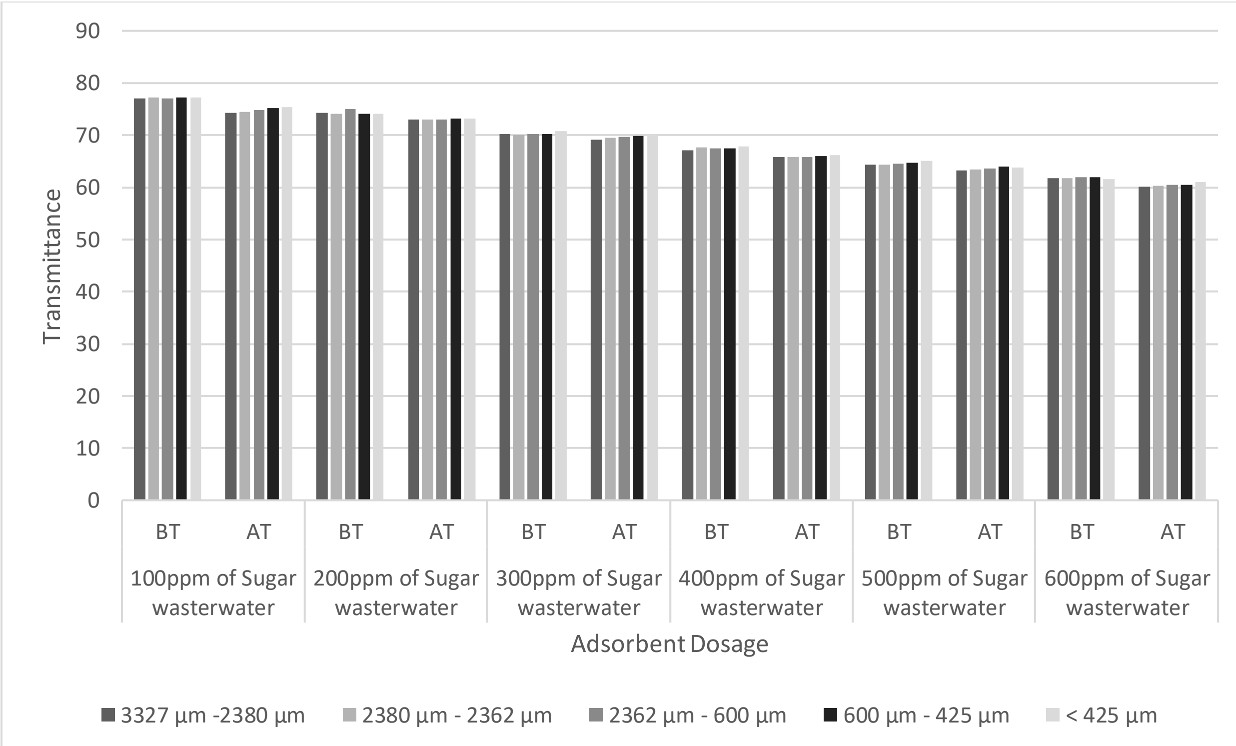


Figure 41. Transmittance of Disperse Blue 14 (500 ppm) with peanut hull

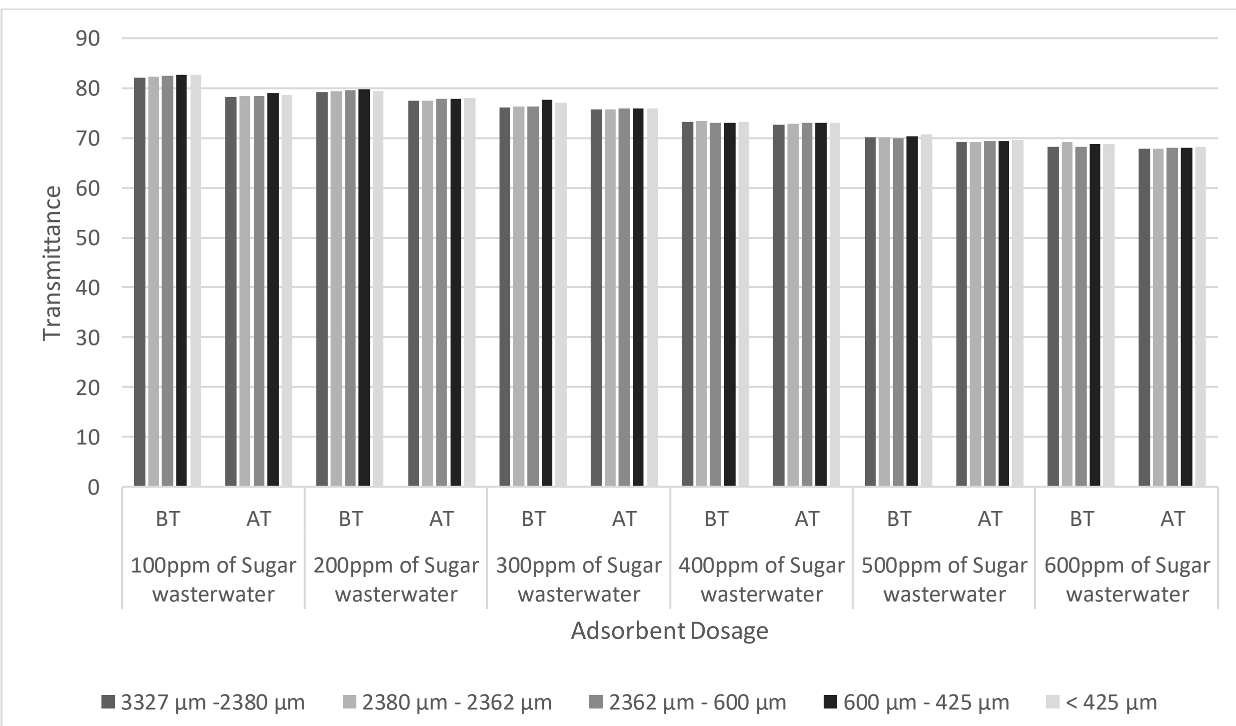


Figure 42. Transmittance of Disperse Blue 14 (250 ppm) with peanut hull

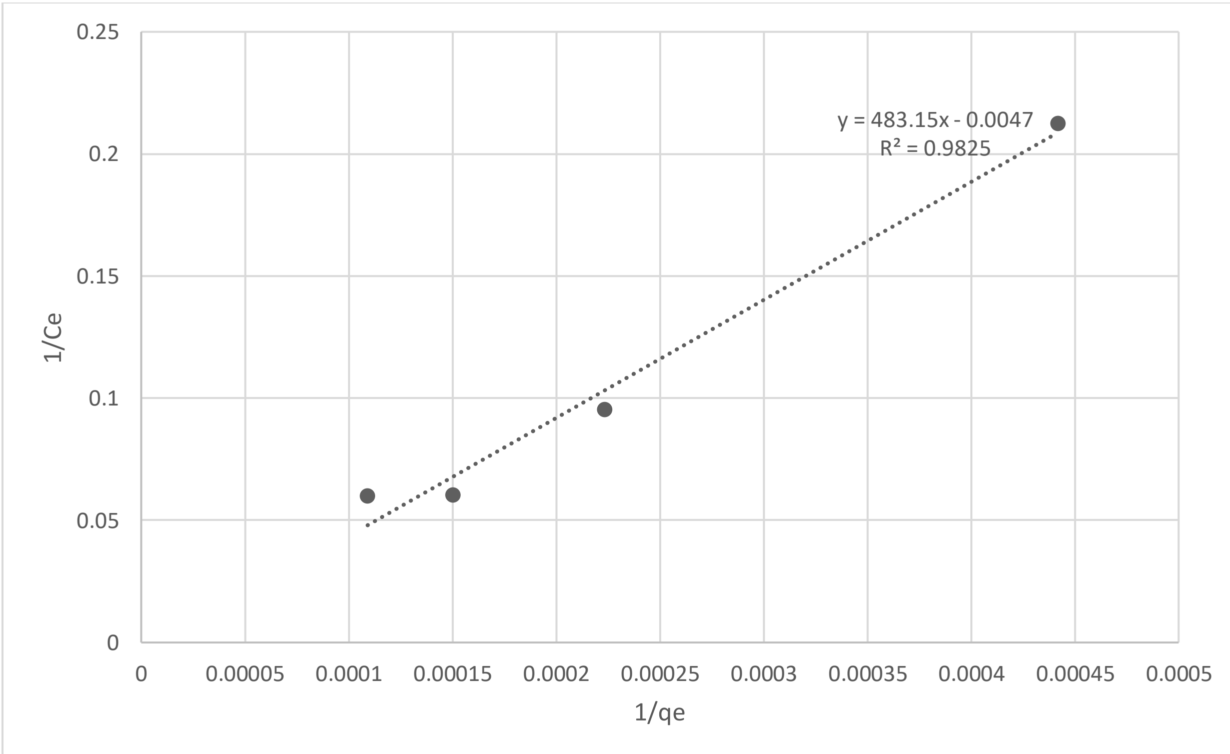


Figure 43. Langmuir isotherm model of Naphthol Green B adsorption on Activated carbon

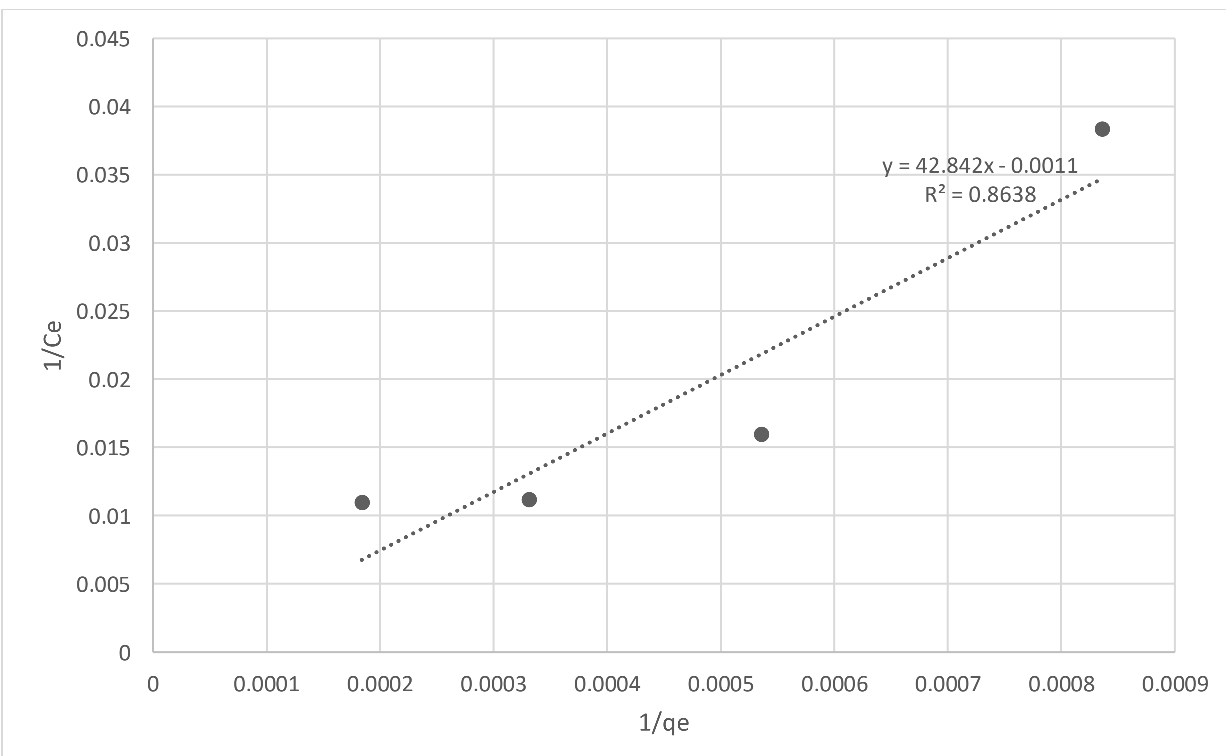


Figure 44. Langmuir isotherm model of Naphthol Green B adsorption on Orange peel

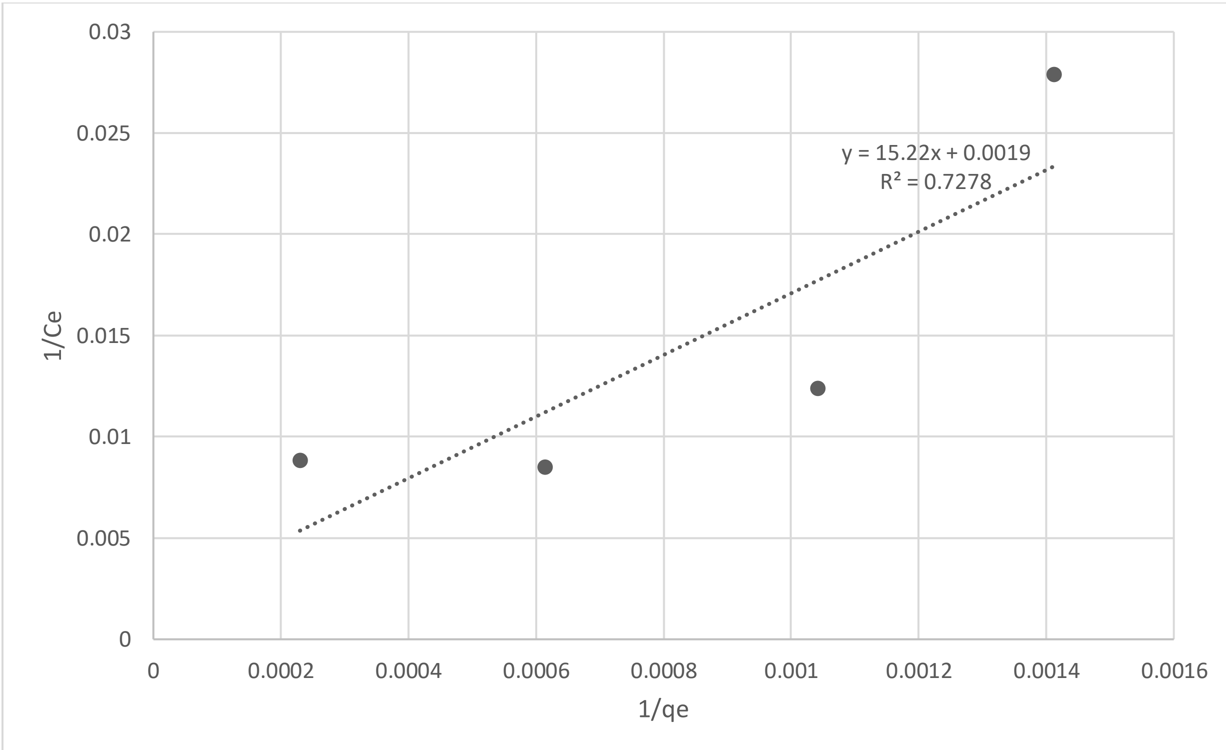


Figure 45. Langmuir isotherm model of Naphthol Green B adsorption on Peanut Hull

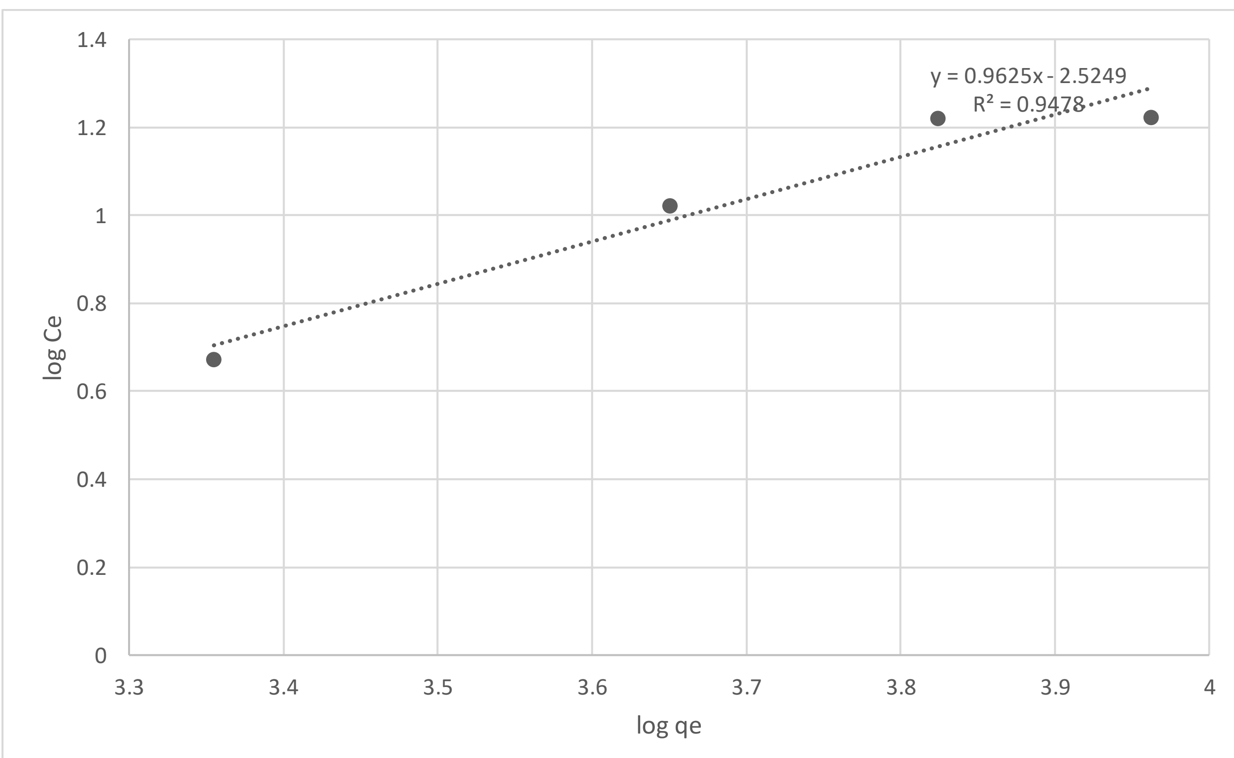


Figure 46. Freundlich isotherm model of Naphthol Green B adsorption on Activated carbon

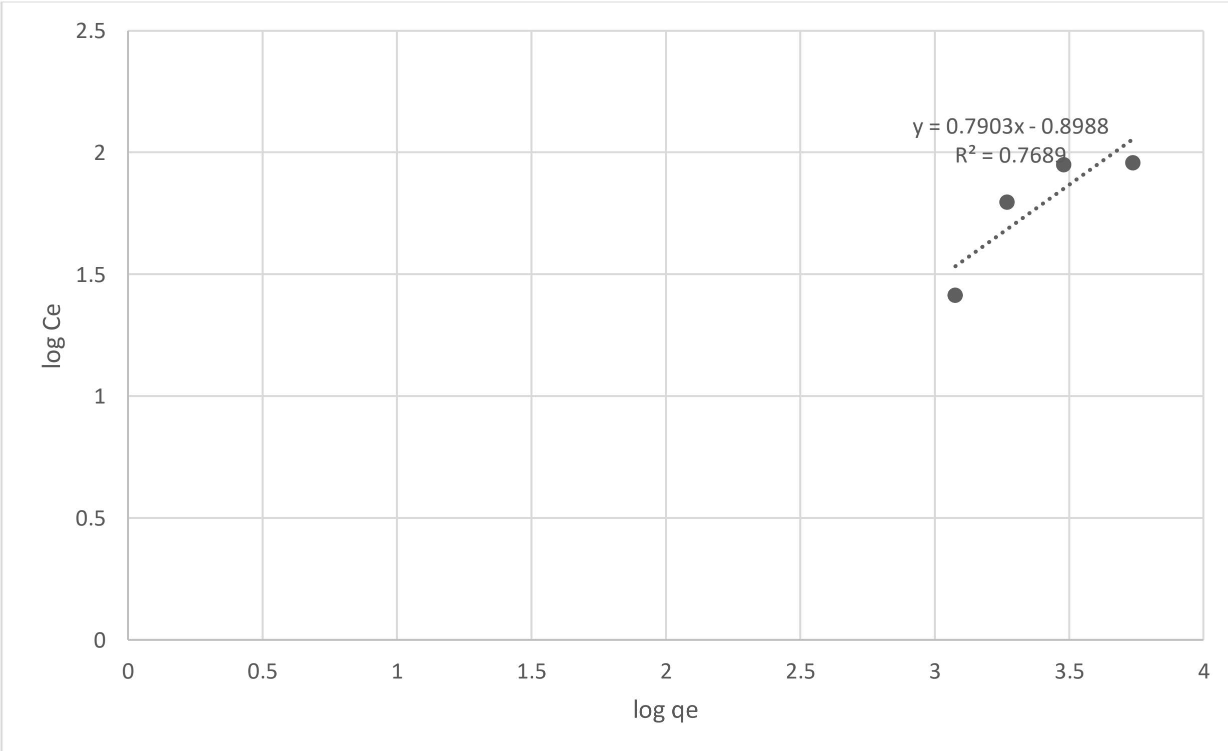


Figure 47. Freundlich isotherm model of Naphthol Green B adsorption on Orange peel

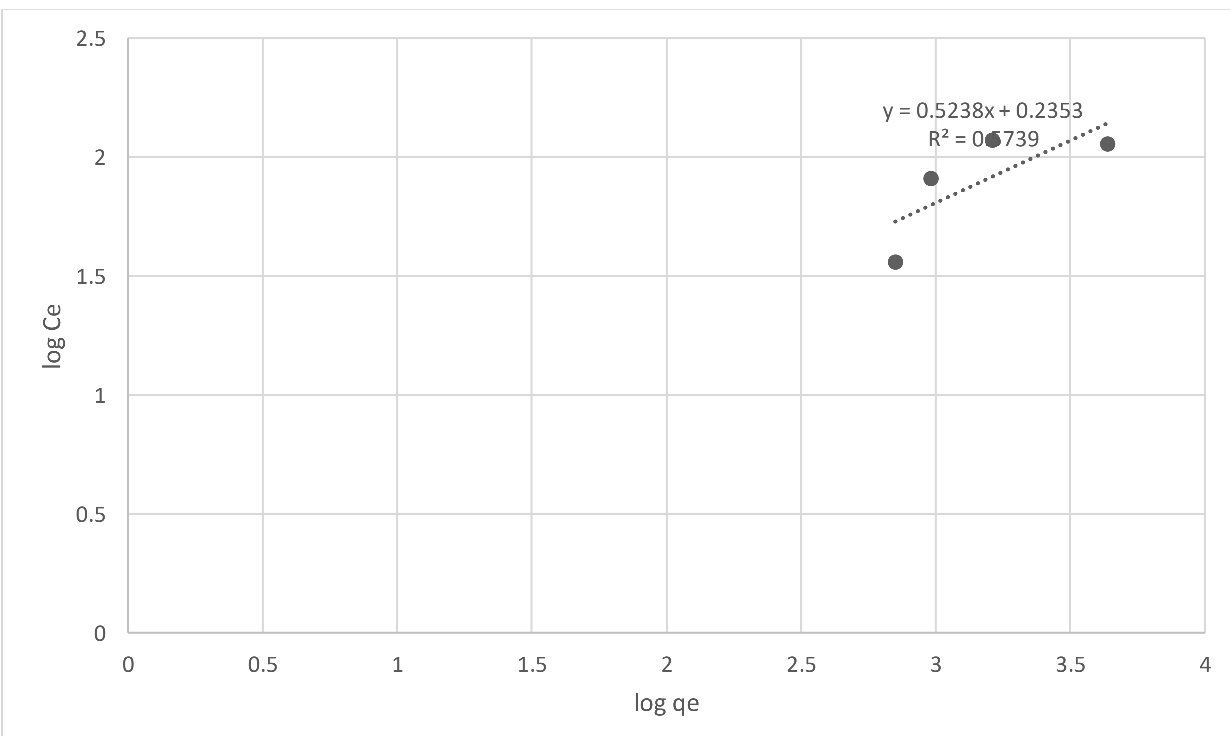


Figure 48. Freundlich isotherm model of Naphthol Green B adsorption on Peanut Hull

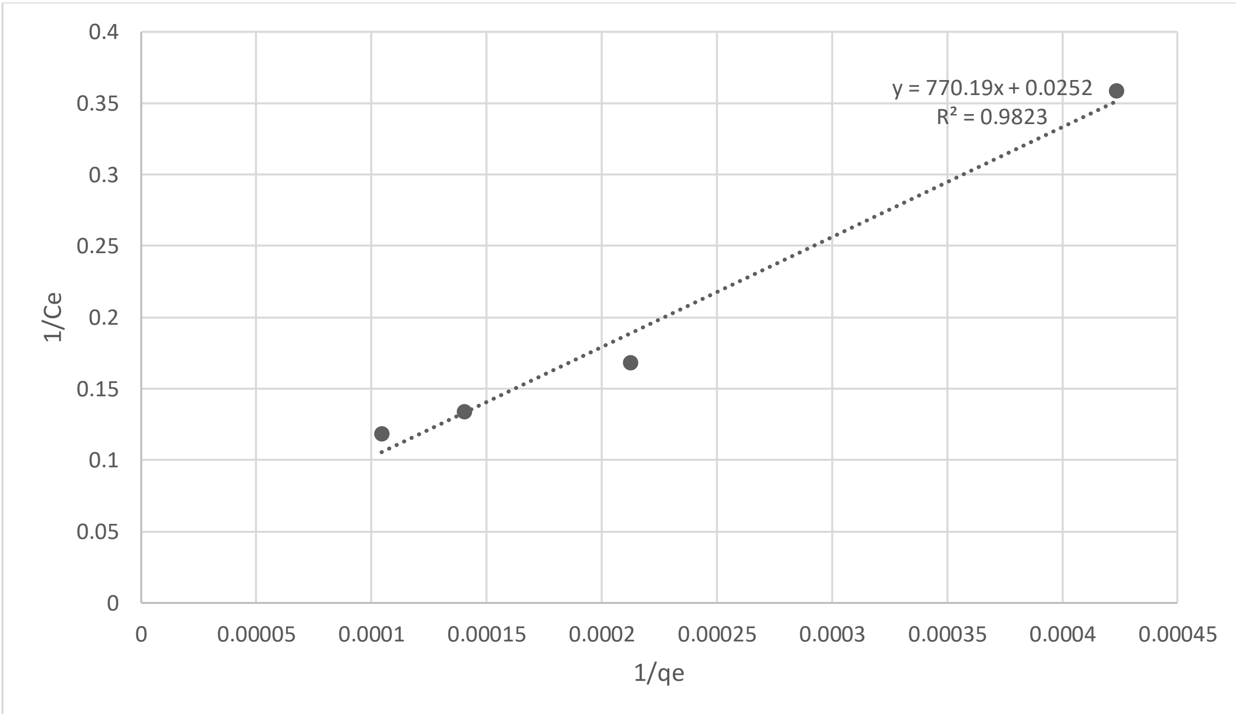


Figure 49. Langmuir isotherm model of Acid Orange 74 adsorption on Activated carbon

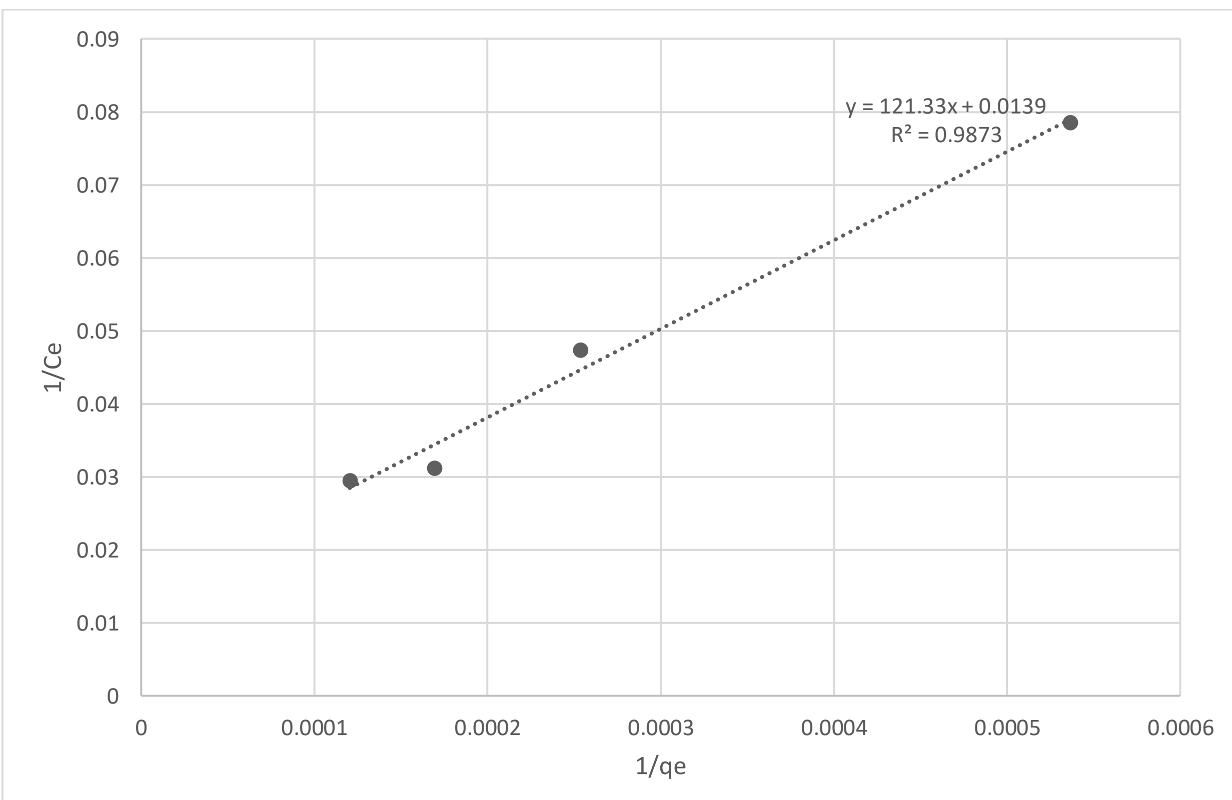


Figure 50. Langmuir isotherm model of Acid Orange 74 adsorption on Orange peel

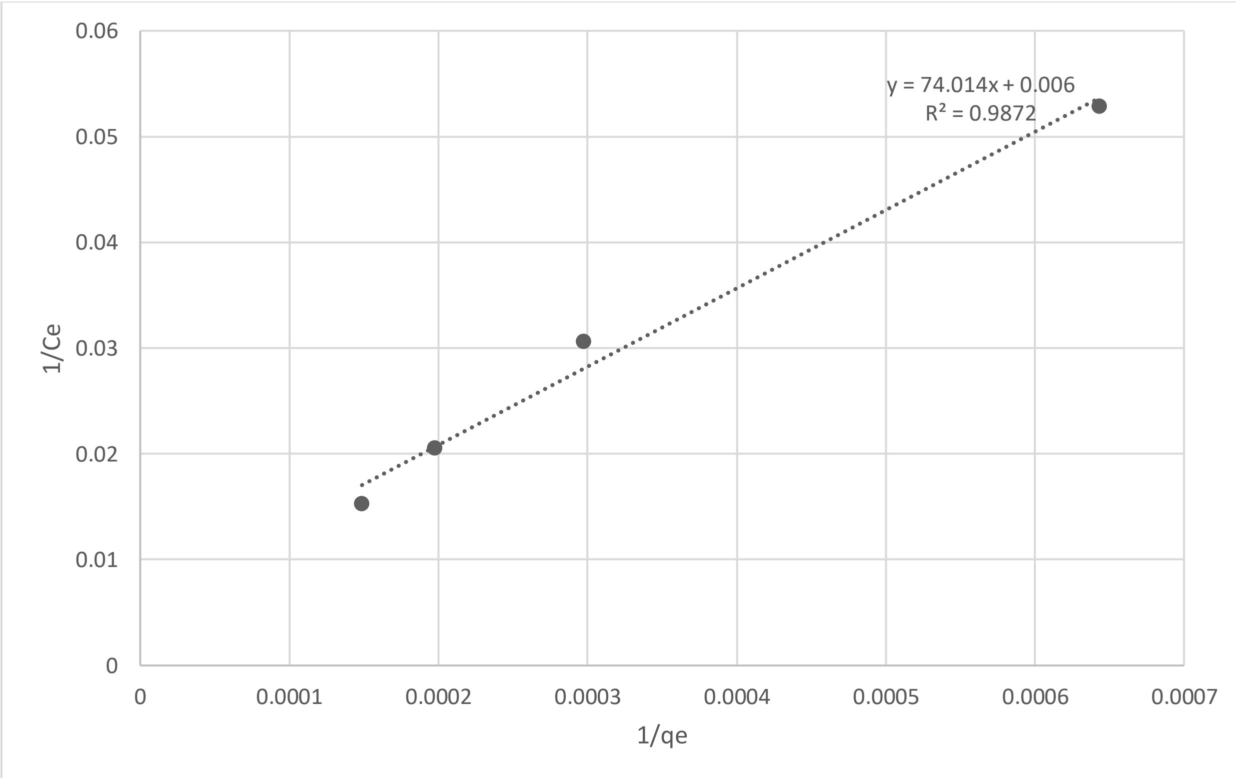


Figure 51. Langmuir isotherm model of Acid Orange 74 adsorption on Peanut Hull

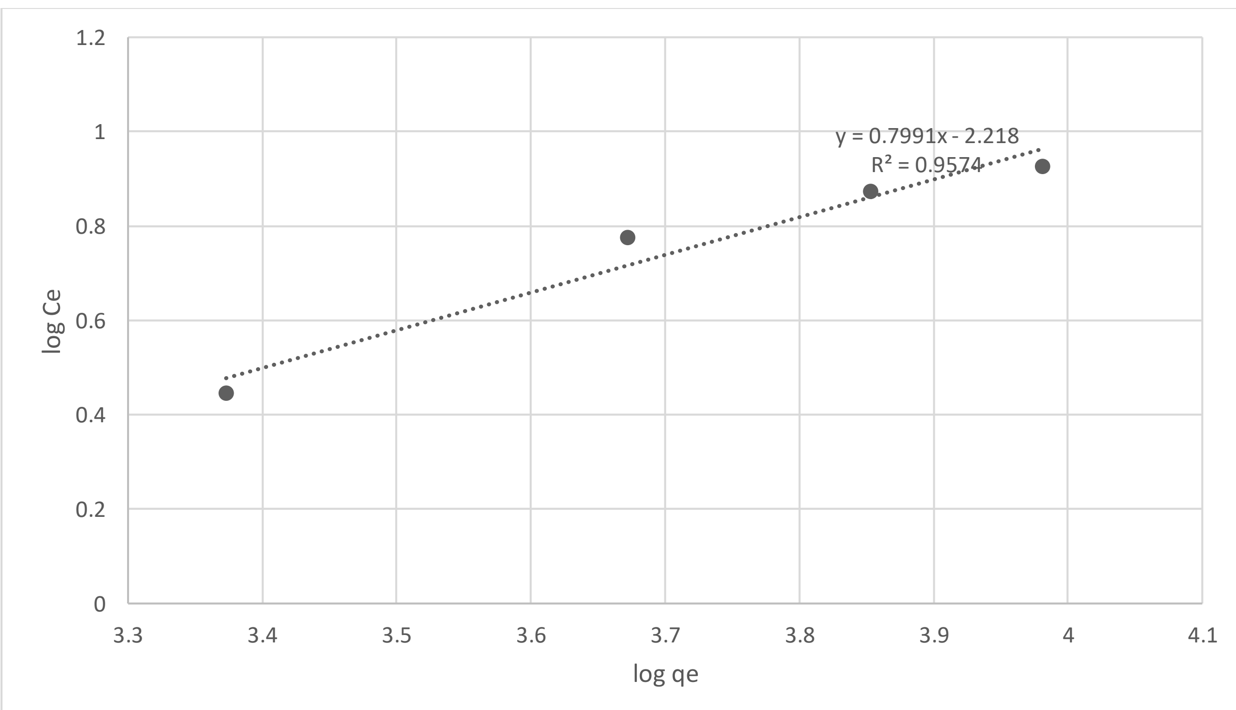


Figure 52. Freundlich isotherm model of Acid Orange 74 adsorption on Activated carbon

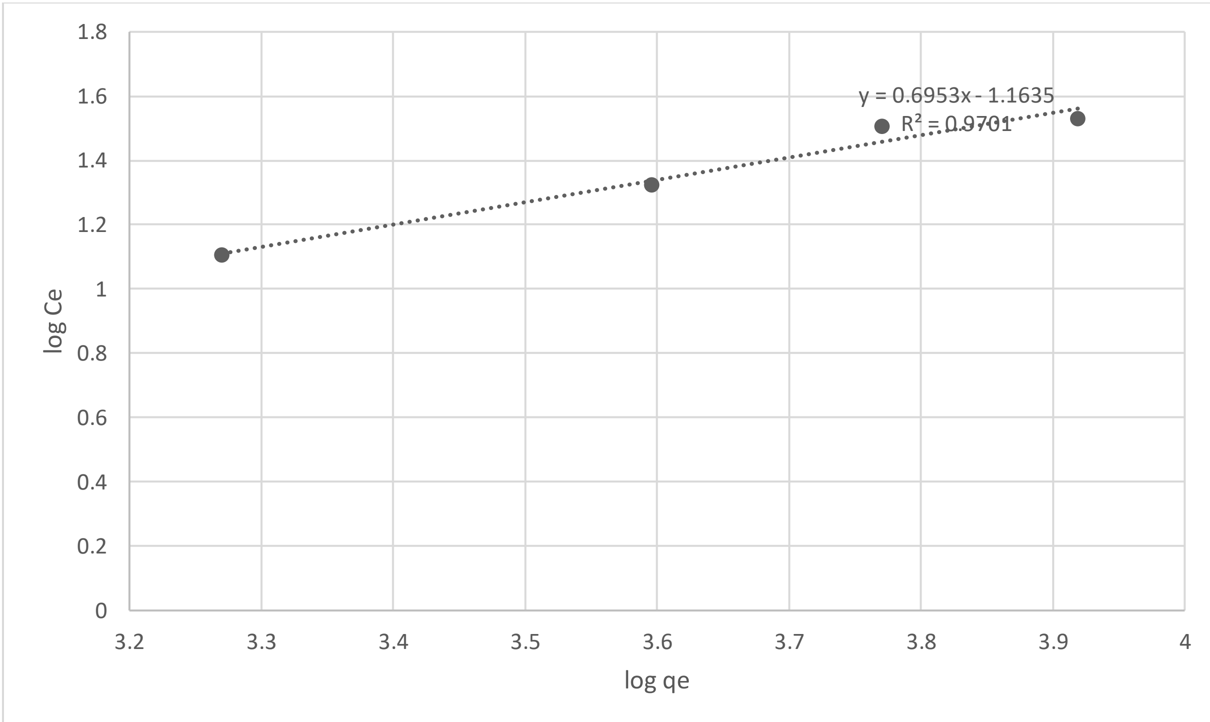


Figure 53. Freundlich isotherm model of Acid Orange 74 adsorption on Orange peel

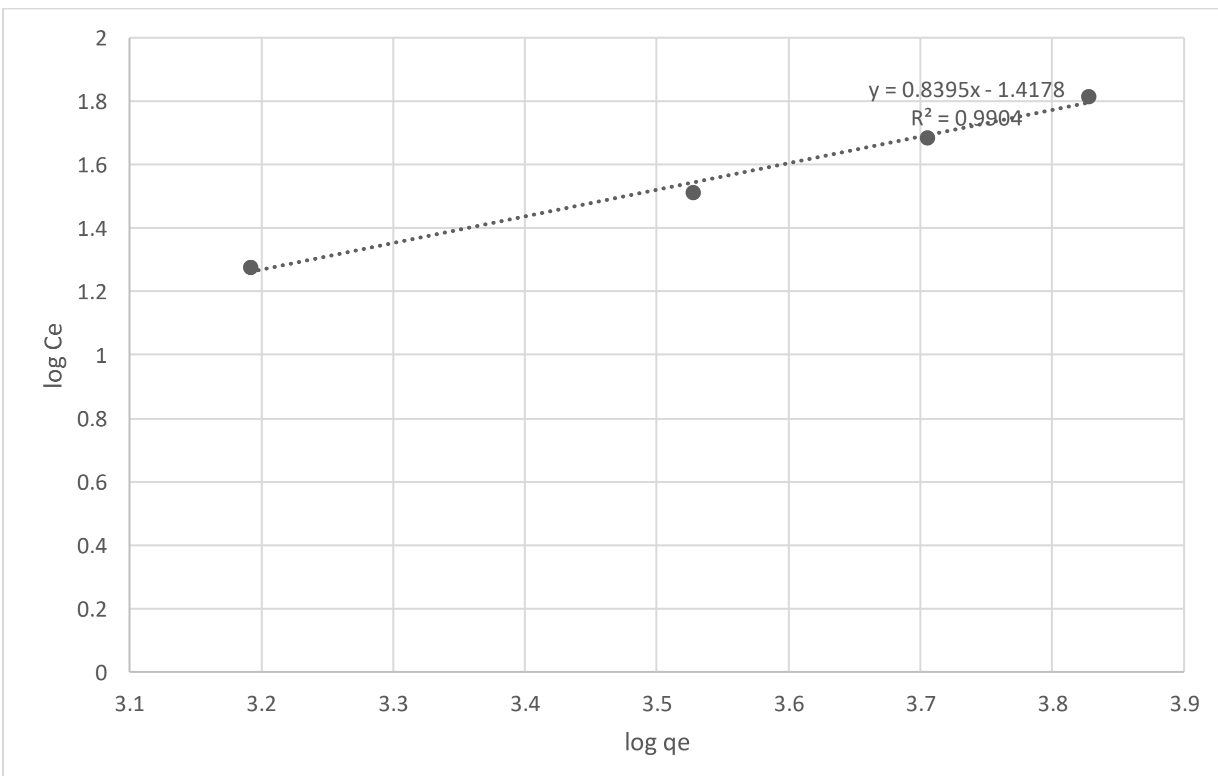


Figure 54. Freundlich isotherm model of Acid Orange 74 adsorption on Peanut Hull

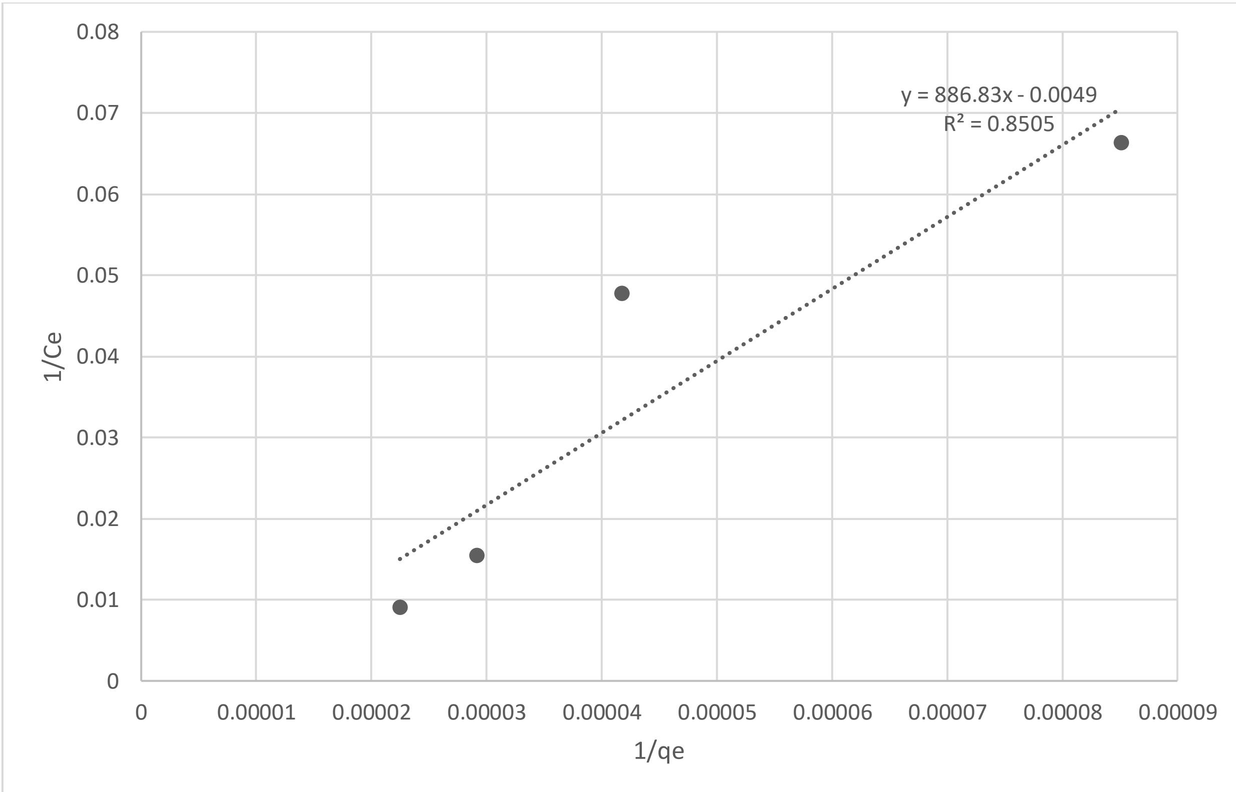


Figure 55. Langmuir isotherm model of Disperse Blue 14 adsorption on Activated carbon

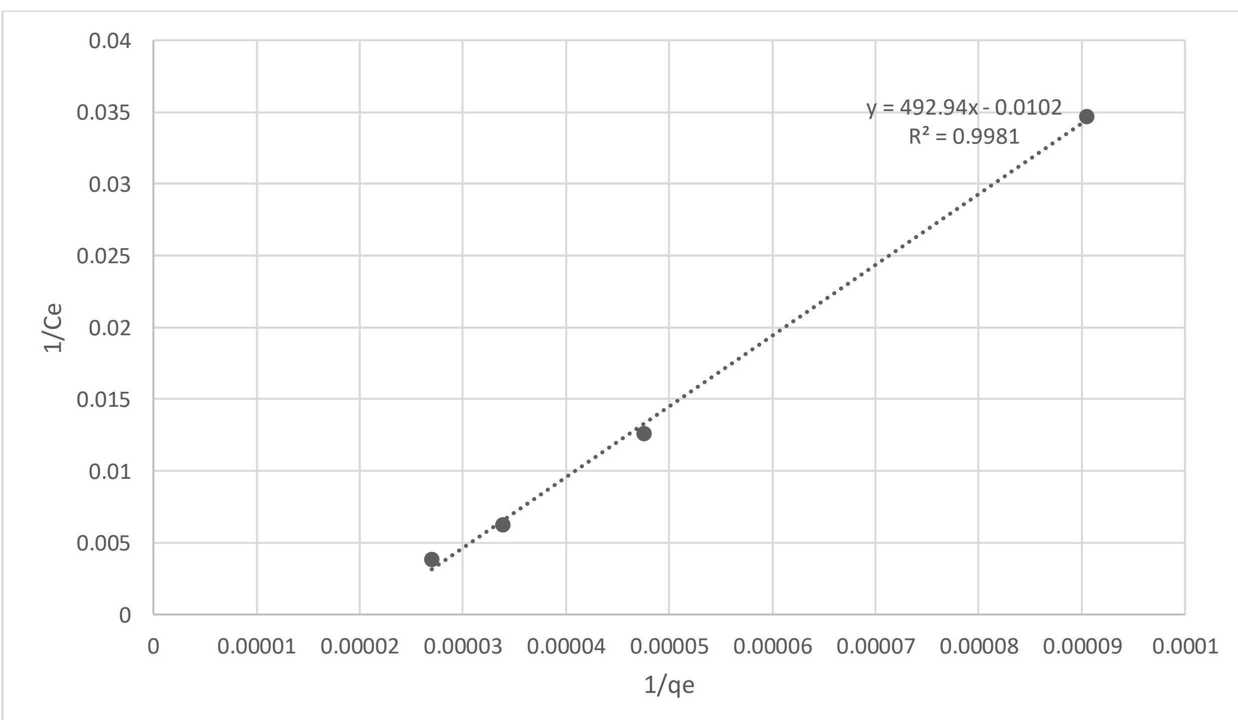


Figure 56. Langmuir isotherm model of Disperse Blue 14 adsorption on Orange peel

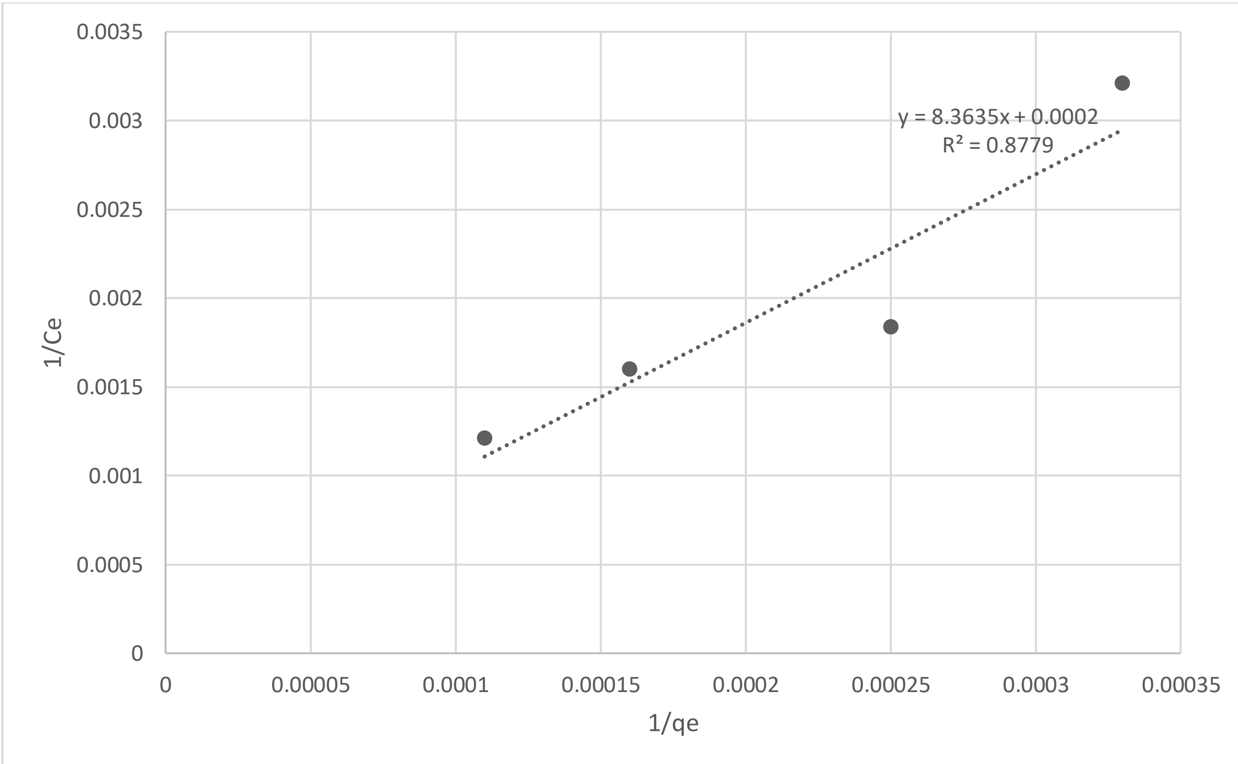


Figure 57. Langmuir isotherm model of Disperse Blue 14 adsorption on Peanut Hull

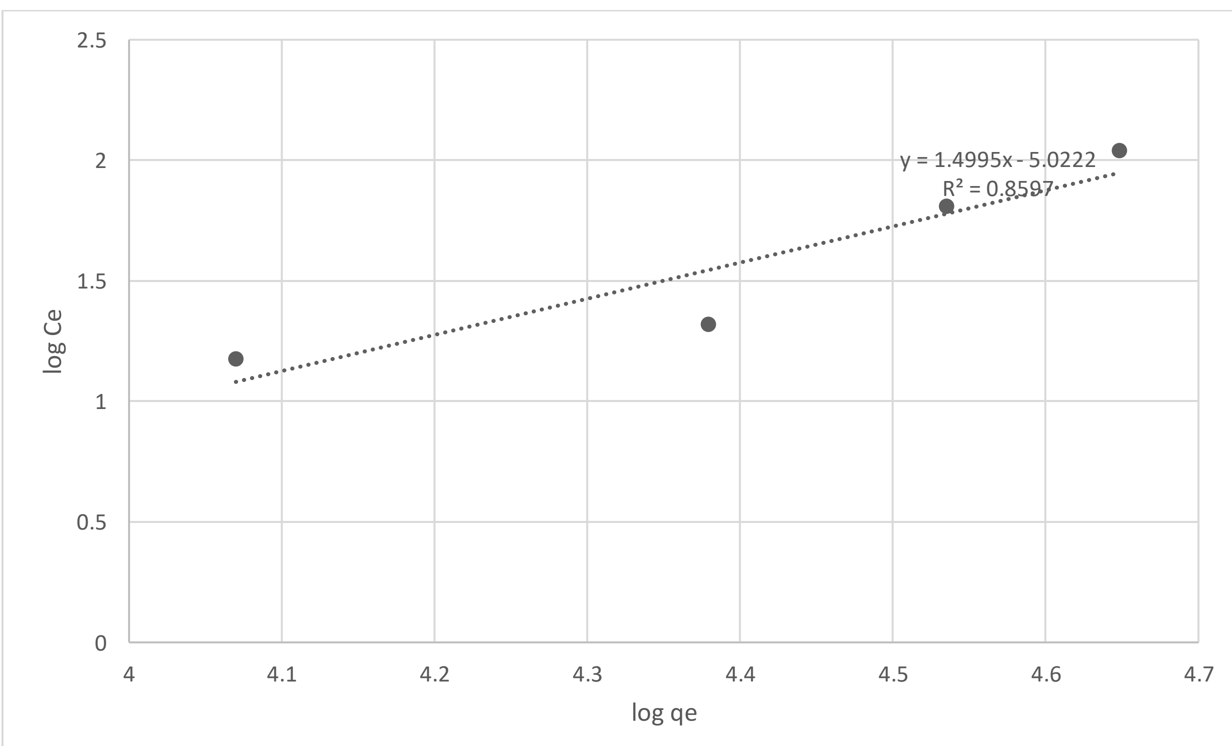


Figure 58. Freundlich isotherm model of Disperse Blue 14 adsorption on Activated carbon

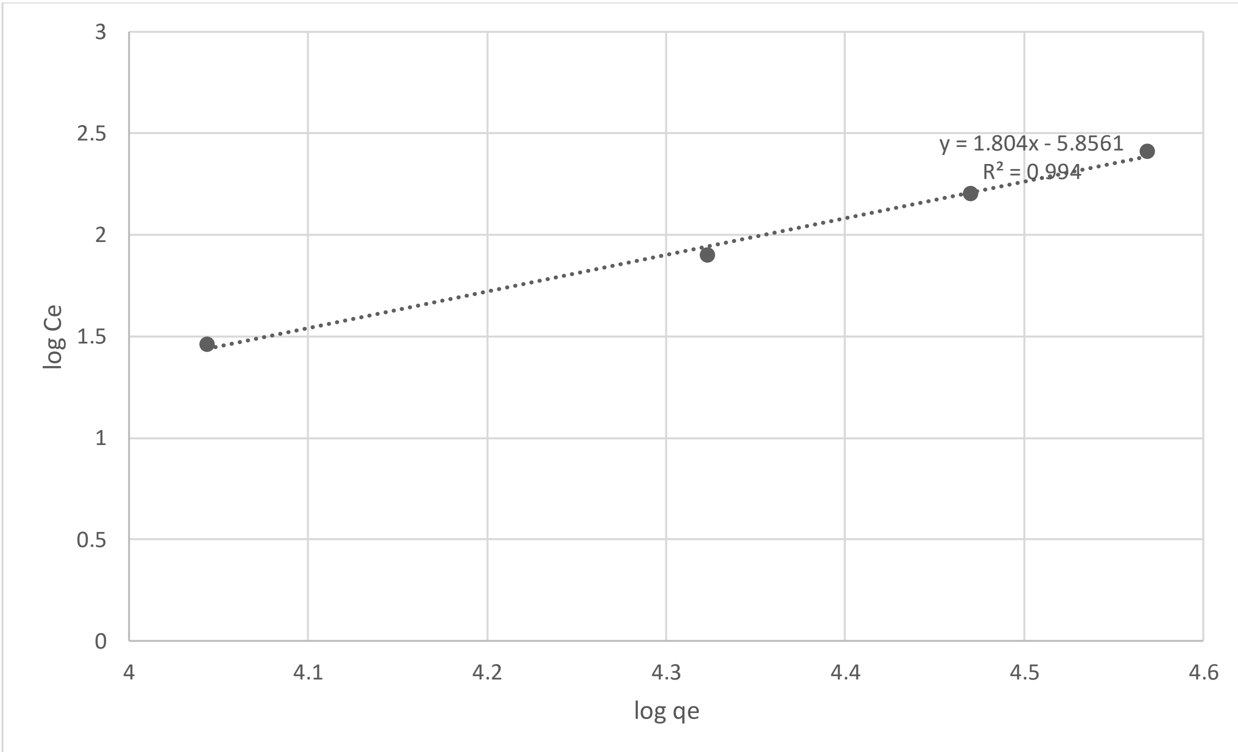


Figure 59. Freundlich isotherm model of Disperse Blue 14 adsorption on Orange peel

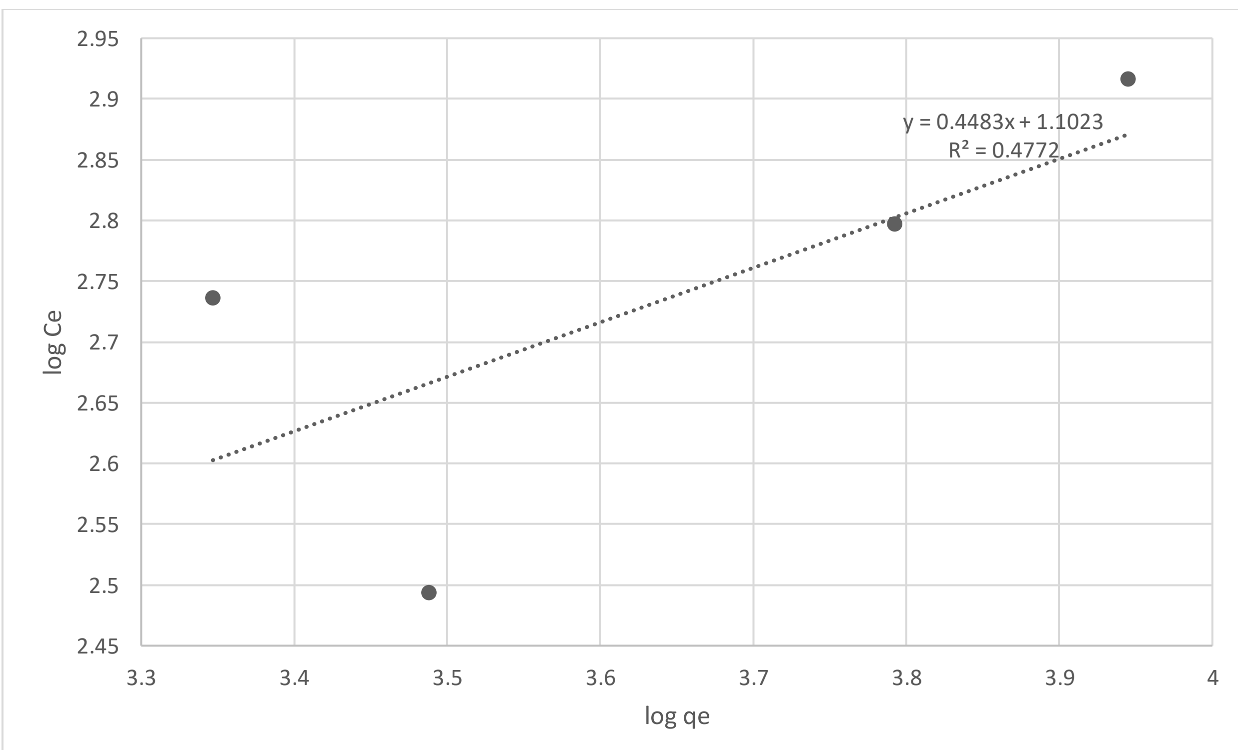


Figure 60. Freundlich isotherm model of Disperse Blue 14 adsorption on Peanut Hull

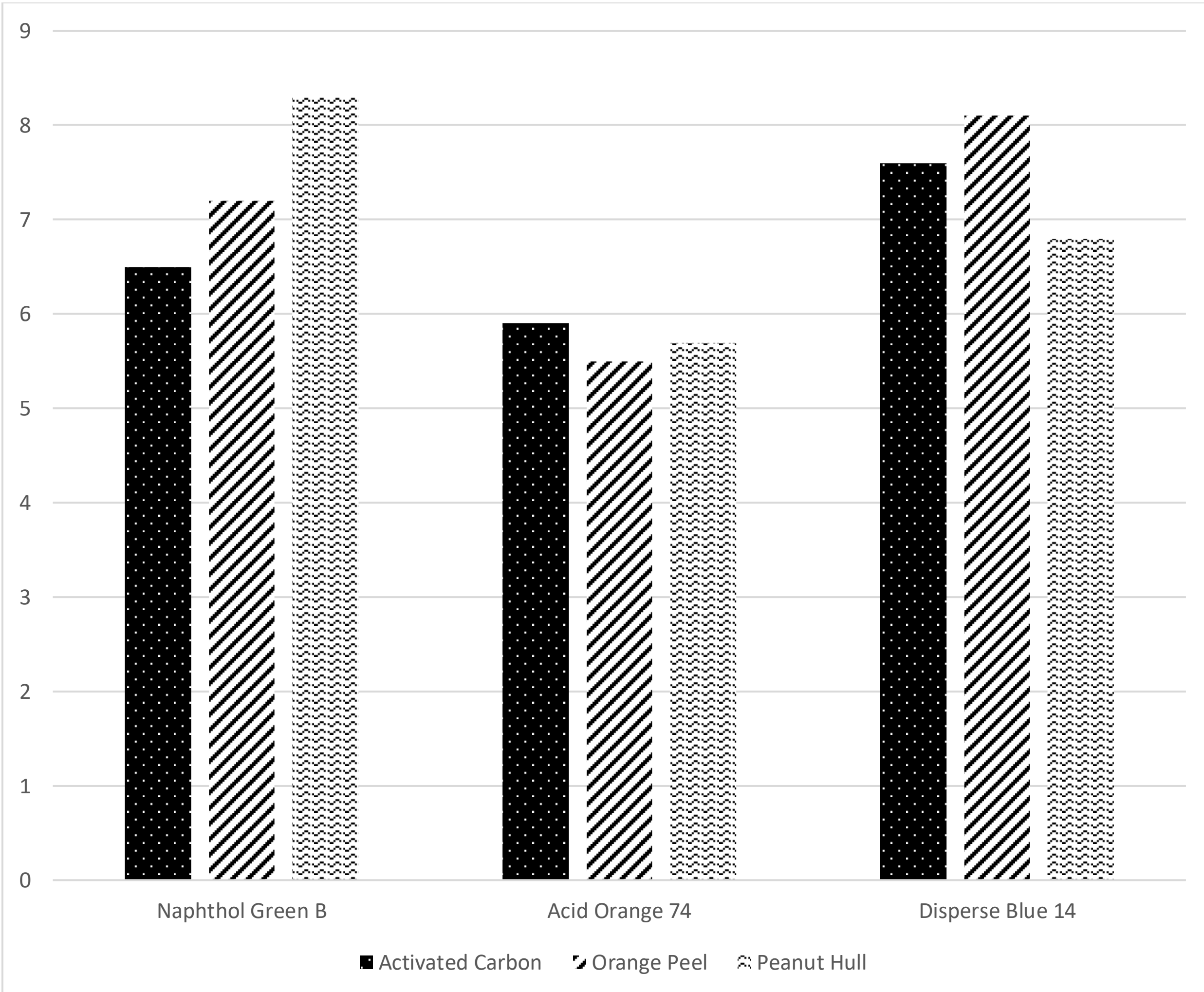


Figure 61. Effect of pH on combined sugar and dye wastewater with varying dyes