Surfactant Removal on Waste Water

by

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Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Chemical Engineering)

SEPTEMBER 2015

Universiti Teknologi PETRONAS,

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Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

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SEPTEMBER 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

SAI-AN MAY CALEJA

ABSTRACT

Surfactants are among the most widespread pollutants that contribute significantly to the pollution profile of sewage and wastewater of all kinds. There are various methods of performing surfactant removal from wastewater, however, most of these methods are not economically feasible and consume a large amount of energy. This project investigates the method of surfactant removal using froth flotation. This method has proved to be comparatively economical and consumes less energy. It is a much simpler process and the equipment used are not complicated. The effects of various parameters such as flotation time, surfactant concentration and air flow rate were investigated. The optimum air flow rate value and flotation time will be determined for effective froth generation.

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Surfactant or surface active agents are responsible for reducing the surface tension of water. Surfactants have cleansing or solubilisation properties. These compounds are responsible for loosening, emulsifying, and keeping dirt in suspension and prevents re-deposition of dirt in surfaces. Surfactants presents great possibilities of cleaning applications. Most common of all surfactants is soap/detergent which, over time, were widely used for laundering, dishwashing, and household cleaning. Eventually, numerous product activities have been done to improve the cleaning efficiency of surfactants, thus, creating vast chemical formula to achieve high quality. Table 1.1 below shows the major usage of surfactants.

Additionally, surfactants have various industrial applications such as in lubricants, emulsion polymerization, textile processing, mining, flocculates, petroleum recovery, wastewater treatment and other processes. It is also used as dispersants in oil spills ("Toxic," n.d.). The consumption of surfactants both for industrial and domestic purposes has increased worldwide production of approximately 17 million tons in the year 2000. It has risen exponentially since then. Anionic surfactants are the most common type that is produced and is responsible for about 50% of the total production (Patel, 2004). These do not undergo chemical change during the washing process and are discharged down the drain. This simple routine poses risk to the environment when finally discharged into the natural waters.

Table 1.1: The major surfactant markets

	Value (£m)	Quantity (kt)
Household detergents	2800	4000
Industrial and institutional cleaning	420	530
Personal care	940	860
Crop protection	290	200
Oilfield	390	440
Paints and coatings	140	160
Textile spin finish	200	160
Textile auxiliaries	450	500
Construction	190	470
Emulsion polymerisation	240	290
Food	190	200
Leather	30	60
ORE/mineral	60	150
Plastic additives	60	40
Pulp and paper	100	120
Explosives	10	10
Other	630	380
Total	*7140*	*8570*

(Source: Royal Society of Chemistry, http://www.rsc.org/chemistryworld/Issues/2003/July/amphiphiles.asp)

The major sources of surfactant releases into the environment are mostly from industrial and sewage discharges ("Toxic," n.d.). The first problem regarding the ineffective removal of surfactant on wastewater treatment plants started when foams appear on rivers and/or to surface waters receiving effluents sometime around 1960s. The most common used surfactant around this time was propylene tetramer benzene phonate (PT benzene) (Scott & Jones, 2000). This specific surfactant was found to be non-biodegradable and was insufficiently removed during wastewater treatment. Another incident occurred in 1980s when a type of surfactant called alkyl phenol ethylates (APE) was used for detergent. It was found that the breakdown products are toxic to aquatic organisms. When APE goes through biodegradation, the breakdown products are nonyl and octyl phenols. Nonyl phenols from treated wastewater that is discharged to the rivers affect the zooplankton and interferes with their sex determinations and development (Scott & Jones, 2000). Several other incidents have occurred over time that encouraged study of surfactant removal.

To address the impact of the detergent surfactants, industries and regulatory authorities began to evaluate the ingredients of the product and possible effects to the consumers and mainly, to the environment. Various risk assessment studies have been done to study the concentrations and effect of the individual ingredients of detergent surfactants (“American,” 2015). A risk assessment program was carried out in the Netherlands by the European Detergents and Surfactants Industry with Regulatory Authorities to ensure that surfactants are removed at a high degree (Pratz et al., 1997). The study consisted of monitoring seven treatment plants that has different types, sizes, and degrees of loading. The aim of this assessment was to evaluate removal process of surfactant and to guarantee high yield removal in wastewater treatment facilities before being discharged into the environment or reused for irrigations or ponds.

In order to reduce the concentrations of surfactants in wastewater effluents, new methods/technologies are being developed. Several types of treatment methods include coagulation and flocculation, adsorption, ultrafiltration, and removal by rice husk. Each methods have their own advantages and disadvantages that will be briefly discussed later on.

1.2 Problem Statement

Detergent surfactants is widely used throughout the world. Some surfactants are synthesized and are used as textiles, fibbers, food, paints, polymers, cosmetics, pharmaceuticals, micro electric, etc. (Abdulhassan et al., 2006). Surfactants are commonly used to formulate an effective cleaning detergent. Surfactants are present in low concentrations in effluent wastewater from various industrial and domestic operations. This presents a great risk because surfactants are harmful to human beings, fishes, and vegetation and as the past incidents have indicated, detergent surfactants are the main cause of formation of foams in rivers and wastewater treatment plants. Surfactant concentrations must be reduced to permissible limit to meet environmental standards. Due to these reasons, it is important to select an efficient way of removing surfactant in wastewater effluent before discharge or reuse.

The aim of this project is to investigate another method to remove surfactant from wastewater. Batch froth flotation is the selected method. Advantages and efficiency, as well as, limitations (if there are any) of froth flotation process upon the removal of surfactant in wastewater treatment is investigated.

1.3 Objective and Scope of Study

The scope of this report is to remove surfactants on wastewater by batch froth flotation. It is necessary to study the properties of surfactant to evaluate its removal effectiveness on wastewater. It is in the interest of this project to understand the operations that undergo during froth flotation. This is to identify the parameters that must be monitored and will be adjusted when necessary. Furthermore, study of the operation will also help understand the design of the process unit being used and its efficiency.

With that said, the objective of this study is to investigate the efficiency and effectiveness of surfactant removal on wastewater by batch froth flotation process. Different parameters will be observed such as; surfactant concentration, air flow rate, and flotation time.

The parameters mentioned above will be varied and/or adjusted to investigate the max/min values that will produce the most desired effluent quality. It is in the hope of this project to be able to efficiently remove surfactant on wastewater.

1.4 Feasibility of Project

This project aims to investigate the efficiency of froth flotation process as another possible way of removing surfactant from wastewater. This project requires extensive research on froth flotation technology and principles of surface-active agents to understand the process. It will also require the student to perform laboratory experiments to generate data that will be evaluated later on. The experimental procedure is safe and appropriate to carry out the project.

The project is within the capability of a final year student. It will be executed with the supervision of the coordinator and supervisor. The time frame allocated is reasonable and the project can be completed.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Methods for Removing Surfactant on Wastewater

Membrane Ultrafiltration. Surfactant is removed by using pressure or concentration gradients that will allow separation through semi-permeable membrane where suspended solids and solutes that has a high molecular weight will be retained. Consequently, water and solutes that has high molecular weight will pass through the membrane, it's a separation technique that is based on size exclusion or particle capture to produce potable water (Futselaar et al, 2003). A student done by Kowalska et al. (2005) have focused on application of this method to detergent factory that produces different kinds of domestic detergents and washing powders. The wastewater content are 1,552 – 1,650 (g/m^3) of anionic surfactants and COD amount of 40,132 – 59,027 ($g\ O_2/m^3$). The experiment uses three different types of membrane that has different molecular weight cut-off values for the ultrafiltration process using a cross-flow system. The principle of cross-flow system allows pumping the material to be filtered along the membrane surface to avoid "fouling" where only a small portion is filtered through the membrane. The solids that were retained are washed away to the drain and the whole process is repeated (Futselaar et al, 2003). The result of the experiment shows that a decrease in the membrane cut-off value yields high separation; 65-85% reduction on COD and over 95% retention of anionic detergents (Kowalska et al, 2005). Although ultrafiltration membrane gives a high efficiency retention of anionic detergents, it is also costly due to membrane fouling and replacement and additional pretreatment of feed water requirement. Additionally, ultrafiltration consumes a lot of energy.

Coagulation and Flocculation. It is a more conventional method that removes contaminants in wastewater by destabilizing colloidal material and causing small particles to form flocs by using appropriate dosage of coagulant (ferric chloride) and maintaining it at a specific pH level. Abdulhassan et al. (2006) conducted an experiment to observe the efficiency of coagulation process with the interest in surfactant removal rate. Wastewater sample from a microelectronic factory in Morocco with high organic and surfactant contents is examined. The sample wastewater failed to comply with the Moroccan guide for effluent standards. Surfactant content was 915.32 – 956.51 (mg/L), whereas, the Moroccan acceptable environmental standard is 3 mg/L. Similarly, concentration of organic matter expressed as chemical oxygen demand (COD) has an average wastewater content of 5846.76 mg/L compared to the Moroccan standard effluent of 500 mg/L. At the end of the experiment, it was found that a dosage of ferric chloride at 900 mg/L maintained at a pH level 8 will reduce the surfactant content to as low as 4.6 ± 1.25 mg/L and COD content to 400 mg/L, complying to the Moroccan effluent standard, although, the surfactant content was still slightly higher. The flocculation of anionic surfactants and organic matters was also achieved at a pH level of 2.4 due to adsorptive micellar flocculation (AMF). The cations of Fe^{3+} bind itself to a micelle that subdues repulsion between micelles. Flocs are then formed, allowing organic compounds to bind to the flocs and are removed as aggregates. It is concluded in this experiment that there is a similar mechanism to remove surfactants and organic matters. It was also suggested that coagulant aids such as polyelectrolytes and clay minerals are added for an improved process performance. However, the drawback of this method is the high operating costs due to the use of chemical substances and high amount of sludge and disposal costs (Aygun & Yilmaz, 2010).

Adsorption by Rice Husk. High operating costs and energy consumption are proving to be the factors that reduces the economic feasibility of the methods discussed above. In response to this concern, a research delved on to another possibility of removing surfactant on wastewater has been explored. Adsorption by rice husk is an attempt to remove surfactant on wastewater at a low cost. Adsorption uses an adsorbent, a solid that binds molecules by physical attractive forces, ion exchange or chemical binding. Ultimately, the adsorbent used should be readily available, easy to regenerate and economical (Hosseinnia et al., 2006). A research performed in Department of Energy and Materials and Energy Research Center in Iran tested the ability of a rice husk as a low cost adsorbent for anionic and nonionic surfactants in wastewater. Rice husk is a layer of cellulose protecting the rice grain. Three different ways of using rice husk as an adsorbent was observed; (1) addition of 2 grams of rice husk on 100 ml aqueous solution of anionic and nonionic surfactants (separately) with different pH values, (2) burning the husk to use white ash and added to anionic and nonionic aqueous solutions without changing the pH value and (3) using a glass column packed with whole rice husk where surfactant solutions are passed through it. For anionic surfactants, the first part of the experiment shows that a low pH value favors adsorption within 3 hours for a surfactant type called linear sodium alkyl benzene sulfonate (LABS). Any longer than three hours, desorption occurs. But for another type of surfactant called sodium lauryl ether sulfate (AES), more surfactant is adsorbed as time increased. The second part of the research concluded that the husk ash was not responsible for adsorption process for anionic surfactants. But for the third part, the husk packed column shows a mean adsorption value of 75%. For nonionic surfactants, time and pH level variations do not have significant effect on the adsorption amounts. Lastly, the use of husk column shows a higher adsorption value and increases with decreasing flow rate. In the end, this study is concluded that it needs more improvement as the behavior and ability of rice husk as an adsorbent varies in different parameters.

The technologies discussed above uses chemical, mechanical and biological methods by removing surfactant on wastewater. These methods, although proved to be highly efficient, comes with high operating costs. This project attempts to explore another method of surfactant removal where it is economically feasible. The method to be discussed is batch froth flotation. The properties of surfactants are explained so that its removal effectiveness using batch froth flotation is understood.

2.2 Properties of Surfactant

Surfactants are synthetic organic chemicals used in detergents, personal care and household cleaning products. Surfactants or surface active agents are responsible for the reducing the surface tension of water so it can wet fibers and surfaces. A surfactant is a molecule that is structured with a water soluble end (hydrophilic) and a water insoluble component (hydrophobic) as show in Figure 2.1 below. The hydrophilic end are carboxylates (soaps), sulphates, sulphonates and phosphates, amine product and ether oxygen of polyethylene glycol chain which has a strong affinity to water. The hydrophobic group are aliphatic, aromatic and/or a mixture of both which lacks the affinity to water ("Surfactants," n.d.). Because of these characteristics, surfactants suspend materials by creating a protective coating around it having the hydrophilic end directed to the water phase. For example, in emulsification, an emulsion can be oil droplets suspended in water, certain type of emulsifier (surfactant agent) stabilizes emulsions and prevents separation by having the hydrophobic group attach to the oil droplet and the hydrophilic end oriented to the water.

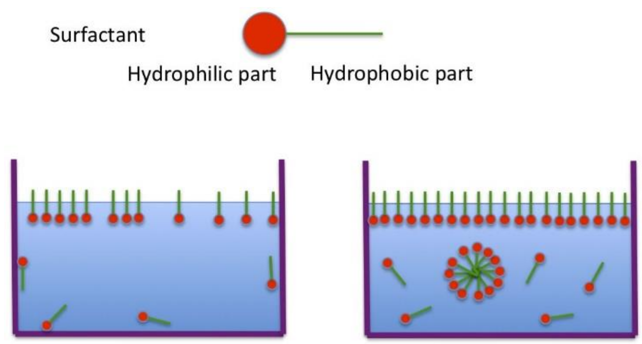

Figure 2.1: Surfactant Molecule

The types of surfactants are classified depending on the nature of the hydrophilic end of the molecule. These types are listed below according to ETSA:

- Anionic Surfactants – hydrophilic part consists of negatively charged group and are sensitive to water hardness. (e.g. basic soaps)
- Non-ionic Surfactants – are non-charged hydrophilic part and are not sensitive to water hardness. (e.g. cleaning detergents)
- Cationic Surfactants – hydrophilic part is positively charged and attach to the surface where they will provide softening, antistatic, soil repellent, and/or anti-bacterial. (e.g. fabric softeners)

- Amphoteric Surfactants – the charge of hydrophilic part is controlled by the pH of the solution.

The most common used surfactant types in commercial detergent applications are anionic and nonionic which are; linear alkyl benzene sulfonates (LABS), alkyl sulfates (AS), alkyl ether sulfates (AES), alkyl ethoxylates (AE), alkyl phenol ethoxyltes (APE) and quaternary ammonium halide compounds.

2.3 Froth Flotation

Flotation process is used in several industries such as wastewater treatment and paper recycling. Flotation process takes advantage of the difference in surface properties of particles. Normally, surfactants are added in the process because of its ability to determine the hydrophobicity of the particles and the probability of attachment to bubbles during the process (Somasundaran & Ramachandran, n.d.). There are several types of flotation processes that exist and these are categorized in terms of size and mechanism of flotation as shown in Table 2.1 below.

Table 2.1: Flotation Techniques

Mechanism	Size range		
	Molecular	Microscopic	Macroscopic
Natural surface activity	Foam fractionation; example: detergents from aqueous solutions	Foam flotation; examples: microorganisms, proteins	Froth flotation of non-polar minerals; example: sulfur
In association with surface-active agents	Ion flotation, molecular flotation, adsorbing colloid flotation; examples: Sr^{2+}, Pb^{2+}, Hg^{2+}, cyanides	Microflotation, colloid flotation, ultraflotation; examples: particulates in wastewater, clay, micro-organisms	Froth flotation; example: minerals such as silica Precipitate flotation (first and second kind); example: ferric hydroxide

Source: Surfactants on Flotation, P. Somasundaran and R. Ramachandran

Among the flotation processes presented on Table 2.1 above, froth flotation is the most common technique that has a broad industrial application. Froth flotation takes place in gas-liquid interface. It functions in a way that it is able to separate the hydrophobic and hydrophilic materials. Hydrophobic particles are adsorbed or attached to the surface of gas bubbles rising through suspension. The bubbles are then separated from the suspension in the form of froth (Lelinski et al., 2011).

In an article in Separation and Purification Technology, researchers have performed an experiment using extended surfactant for motor oil removal from water. Froth flotation with the aid of extended surfactant was used to investigate the effects of air bubble parameters and surfactant concentration that will provide the most effective way to remove oil. This experiment was divided into 5 parts; (1) study of microemulsion formation, (2) dynamic surface tension measurement, (3) continuous froth flotation experiments with various surfactant concentrations, (4) study of air bubble size distribution, and (5) froth characteristics experiments. The relationship between the minimum surfactant concentration and the maximum specific surface area of the bubbles was found to yield the highest oil removal (Watcharasing et al., 2009). This experiment explored the operation process of froth flotation and its effectiveness in removing motor oil with the aid of surfactant. The same idea is hoped to be performed in this project by taking into account the hydrophilic and hydrophobic structure of a surfactant molecule. Instead of using surfactant to remove specific materials in the sample wastewater, the aim of this project is to simply remove surfactant molecules. In theory, batch froth flotation process will be able to create more surface area between water and air for the surfactant molecules.

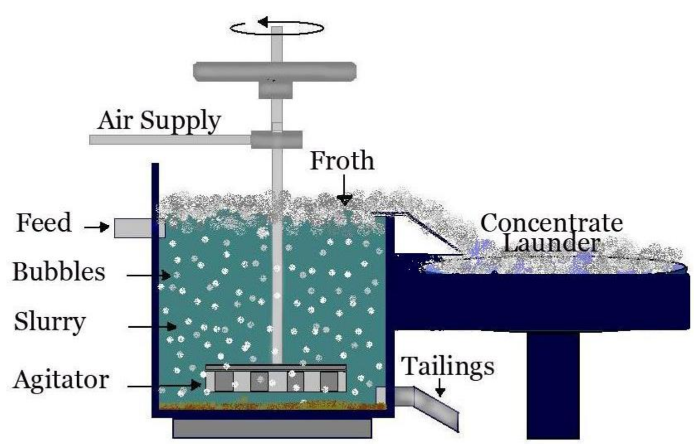

Figure 2.2: Froth Flotation

Figure 2.2 above shows the basic process that happens during froth flotation. The feed that enters the flotation cell is normally conditioned first with an appropriate reagent. The feed is agitated by impellers and air is fed into the cell near the impeller. This action is what creates fine bubbles. The particles with the required hydrophobicity collide and attach with the fine bubbles. The bubbles and the particles rise to the surface and form froth. The froth is removed as a flotation concentrate by skimming. (Gosh, n.d).

The application of froth flotation process on surfactant removal will depend on the surface contact between air and water. Generated bubbles in froth flotation tank will allow for surfactant molecules to attach its hydrophobic ends to the bubbles and the hydrophilic ends directed to the water. The bubble with attached surfactant molecules rise up to the surface of the water, thus, creating froths. This process will allow surfactant contaminants to be taken out of the tank and into the concentrate launder. The hydrophilic ends will stay in the water and any solids left will be taken out at the bottom of the tank as tailings. With that said, one of the aims of this project is to determine the optimum parameters that will ensure high removal of surfactant content in the water.

CHAPTER 3

METHODOLOGY AND PROJECT WORK

This project is experimental based that will be performed in laboratory. Hence, the analysis will be focused on the results obtained upon performing various experimental tests done in the laboratory with the appropriate materials and equipment. The parameters that are going to be monitored are:

- Air flow rate
- Surfactant concentration
- Flotation time

The data generated will be analyzed and justified accordingly.

3.1 Research from literature

Research from literature and articles provided was the first phase done in this project. A background was done by studying the articles from Separation and Purification Technology. All relevant literature regarding properties of surfactants, froth flotation technology and related wastewater treatment process applications were collected and studied.

3.2 Experimental Activity Part I: Froth Flotation Demonstration

3.2.1 Material

- Dirty water to be treated with will be created by the student shown in Figure 3.1. It is composed of water, oil, and soil.

Figure 3.1: Wastewater Sample

- Dishwashing liquid manufactured by Proctor and Gamble, Philippines was produced from the local grocery store shown in Figure 3.2. The major constituent of this liquid dishwasher is anionic surfactant.

Figure 3.2: Anionic surfactant

3.2.2 Flotation Cell

- A container (beaker or cup) will be used to act as a flotation cell.
- A container will be placed underneath the beaker/cup to act as froth collector.
- Bubbles will be produced by using tube connected to an air faucet.
- Air flow rate is measured by using available air flow meter.
- Flotation time is monitored by using a stopwatch.

3.2.3 Procedure

i. Wastewater preparation

Dirty water to be treated was made by mixing dry soil and oil to a bucket of water. 500 mL will be taken from the sample bucket to be used for each experiment that will be done.

ii. Surfactant values

Four values of surfactant, e.g., 0.2, 0.4, 0.6, 0.8 mL are used for the experiments.

iii. Air flow rate

Air flow rate is varied. Four different appropriate values were selected. Flow rate will be measured by using available digital flow meter as in Figure 3.3. Values selected are 0.2, 0.4, 0.6, 0.8 m/s.

The experiments were conducted at room temperature. All experiments were to be repeated twice. Therefore, there are 16 flotation experiments with various surfactant concentration and air flow rate.

Figure 3.3: Digital Air Flow Meter

iv. Flotation time

Time is monitored by observing the rate of froth formation at different times, e.g. 5, 10, 15, 20 minutes.

v. Froth flotation process

Air flow rate: The prepared wastewater with a known volume (500mL) is poured into a beaker. Surfactant is added. A container is placed under the beaker. Air flow rate is measured by placing the digital air flow meter in front of the air faucet, adjusting the faucet to the desired value. Once, desired flow rate is found, a tube is attached to supply bubbles to the mixture. The experiment is repeated for all the values of surfactant and air flow rate. A sample set up is shown in Figure 3.4.

Flotation time: The same set up as above is used. Air flow rate is kept constant at 0.4 m/s. The method is repeated for all the values of surfactant and time.

Figure 3.4: Froth Flotation Set-Up

vi. Analysis of the froth

The froth from the beaker/cup is collected in the container. The froth will be left to settle. Once settled, the mixture is separated into two phases; oil-water emulsion and oil. Sulfuric acid will be used to break the emulsion. Oil and surfactant-water mixture will appear as two-distinct phases.

3.3 Experimental Activity Part II: Froth Flotation Scale-Up

3.3.1 Material

The wastewater to be treated is the same as the one used in Part I of the experimental activity.

3.3.2 Flotation cell

The available flotation cell has the capacity of 2 L. Air is introduced via tubing. Air flow rate is measured by digital air flow meter. Stirring will not be performed.

3.3.3 Procedure

About 1000 mL of the prepared wastewater will be taken from the sample bucket. Four values of surfactant, e.g. 5, 10, 15, 20 mL are used for the experiments. Air flow rate is kept constant at a value of 0.4 m/s. Flotation time will range between 10 – 12 minutes.

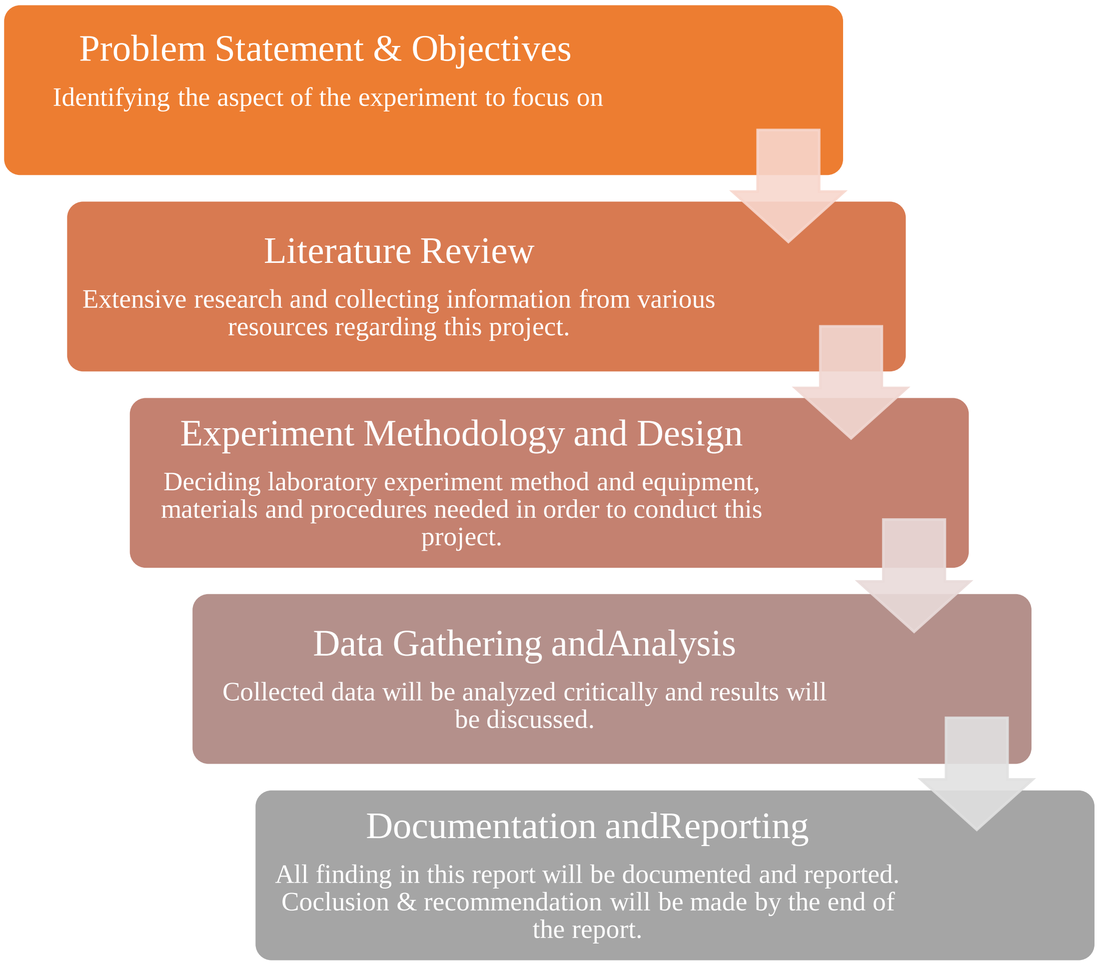

Figure 3.5: Process Flow of the Project

Table 3.1: Project Timeline and Key Milestones

No	Details	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Designing of evaluation methods															
2.	Submission of Progress Report															
3.	Continuation of Project work (simulation)															
4.	Pre- SEDEX															
5.	Submission of First Draft of Final report															
6.	Submission of Dissertation (Softcopy)															
7.	Submission of Technical Paper															
8.	Viva															
9.	Submission of Project Dissertation (Hardbound)															

Process

Key Milestone

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Part: Determining Optimum Parameters

A graph of the collected data for froth volume with different air flow rates and various surfactant doses in the feed is shown in Figure 4.1. It was observed that froth volume increased with air flow rate. This is because as air flow rate increases more bubbles are introduced into the feed. Thus, more surfactant molecules are able to attach themselves to the bubbles and form froth. Although, it was noted that the froth recovered for all the experiments is not pure surfactant as can be seen in Figure 4.2. This was because when air is introduced through tube, the air flow rate was too high for the surface of the liquid whch caused it to fall over the rim of the beaker. This was true for all the air flow rate values. However, based on the experiments done, an air flow rate value of 0.4 m/s produces the best froth volume. This is also with consideration of the time it took for one experiment to finish and how much feed escaped the beaker.

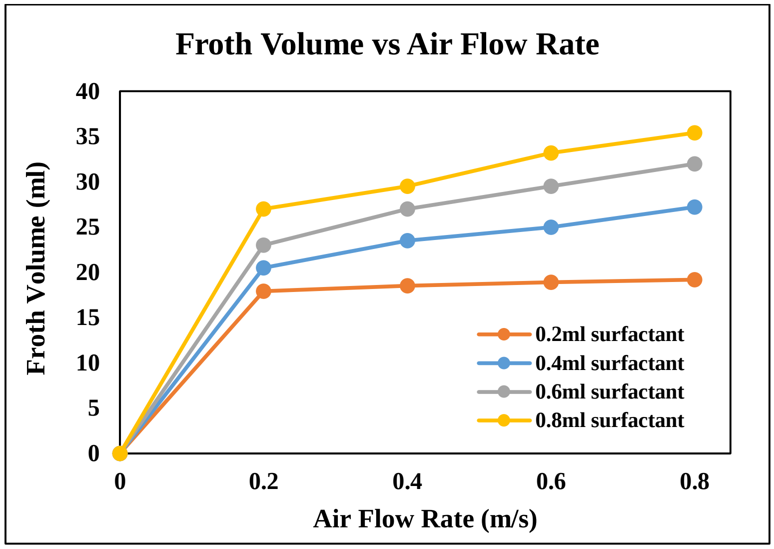

Figure 4.1 Froth volume data with various air flow rate for various surfactant doses

For all the surfactant doses with 0.4 m/s flow rate, it took about 10 to 15 minutes to recover the surfactant. When the flow rate is low, the flotation takes about 30 – 40 minutes. When the flow rate is higher than 0.4 m/s, more feed escaped the beaker.

Figure 4.2: Settled froth for 0.4 m/s air flow rate and 0.4 ml surfactant dose

Additionally, a graph of froth volume versus flotation time for each surfactant doses is produced shown in Figure 4.3. The graph shows that as time of flotation increases the volume of the froth collected decreases. It can be deduced that less froth volume indicates that surfactant present in the feed have decreased. It can be observed from the graph that after 15 minutes, froths were no longer formed for all the surfactant doses. Between 13 – 15 minutes, the froths started to break. Flotation time within the first 10 minutes produce a satisfying froth volume.

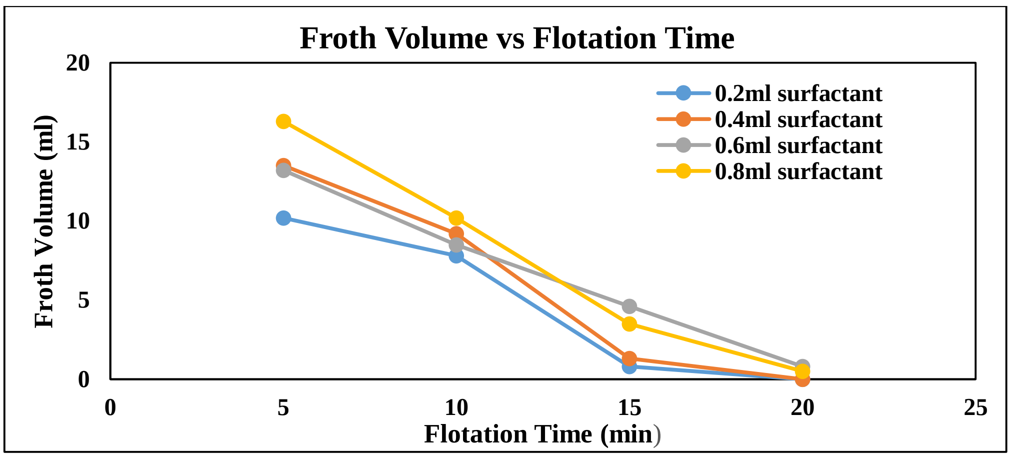

Figure 4.3: Froth volume data with constant air flow rate of 0.4m/s for various

4.2 Part II: Froth Flotation Scale Up

The variation of percentage surfactant recovery from the float with optimum flotation time and air flow rate is shown in Figure 4.4. It was observed that the surfactant recovery increases with time of flotation and approached an asymptote. After 12 minutes, the percentage recovery is marginal. For example, surfactant recovery increased by approximately 2 % for 10 ml surfactant and 10 ml oil in the feed when the experiment was run until 15 minutes.

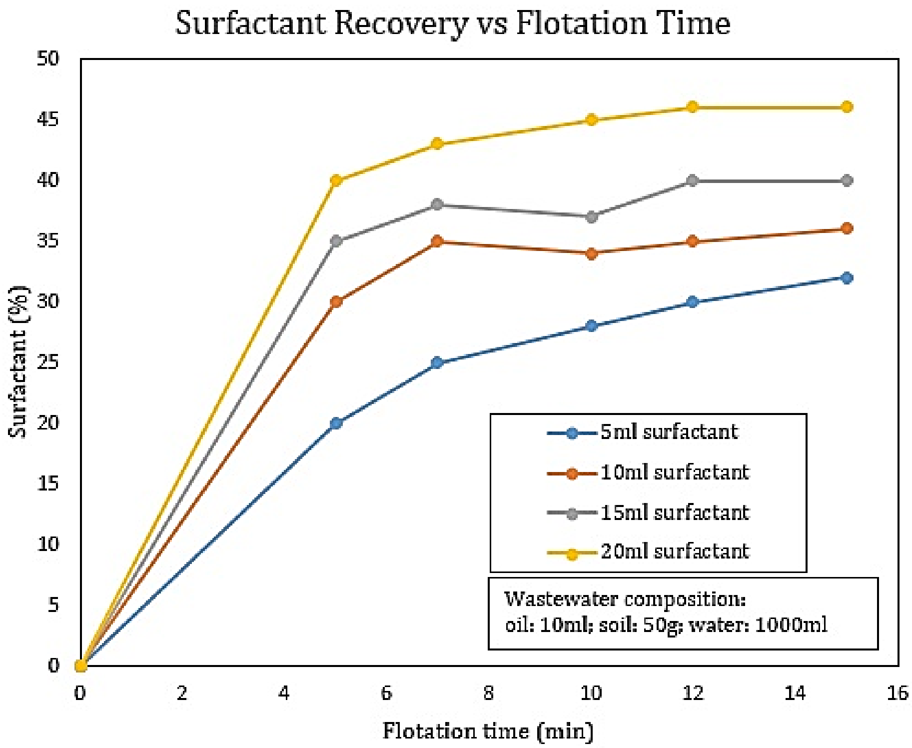

Figure 4.4 Variation of surfactant recovery with flotation time for various surfactant doses in the feed with 10 ml oil.

CHAPTER 5

CONCLUSION

Froth flotation can successfully be applied for surfactant removal. The experiment done was to demonstrate the process of froth flotation and its effectiveness on surfactant removal on wastewater. The generated graphs were able to determine the optimum air flow rate value which is 0.4 m/s. At this air flow rate, there is no rigorous movement in the cell and feed escaping the beaker will be controlled. The optimum flotation time was found to be between 10 to 12 minutes which indicate an effective surfactant removal from the sample. It is likely that the more froth produced indicates that more surfactant is being removed from the sample. However, it is recommended that more iterations for air flow rate and flotation time values should be done to get a more accurate values. Additionally, for Part II of the experiment, different values of oil for the various surfactant doses should be explored to determine a more accurate surfactant percentage removal. With this method, surfactant removed will reduce its toxicological effects to the environment. It is an easy and simple process and economically feasible.

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