Study of Different Particle Size Analyzers for Waste Water Treatment

By:

Wan Nur Syuhada Bt Wan Ata

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the requirement for the
Bachelor of Engineering (Hons)
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Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Chemical Engineering Programme
Universiti Teknologi PETRONAS
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(CHEMICAL ENGINEERING)

Approved by,

____
(Dr Taslima Khanam)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

MAY 2014

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.

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WAN NUR SYUHADA BT WAN ATA

ABSTRACT

Wastewater treatment is a process of removing the contaminants in the wastewater before discharging it into the water body. The efficiency of the wastewater treatment plant is very crucial and need to be strictly monitored in order to treat the waste water until it complies with the standard discharge value that has been set by the government. One of the important parameters that can be used to measure the efficiency of the wastewater treatment plant is particle size. Particle size represents the level of contamination of the wastewater. The studies and researches about the particle size have been done widely especially in environmental area, but there is still a lack of comprehensive study being done in covering the limitations and advantages of using specific equipment to determine the particle size. Hence, this project will cover the study on the limitations and advantages of using specific equipment which is Particle Size Analyzer (PSA) and microscope to determine the particle size in various waste water samples. The usage of microscope along with the ImageJ software to determine the size of particles in the waste water sample is believed to give a high contribution to the environmental field especially for structural analysis. This is due to the ability of this software to measure the size of irregular particles.

ACKNOWLEDGEMENT

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Last but not least, special credit goes to the author's parents, family members and friends, who had dedicatedly provided the author with additional support and encouragement throughout this project either directly or indirectly. Thanks again to all, your kindness and helps will always be remembered and may Allah reward you with His blessings.

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Particle size analysis or simply particle sizing is the collective name of the technical procedures or laboratory techniques which determines the size range, the average or mean size of the particles in a powder or liquid sample. This analysis has been applied in the various fields including chemical, mining, agricultural, pharmaceutical and aggregate industries which emphasized on the control of particle size for their operations. One of the most important fields that focused on the particle size analysis is the waste water treatment (T. Vítěz, 2010).

Waste water is liquid discharged by domestic residences, commercial properties, industry or agriculture which often contains some contaminants. The waste water need to be treated before being discharged to the water source or being reuse again. The treatment may involve physical, chemical or biological processes or combination of these processes depending on the required standard value of discharge. Most treatment plants have primary treatment which involve physical removal of floatable and settable solids and also secondary treatment for biological removal of the dissolved solids. After the primary and secondary treatment, the waste water is usually disinfected using chlorine (Agency, 2004). The types of treatments are different according to the requirement of treating the waste water up to the standard value allowable to be discharged.

The treatment is essential in order to comply with the standard value of discharge that has been set by the Malaysia's Environmental Law, ENVIRONMENTAL QUALITY ACT 1974(Act, 1974). Hence, the efficiency of the waste water treatment needed to be monitored to achieve this target. One of the important parameters to measure the efficiency of the waste water treatment is particle size which can determine the degree of contaminant removal in waste water (A.Tiehm, 1999). The size of the suspended solids in the waste water has considerable impact on the separation process such as sedimentation and filtration (A.Tiehm, 1999). Hence, this project will focus mainly on the particle size analysis in the waste water treatment using different equipment to determine the feasibility of the equipment for measuring different type of waste water.

1.2 PROBLEM STATEMENT

Wastewater regulation and treatment is still a major concern in planetary pollution management. The fundamental purpose of the waste water treatment is concerns with the protection of public health. Environmental protection is the second major purpose. It is the responsibility of the engineers, scientists and public officials involved to ensure that waste treatment systems achieve this goal. This goal means to achieve the standard discharge value stated by Malaysia's Environmental Law, ENVIRONMENTAL QUALITY ACT 1974(Act, 1974).Hence, the waste water treatment plant needed to be monitored frequently for its efficiency in treating the waste water. One of the parameters being monitored is particle size in the waste water. Particle size is important parameters being measure to determine the level of contaminants removal in the waste water, hence provide the efficiency of the waste water treatment plant (A.Tiehm, 1999). Particle size is one of the most important physical properties of solids, which is used in many fields of human activity, such as construction, waste management, metallurgy, fuel fabrication, etc. Nowadays, many tools and equipment have been developed for measuring the particle size. Some of them are Particle Size Analyzer (PSA), sieving, sedimentation, microscope counting, Coulter Counter, Dynamic Light Scattering and Imaging Particle Analysis (Gregorová, 2007). All of these tools are very well-known and common in particle size analysis. Despite availability of large number of tools, each tool associated with some short comings limiting robust applicability of one tool for handling large variety of sample. To date, there is still a lack of comprehensive study covering limitations and advantages of using the specific equipment to measure the particle size in different waste water. Hence, this project will provide the data for determination of the limitations and advantages of different equipment being used for measuring particle size.

1.3 OBJECTIVE

(1) To compare the feasibility of using two equipment which are Particle Size Analyzer and microscope for measuring particle size in terms of their limitations and advantages for the study of waste water.

1.4 SCOPE OF STUDY

(1) Waste water are collected from two different sources:
    - Domestic waste water of UTP
    - Palm Oil Mill Effluent (POME)

(2) Experimental work on particle size by using two equipments; Particle Size Analyzer (PSA) and microscope. The usage of only two equipments is due to some limitations of the time frame and the availability of the equipment in UTP.

(3) Repetition of experimental works for each equipment in two different waste water samples.

(4) Analysis on the results obtained to determine the limitations and advantages for each tool being used for particle size analysis.

CHAPTER 2

LITERATURE REVIEW

Particle can be defined as a small localized object to which it can be ascribed several physical or chemical properties such as volume or mass(Wikipedia, 2014). Particles are 3-dimensional objects, and unless they are perfect spheres (emulsions or bubbles), they cannot be fully described by a single dimension such as a radius or diameter. In order to simplify the measurement process, it is often convenient to define the particle size using the concept of equivalent spheres. In this case the particle size is defined by the diameter of an equivalent sphere having the same property as the actual particle such as volume or mass for example. It is important to realize that different measurement techniques use different equivalent sphere models and therefore will not necessarily give exactly the same result for the particle diameter.

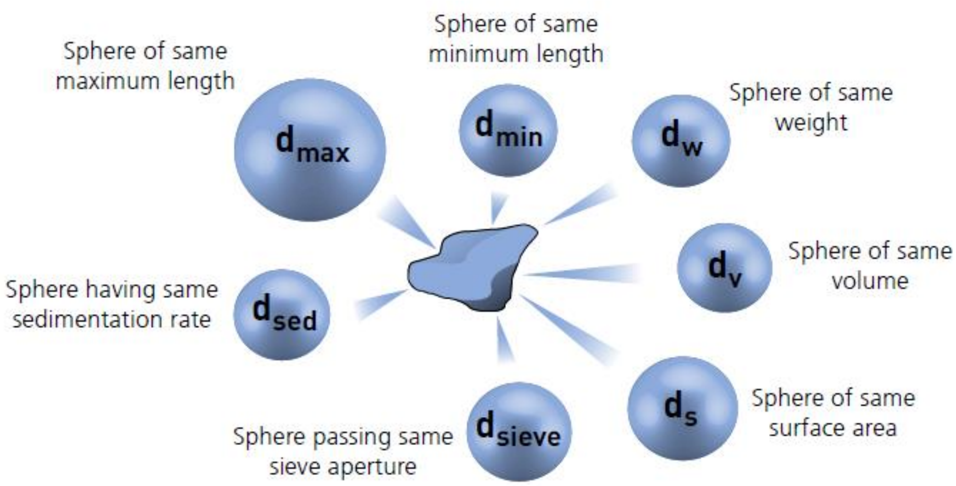


Figure 1: Illustration of the Concept of Equivalent Spheres.

If the sample is perfectly mono disperse, for example, every single particle has exactly the same dimensions, it will consist of a statistical distribution of particles of different sizes. It is common practice to represent this distribution in the form of either a frequency distribution curve, or a cumulative distribution curve. There are four types of particle size distribution:

1) Weighted distributions

   A particle size distribution using the weighting mechanism will depend upon the measuring principle being used.

2) Number weighted distributions

   A counting technique such as image analysis will give a number weighted distribution where each particle is given equal weighting irrespective of its size.

3) Volume weighted distributions

   Static light scattering techniques such as laser diffraction will give a volume weighted distribution. Here the contribution of each particle in the distribution relates to the volume of that particle (equivalent to mass if the density is uniform).

4) Intensity weighted distributions

   Dynamic light scattering techniques will give an intensity weighted distribution, where the contribution of each particle in the distribution relates to the intensity of light scattered by the particle.

Particle size influences many properties of particulate materials and is a valuable indicator of quality and performance(HORIBA Instruments 2012). It is one of the important parameters being measured for the waste water treatment to measure the performance and efficiency of the treatment. Other industries where particle size plays an important role include nanotechnology, proteins, cosmetics, polymers, soils, fertilizers, and many more. There are many research have been done to investigate the effect of particle size analysis on the performance of waste water treatment. Separation steps such as screening, filtering, cyclones, etc. may be monitored by measuring particle size before and after the process. According to (A.Tiehm, 1999), particle size analysis can provide the assessment of the functionality of clarifiers and deep bed filtration in the waste water treatment as the size of suspended solids has considerable impact on separation processes such as sedimentation, flocculation and filtration. The result of the assessment can be done to design the treatment with optimum working conditions which surely can improve the efficiency of the waste water treatment. Optimum working parameters for each treatment is crucial as it can guarantee relatively low cost and enough removal efficiency with respect to the time(Zielina, 2007). Particle size control is crucial in the waste water treatment and the need for highly reproducible particle size assessment techniques has grown significantly in the past decade.

Sieving is particularly useful since particles are sorted into categories solely on the basis of size, independently of other properties. Sieving consists of placing a sample on a sieve containing openings of a fixed size and agitating the sieve in such a way that the particles that can pass through the openings do so. To speed up the analysis, several sieves are stacked on top of each other, with the sieve containing the largest openings on top. These sieves are vibrated until the residue on each sieve contains particles which can pass through the upper sieve and cannot pass through the lower sieve. A variety of sieve apertures are currently available, ranging in size from around 20 µm to mm sizes for woven wire sieves, down to 5 µm or less for electroformed sieves, and above 1 mm for punched plate sieves. Sieving is probably the most used and abused method of particle size analysis because the equipment, analytical procedure and basic concepts are so simple.

Particle size analysis by image analysis is carried out by using the microscope. Due to the wide availability of computers and software for images capturing such digital pictures can be utilized for a rapid and convenient analysis of particle size and shape. Microscopy is often used as an absolute method of particle size analysis since it is the only method in which the individual particles are observed and measured(Allen, 1997). Sample preparation in the case of microscopy is very simple, requiring only the sandwiching of ~100 microliters of sample between a slide and a cover slip with gentle pressure to achieve a sample thickness of ~25 micrometers(Philo Morse, 2009).

Other than that, the second method is by using the Particle Size Analyzer (PSA).This method is using the laser diffraction technique. Over the past years, laser diffraction has become an important tool in environmental field to measure the particle size (S.A.Ha, 2003). This method has been used by many environmental agencies and researches to determine the particle size in particular area as being applied by Department of Environmental Sciences, University of California(Eran Segal, 2009). By laser diffraction analysis it is possible to measure particles sizes between 0.02 and 2000 µm. The sample is dispersed in either air or a suitable liquid media. The laser passes through the dispersion media and is diffracted by the particles. The blue laser is used for measuring the small particles, while the red detects the larger particles. The diffraction pattern is measured by detectors, and the signal is then transformed to a particle size distribution based on an optical mode. Laser diffraction (LD) is well established across the particulate processing industries as an effective technique for measuring particle size and particle size distribution. It exploits the Mie theory of light, which relates the scattering pattern produced as light passes through a sample to the size of any particles present. Large particles scatter light strongly at small angles to the incident ray while smaller particles scatter more weakly at wider angles. Through the analysis of detected angular scattering intensity data it is, therefore, possible to determine particle size and distribution(Levoguer, 2013).

If particle size is to be a quality control for specific project or analysis, the method of particle size distribution determination will have to be validated. This can be achieved by comparing the feasibility of the equipment being used to measure the particle size in terms of their limitations and advantages. Up to this time being, there is still a lack of comprehensive study for this analysis. Hence this project is expected to provide quantitative review on particle size analysis equipment from the experiments of wastewater analysis.

CHAPTER 3

METHODOLOGY/ PROJECT WORK

3.1 RESEARCH METHODOLOGY

Throughout the Final Year Project, the whole activities of the research is divided into three main phase; Early Research Development, Middle Research Development and Final Research Development as shown below.

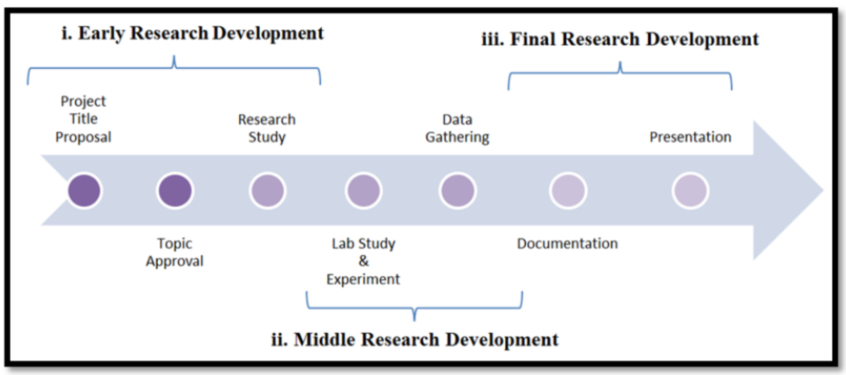


Figure 2: Key Milestone of the Project

In the **early research development** phase, the activities are mainly focusing on collecting information on the topic and background studies. The main references used are technical paper, journal and books. This phase allows author to have a clear understanding on the whole principle of this study as well as to prepare a concise guideline in executing this project. Throughout this phase, author will have a routine discussion with project supervisor in getting advices and assistance to understand the theory in depth.

The next phase is **middle research development** in which the laboratory experiment will be conducted. For this project, the experiments will be conducted by using different equipment with different wastewater samples. Result obtained will be gathered for further interpretation and discussion.

In the **final research development**, all the data obtained will be documented and discussed. A proper report will be completed and the research will be open for further improvement. The author will then make a presentation to present the outcome or finding from this project.

The Gantt chart of this project as shown below is to ensure this project is being done effectively and according to the timeline.

No.	Activities /Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Planning														
2	Experimental Work Using Particle Size Analyzer														
3	Experimental Work Using Microscope														
4	Analysis the Data Obtained														
5	Submission of Progress Report														
6	Project Work Continues														
7	Pre-EDX														
8	Submission of Technical Paper														
9	Oral Presentation														
10	Submission of Project Dissertations														

Figure 3: Gantt Chart of FYPII

3.2 EXPERIMENT METHODOLOGY

In this section, a preliminary plan of this project is being discussed in terms of the wastewater sample preparation, tools and equipment that will be used for measuring particle size and also the proposed experiment procedure.

3.2.1 Waste Water Sample Preparation

The wastewater samples for this project are taken from two different places:

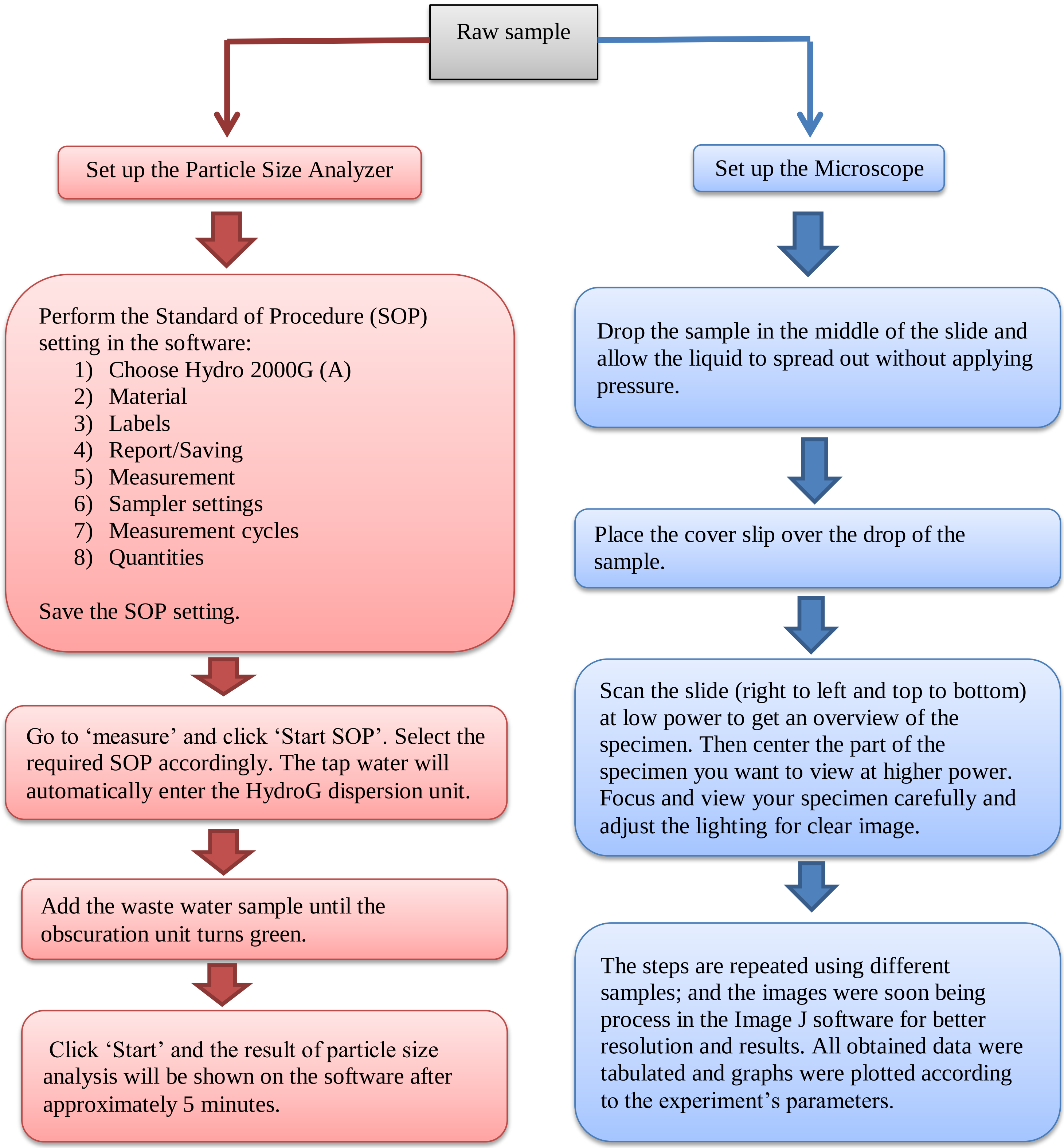
1. Palm Oil Mill Effluent (POME)
2. Domestic wastewater of UTP

Three liters of domestic waste water sample of UTP was taken on the day of the analysis and it must be collected in such a manner that nothing is added or lost in the portion taken. The sample should be taken where the wastewater is well mixed and the sampling point is located at turbulent flow. The sampling points should be readily accessible, proper equipment should be at hand and safety precautions are established. This project will be using the sample before and after the treatment for the domestic waste water of UTP. For the Palm Oil Mill Effluent, one liter of sample was taken. For the analysis using microscope, the dilution technique has been used to get a better and clear image of the particles inside the waste water. The dilution is done by using distilled water. Each sample should be labeled or tagged for identification including the date, time of collection, name of collector and location.

3.2.2 Tools and Equipment

The equipments that will be used in this project are Particle Size Analyzer (Mastersizer MS2000) and also MEIJI microscope (ML 5000). This project is using only two equipments due to limitations of the time frame and the availability of the equipment in UTP.

3.2.3 Proposed Experiment Procedure



CHAPTER 4

RESULTS AND DISCUSSION

4.1 EXPERIMENTAL WORK FOR PARTICLE SIZE ANALYZER

The analysis of particle size by using two equipments which are Particle Size Analyzer and microscope was done for the sample from domestic wastewater in UTP and also Palm Oil Mill Effluent (POME) sample. There were two different types of domestic waste water which is influent, the raw waste water coming into the waste water treatment plant and the effluent which is the water after the treatment at the waste water treatment plant.

Figure 4: The Influent Sample

Figure 5: The Effluent Sample

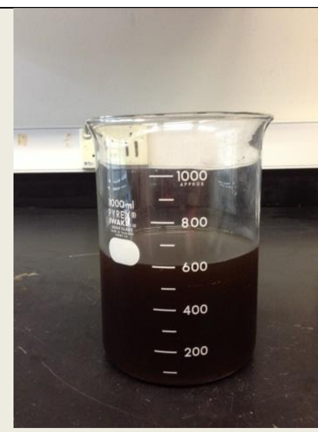


Figure 6: The Palm Oil Mill Effluent (POME) Sample

The observation was made by looking at both of the wastewater samples, influent and effluent. The influent was cloudy and dark in color with some of big particles were suspended at the bottom of the beaker. The effluent was clear and no visible particles can be seen from the observation. The POME sample also has cloudy and dark color with small pieces of particle can be seen.

The results were obtained in the form of particle size distribution's graph for these two samples.

(1) Influent Sample

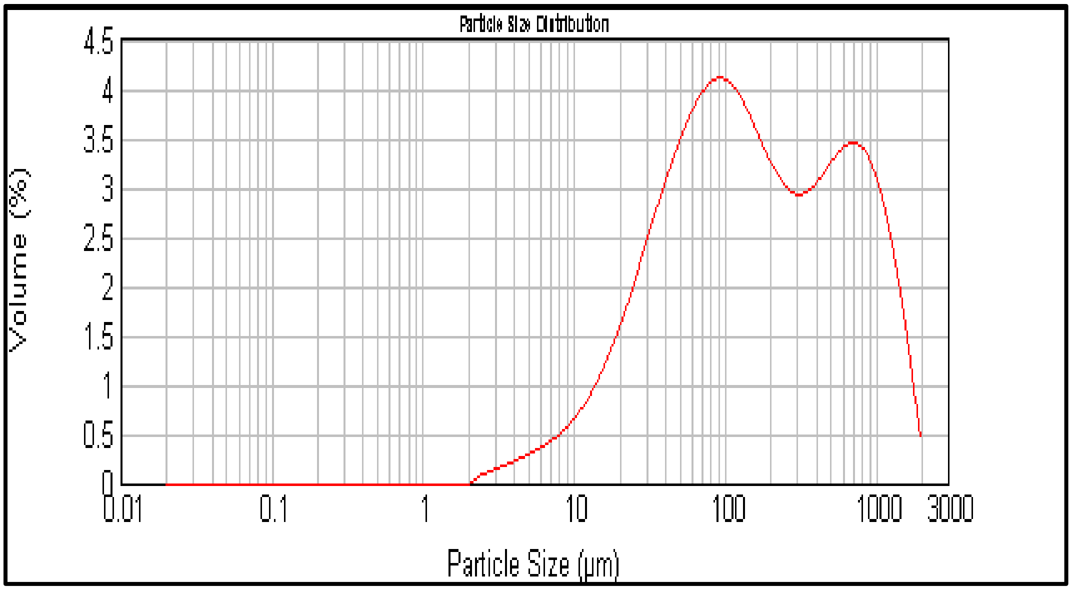


Figure 7: Graph of Volume (%) vs. Particle Size (μm) For Influent

The result from the Particle Size Analyzer (PSA) shows the graph in the form of volume (%) versus particle size (μm).This means that when the result lists,for example 11% of the distribution is in the size category 6.97-7.75 microns thismeans that the total volume of all particles with diameters in this range represents 11% of the total volume of all particles in the distribution. Based on the result above, it showed that the highest volume of particle present in the size of 100µm and also 500µm. There is no particle detected at particle size ranges 0.01 until 1.2µm. This is relatively relevant with the sample as it is an influent sample which indicates, many large particles are present before the wastewater treatment.

(2) Effluent sample

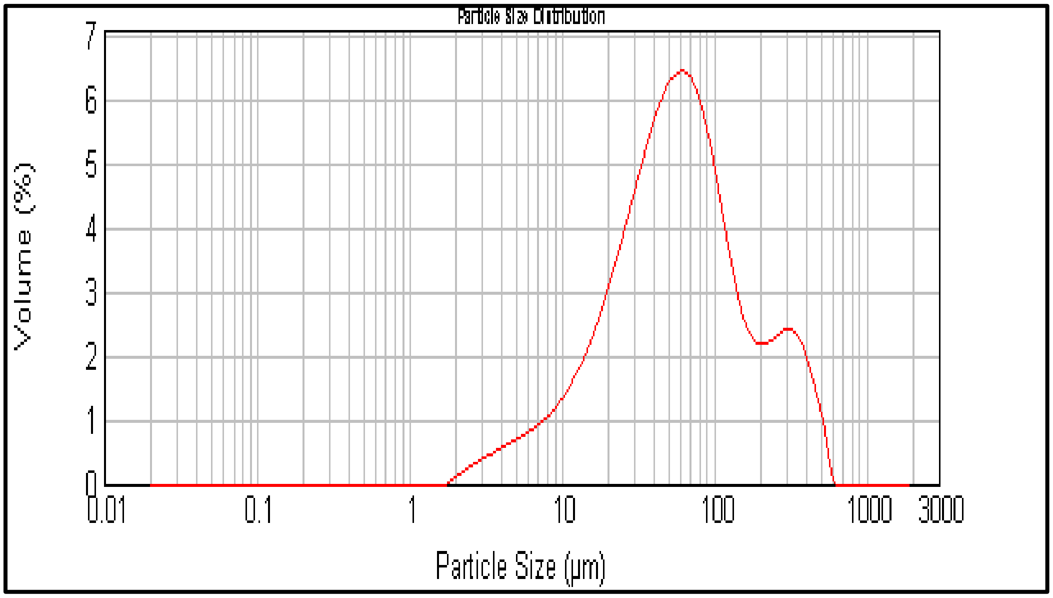


Figure 8: Graph of Volume (%) vs. Particle Size (µm) For Effluent

The result for effluent sample also showed no particle size ranges from 0.01µm to 1.2µm is being detected. The particle size in the effluent is smaller compared to the influent. This is by right, is reliable result as effluent has undergone some treatments in the wastewater treatment plant to remove all the contaminants and big particles in order to comply with the standard discharge value to the environment. The highest volume of particle was detected at particle size of 60µm and also 300µm. This showed the reduction of particle size in effluent compared to the particle size in influent from the previous analysis. The analysis on particle size will be continued by doing the study on the treatments in the wastewater treatment plant in order to determine what compound are being removed from the wastewater after the treatment.

(3) Palm Oil Mill Effluent (POME) sample

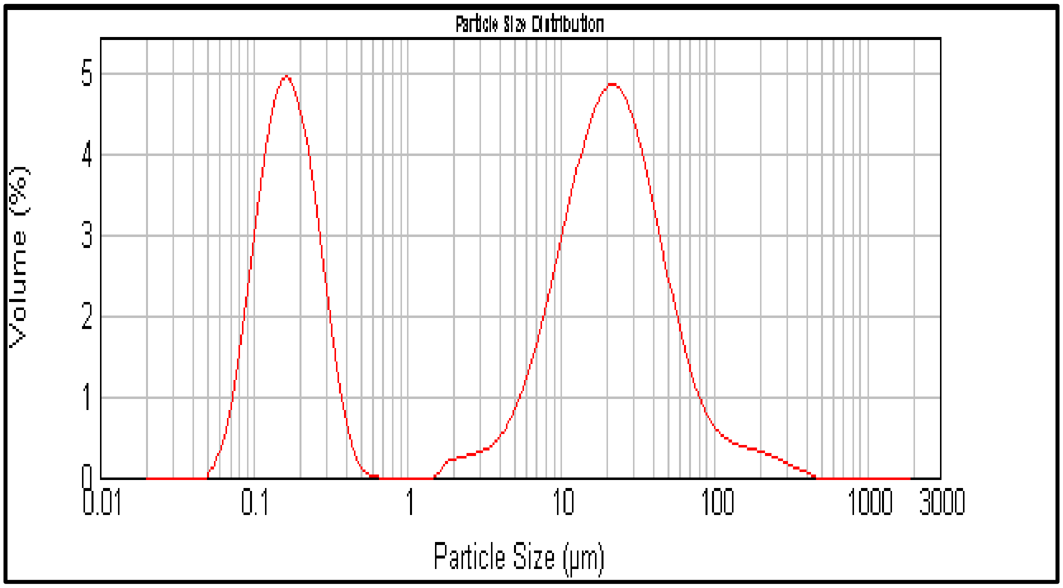


Figure 9: Graph of Volume (%) vs. Particle Size (µm) For POME

Based on the graph shown above, the palm oil mill effluent (POME) sample has a highest volume of particle at particle size 0.15µm and 20µm. This showed that POME sample has the smallest particle compared to influent and effluent sample. The result is said to be reliable as the POME sample is the sample taken after the treatment at the palm oil water treatment. The dark color of the sample is believed due to the color from the palm trees themselves as the viscosity of the sample is also low which indicates, less particle is present in it.

4.2 EXPERIMENTAL WORK USING MICROSCOPE

The same samples which are being used in Particle Size Analyzer will be used to analyze the particle size using the MEIJI Microscope. The microscope has different magnifying lens and different angles of view which means, for example a sample is labeled 65x4, it means it is 4 times magnifying with 65° angle of view. This analysis is only using 65° angle of view for consistency of the images as images shown and captured in the computer are relatively same regardless of different angle of view. The angle of view is only useful for the view at the microscope itself. There are three magnifications for the lens which are 4, 10 and 40. The analysis is done by dividing the glass slide which contains sample into 4 different areas as illustrated below:

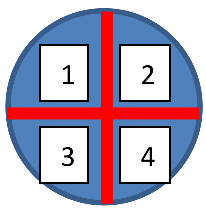
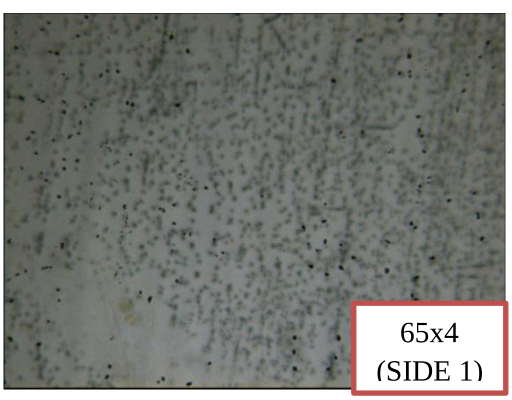
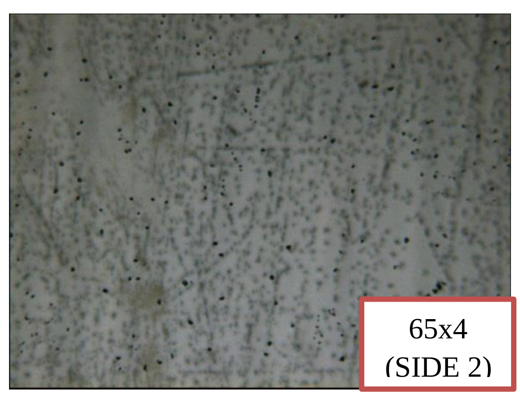


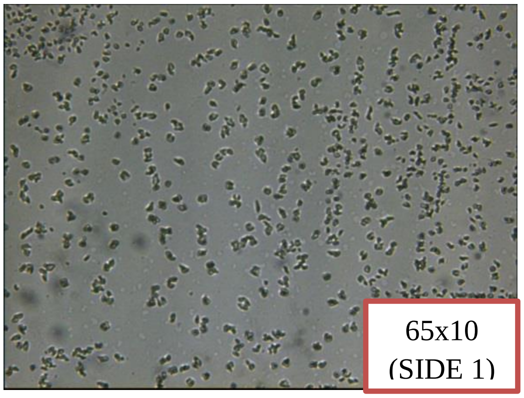
Figure 10: Area Distribution for the Sample on Glass Slide

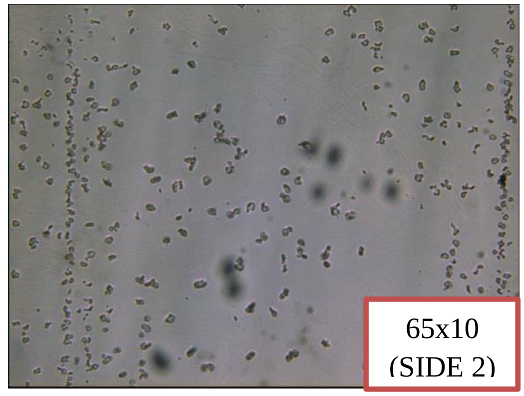
There were many images of the samples being captured, but for the purpose of this report, only some of the images will be discussed. The magnification and the angle of view from the microscope have been adjusted for each sample to get a better and clear image. The images captured from the influent sample are listed below:



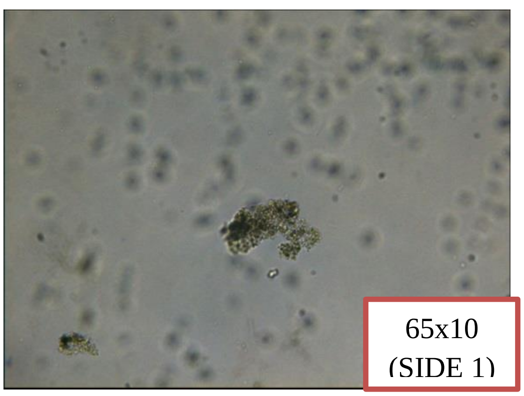


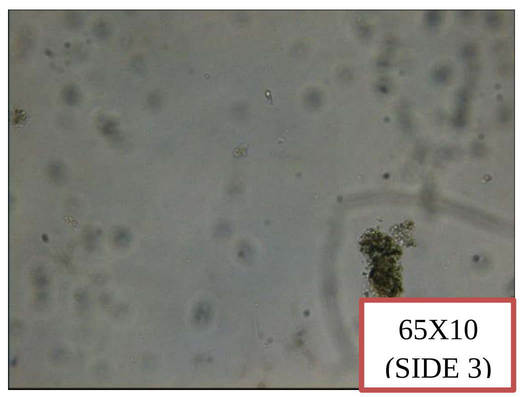
The images captured by using x4 magnification was not clear and sharp, hence it was decided to use the images obtained by using x10 magnification throughout the project analysis.

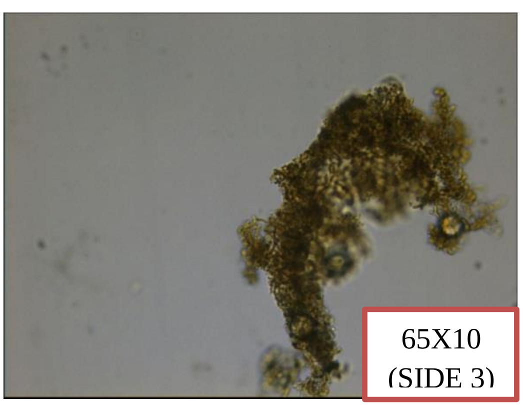

65x10 (SIDE 1)

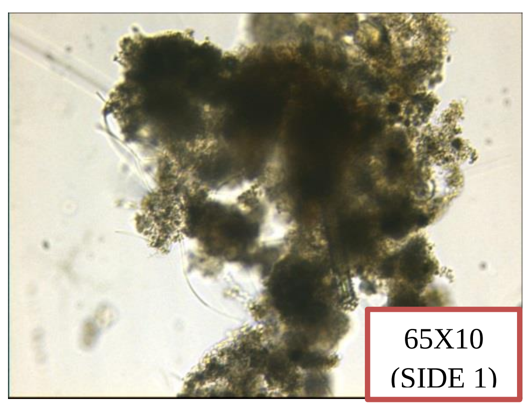

65x10 (SIDE 2)

The images captured above were obtained from side 1 and side 2 of the influent sample with the 10 times magnification at 65° of view. Both of these images showed many particles with different size ranges.


65x10 (SIDE 1)

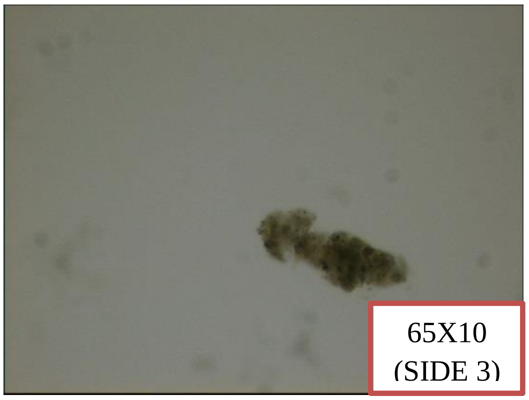

65X10 (SIDE 3)


65X10 (SIDE 3)

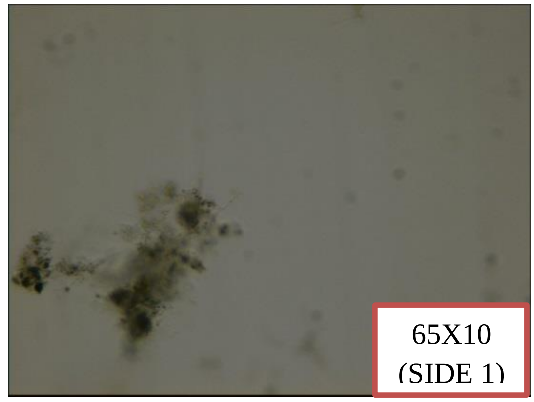

65X10 (SIDE 1)

There were also some big particles can be seen from these images as shown above. It was predicted earlier in the influent sample, that it should contain a bigger size of particle as it has been contaminated with many contaminants. All of these images supported the physical appearance of the influent sample which is cloudy and dark color.

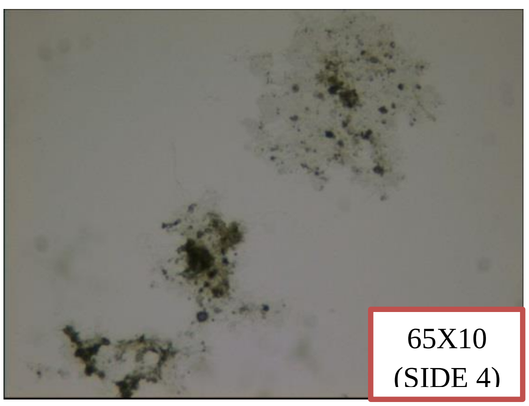
The analysis using microscope was repeated with the effluent sample by using 65° angle of view and x10 magnification as previous sample. The images obtained as per below:



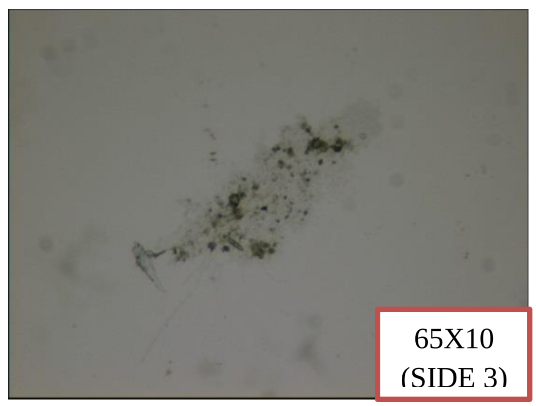
65X10
(SIDE 3)



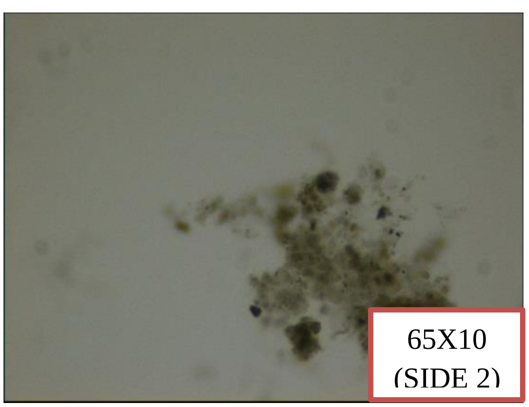
65X10
(SIDE 1)



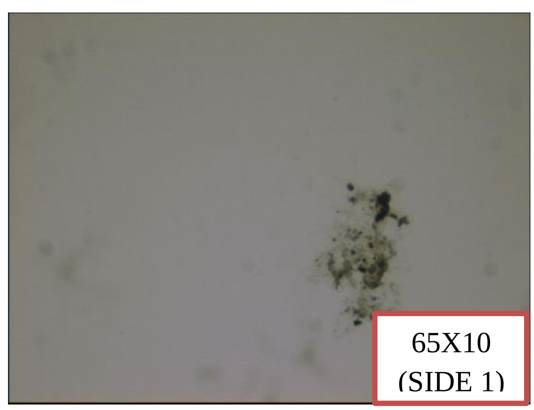
65X10
(SIDE 4)



65X10
(SIDE 3)



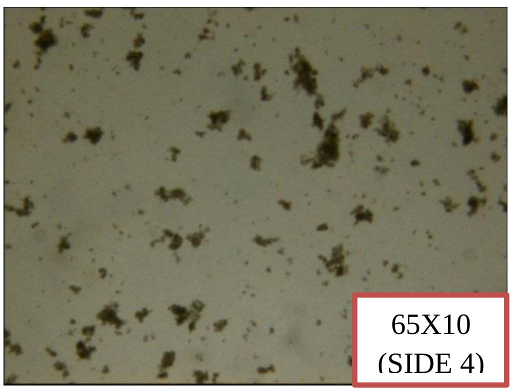
65X10
(SIDE 2)

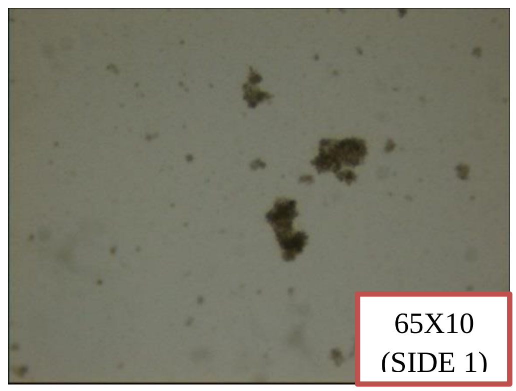


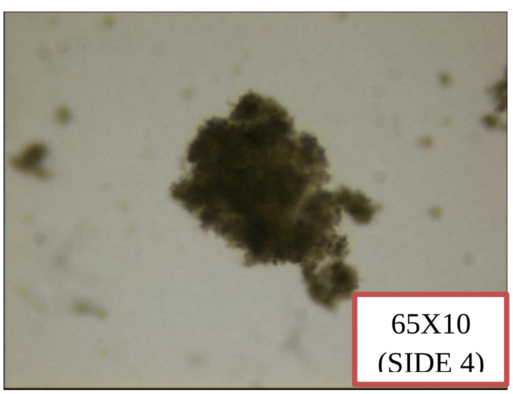
65X10
(SIDE 1)

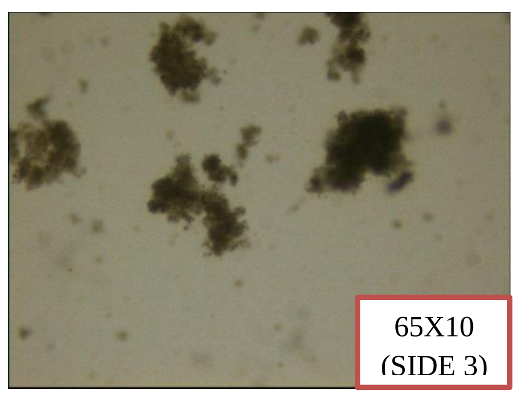
There were many images obtained from the effluent sample, but for the purpose of this report, only some images will be discussed. The images above showed some smaller particles compared to those in the influent sample previously. In fact, it was true as this effluent sample has undergone several types of treatments which reduce the contaminants inside it. Based on these images, it will surely support the result of the particle size which will report a smaller size of particle in effluent sample.

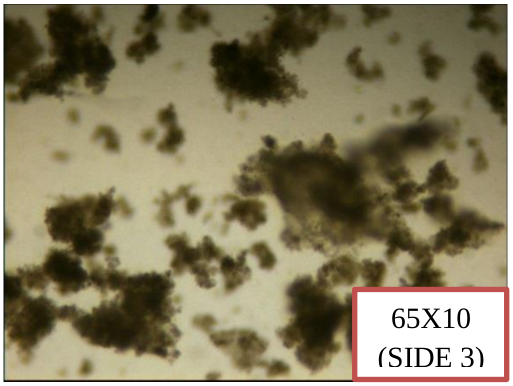
The last analysis using the microscope was done for the POME sample. It also used 65° angle of view with x10 magnification as previous sample. The images obtained from this sample were shown below:

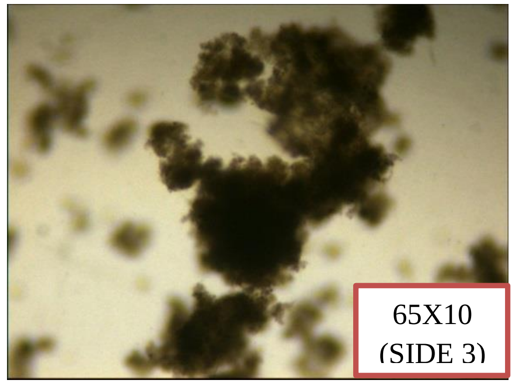












The dilution technique is being done by using the distilled water in order to obtain a clear image of the particles in this sample. The images obtained from the POME sample as shown above showed that it contained a lot of particles with varying size. There were some clog particles but in a small size. The result was expected as there were some small particles can be seen in the POME sample before the analysis is done.

All of the images obtained from the microscope will be transferred to the software called ImageJ. This software will count the size of particles those can be seen in the images for these three types of waste water.

4.3 IMAGEJ SOFTWARE ANALYSIS

The images captured from the microscope will be transferred to ImageJ software. ImageJ is a free Java image processing program. It can calculate area and pixel value statistics of user-defined selection and measure distances and angles. It supports standard image processing functions such as contrast manipulation, sharpening, smoothing, edge detection and median filtering.

The standard procedure to do the analysis on the particle counting is:

1. Open file where the images are located
2. Click image>type>8 bit
3. Click image>adjust>threshold (set to 70)
4. Click process>binary>outlines
5. Click analyze>set measurement> choose ferret's diameter and display results
6. Click analyze>analyze particles (choose show outlines)
7. Outline image will be pop-out with the excel sheet for the data for respective particle.

4.3.1 Influent Sample

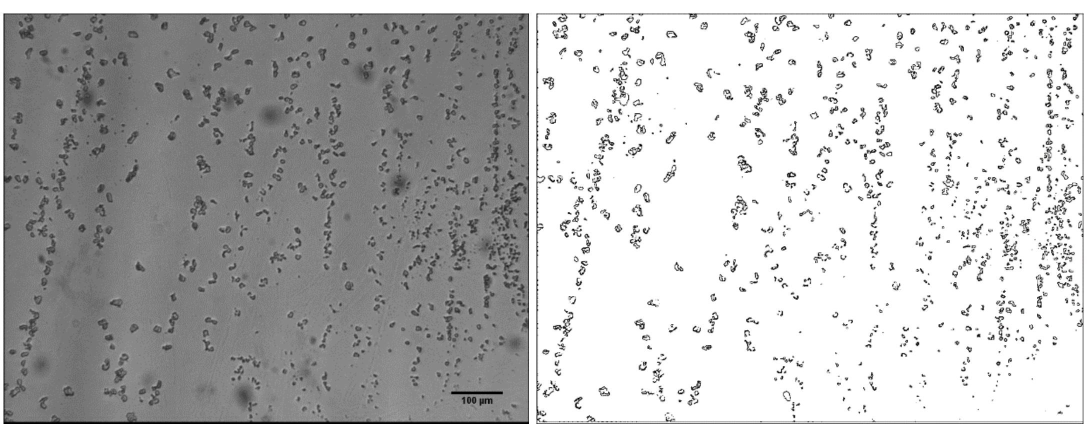


Figure 11: Analysis on the influent sample for sample 2 at side 1 with x10 magnification. *Right image is the outlines image.*

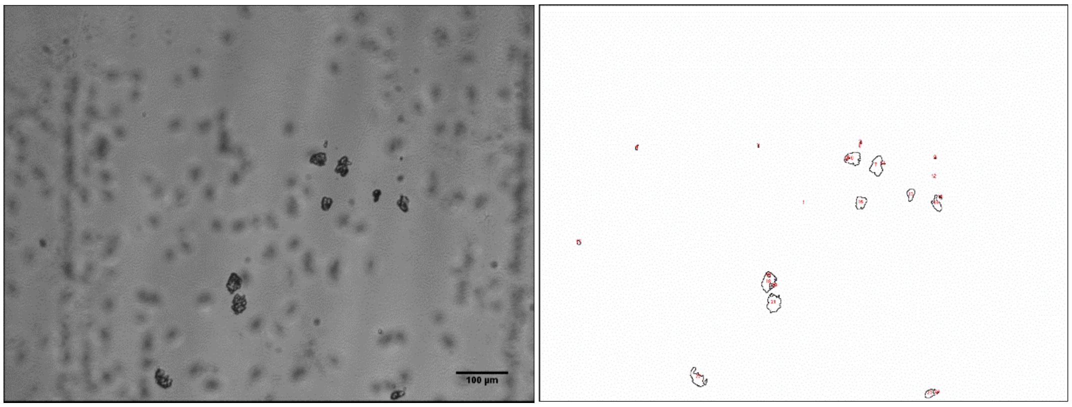


Figure 12: Analysis on the influent sample for sample 2 at side 2 with x10 magnification. *Right image is the outlines image.*

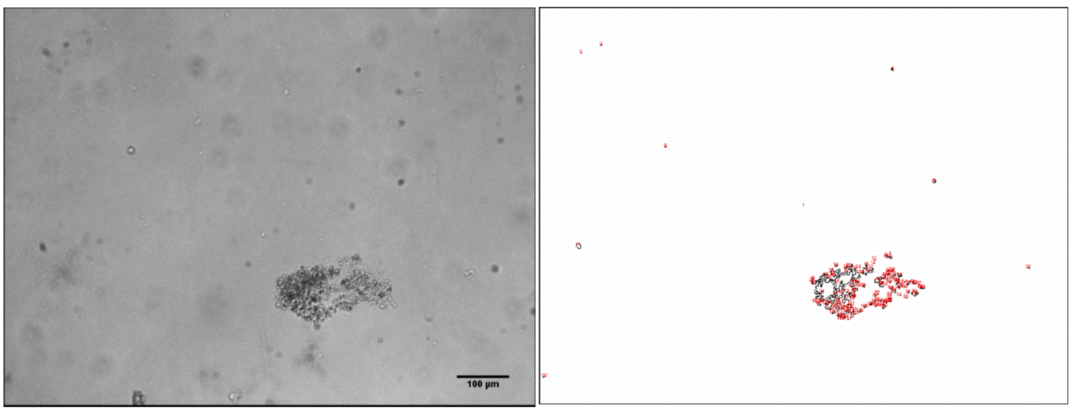


Figure 13: Analysis on the influent sample for sample 3 at side 4 with x10 magnification. *Right image is the outlines image.*

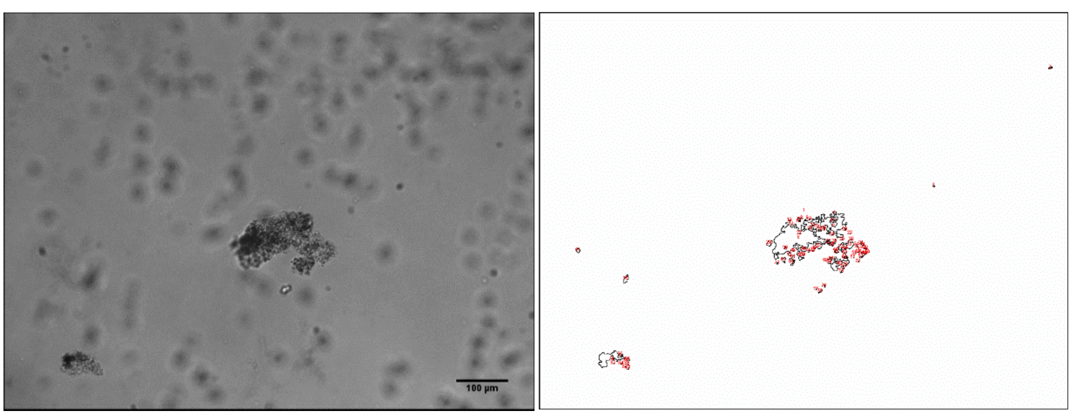


Figure 14: Analysis on the influent sample for sample 3 at side 1 with x10 magnification. *Right image is the outlines image.*

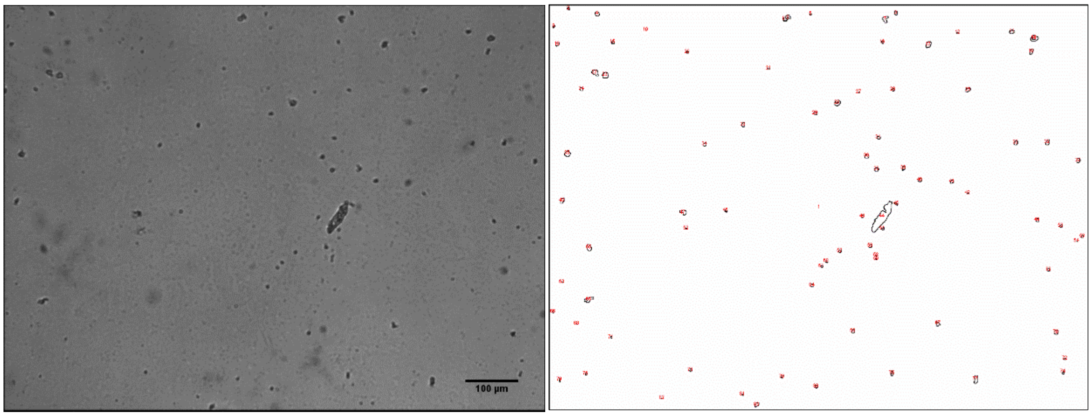


Figure 15: Analysis on the influent sample for sample 3 at side 2 with x10 magnification. *Right image is the outlines image.*

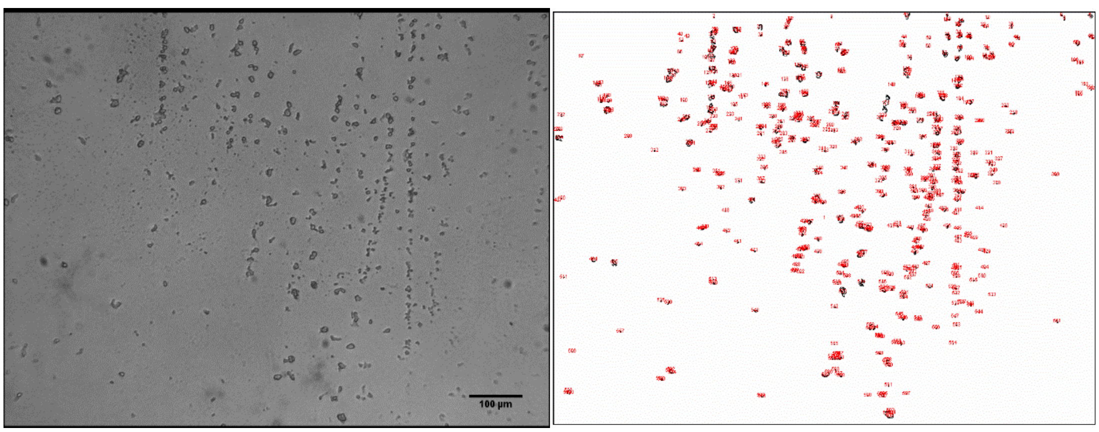


Figure 16: Analysis on the influent sample for sample 3 at side 2 with x10 magnification. *Right image is the outlines image.*

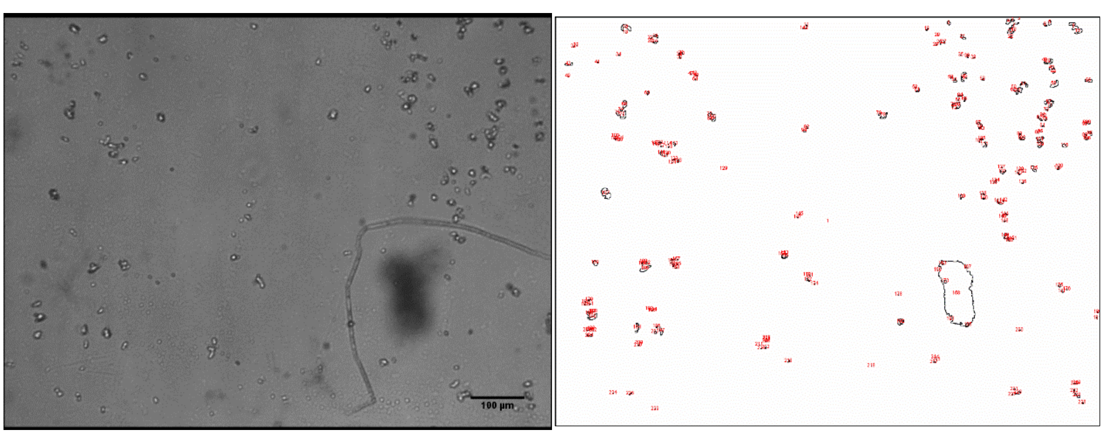


Figure 17: Analysis on the influent sample for sample 3 at side 3 with x10 magnification. *Right image is the outlines image.*

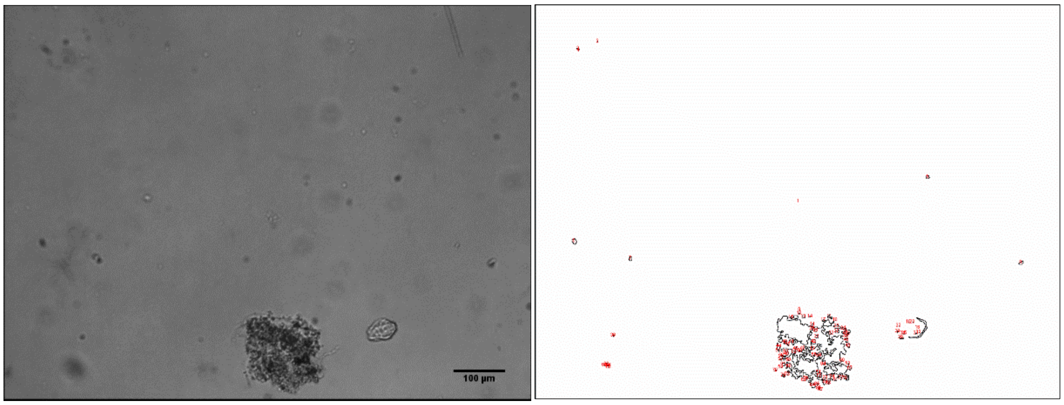


Figure 18: Analysis on the influent sample for sample 3 at side 3 with x10 magnification. *Right image is the outlines image.*

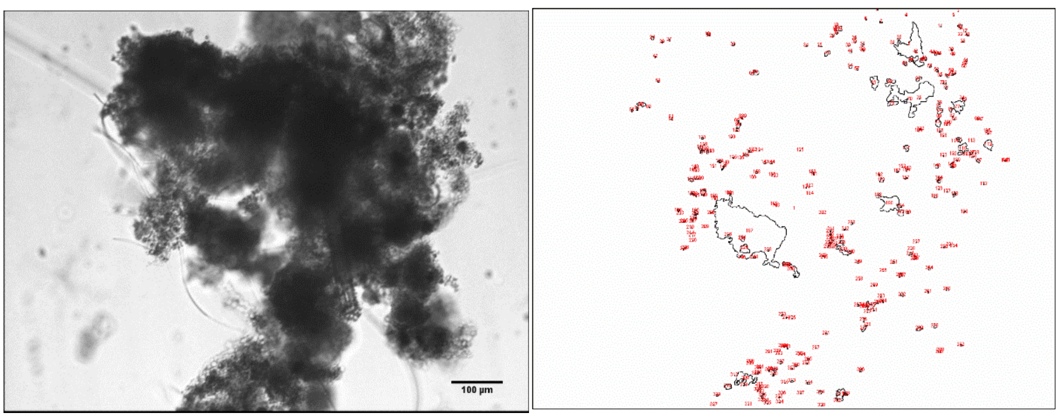


Figure 19: Analysis on the influent sample for sample 4 at side 1 with x10 magnification. *Right image is the outlines image.*

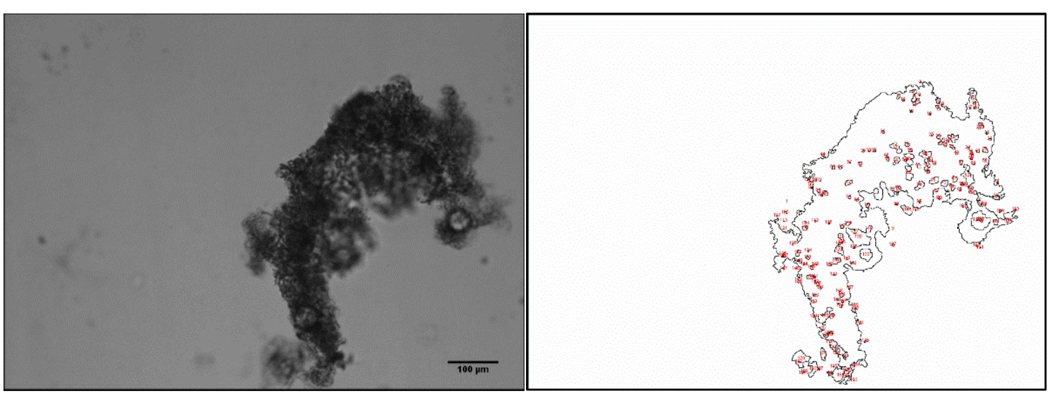


Figure 20: Analysis on the influent sample for sample 4 at side 3 with x10 magnification. *Right image is the outlines image.*

4.3.2 Effluent Sample

Analysis is being repeated for effluent sample. The analysis is using many images but for the purpose of this report, only 10 images are displayed.

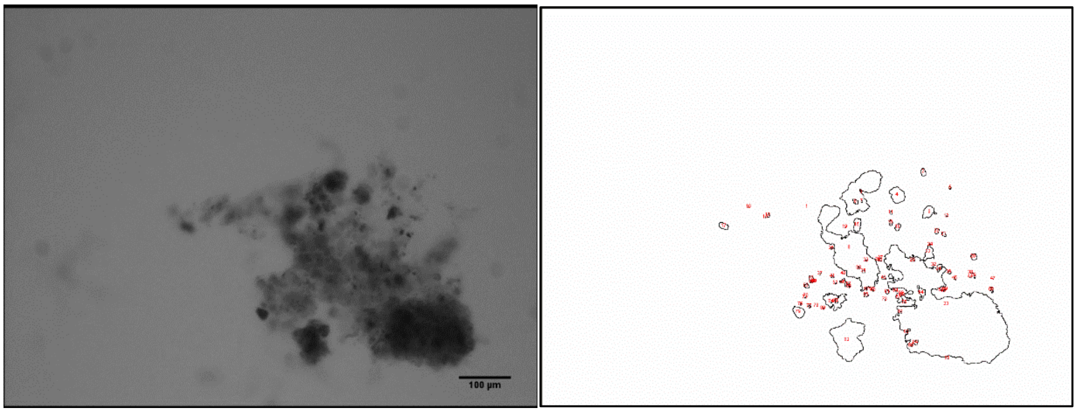


Figure 21: Analysis on the effluent sample for sample 1 at side 2 with x10 magnification. *Right image is the outlines image.*

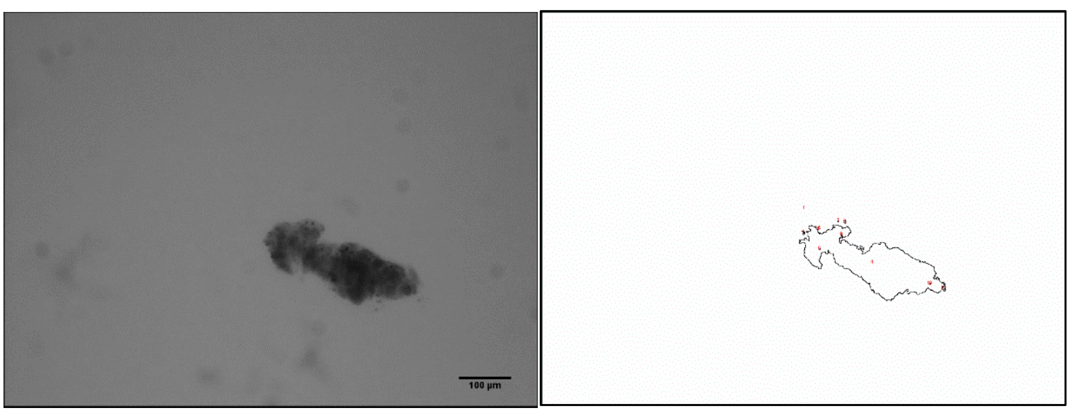


Figure 22: Analysis on the effluent sample for sample 1 at side 3 with x10 magnification. *Right image is the outlines image.*

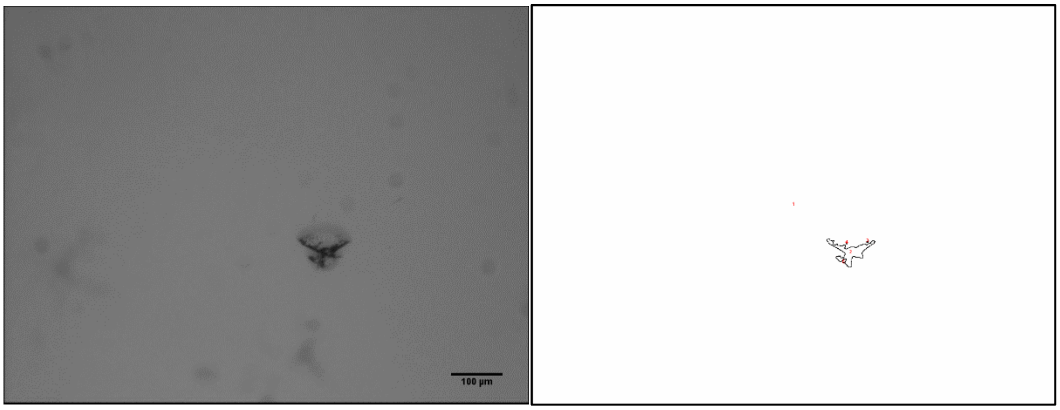


Figure 23: Analysis on the effluent sample for sample 2 at side 2 with x10 magnification. *Right image is the outlines image.*

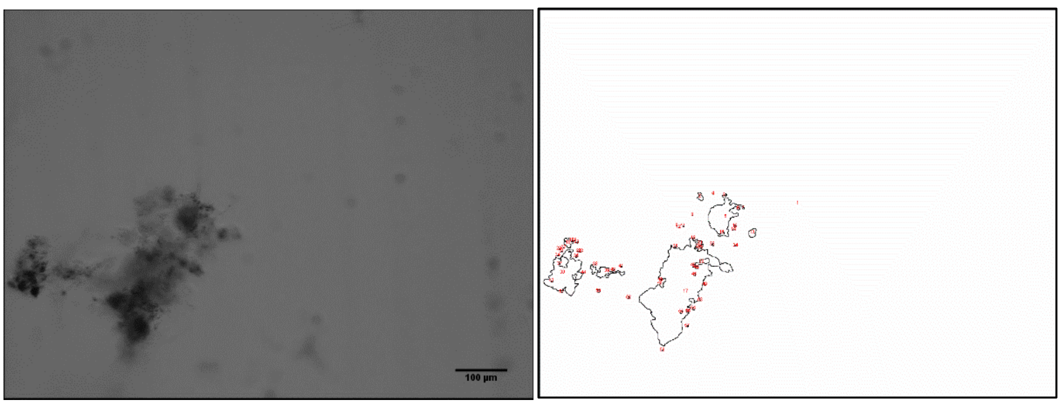


Figure 24: Analysis on the effluent sample for sample 3 at side 1 with x10 magnification. *Right image is the outlines image.*

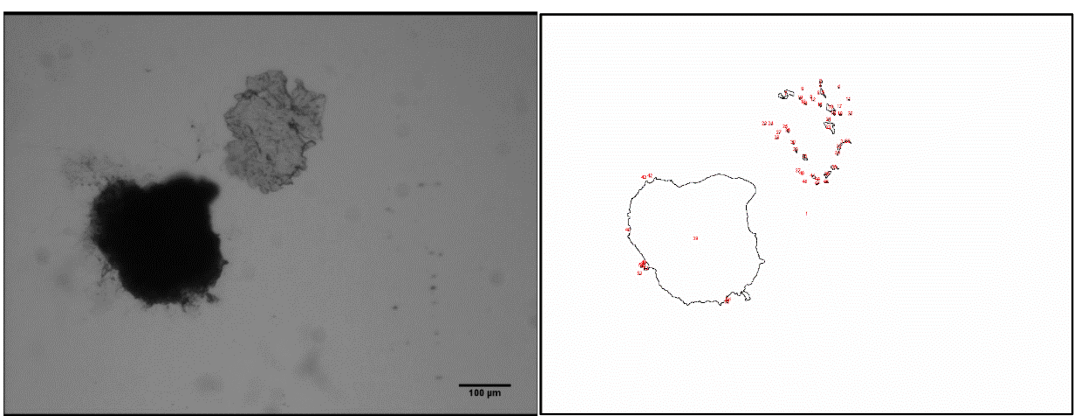


Figure 25: Analysis on the effluent sample for sample 4 at side 3 with x10 magnification. *Right image is the outlines image.*

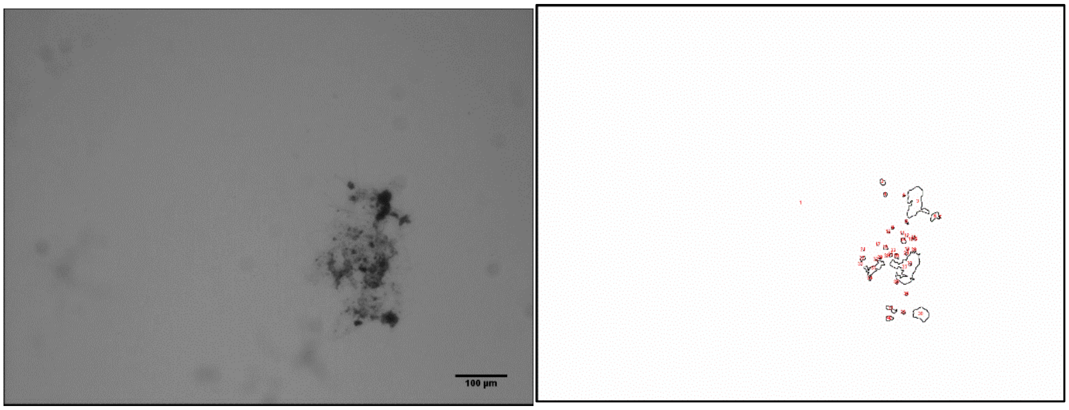


Figure 26: Analysis on the effluent sample for sample 4 at side 1 with x10 magnification. *Right image is the outlines image.*

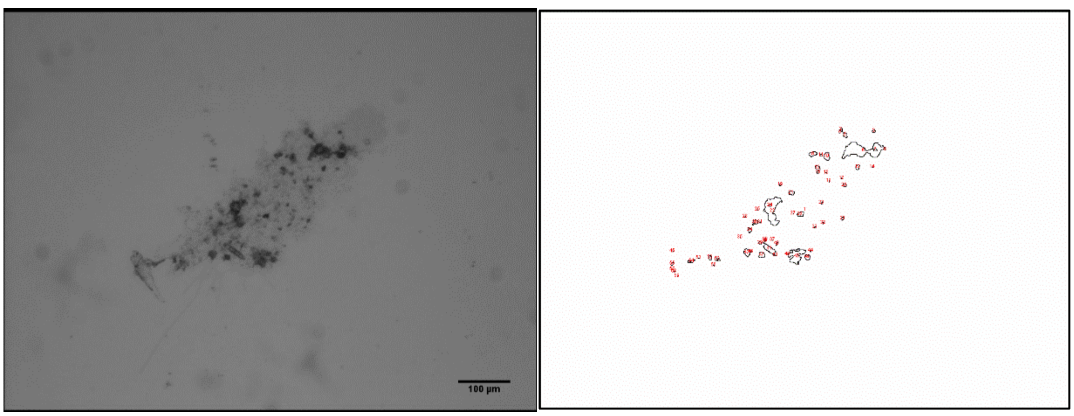


Figure 27: Analysis on the effluent sample for sample 4 at side 3 with x10 magnification. *Right image is the outlines image.*

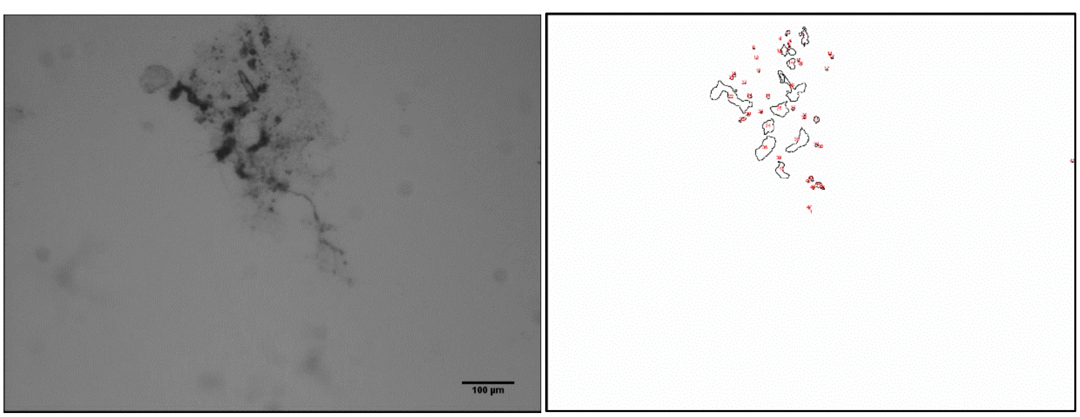


Figure 28: Analysis on the effluent sample for sample 4 at side 3 with x10 magnification. *Right image is the outlines image.*

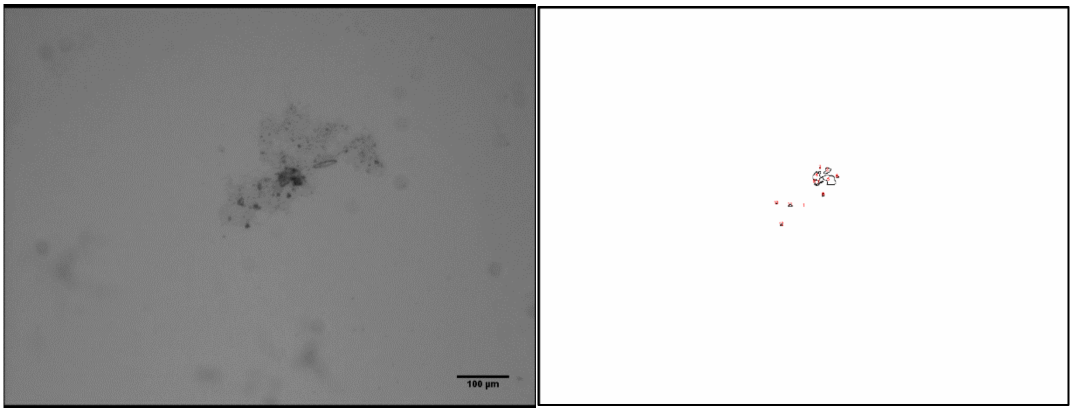


Figure 29: Analysis on the effluent sample for sample 4 at side 3 with x10 magnification. *Right image is the outlines image.*

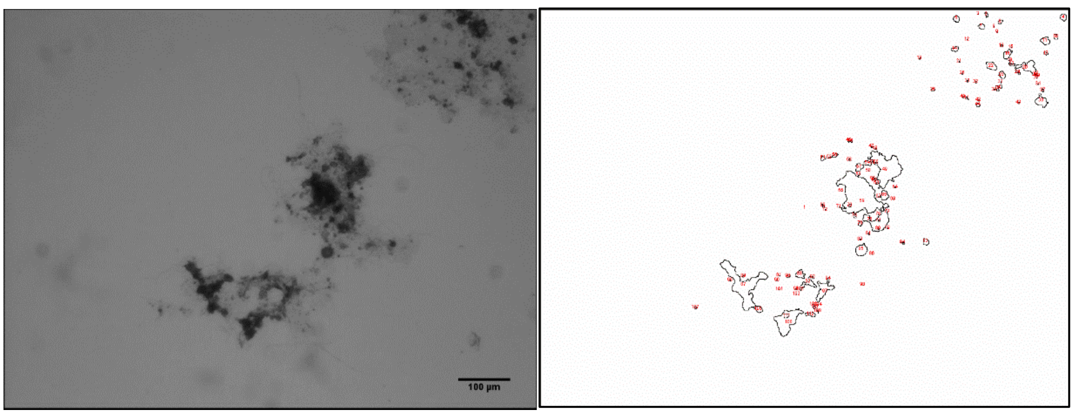


Figure 30: Analysis on the effluent sample for sample 4 at side 4 with x10 magnification. *Right image is the outlines image.*

4.3.3 POME Sample

Analysis is being repeated for POME sample. The analysis is using many images but for the purpose of this report, only 10 images are displayed.

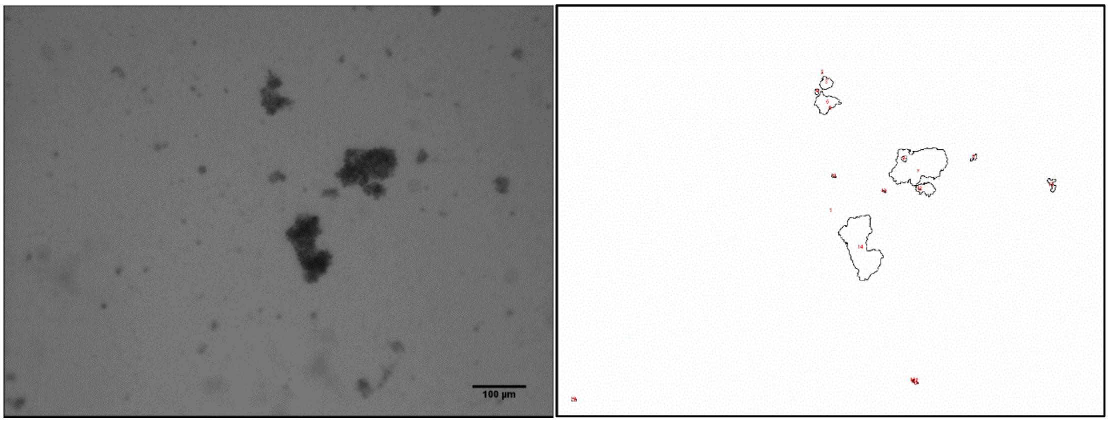


Figure 31: Analysis on the effluent sample for sample 1 at side 1 with x10 magnification. *Right image is the outlines image.*

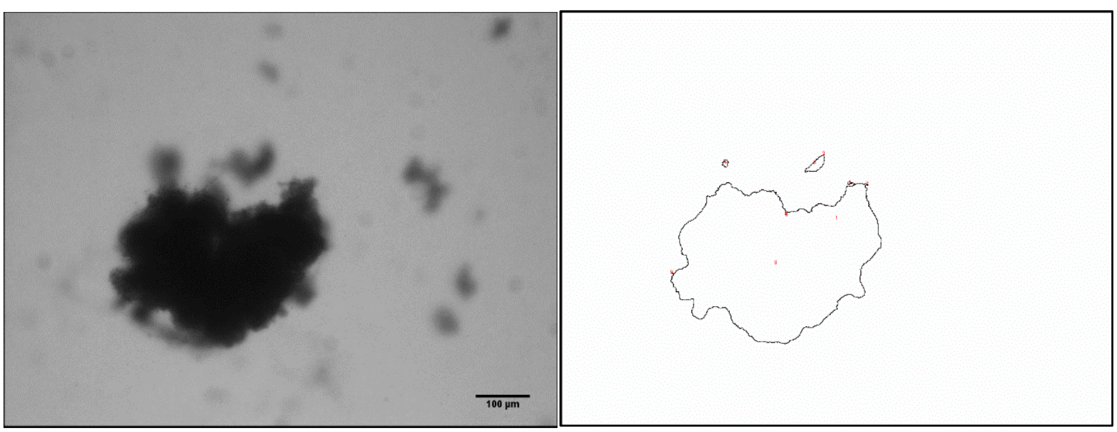


Figure 32: Analysis on the effluent sample for sample 1 at side 2 with x10 magnification. *Right image is the outlines image.*

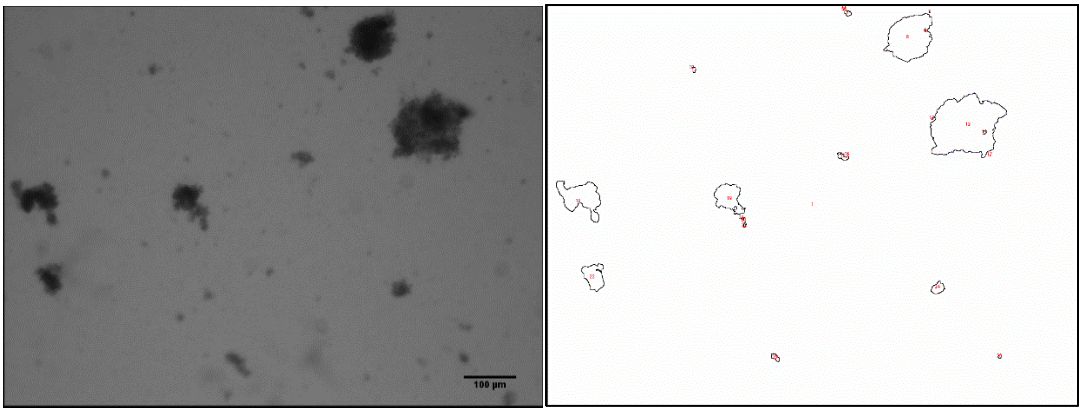


Figure 33: Analysis on the effluent sample for sample 1 at side 3 with x10 magnification. *Right image is the outlines image.*

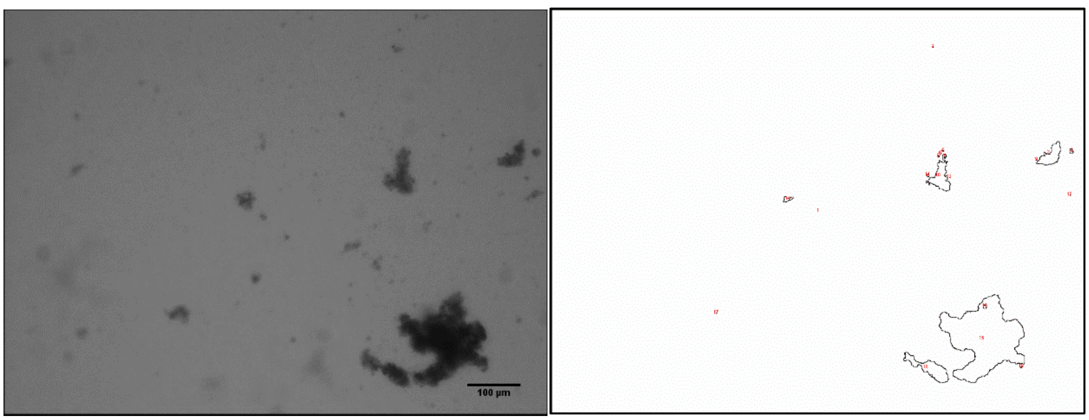


Figure 34: Analysis on the effluent sample for sample 1 at side 4 with x10 magnification. *Right image is the outlines image.*

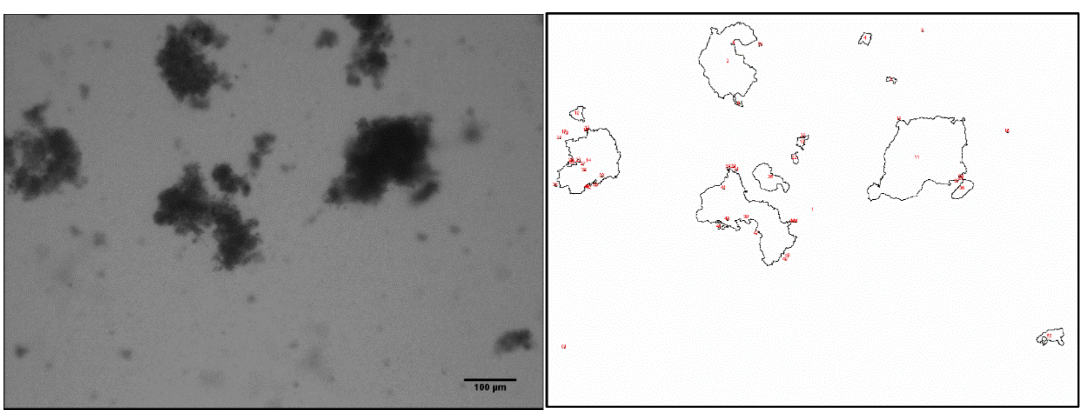


Figure 35: Analysis on the effluent sample for sample 2 at side 3 with x10 magnification. *Right image is the outlines image.*

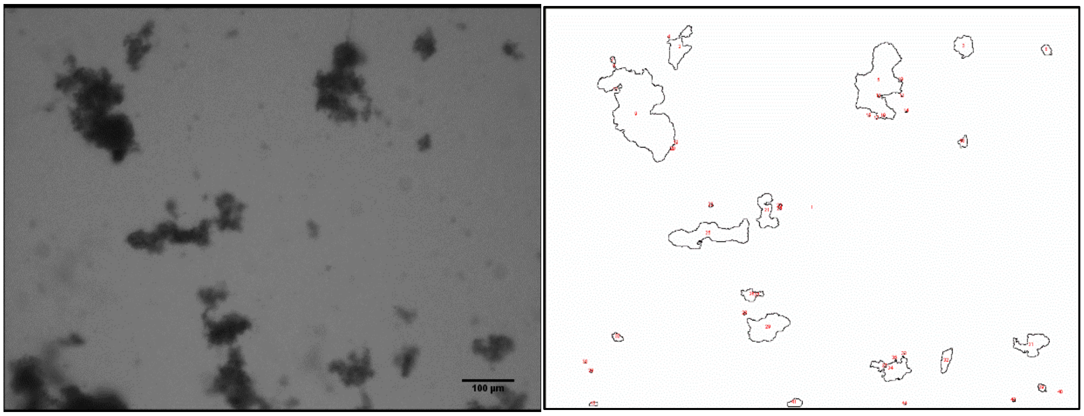


Figure 36: Analysis on the effluent sample for sample 3 at side 3 with x10 magnification. *Right image is the outlines image.*

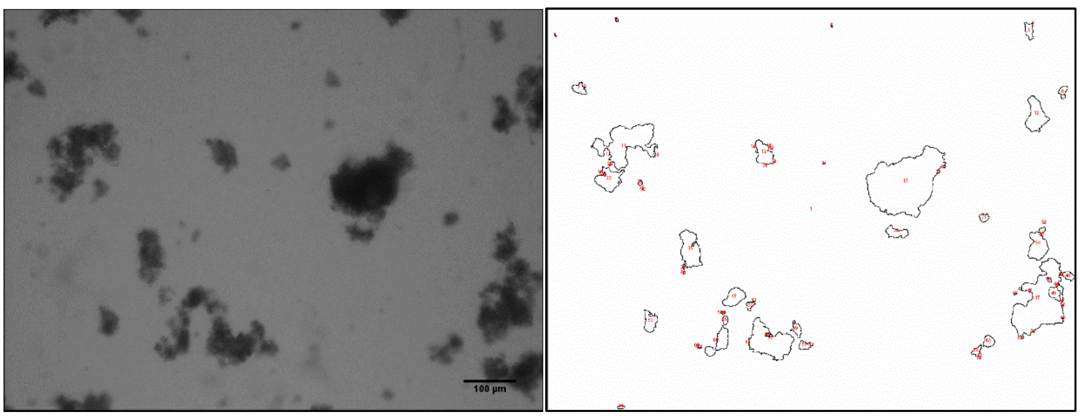


Figure 37: Analysis on the effluent sample for sample 3 at side 1 with x10 magnification. *Right image is the outlines image.*

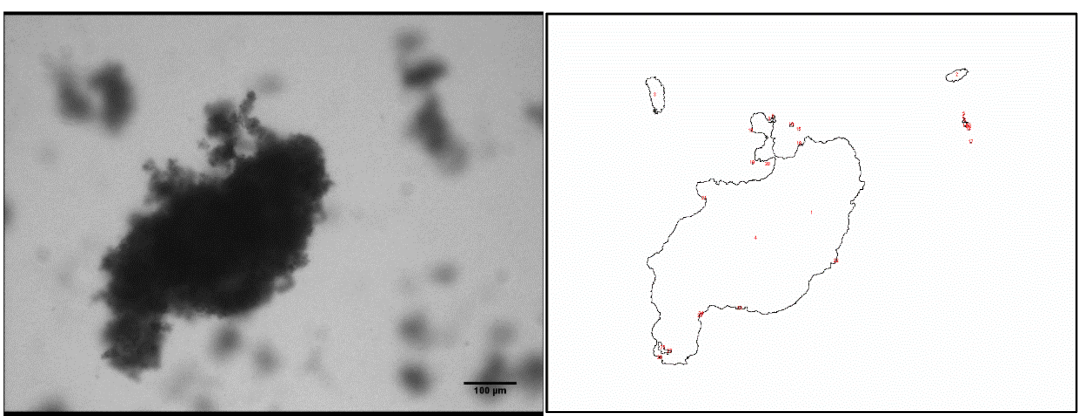


Figure 38: Analysis on the effluent sample for sample 3 at side 3 with x10 magnification. *Right image is the outlines image.*

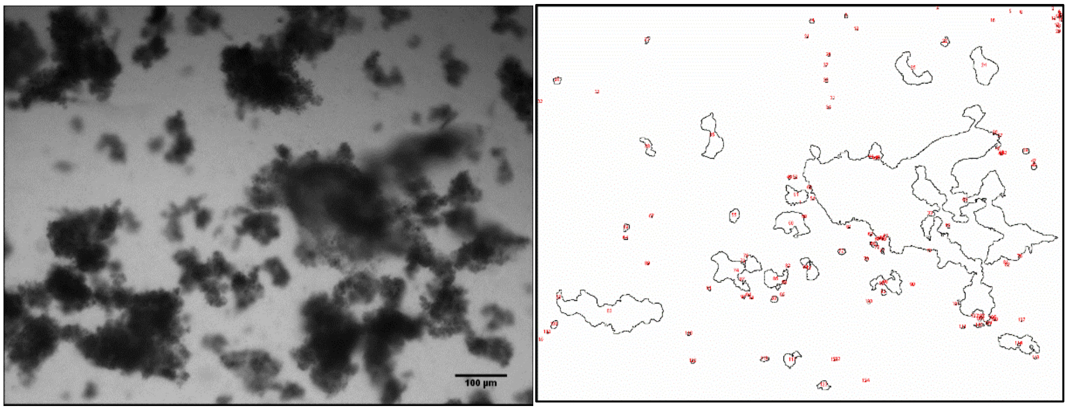


Figure 39: Analysis on the effluent sample for sample 3 at side 3 with x10 magnification. *Right image is the outlines image.*

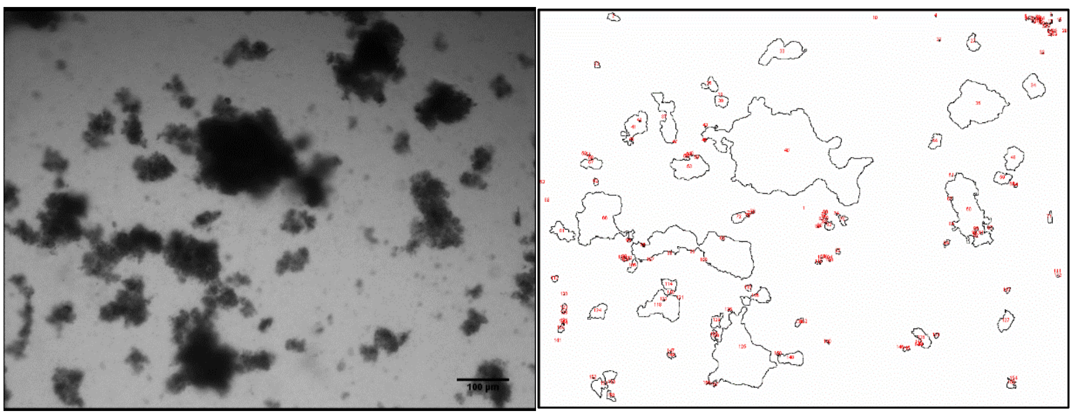


Figure 40: Analysis on the effluent sample for sample 3 at side 3 with x10 magnification. *Right image is the outlines image.*

4.4 RESULT ANALYSIS

The result from imageJ shows the Feret's diameter which is the diameter expressed for the irregular shape. Hence, in order to determine the particle size, the formula below is being used:

Diameter: $\sqrt{Feret * MinFeret}$

Particle Size: Diameter x 0.59 (pixel in the microscope)

The particle sizes for all particles in the images are determined and a graph of normalized particle number vs. particle size is being constructed for all three types of waste water.

4.4.1 Influent Sample

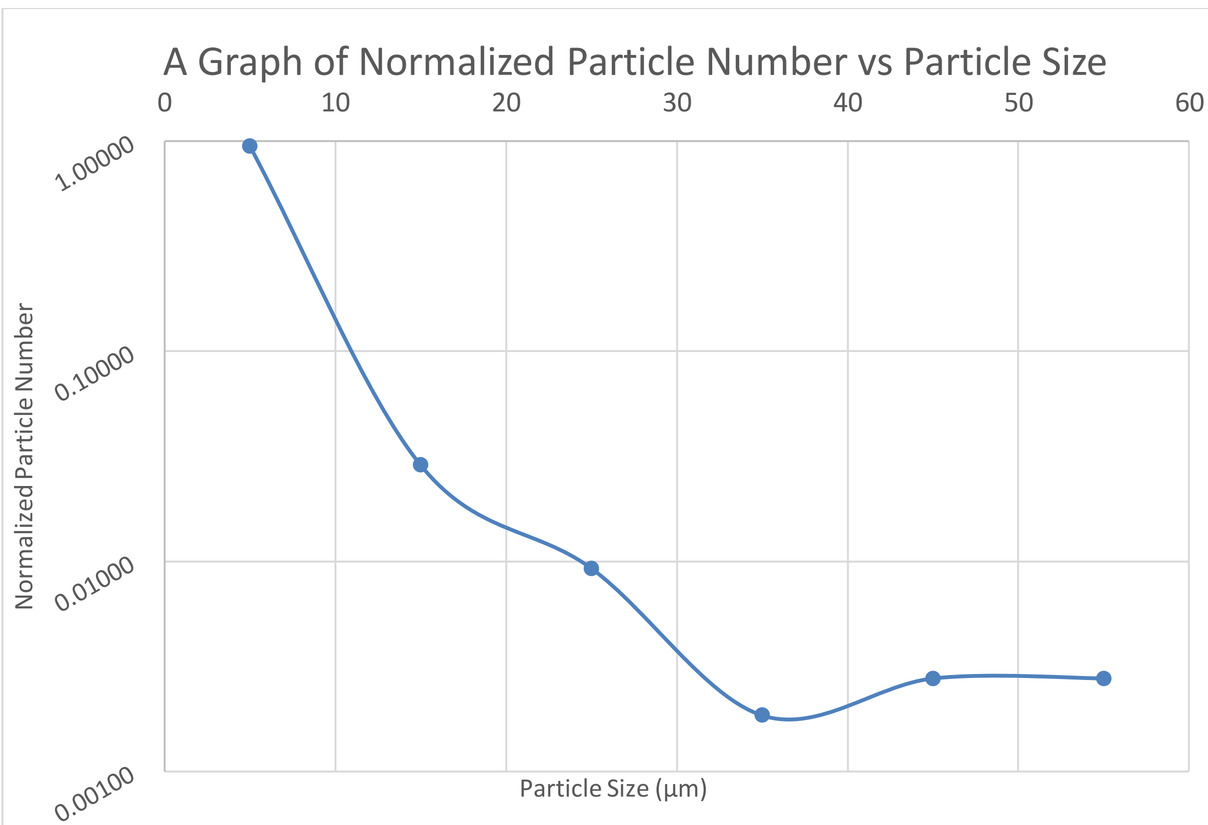


Figure 41: Graph of normalized particle number vs. particle size for influent

4.4.2 Effluent Sample

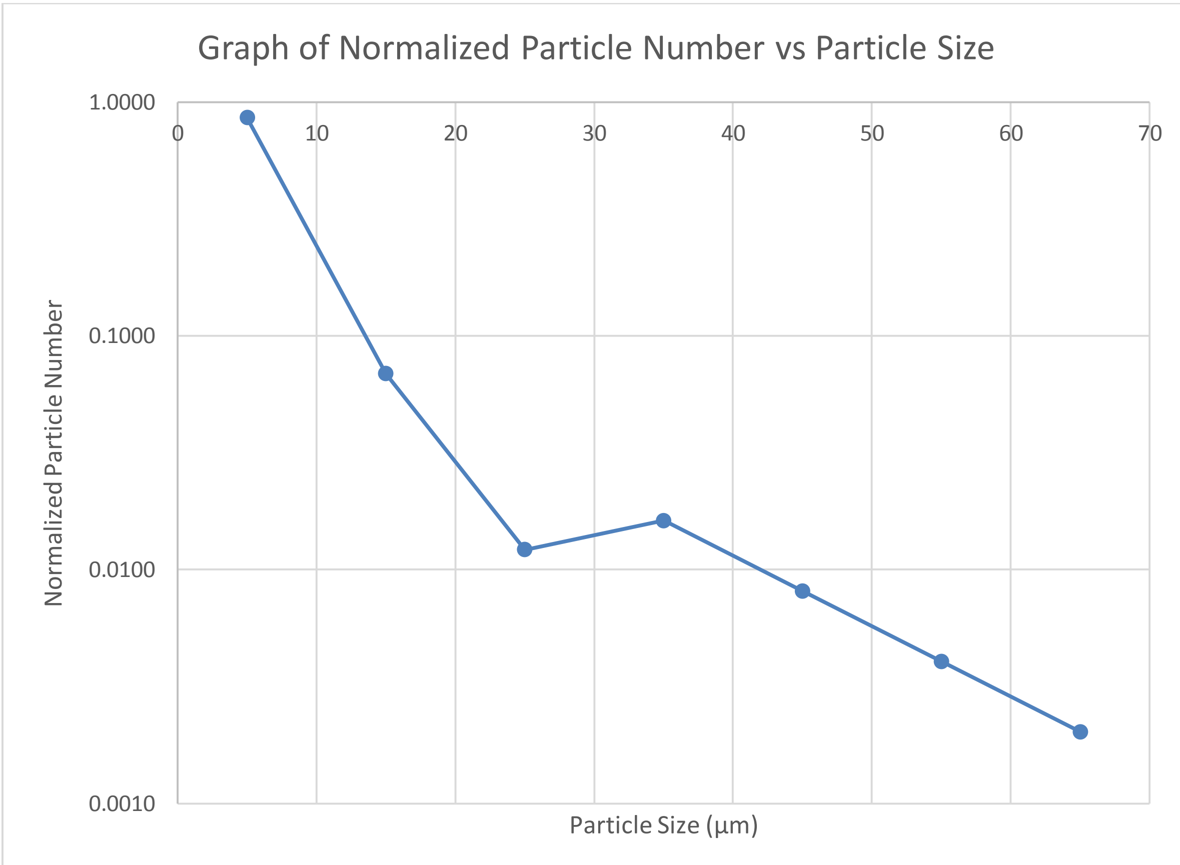


Figure 42: Graph of normalized particle number vs. particle size for effluent

4.4.3 POME Sample

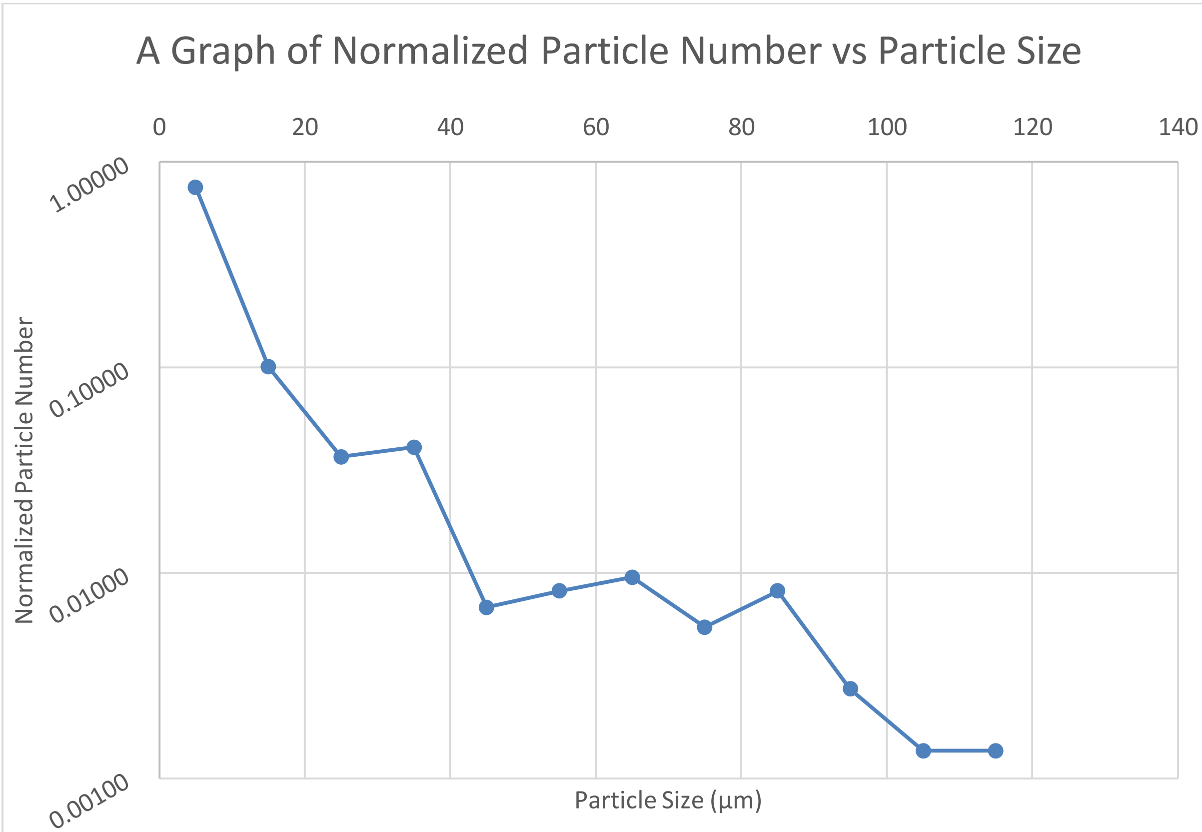


Figure 43: Graph of normalized particle number vs. particle size for POME

The result from PSA showed the graph of volume (%) versus particle size (µm). For result comparison, both of them need to be in the same unit. Hence, the result for PSA in volume per cent will be converted into the normalized particle number by using this formula:

$$X_i = \frac{100V_i / d_i^n}{\sum V_i / d_i^n}$$

Where;

Xi: the transformed percentage distribution

Vi: the volume distribution result

di: the mean size of class i

n: required distribution type (n=3 for number based)

The result transformation to normalized particle number is done for all three types of waste water. The graphs obtained from the transformation are shown below:

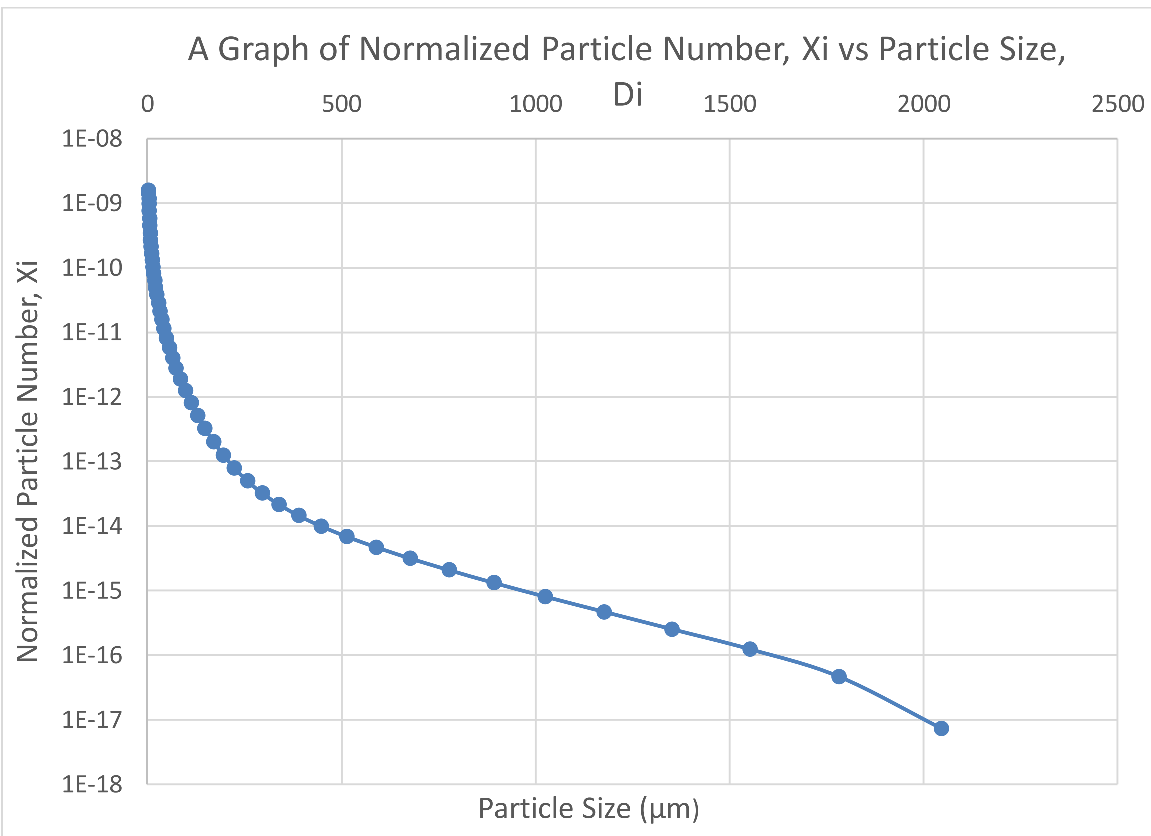


Figure 44: Graph of normalized particle number vs. particle size for influent

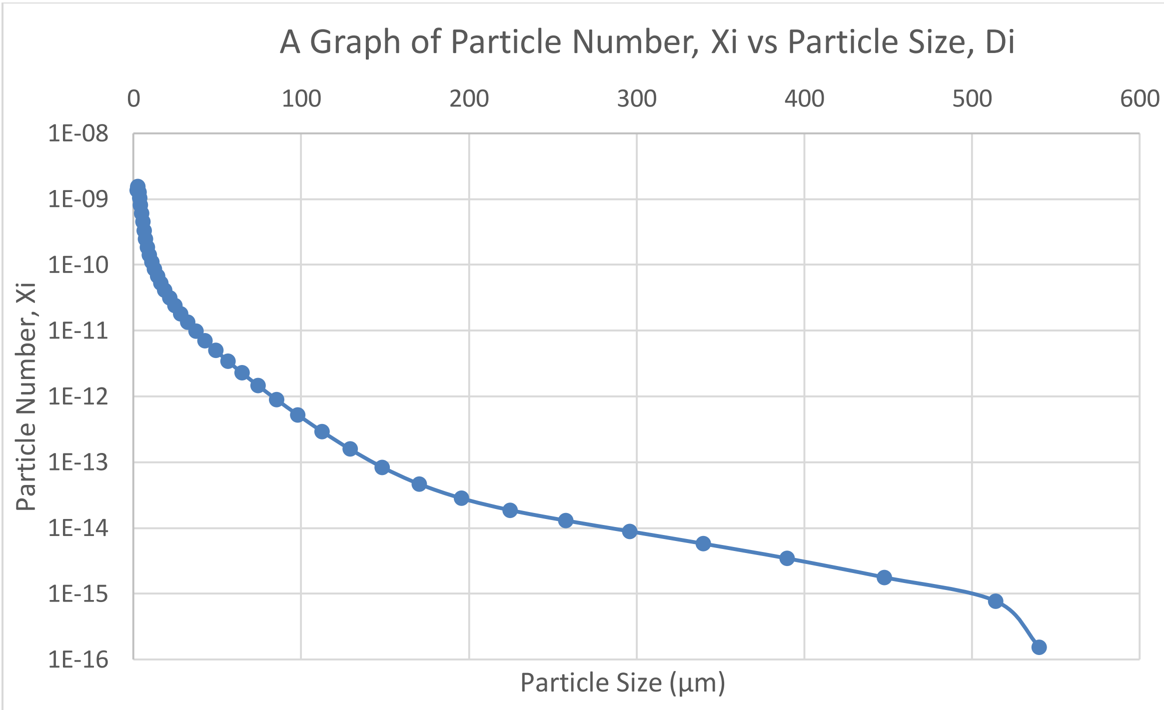


Figure 45: Graph of normalized particle number vs. particle size for effluent

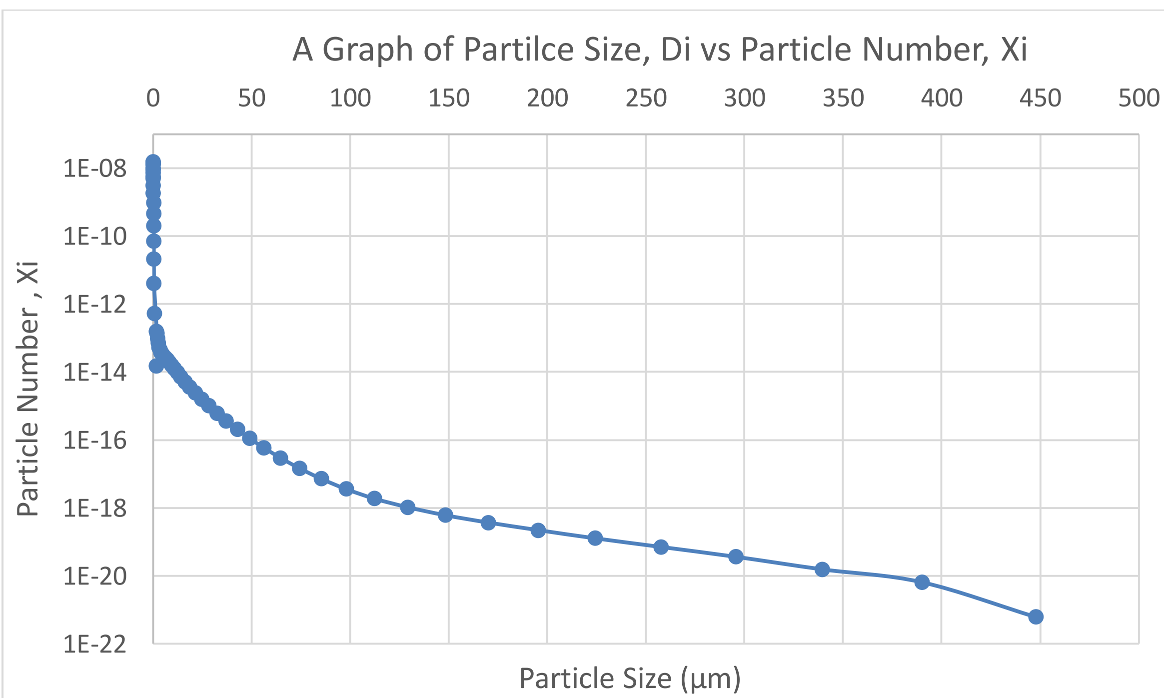


Figure 46: Graph of normalized particle number vs. particle size for POME

Based on the graphs obtained from PSA and also ImageJ analysis, the trends of the graph are decreasing. The results for PSA need to be converted into particle number distribution in order to make the result comparison with the ImageJ analysis. Taking for example, the result obtained from the ImageJ for influent, the most size of particle present in the sample is 5µm, while from the PSA, the particle size at 2µm is the most present in the sample. The result shows a bit deviation but acceptable. This is due to the working principle of the equipment itself. As for PSA, it uses the laser diffraction technique which measures particle size distributions by measuring the angular variation in intensity of light scattered as a laser beam passes through a dispersed particulate sample. Large particles scatter light at small angles relative to the laser beam and small particles scatter light at large angles. The angular scattering intensity data is then analyzed to calculate the size of the particles responsible for creating the scattering pattern, using the Mie theory of light scattering assuming the particle is equivalent to sphere model. Hence, all the particles present in the waste water will be assumed as sphere. Differently by using microscope, the images of all particles can be seen. Based on the experimental work being done throughout this project, it can be concluded that not all particles are in sphere model. Most of the particles are present in the irregular shape. Hence, by using microscope, the images of irregular particles can be captured and the particle size can be obtained by using ImageJ software. The usage of microscope in this project is believed to give a high contribution to the environmental field as for example, to measure the bacteria and microorganisms in the waste water, specific measurements are required as they are in irregular shapes. Hence, by knowing the size of bacteria and microorganisms, the feasible waste water treatment can be designed. Unfortunately, the analysis using the microscope tends to be repeated. The images of the same particles are sometimes being captured twice as many particles are present in one waste water sample.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Based on the study, background research and literature review that have been carried out, the project seems to be relevant and feasible to be executed within the time frame and the scope of study. Although there are many tools being developed for particle size analysis, there is still a lack of comprehensive study covering limitations and advantages of using the specific equipment to measure the particle size in different wastewater. Hence, this project will provide the data for determination of the limitations and advantages in different equipment being used for measuring particle size. There are only two equipment will be used in this project which is Particle Size Analyzer (PSA) and microscope due to some limitations of time frame and the availability of the equipment in UTP. The usage of microscope along with the ImageJ software to determine the size of particles in the waste water sample is believed to give a high contribution to the environmental field especially for structural analysis. This is due to the ability of this software to measure the size of irregular particles. In conclusion, the image analysis method is beneficial and should be further developed in the future.

5.2 RECOMMENDATIONS

Suggested further works for expansion and continuation:

- Purchase more equipment for measuring particle size to wider the coverage area of the research in terms of equipment being used.
- Increase the waste water samples to compare the feasibility of the equipment being used with more different samples.

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