OIL AND GREASE CONCENTRATION IN WATER AND SURFACE SEDIMENT FROM FSSA LAKE

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THIS DISSERTATION IS SUBMITTED AS A PARTIAL REQUIREMENT FOR THE DEGREE OF BACHELOR OF SCIENCE WITH HONOURS

INDUSTRIAL CHEMISTRY PROGRAMME

FACULTY OF SCIENCE AND NATURAL RESOURCES

UNIVERSITI MALAYSIA SABAH

2014

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JUDUL: OIL AND GREASE CONCENTRATION IN WATER AND SURFACE SEDIMENT FROM ESSA LAKE.

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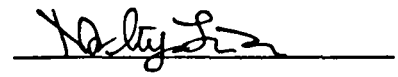

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ACKNOWLEDGEMENT

First and foremost, my deepest gratitude to Allah S.W.T for His blessings and permissions enables me to complete this study. This dissertation has accumulated many debts of gratitude throughout its completion. Thus, I would like to express my hearties appreciation to a great number of people who have contributed directly and indirectly in my conquest of completing this dissertation. Although that is an inadequate recompense for their contribution, this dissertation would not have been successful without their full commitment. Firstly, I would like to thank to my family where they give the financial support and love to finish my dissertation and courageous that I needed along my study journey, until I was able to complete this project. Next, my deepest appreciation goes to Mr. Tan Wei Hsiang as my supervisor and my mentor, who has been a great help in constructive advices on my work, valuable suggestion, continuous encouragement at various stages throughout the completion of dissertation and providing me a wide range of references, also for his expert guidance and for his patience, without which this work could not have been accomplished. I also want to thank to all the lecturers, office staff and not forget to the Dean of FSSA for their support and encouragement. My thanks also expressed to lab assistant especially Mr. Jerry, Mr. Neldin Jeoffery and Mr. Taipin who helped me a lot during my laboratory analysis study, always providing all the equipments in the laboratory and helping me to solve many laboratory problems. Last but not least, my grateful thanks goes to my colleagues especially to my coursemates of Industrial Chemistry who helped me in the preparation of the project and committed in giving maximum effort while working in groups to complete this task. I cherish our memories together and three years of our friendship during our time of hardship and happiness will never been forgotten. All of the kindness will be remembered.

ABSTRACT

This study was carried out to determine the concentration of oil and grease (OG) in water and surface sediment of FSSA lake, UMS. The concentration of OG in water and surface sediment was also compared. Sampling was done twice and six sampling stations were chosen. The samples were taken from the water (taken from 2.0 to 3.0 cm from surface water) and surface sediment (depth of 0.04 m to 2.89 m) according to each sampling station. Each sample of water and sediment has been replicated 3 times to obtain more accurate reading. The concentration of OG in water and sediment were analyzed at the laboratory by using liquid-liquid extraction method with the solvent of petroleum ether for water samples and method of soxhlett extraction for sediment samples. The OG concentration in water were found to be lowest at Station 1 with the mean of 0.0019 $\pm$ 0.0002 mg/L for the first sampling and 0.0021 $\pm$ 0.0002 mg/L for second sampling respectively. Meanwhile, the highest concentration of OG in water were found at Station 6 which gives the mean value of 0.0067 $\pm$ 0.0006 mg/L in the first sampling and 0.0071 $\pm$ 0.0002 mg/L in second sampling. Since there is a strongly linear correlation (r = 0.996 for first sampling and r = 0.989 for second sampling) with significant-p < 0.05 between the concentration of OG in water and the OG concentration in sediment, thus the concentration of OG in surface sediment will be affected by the concentration of OG in water. An increase in the OG concentration in water will increases the OG concentration in sediment. According to the National Water Quality Standards (NWQS) and the Provincial Sediment Quality Guideline (PSQG), the OG concentration in water and surface sediment at all stations from FSSA lake were not exceeded the standard limit that is below 1.5 mg/L. Overall, the results of this study indicated that there is no serious OG pollution in water and sediment of FSSA lake and also still considered as safe and clean.

KEPEKATAN MINYAK DAN GRIS DALAM AIR DAN PERMUKAAN SEDIMEN DARI TASIK FSSA, UMS

ABSTRAK

Kajian telah dijalankan untuk mengenalpasti kepekatan minyak dan gris (MG) dalam air dan permukaan sedimen di Tasik FSSA, UMS. Kepekatan MG dalam air dan permukaan sedimen juga telah dibandingkan. Persampelan telah dilakukan sebanyak dua kali dan sebanyak enam stesen persampelan telah dipilih. Sampel yang diambil adalah daripada air (diambil 2.0-3.0 cm dari permukaan air) dan permukaan sedimen (kedalaman 0.04m hingga 2.89m) mengikut kedalaman stesen persampelan masing-masing. Setiap sampel air dan sedimen telah direplikasi sebanyak tiga kali untuk mendapatkan bacaan yang lebih tepat. Kepekatan MG dalam air dan sedimen telah dianalisis di dalam makmal dengan menggunakan cara pengekstrakan cecair-cecair (liquid-liquid extraction) dengan pelarut petroleum eter bagi sampel air dan cara pengekstrakan soxhlett bagi sampel sedimen. Kepekatan MG dalam air telah didapati rendah di Stesen 1 dengan purata masing-masing 0.0019 ± 0.0002 mg/L untuk persampelan pertama dan 0.0021 ± 0.0002 mg/L untuk persampelan kedua. Manakala, kepekatan MG dalam air yang paling tinggi didapati di Stesen 6 dengan nilai purata yang diperolehi sebanyak 0.0067 ± 0.0006 mg/L pada persampelan pertama dan 0.0071 ± 0.0002 mg/L pada persampelan kedua. Apabila terdapat linear korelasi yang kuat ($r = 0.996$ untuk persampelan pertama dan $r = 0.989$ untuk persampelan kedua) dengan signifikan-$p < 0.05$ antara kepekatan MG dalam air dan kepekatan MG dalam sedimen, maka kepekatan MG di permukaan sedimen akan dipengaruhi oleh kepekatan MG dalam air. Peningkatan kepekatan MG dalam air akan meningkatkan kepekatan MG dalam sedimen. Menurut National Water Quality Standards (NWQS) dan Provincial Sediment Quality Guidelines (PSQG), kepekatan MG dalam air dan permukaan sedimen di kesemua stesen dari Tasik FSSA adalah tidak melebihi had limit piawaian iaitu kepekatan di bawah 1.5 mg/L. Keseluruhannya, keputusan kajian ini menunjukkan bahawa tiada pencemaran MG yang serius dalam air dan sedimen di Tasik FSSA dan juga masih dianggap bersih dan selamat.

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LIST OF ABBREVIATIONS

OG	Oil and grease
FSSA	Faculty of Science and Natural Resources
DO	Dissolved Oxygen
TPH	Total Petroleum Hydrocarbon
PAHs	Polyaromatic Hydrocarbons
	Polynuclear Aromatic Hydrocarbons
PHC	Petroleum Hydrocarbons
MTBE	Methyl tert-butyl ether
TBA	tert-butyl alcohol
COD	Chemical Oxygen Demand
VOCs	Volatile Organic Compounds
MOP	Manual of Practice
CFC-113	1,1,2-trichloro-1,2,2-trifluoroethane
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
BOD	Biological Oxygen Demand
SPM	Suspended Particulate Matters
Al	Aluminium
HCl	Hydrochloric acid
$MgSO_4$	Magnesium Sulphate
DCM	Dichloromethane
HNO_3	Nitric acid
H_2O	Water
C_2H_5OH	Ethyl Alcohol
H_2SO_4	Sulphuric acid

CHAPTER 1

INTRODUCTION

1.1 Significance of Study

The importance of this study is the concentration of OG in FSSA lake water and surface sediments can be investigated. The concentration level of OG in the water and sediment must be known since the water and sediment is acts as the indicator for water body pollution (Ulrich, 1976). This study is the basis for environmental research. So far, there is no report done on the study OG data in FSSA lake. In future, further study about the same topic but in different location such as in industrial location can be carried out and already understand how to determine or analyze the OG concentration. The study of OG in aquatic ecosystems is an extremely important and complex environmental issue. In order to gain more knowledge on the concentration of OG, this project is carried out to know whether the FSSA lake is polluted or not by comparing the concentration of OG between the water and surface sediment of the lake. Besides, the knowledge of the quantity of OG present is helpful in proper design and operation of wastewater treatment system and may also call attention to certain treatment difficulties. This is because when OG were discharged in wastewater or treated effluents, they may cause surface films and shoreline deposits leading to an environmental degradation.

1.2 Background of Study

Oil and grease (OG) is a measure of a variety of substances including fuels, motor oil, lubricating oil, hydraulic oil, cooking oil and animal-derived fats (Martin, 2000). The concentration of these substances is typically measured within a body of water and sediment. Lakes, river, storm water runoff and wastewater are all monitored for OG.

Sources of OG are mainly from anthropogenic sources. OG need to be contained or recycled typically to keep them from entering the environment. Domestic cooking oil should be poured into a disposable container and thrown out in the trash, not disposed into the lakes, river or seawater. Used motor oil and hydraulic fluids should be disposed at a local automotive part store or a certified hazardous waste facility (Stormwater Management Joint Task Force, 2010). With the growing concern about oil pollution of the marine environment or aquatic environment, the problem of hydrocarbon contamination in freshwater systems often receives less attention.

Hydrocarbons are minor but ubiquitous components of the aquatic environment, with the primary natural sources being biosynthesis by aquatic organisms and terrestrial organic matter (Wakeham, 1976). However, due to the increased dependence on petroleum and its products including OG, inputs of petroleum-derived hydrocarbons often may swamp the natural inputs and may have consequent undesirable effects on the aquatic ecology. In order to determine the presence of OG, also to determine the concentration of OG in the environment, an appropriate chemical analysis is required.

Oil is the necessity that is being used in the worldwide as the source of energy. The crude oil production is rising as the demand for oils of all kinds is continuously increasing. Increased crude oil production will result in a continual increase in the total amounts of crude oil and oil products that are processed and transported each year. Over the years, there have been considerably increasing in chances of accidental spillage and the operational discharge of persistent oils. The estimate for the amount of

oil entering the world's marine environment is about 2.4 million tons per year (Tong *et al.*, 1999).

Pollutants in the FSSA lake water and surface sediment may include organic and inorganic substances. These organic substances are including food processing waste from FSSA cafeteria which can include oxygen-demanding substances, OG. Trash or garbage such as bottles, polystyrene, plastics and food wastes also can be disposed into surface waters leading to the formation of OG in water and sediment. Other than that, improper waste from laboratory also may let to formation of OG in the lake water. As a consequence, the releases of OG in aquatic system are harmful for aquatic plants and fishes.

Sediment is an essential part of water systems. Surface sediment of the lake or canal is an important medium for OG accumulation. OG in water could accumulate the sediment by adsorption and deposition (Ulrich & Wim, 2010). Then, OG in the sediment could go into water and air by geochemical circulation thus bringing secondary pollution, even intrude human through their food chain. Sediment becomes a primary carrier and environmental termination of OG (Müller *et al.*, 1977).

Nowadays, water and sediments contamination has been a growing concern because it can be a source of drinking water contamination. Besides, contaminated sediments can reduce the usability of soil and land for development. The concentrations level of OG in the water and surface sediments is taken and functioned as indicator for OG pollution at a particular area (Ulrich, 1976).

The study area that was chosen in this research is Faculty of Science and Natural Resources (FSSA) lakes area. It is important to know whether this area is polluted by OG or not. The sources of OG in the FSSA lake may come from chemical wastes by laboratory, cigarette smokes by peoples surrounding, combustion emissions and smokes by car fuels or engine exhausts coming from the main roadway in front of the FSSA

lake. Besides, wastes from cleaning floors and washroom detergents also may be the sources of OG and also may be from the wastes such as plastics, polystyrene and oil processing food by cafeteria near to that FSSA lake.

1.3 Objectives of Study

The objectives of this research are:

i. To determine quantitatively the concentration of oils and grease (OG) in water and surface sediments from FSSA lake.

ii. To compare the concentration of oils and grease (OG) between water and surface sediment.

1.4 Scope of Study

The scope of this study is to focus on the concentration of OG in the water and surface sediment at FSSA lake. The sources of OG pollution in this area may come from the cafeteria (food stalls) and laboratory nearby.

There are total six (6) sampling stations for this research. Each sampling station will have replicates water sample and surface sediment sample. The samples are taken and then analyzed in the laboratory by using liquid-liquid extraction for water samples and soxhlet extraction for sediment samples. The sampling collection and analysis will be done twice at different month for comparing the concentration of OG in the water and surface sediment between the months.

In order to measure the concentration of OG content in water and surface sediments, the methods involves is the liquid-liquid extraction of hydrocarbons from the water samples and soxhlet extraction of hydrocarbons using petroleum ether as the solvent, followed by the evaporation of the solvent itself from that phase and lastly the determination of the OG content by weighing the residue filtered (gravimetric analysis).

Petroleum ether is an excellent solvent for this purpose because of its solvent power for OG and because of its volatility, in which the latter makes it easy to evaporate from the OG analyte (Johnson *et al.*, 1996).

In-situ parameters for the research are pH, temperature, conductivity, salinity, turbidity and dissolved oxygen (DO) will be carried out at the field of sampling station (lake area), while the concentration of OG will be analyzed at the laboratory.

CHAPTER 2

LITERATURE REVIEW

2.1 Oil and Grease

According to Martin (2000), oil can be defined as any one or a combination of mineral, vegetable, and synthetic substances and also animal and vegetable fats that are used in a variety of processes, while grease includes the accumulation of oils, fats, cellulose, starch, proteins, and wax. Oil and grease (OG) is any material recovered as a substance soluble in the solvent (APHA, 2005). Otherwise, oil and grease (OG) is defined as a group of organic substances that are insoluble in water (Pawlak *et al.*, 2008). OG is a water insoluble organic material, but oil is liquid at room temperature, while grease known to be solid or semi-solid at room temperature (Solomon *et al.*, 2010). The property of OG is its ability to separate and float on the water. In the other meaning, they are hydrophobic compounds. Once the OG cool, it will become solidify and will be collected as fats in the water system. In addition, OG is an organic material that can be extracted. OG can be easily cause blockage when accumulated. Usually the cleaned up process for blockages are difficult, time consuming and costly. There is a combination of four forms in which OG can exist namely:

i) Oil dissolved in water
ii) Chemically emulsified oil
iii) Free oil which is a liquid that floats in the water surface; and
iv) Mechanically emulsified oil (Pawlak *et al.*, 2008).

Oil and grease (OG) is composed primarily of a fatty matter from animal and vegetable sources, hydrocarbons of petroleum origin, the interferences include sulfur compounds, certain organic dyes, soaps, waxes, chlorophyll and related industrial compounds (Mills *et al.*, 1999; Eaton *et al.*, 1995). High concentrations of OG can cause toxicity in receiving waters, and most disposal regulations require that there must be no disposal of oily wastes that produce the sheen on the surface of the receiving water.

When OG was released to the lake, they will undergo certain processes, which contribute to their ultimate fate over various time periods. OG in the water will undergo the processes that they are led to accumulate in the water and sediment. The processes mentioned are spreading, evaporation, dispersion, emulsification, dissolution and sedimentation. Spreading process is the most obvious process that immediately undergone by released oil into the water surface. In this process, OG will begin to spread as a coherent slick at a rate determined by its viscosity (Douglas, 1999).

Besides, evaporation process will causes a major physical change in oils discharged at the lake since these have volatile components (Douglas, 1999). This process is helped by the spreading of the oil in which increases the surface to volume ratio. The rate of evaporation is determined by the volatility of the OG. For dispersion of OG in water, turbulence and wave motion will causes the OG to disperse, producing various size droplets (Douglas, 1999). The large droplets rise back to the water surface while small droplets may be suspended in the water column.

Other than that, emulsification can increase by three or four times the total volume of the floating oils because OG often absorb water creating a highly viscous emulsion (Douglas, 1999). Some components of oil will dissolve slightly in water, particularly those with oxygenated groups within the component. Solubility is a fundamental physical property directly related to environmental mobility of a compound and reflects the degree of non-ideality between a solute and water (Shiu *et al.*, 1990; Opperhuizen *et al.*, 1988). Compounds that exhibit high water solubilities tend to become quickly dispersed in the environment via the hydrological cycle, are associated

with the sediment and biological phases to lesser extents and often have higher degradation rates relative to sparingly soluble compounds (Lyman *et al.*, 1990). Therefore, in the water, there is the concentration of OG can be found. OG has the low solubility and tends to form floating scum layers in surface water and wastewaters (Radojević & Bashkin, 2006).

While sedimentation occurs when organic particles or other suspended solids cling to drops of oil causing them to sink. Sedimentation refers to sinking through the uptake of sediments which would tend to increase the density and therefore eventually lead to sinking. However, it is hard to see this process occurs with the floating OG, unless during the emulsification process in which the sediment might be introduced to the OG with the water (Douglas, 1999).

2.2 Properties of Oil and Grease

OG floats and can cover a wide area, carried along by wind and wave motion. Spilled oil is generally classified according to whether it is persistent or non-persistent (Douglas, 1999). It is worth noting that even though the volatile compounds that comprise the non-persistent oils do evaporate rather quickly, they can still contaminate the water and the sediment.

2.2.1 Density

The mass per unit volume of the oil is known as its density. In general, the less dense the oil, the more volatile it is and the more mobile it is, also become less viscous (Douglas, 1999). The density of the OG is related to its specific gravity.

2.2.2 Specific gravity

Specific gravity is the density of OG in relation to pure water which has specific gravity equal to 1. Most of OG are lighter (less dense) than water and therefore have a specific

gravity less than 1. This means the OG will float on water. But the density difference between OG and water is significantly reduced as the OG emulsifies (Douglas, 1999).

2.2.3 Volatility

When the components of the OG are lost easily to the atmosphere by evaporation, it is referred to its volatility. As the volatility of the OG is higher, its mobility also greater and the dispersion of OG will become more easily (Douglas, 1999). Besides, the volatility of oil is described by its distillation characteristics. The compounds in oil have different boiling points. Those with lower boiling points evaporate more quickly, but are often more toxic.

2.2.4 Viscosity

Viscosity is describes the resistance of oil to flow. High viscosity oil will flows very slowly and with difficulty, while low viscosity oil will flows easily. The viscosity drops as the temperature of oil increases. For this reason, water temperature and heat from the sun can affect the behavior of oils (Douglas, 1999).

2.2.5 Pour point

Pour point is the temperature at which the oil stopped to flow as the temperature falls and at which it begins to flow as the temperature rises. Oil with a temperature lower than its pour point will behave as a solid. If the pour point is lower than the temperature of lake water, then the oil will remain as liquid and will disperse according to its density, volatility and viscosity since these properties would affect the outcome normally (Douglas, 1999).

2.3 Hydrocarbons Constituent in Oil and Grease

The oils and fats are the mixtures of lipids. They are mainly triacylglycerols (generally > 95%) accompanied by diacylglycerols, monoacylglycerols and free fatty acids, but they may also contain phospholipids, free sterols and sterol esters, tocols (tocopherols and

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