Oil and Grease (OG) Content in Seawater and Sediment of
The Jakarta Bay and its Surrounding

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Abstract. Oil and grease (OG) pollutants were found and measured in seawater and sediment, causing damage to the marine environment. Observations of total concentrations of OG in seawater and sediment have been conducted in the waters of Jakarta Bay and surrounding areas in March 2017. This study investigates the total contamination levels and spatial distribution of OG in seawaters and sediments in the Jakarta Bay and vicinity area. Seawater and sediment samples were taken at six sampling points in three locations; Ancol, Muara Gembong, and Pari Island. The samples were extracted by dichloromethane and n-hexane solvent, followed by an analysis in the Fourier Transform Infra-Red (FTIR) instrument at a wavelength of 2900-3000 cm⁻¹. The concentration of OG in seawater from Ancol, Muara Gembong, and Pari Island has an average of 258.547 mg/L, 114.454 mg/L, and 240.533 mg/L, respectively. On the other hand, the OG levels in sediments from Ancol, Muara Gembong, and Pari Island have a mean concentration of 18.084 mg/kg, 17.218 mg/kg, and 15.254 mg/kg, respectively. The result showed that the level of OG obtained in these waters is higher than the threshold value based on the Decree of Environment Ministry No. 51/ 2004 regarding seawater quality, meanwhile in the sediment sample is lower than the threshold value based on the Australian and New Zealand Environment and Conservation Council (ANZECC) sediment quality guidelines (SQGs).

1. Introduction
Jakarta Bay has become an aggregate of 13 rivers and dozens of tributaries that heavily polluted. The massive anthropogenic activities dispose of waste to the riverine and decreasing environmental quality in Jakarta Bay [1]. In recent decades, almost an average of 50% of the total oil production was transport of oil in the marine worldwide [2], including Jakarta Bay as shipping line and cargo activities both domestic or international [3]. Oil and grease (OG) are one of the most widespread contaminants in the sea [4], estimated that 1 to 10 metric tons of oil came into the sea from various sources and accumulated in the coastal significantly [5]. OG consists of volatile hydrocarbons or oil released from the engine’s incomplete combustion emissions, found higher than oil that directly into the sea [6]. From the ecotoxicological perspective, Tam et al. [7] reported that 100% mortality of Flounder fry occurred at an oil content of 1,000 μg.L⁻¹ (1 ppm), abnormal growth occurred at an oil level of 10 μgL⁻¹ (0.01 ppm).

The source of OG pollution can be due to the oil spilled from leakage of tanker shipping, river runoff, domestic pollution, sea transportation, or offshore platform in Jakarta Bay waters and its surrounding [8]. The oil spilled into the sea from both offshore platforms, and leakage of tanker ship was carried out by hydrodynamics of water and eventually reached the coastal area of Jakarta Bay [9].
This case always attracted great attention from the broader community because of adverse effects around the coast and has significant damage to organisms in aquatic environments [10]. Furthermore, oil pollution can degrade the quality of seawater physically, chemically, and biologically such as disruption of photosynthesis and respiration process in marine organisms [11,12]. This pollutant can also be harmful to the living biota because it is affected by organisms’ fertilization[13]. Therefore, it is necessary to assess the contamination level and oil distribution pattern in these seawaters. Besides, the study of OG level in seawater and sediment is still limited data in these regions.

This study aims to determine the pollution level and spatial distribution of OG in seawaters and sediments in Jakarta Bay, especially in Ancol, Muara Gembong, and Pari Island. Due to part of the Jakarta Bay ecosystem, these locations were chosen, densely anthropogenic activities, particularly industrial and shipping activities. Providing information about OG concentration and distribution can be a guideline for local governments to manage marine ecosystems’ sustainability.

2. Materials and Method

2.1 Sample Collection

This study was conducted in March 2017 (Inter monsoon 1) in three locations: Ancol, Muara Gembong, and Pari Island, presented in Figure 1. A total of 18 samples respectively for seawater and sediment were retrieved. In particular, every location distributes to six selected points. Two liters of surface seawater were collected and stored in a pre-cleaned amber glass bottle. The sample sediment was collected using Van Veen grab samples and stored in a pre-cleaned glass jar wrapped with aluminum foil. Sediment and seawater samples were kept in cool boxes (4°C) prior to analysis in the laboratory.

2.2 Chemicals

All solvents were purchased from Merck, Germany, such as dichloromethane, n-hexane, tetrachloroethylene, and sodium sulphate with pro analyst grade.

2.3 Sample Analysis

Analysis all glassware was treated by washing it with teepol detergent (common trademark) non-perfume, soaking in hot water, and rinsing with distilled water to eliminate contaminant. The analysis was based on the ASTM D7066-4 method applied by Strother using Nicolet iS5 FT-IR spectrometer [14]. Briefly, seawater samples were filtered through 0.45 µm glass fiber filters (Whatman GF/C), and 2 L filtrate water was extracted by n-Hexane solvent (emsure grade, Merck) with 60 mL, 30 mL and 30 mL using a separator funnel, respectively. Water residue was removed by sodium sulphate anhydrous from organic. Ten grams of sediment were extracted using solvent as follows: 40 mL dichloromethane, 40 mL n-Hexane, and 40 mL of dichloromethane and n-hexane mixture [15–17]. Both seawater and sediment organic phase evaporated in a rotary evaporator for 60 minutes at 40°C until 1 mL. The last sample was added by tetrachloroethylene solvent to 4 mL [18,19]. The concentration of OG was measured with a single measurement using Fourier Transform Infra-Red (FTIR) Nicolet iS5 Thermo Scientific, with the following conditions: final format: Absorbance; detector: DTGS KBr; block divider: KBr; source: IR; accessories: iD1 transmission. Wavelength transmission range was suggested at 4000-400 with maximum range limit as 4000 and minimum range limit as 1000. A blank was analyzed for every 54 samples to ensure batch-to-batch quality and checking of the FTIR background [14].

2.4 Data Analysis

The data presented here were calculated using Microsoft Office Excel 2007 for OG, and the graph was generated using the chart menu provided. Quantitative results of these measurements were developed using the Thermo Scientific™ OMNIC™ TQ Analyst™ software. Maps showing the sampling location were produced using ArcMap10.1, Environmental Systems Research Institute, ESRI®.
2.5 Quality Control

Tetrachloroethylene 99.9% IR-PAI grade was purchased from Panreac Quimica SA. Isooctane and n-Hexadecane (purity 99.5%), were purchased from Merck. Anhydrous granular sodium sulfate 99.0% was purchased from Fluka Chemie GmbH. Iso-octane and octanoic acid were used in the initial calibration standard within a concentration range from 0.0006–0.05 mg/mL with $R^2 > 0.90$. Transmission of spectra waves was obtained from the standard solution in a 10 mm path length cell in a Nicolet iS5 spectrometer. Each measurement needs under one minute at 8 cm$^{-1}$ resolution. Limit of detection (LOD) was calculated < 0.0001 mg/mL. A blank sample was used as comparable in each sampling location, and every single sample has one replicate.

![Sampling location for seawater and sediments of Ancol (ANCOL), Gembong estuary (MG), and Pari Island (PPARI).](image)

**Figure 1.** Sampling location for seawater and sediments of Ancol (ANCOL), Gembong estuary (MG), and Pari Island (PPARI).

3. Result and Discussion

Spatial distribution of OG extent measured from 18 sampling stations showed there has no significant differences between three locations, Ancol, Muara Gembong, and Pari Island (Figure 2), both for seawater and sediment. OG concentration of seawaters from three areas are ranged 49.06–508.18 mg/L with an average of 214.69 mg/L.

In general, the OG concentration of seawater in Muara Gembong was lower compare with Ancol and Pari Island (Figure 2). The lower concentrations of OG in Muara Gembong may correlate with low salinity and low pH from this estuary. This indicates high physical and microbial activity which reduce of OG compound from terrestrial area [20]. Overall, the OG content in seawater surpasses the standards of Decree of Environment Ministry No. 51 the year 2004 on seawater quality standards [21].

Sediments from three locations have OG concentrations in the range of 0.69 to 24.18 ppm, with 16.92 ppm. Interestingly, Pari Island (PPAR103) sediments have the lowest OG concentrations than any other sampling location, such as Ancol, Muara Gembong, and even Pari Island itself, which are...
greater than 15 ppm (Figure 2). It can be occurred due to at this location was low anthropogenic activities.

Oil content in either the Ancol, Muara Gembong, or Pari Island does not affect oceanographic parameters such as salinity, temperature, and pH (Table 1). However, this contradicts the composition of physical chemistry in oil. High salinity will affect the solubility of one oil fraction, namely the structure of polycyclic aromatic hydrocarbons (PAH) in seawater [22], which will impact marine organisms. The hydrodynamic condition and organic matter contents in Jakarta Bay could be affected by the spreading of oil contaminants in seawater and sinking processed oil contaminant particulates in sediment. Even more, Pari Island was located in the open sea that was affected by the monsoon regime. In coastal waters, the source of oil contaminants was dominated come from riverine input, and its spreading was affected by the current and tidal regime [23].

Figure 2. OG concentrations in seawater (A) and sediment (B) in Jakarta Bay and its surrounding.
Table 1. Seawater characteristics in Ancol, Muara Gembong, and Pari Island

| Sampling Point | Depth (m) | Salinity | Temperature (°C) | pH   |
|----------------|-----------|----------|------------------|------|
| ANCOL01        | 0,2       | 25,9     | 31,02            | 8,64 |
| ANCOL02        | 0,2       | 25,7     | 31,72            | 8,72 |
| ANCOL03        | 0,2       | 24,6     | 31,06            | 8,57 |
| ANCOL04        | 0,2       | 25,9     | 31,13            | 8,64 |
| ANCOL05        | 0,2       | 25,4     | 31,13            | 8,51 |
| ANCOL06        | 0,2       | 25,6     | 31,52            | 8,56 |
| MG01           | 1         | 10,5     | 30,58            | 7,84 |
| MG02           | 1         | 2,28     | 32,9             | 7,36 |
| MG03           | 1         | 2,1      | 32,57            | 7,39 |
| MG04           | 1         | 2,19     | 33,47            | 7,45 |
| MG05           | 0,5       | 2,22     | 33,21            | 7,44 |
| MG06           | 1,5       | 4,11     | 32,4             | 7,57 |
| PPAR101        | 0,3       | 31,6     | 33,28            | 8,41 |
| PPAR102        | 0,3       | 31,5     | 33,4             | 8,17 |
| PPAR103        | 0,25      | 31,3     | 34,51            | 8,4  |
| PPAR104        | 0,51      | 31,08    | 35,2             | 8,24 |
| PPAR105        | 0,4       | 31       | 31,49            | 8,35 |
| PPAR106        | 0,2       | 30,6     | 33,77            | 8,4  |

A comparison of measured oil content data in seawater samples from various Indonesia locations was shown in Table 2. Sunda Strait (Merak - Anyer) transportation lane and vessels near oil exploration and exploitation have lower OG concentration than Jakarta Area. It was probably occurred due to the Sunda Strait highly affected by the hydrodynamic condition of the Indonesian throughflow (ITF) that come from the South China Sea to the Indian Ocean [24], with high current and wind intensity [25]. Therefore, oil pollutants would be segregated and spread following the surrounding hydrodynamical, eventually to the coastal area near the Sunda Strait area. OG content in Ancol, Muara Gembong, and Pari Island waters is dramatically higher compared to five locations, which according to the Decree of Environment Ministry No. 51/ 2004 [21]. Meanwhile, in the sediment sample, Indonesia has not any regulation of the threshold value yet. Therefore, this study’s oil level was compared with neighboring countries such as Australia and New Zealand region, which have had sediment quality guidelines (SQGs). The result of this study showed that the oil level in sediments was lower than the SQG threshold value from the Australian and New Zealand Environment and Conservation Council (ANZECC) (< 280 mg/kg) [26].

Table 2. The range of OG levels and average in seawater in several locations in Indonesia

| Location                | OG [mg/L]  | Average [mg/L] |
|-------------------------|------------|----------------|
| Ancol                   | 84,66-508,18 | 258,55         |
| Gembong Estuary         | 49,06-236,97 | 114,45         |
| Pari Island             | 99,27-483,01 | 240,53         |
| Southern Leti Waters    | 0,10-0,27   | 0,18           |
| Northern Leti Waters    | 0,08-0,12   | 0,10           |
| Between Merak and Cilegon | 6,47-9,86 | 8,64           |
High levels of oil in seawater will reduce the absorption of oxygen, so that will cause an environmental hypoxic condition. Also, the performance of oil-breaking microbes is disrupted by the reduction in dissolved oxygen levels [27]. According to Zobell and Hittle [20], for complete oxidation of one gallon of crude oil, dissolved oxygen is needed from 320,000 gallons of seawater saturated with air. The natural remediation process by these microbes will break the fraction of regular paraffin crude oil. In contrast, oils with a more toxic aromatic ring will be solved longer (degradation) [28]. Disturbance to the life of marine biota against oil pollution generally occurs around estuarine and beaches because the frequent oil pollution usually occurs [20]. However, when the ability to recover from the environment has exceeded, then marine biota damage could happen very quickly. As the recovery of this damage in marine biota takes a long time [29], this scenario could pose a serious danger to the marine ecosystem where the contamination occurs.

The literature study shows that when the OG fraction enters waters, it will reduce by a natural evaporation process [30]. However, this is a complicated process in oil accumulation of sediments and biota [31]. The bioaccumulation process will bind to fat tissue and naturally concentrated following the food chain pathway to a higher consumer level [30]. Fish and other seafood as an essential protein intake for humans will have a high risk to human health if they accumulate compounds from highly toxic and persistent oil fractions such as PAH [32]. Therefore, it needs circumspection and vigilance to benefit from fish and other marine biotas as a daily consumption due to oil contaminants content.

4. Conclusions
The level average of oil and grease in Jakarta Bay and its surroundings are 114.454 - 258.547 mg/L and 15.254 - 18.084 mg/kg in seawater and sediment samples, respectively. OG contaminants were detected and distributed in each sampling station with a variety of concentrations. It is necessary to monitor and evaluate the quality environment of Jakarta Bay through seawater and sediment samples frequently. In case of an oil spills incident both from the off-shore platform or tanker shipping, environmental baseline data has been provided. Strict supervision is needed for all ships across these waters, including ships docking process and oil dumping waste.

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